Once upon a time, back about 1979, there was a search for an overdue hunter in the Blue Ridge mountains south of Shenandoah National Park. It was a medium-size search, less than a hundred people, including local fire and rescue personnel and local hunters. The effort was led by the Appalachian Search and Rescue Conference (ASRC), and most of the ASRC members there were from the ASRC's Blue Ridge Mountain Rescue Group (BRMRG) in nearby Charlottesville, Virginia.

Now BRMRG was (and is) based at the University of Virginia, and there is a certain ethos that abounds in collegiate SAR teams. In this particular case, it had led to semi-tech evac races – rival teams seeing how quickly they can move the litter up or down a mountainside, with a belay or lowering rope.

We found the hunter deceased, on the eastern slopes of Bear Den Mountain, not far from the Appalachian Trail at Beagle Gap. He was not far from an old woods road, in a relatively flat area, but right near where the mountainside suddenly steepened to the east.

After permission from the coroner to bring the body to the roadhead, discussion turned to the best way to evacuate the body. Since there was no hurry, we decided to do it as a training exercise. Round about this time, some of the other search teams were congregating at the find site, so we had plenty of personnel, and more importantly, plenty of trained and well-practiced personnel. We considered going up Bear Den Mountain (really more of a sloping hill) up to Skyline Drive. But we thought some more. We looked at the steeper but mostly open slope downhill to the southeast from us. We looked at the map and saw the jeep trail in Greenwood Hollow right at the bottom. We realized the longer downhill route would be both faster and easier. We decided to use our 200’ rope, and do a semi-tech evac multiple pitches down to the road. We called the Western Albemarle Rescue Squad (it helped that some BRMRG members also run with WARS) and they detailed an ambulance to await us at the bottom.

We loaded the subject’s body in a body bag, and then tied it into the litter.

We assigned a team of three people to be the rotating belay team: **Belayer**, **Uphill Ropehandler**, and **Downhill Ropehandler**. There was no urgency. But, we were going to do this as race against time, both for fun and to test ourselves. So we picked those who'd done the best jobs during the BRMRG semi-tech evac races. (Getting a belay set up quickly and cleared quickly takes plenty of practice.)

We discussed using Figure 8 descenders as lowering devices – we had the Figure 8s and slings with the litter – but finally decided to go with tree belays, where the rope is simply wrapped around a tree. Tree belays are a bit harder to set up, work,
**Educational Objectives**

**Field Team Member (FTM)**

- Define the following terms used to describe ropes used in wilderness rescue:
  1. Kernmantle construction;
  2. Static Rope;
  3. Dynamic Rope; and
  4. Tubular Webbing.

- Describe the use and care of the carabiner, the Figure-8 descender and the brake-bar rack descender.

- Demonstrate the ability to tie correctly these knots:
  1. Figure-8 loop;
  2. Figure-8 bend;
  3. Square knot;
  4. Water knot (overhand bend);
  5. Prusik knot;
  6. Double fisherman’s knot/barrel bend;
  7. A redundant seat harness;
  8. Bowline knot;
  9. Girth hitch; and
  10. Simple overhand.

- Demonstrate these rope handling techniques:
  1. Uncoiling and stacking a rope;
  2. Inspection.

- Demonstrate these litter handling techniques with appropriate calls:
  1. Patient loading;
  2. Litter lift, lower and carry;
  3. Litter bearer rotation;
  4. Litter laddering, including toe-nailing;
  5. Turtling;
  6. Lap pass; and

- Act effectively and efficiently as litter captain in a non-technical evacuation, including the proper use of toenailing, ladderling, and rotation of litter bearers.

- Act effectively and efficiently as litter team member on a semi-technical evacuation and describe the personal equipment required for the rescuer’s safety.

- Demonstrate proper belay techniques including:
  1. Anchoring;
  2. Belayer tie-in;
  3. Stance;
  4. Aim;
  5. Uphill and downhill travel;
  6. ASRC standard calls; and
  7. Tree-wrap and mechanical brakes.

**Field Team Leader (FTL)**

- Demonstrate the ability to tie correctly the knots below (in addition to those knots listed in the FTM standards):
  1. Butterfly;
  2. Bowline;
  3. ASRC seat harness.
  4. Load-releasing hitch; and
  5. Cross-chest harness.

- Assemble and use a single line rappel system that includes a belay.

- Demonstrate the ability to direct a six person litter team safely in rigging a Z-haul system (3:1 system), a 4:1 hauling system, a “brute force” hauling system, and, using the systems, to move a litter a minimum of 100 feet up a 45 degree slope.

- Demonstrate the ability to rig to an anchor using the following methods:
  1. Tree-wrap and tie-off; and
  2. Using webbing sling loops.

- Demonstrate the ability to cast, pad, and rig static lines.

- Demonstrate the ability to belay competently, including:
  1. Proper anchoring, stance, tie-in and aim;
  2. Correct use of calls and fall catching; and
  3. Tandem Prusik belay.

- Demonstrate competence in braking litters with tree wrap belays and mechanical devices.

- Serve competently in all positions on a semi-technical rescue, including:
  1. Serving as rope team leader with tree-wrap brakes, Figure-8, and brake bar rack; and
  2. Selecting suitable anchor points.

- Demonstrate the ability safely to load and tie a patient into a litter, and rig it for semi-technical evacuations.

- Demonstrate competence in route selection for a semi-technical evacuation.

- Demonstrate the knowledge of and ability to care properly for ropes and technical rescue equipment.

These objectives are taken from the Training Standards of the Appalachian Search and Rescue Conference (v7.1, 5/12).
and clear, at least if you want enough friction to handle a body, a litter, and four litter bearers going down a steep slope. But our rope team was well- and recently-practiced, and thought that the tree belays would be adequate even for this fairly-steep descent. And, they would be faster to set up and clear, at least for our experienced rope team.

We tied the 200’ BlueWater II static belay rope into the head of the litter with a bowline, with the bowline loop twisted around the top litter rail for extra security. (We were using a metal Stokes basket litter, but remember, this was in the days before plastic Ferno and Junkin litters.) We then ran the rope uphill from the litter past the tree The Belayer had selected for the first belay. We took the remainder of the rope and stacked (randomly piled) the rope a few feet above the tree, after removing any downed twigs that might snag on it.

The mountainside was fairly steep, so we thought we’d be OK with a team of just four litter bearers. We didn’t think there were any cliffs along the way, but we expected some very steep sections hiding between those contour lines, so we had our litter bearers put on seat harnesses and once we were ready to go, they would clip into the litter rail with short slings.

We were about ready to head down the mountainside in good order. But then there was a complication.

As usually happens, some of the Field Teams that had been out on search tasks started showing up at the find scene. This always seems to occur. Some sort of magnetic effect, perhaps. Mostly it’s a good thing as you may need extra people at the scene, but sometimes it gets a bit crowded. In this case, it was crowded; there were maybe 20-30 people there, including a bunch of local hunters who had served as untrained volunteers with some of the Field Teams.

One of the hunters, a young man with a big Bowie knife on his belt, appeared to decide that he needed to chop down a small (2-3” diameter) tree with his Bowie knife. To make a fire. I’m not sure why we needed a fire, or why he thought chopping down a green tree would contribute to building a fire. Sometimes it’s better not to ask.

Anyway, he was trying to chop down this innocent little tree with a Bowie knife, the knife somehow slipped and stabbed his right lower leg down to the bone (as we found out later, severing his popliteal artery, the major and pretty much sole artery to the calf and foot).

He was both lucky and unlucky that seven EMTs were standing just a few feet away. Lucky, in that he didn’t lose more than a few drops of blood. Unlucky, because it looked like a rugby scrum with all seven jumping on top of him at once.

In a matter of a minute or less, the wound was wrapped with a pressure bandage that controlled the bleeding. (It was a transverse laceration of the artery, which tends to retract and stop bleeding, otherwise the bleeding would have been much harder to control.)

There really wasn’t any discussion about what to do. We quickly took the hunter’s body out of the Stokes, and packaged our live patient in the litter.

The Belayer stepped in front of the rope, faced away from it, squatted, and reached back so that both her hands grabbed the rope. She then lifted up the rope, so it was running behind her waist. She then quickly and nimbly backed around the top of the tree and then one more time around the tree, dragging both ends of the rope with her. “Belay on!” she shouted.

The Downhill Ropehandler started trotting down the hill ahead of the litter, picking a route for the litter.

“Ready!” shouted The Litter Captain (front left litter bearer). “Lift!” Turning to The Belayer, he shouted “On Belay! Down Slow!” (with an echoing “Down Slow!” from The Belayer) and then after a couple of seconds, “Down Fast!” and again The Belayer echoed “Down Fast!” She was in standard belay stance, using the friction of the rope around the tree to lower the litter, patient, and litter bearers smoothly at the indicated speed.

The Uphill Ropehandler grabbed hold of the tense rope uphill of the litter, to help lift and guide the litter a bit, but mostly to help keep himself stable as he walked quite rapidly down the steep mountainside with the litter. He kept a close watch on the rope both above and below his position, to make sure it didn’t get caught and bent around a tree or rock. (If the rope were bent around a rock and then slipped off, it could cause the litter to suddenly plunge several feet, resulting in a shock load.)

The litter moved down the mountainside at a fast walking pace, most of the weight on the rope and thus making it easy for the litter bearers. It went about a hundred and seventy feet.

From far above, The Belayer shouted...
The Downhill Ropehandler pointed to a big, solid-looking tree with a somewhat level, clear area just below it. He quietly told The Litter Captain “right below this tree!” The litter bearers brought the litter down past the indicated tree and set it down securely. As soon as it was down and secure, the Litter Captain shouted “Stop! Off Belay!”

The Belayer echoed “Stop! Belay Off!” She dropped the rope, and stepped out of the loop in which she’d been standing. She picked up the rope loop, and carefully but rapidly unwrapped it from around the tree. As soon as it was clear from around the tree, she shouted “Clear!” and immediately started a sort of controlled and careful slide down the mountainside along the now slack rope.

At the same time, the Downhill Ropehandler had climbed above the tree, and was standing sideways to the slope, with the rope in both hands and running across the small of his back. As soon as he heard the “Clear!” he backed around the tree about a time and a half; having now become The Belayer, shouted “Belay On!” – and at the same time, the Litter Captain had given a quick “Ready! [Pause] Lift!” to the litter bearers. He then shouted “On Belay! Down Fast!” to which The Belayer (the new belayer, that is) shouted “Down Fast!” and started the rope slipping around the tree quickly but smoothly.

The man who had previously been The Uphill Ropehandler now moved down below the litter and started heading down the hill, now becoming The Downhill Ropehandler. He scouted a course for the litter while keeping an eye out for likely belay trees.

The woman who was at first The Belayer now became the Uphill Ropehandler, and she slid and walked down past the man who was now The Belayer and his tree; once below the tree, she grabbed the taut rope between the belay tree and the litter, using it as a moving handrail as she moved down with the litter.

The team repeated this process, over and over some twenty times, until they reached the ambulance waiting along the road at the bottom. The waiting EMS crew whisked the patient to the Emergency Department at the nearby University of Virginia Hospital. He was there about 45 minutes after the injury. When the vascular surgeon came to the ED to see the patient to arrange for an emergent arterial repair, he reportedly said “It’s a good thing this happened right here in the city, or he would have lost this leg.”

You can’t learn how to do a semi-tech evac like that from reading this or any book. But a bit of study prior to practice will make your practice a bit easier and a more effective learning experience.

*Translation: “About twenty feet of rope left.”*
Types of Evacuations

In search and rescue, at least ground-mountain-wilderness SAR, and at least in the Appalachians, we use the term “evac” to refer to carrying a patient, usually in a litter (stretcher), from the backcountry and usually to a trailhead or roadhead. (A trailhead is where a trail starts from a road, and a roadhead is the end of a road.) Once the patient gets into an ambulance, we call it transportation rather than evacuation. There are no official rules about such grammatical usage, it’s just the way we talk about things.

We generally talk about three types of evacs:

- Nontechnical evacs,
- Semi-tech evacs, and
- Technical rescue.

A nontechnical evac is when you need to carry the patient out to a road, but you don't need a rope, except maybe a short line for a quick belay for a few feet here or there. We often have a 20-30 foot rope attached to the head of the litter but tucked in next to the patient for such situations. On a nontechnical evac, if a litter bearer falls, there is no danger to the litter bearer, the team, or the patient.

A semi-tech evac is where the terrain is rugged enough that the litter needs a belay or lowering line, but the litter bearers do not.

Well, more or less. Because if we clip the litter bearers into the litter, that's a sort of belay, but we still call it a semi-tech evac. It makes sense, in a way. The only difference between a “regular” semi-tech evac and one where the litter bearers clip into the litter is the clipping into the litter bit. You still have the rope attached to the head of the litter, and use the same sort of belays, though likely with more friction, so it makes sense to group them together.

Note that we always speak of “nontechnical evacs” but it's always “semi-tech evacs,” not “semi-technical evacs”; I have no idea why; maybe “semi-tech” just rolls so trippingly off the tongue. In drier climes than the Appalachians, people sometimes call this a “steep scree evac.” (Scree is a natural slipp-slide of gravel.) But since most of the steep scree in the wet Appalachians has green stuff or trees growing all over it, we don't use that term much here.

And then there is The Technical Rescue. Note it seems to be always singular, and in capitals. And it's always a “rescue” and not an “evac.” (Sorry, it's just the way we talk when discussing such things. It just grew that way.) Technical rescue is when terrain is vertical enough that you usually have a “spider” set of slings on the litter to keep it more or less level. Well, actually, in cave rescue, you may have to do a vertical raise with the litter vertical, but if the litter's hanging free like that, even if it's hanging by the head of the litter, it's still “a technical rescue.” In fact, “vertical rescue” is pretty much a synonym for “technical rescue.” Again, as with semi-tech evacs, this grouping of such evacuations makes sense: in a technical rescue, there is much more stress on anchors and hardware, and the rigging is much more complex.

Some people try to define these classes in terms of the angle of the slope. I've seen fancy diagrams decreeing which precise angles are technical and which are not. I applaud the attempt to be rigorous, but I think it's a bit misguided.

First off, some compasses include clinometers, but most don't. And except for a couple of civil engineers and foresters, I don't know anyone who can come anywhere close to estimating a slope accurately by looking at it, unless it's flat or vertical. Try it, you'll be surprised how hard it is. (Yes, I know you can get clinometer apps for your phone. I have one on my phone. But I'm on a rant here, let me continue.)

The problem is that simple slopes don't solely determine how dangerous a slope is. Even if the slope is not that steep, mossy, wet boulders in a ravine are extremely dangerous and require a belay. A fall forest floor after a rainstorm, covered with slippery wet leaves, can likewise be dangerous. And let's not even talk about ice storms.

The point being that an experienced SAR team member can take a look at a slope and determine what kind of a belay the litter needs in a second or two. Whereas a newbie/greenhorn with a clinometer app on his phone probably won't get it right.

This essay will deal with nontechnical and semi-tech evacs.
Nontechnical Evacs

Carrying a litter is easy. Well, no, it’s not really, it’s pretty hard work, but learning how to carry a litter isn’t very hard.

The first rule is to not get hurt. The easiest way to get hurt is to pick up the litter wrong and mess up your back.

You have probably heard all the hype about “lift with your legs, not your back.” But it’s all true. Bending over a litter and then lifting is a great way to give yourself pain and misery for a week or so.

Picking Up The Litter

With a litter, though, it’s hard to get close enough to lift with your legs. There are a couple of tricks.

1. Face the litter
2. Squat down on one knee. Keep the other knee up. (Some obsessive-compulsive people insist that everyone get down on the same knee. Ignore them)
3. Put both hands on the litter rail. Lean away from the litter. This keeps your back reasonably straight and upright.

Here’s the second trick. When it’s time to lift the litter and you hear The Litter Captain say “READY! [pause] LIFT!” don’t lift. Right. Don’t lift.

Instead, pull out. Pull directly away from the litter bearer across from you. The litter will lift slowly and smoothly. (Slowly and smoothly is good for preventing bad things. Like back strains. Like dropping the litter.) I know it seems like magic, and maybe it is, but try it, you’ll like it.

Now for a joke.* (Bear with me, it’ll be relevant in a bit. Well, a little bit relevant.) Goes like this:

* This was written by comedian Emo Philips in 1985 and was voted best religious joke of all time by the website Ship of Fools.

Once I saw this guy on a bridge about to jump. I said, “Don’t do it!”

He said, “Nobody loves me.” I said, “God loves you. Do you believe in God?”

He said, “Yes.” I said, “Are you a Christian or a Jew?”

He said, “A Christian.” I said, “Me, too! Protestant or Catholic?”

He said, “Protestant.” I said, “Me, too! What franchise?”

He said, “Baptist.” I said, “Me, too! Northern Baptist or Southern Baptist?”

He said, “Northern Baptist.” I said, “Me, too! Northern Conservative Baptist or Northern Liberal Baptist?”

He said, “Northern Conservative Baptist.” I said, “Me, too! Northern Conservative Baptist Great Lakes Region, or Northern Conservative Baptist Eastern Region?”

He said, “Northern Conservative Baptist Great Lakes Region.” I said, “Me, too!”

I said, “Northern Conservative Baptist Great Lakes Region Council of 1879, or Northern Conservative Baptist Great Lakes Region Council of 1912?”

He said, “Northern Conservative Baptist Great Lakes Region Council of 1912.”

I said, “Die, heretic!” And I pushed him over.

Now, about calls for lifting the litter.

Some insist that the One True Call is “PREPARE TO LIFT!” Or maybe “READY TO LIFT!” And then there are the Trinitarians who insist on “ONE, TWO, THREE, LIFT!”

Personally, I think that fewer words are better, especially if you’re doing something that will likely leave you short of breath. And, in the early days of the Appalachian Search and Rescue Conference, “READY! [pause] LIFT!” is what we chose as the standard.

So do it this way. Or get pushed off the bridge.

The most important thing for The Litter Captain is not what words he or she uses, but that little pause. During that pause The Litter Captain quickly scans all the litter bearers to assure they are ready. Yes, if you’re a litter bearer and you hear “READY!” and you’re not ready, a little enlightened self-interest suggests you say “HANG ON A MINUTE!” or “WAIT!” or something similar. I suppose “STOP!” is more official-sounding. But is simply being official-sounding enough to establish a new standard?

You’re standing right next to the person, so there aren’t likely to be problems communicating. No, there needs to be no One True Call for this.

Even if the litter bearers are expected to respond if unready, still, it’s The Litter Captain’s job to make sure everyone’s really ready.

It is important to have one person on the litter, and only one person, who communicates with
the Rope Team:

**The Litter Captain**

Who, you might ask, gets to be The Litter Captain? Options include:

- whoever is senior in grade (this means the highest ranking person, e.g., a Field Team Leader outranks a Field Team Member, and whoever has been a FTL longer is senior within the grade of FTL)
- whoever wins a vote
- whoever is tallest
- whoever is shortest
- whoever has the coolest helmet or hat
- whoever really, really wants to be The Litter Captain
- whoever wins the fight

Long ago (circa 1974), the ASRC debated these sorts of things and finally decided it’s your position on the litter. It’s easy to remember: whoever is in the driver’s seat gets to be The Litter Captain. Again: the litter bearer in the front left gets to be The Litter Captain. I suppose there might be a bit of jostling to see who ends up in the “driver’s seat” but really, everyone’s supposed to be able to do the job. And, if you’re switching off litter bearers (which is a really, really good idea; see below) then everyone eventually gets to be The Litter Captain.

If you suddenly decide to move the litter backwards for some reason, then a litter bearer who was in the back may suddenly become The Litter Captain.

(And yes, if you go to the UK, then the person in the front right is The Litter Captain. Now stop it and get back to reading.)

Putting down the litter is almost the reverse of picking it up. The standard call is “Ready! [pause] Down!”

Again, you lean out and keep your head up and your butt down as you lower the litter. When training people to pick up and put down a litter, it is customary for the instructor to walk around the litter and litter bearers as they are practicing. Sometimes, to prevent back injury, urgent intervention is appropriate. If the instructor sees a litter bearer who is leaning over – as shown by the bearer’s buttocks protruding from the line of litter bearers – verbal remonstrances are inadequate, and the instructor is expected to rapidly and forcefully place his or her boot on the lower back and top of the offending litter bearer’s buttocks and forcefully push it in line. This is just as much a safety measure as a means of negative reinforcement. And, yes, this is where we get the phrase “kick butt.”

However, there is one major difference between raising and lowering the litter. It’s possible to put the litter down on a punji stick (sharpened sticks left sticking up as a booby trap). Or a shrub someone has cut off with a machete to clear a helicopter Landing Zone (LZ) which is functionally the same. Back when we used to use real Stokes litters, which were also known as Navy Wire Basket Litters, this was a big deal. These original litters had a steel frame with chicken wire in it. Punji sticks left by well-meaning but incompetent machete-wielding landing-zone clearing parties (or trail maintainers) were a real hazard. You’re supposed to cut off right at the ground, and leave it cut flat, not diagonally-pointed.

Now with plastic Stokes litters, this is much less of a concern. However, putting the litter down on a sharp pointy rock can still crack a plastic Stokes, not to mention flexing the Stokes and hurting the patient.

So that [pause] allows everyone, prior to setting down the litter, to check underneath for any impediments, for example, wasp nests, mines, or small furry animals.

It’s also very embarrassing when all of the litter bearers let go at the same time, and the litter then slides down the mountain like an out-of-control Olympic Luge sled. Unlike the wire-basket Stokes, which has lots of friction, the newer plastic Stokes are pretty slippery and this is not just theoretical.

There are some simple solutions. Leaving a couple of people holding onto the litter (usually those on the downhill end) will work. However, this may not be favored by the people on the downhill end of the litter. In forested areas, a simple solution is to have a short (~20’ = 6 m) belay line attached to the head of the litter. (Even if you have a 200’ rope attached to the litter for

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* My 14 year old daughter, on reading this, made me put this in: “You can’t believe a thing he says.”

† The best machete for clearing a LZ is a Woodman’s Pal, made in Pennsylvania since the 1940s. It was standard issue in World War II. I favor the long-reach version. My wife and daughter and I do trail maintenance from time to time. Often when we go out for a hike we take along some trail tools to do a little clearing along the way. At my daughter’s 9th birthday party, the extended family was sitting around the table watching her open her two big presents. One was an American Girl doll. Family approved. When she unwrapped the second, though, family was horrified. It was her own Woodman’s Pal machete. “Now when we’re hiking, I don’t have to borrow yours all the time! Great!”
a semi-tech evac, such a separate short belay line may be handy.) Tie a figure 8 loop with a carabiner about 5’ away from the litter. Whip it around a tree and clip it back into the litter and you’re secure.

There may be times when the Medic tells you that it’s important to keep the litter in a slightly head-down position (perhaps blood loss, dehydration, or hypothermia), or perhaps a slightly head-up positions (perhaps a head injury, or a breathing problem). In such cases some of the litter bearers will just have to suck it up and hold the litter in the appropriate position during a stop.

Speaking of stops: yes, the Medic may need a stop for some medical reason, or you may need to stop to change the litter rigging, or the patient may need to pee. But except for such mandatory stops, the litter should never stop moving; for a rescue team to accomplish this takes study and practice, which is why this essay is so long.

## Carrying the Litter

It is said that “many hands make light work” and so it’s standard to have six litter bearers; any more than six is a crowd, as you’re stepping on someone’s heels. But 12 hands doesn’t make carrying a litter exactly “light work.” Actually, it’s only 6 hands, because when carrying and facing forwards, you can only keep one hand on the litter.

There are things you can do to make carrying easier. The simplest and most effective are load straps. A load strap is piece of 2” seat-belt type flat nylon webbing, about 10’ long, without any knots or hardware. You girth-hitch the middle of it to the litter rail just behind where your hand will be on the rail. (It works better if it’s girth-hitched behind, not in front of, your hand.) You gently pile it on top of the patient.

Let’s assume that you’ve lifted (or rather, pulled-out) the litter. Assume further that you’ve turned left, in the direction of travel, and you have your right hand on the litter. Now you’re ready to carry the litter, but it’s already getting pretty heavy on that right arm. So, with your left hand, you reach across in front of you and grab that load strap off the patient. You grab it right next to the litter rail, then slid your hand out along it until you’ve got about 2-3’ of it stretched out from the litter rail. (Sounds pretty easy but try it while you’re carrying the litter and watching where you put your feet.) Lift your hand up a bit over your head and flip the load strap backwards over your head. It should now be running diagonally across your upper back and forwards across your left shoulder. Now bring your left hand down in front of your chest. Wrap the load strap a few times around your hand, then pull down, hard. Now, some of the litter load is on your left shoulder. Really helps that right arm, doesn’t it?

When you are ready to rotate litter bearers (which should be 1/2-2/3 longer when you’re using load straps), you unwind your hand and then gently drop the load strap on the patient.

We’ve tried this with 1” slings, which are quite inferior to the 2” seat-belt webbing. The 1” webbing really cuts into your shoulder painfully.

If most of your evacuations are nontechnical, it may pay to keep a set of load straps pre-attached to your litter rails. Load straps improve the efficiency of a litter carry-out team by twice or more.

## Rotating Litter Bearers

Even with load straps, carrying a litter is hard work. And you get tired out quickly. Or your arms start hurting.

Just a couple of months prior to writing this, I had changed my weight workout to use a weight plate and doing chops with a 10 lb medicine ball. I did myself a serious injury: both my brachioradialis muscles (in the forearm) were toast. Even lifting light things hurt. And then, as we were training at McConnell’s Mill State Park and I was trying to baby these muscles, we had a real rescue.

The Fire Department was there first and had set up a rappel into a ravine. It would have been easier just to go down to the bridge and walk up an informal trail into the ravine, but the Fire Chief had set up this 200’ rappel (no overhangs, some brush but not too bad, easy rappel) and so that was the way we were going into the scene. As the team doctor, I was going to rappel in fairly early to ramp up patient care. (Ended up deciding not to reduce the open ankle dislocation/fracture as there was mud all over it, and neurovascular was intact, but did give a gram of Rocephin IM.)

As I was getting ready to rig in, a firefighter was starting to rappel, and they were going to send the litter down with him. But he looked pretty unhappy doing this rappel even without guiding a litter down – his lack of experience...
You know, this isn’t my first rodeo!” which term Allegheny Mountain Rescue Group members pushups at a time without any significant (carryout). And, unlike the bit about calls for way can really speed up a nontechnical evac was a very awkward carryout. However, none of the firefighters seemed to have were trying to switch out litter bearers frequently. When she tried to send some people around to carry the litter for a few minutes until my fore- was being lowered by a rope attached to the top. I was calling things like “DOWN SLOW!” and “DOWN FAST!” and “STOP!” as I was guid- ing the litter through the brush. And then as I got towards the bottom, I realized I didn’t have a hand to push the Push-to-Talk button on my radio, that it was pretty noisy, and then I was saying “Stop!” and then shouting “STOP!” and then screaming “STOP!” and then as I was holding the entire weight of the litter with my left hand the litter finally stopped.

Later, with my left brachioradialis hurting even more than before, it was time for me to help carry the litter (down to the bridge, not raising up the cliff). And we were short on litter bearers, so I really needed to help. Apparently one of the Allegheny Mountain Rescue Group members passed on a request to the Fire Chief for more litter bearers, which he acknowledged; but then when she tried to send some people around to the bridge he said “I didn’t say you could have them!” And apparently at some point he said “You know, this isn’t my first rodeo!” which term has now gone quite viral within the local SAR community.

But even with my left hand, I was only able to carry the litter for a few minutes until my fore- arm was hurting bad enough that I was afraid I might get a permanent injury. (Thank you, after about 3 months of avoiding those medicine-ball chops, my forearms are fine and I’m up to 60 pushups at a time without any significant pain.) And no, we didn’t have load straps. It was a rough carryout, along an informal/social trail that went over and between big boulders, so we were trying to switch out litter bearers frequently. However, none of the firefighters seemed to have a clue about how to rotate in litter bearers, so it was a very awkward carryout.

Knowing how to rotate litter bearers the right way can really speed up a nontechnical evac (carryout). And, unlike the bit about calls for lifting the litter, there is only One True Way to rotate litter bearers. The ASRC developed this in the early 1970s, but then as there’s only one way that works best, this has probably evolved independently other places.

Here are some issues with litter bearer rotation:

• The litter should not stop.
• Litter bearers should alternate using their right and left arms.
• Litter bearers should be in pairs roughly matched by height.
• Litter bearers should be ready to rotate in to carrying the litter whenever The Litter Captain indicates a need for rotation by calling “READY [GRUNT] TO ROTATE!” (the grunt indicates that you really need to come off the litter right now).
• Relief litter bearers should not have to fight their way past the litter.

We had tried having the extra litter bearers behind the litter. This didn’t work so well. Say you and your part- ner come up behind the litter and then grab hold, and then all the litter bearers shift up a bit, and the pair in the front peel off to either side. Then they have to wait for the litter bearers and all of the relief bearers to pass them before getting back on the trail at the end. And, when you’re behind the litter and there is a call of “READY TO ROTATE!” (leaving out the grunts from now on), you have to rush up to the litter. And it’s hard to take over on the litter while you’re also walking fast to catch, and trying to watch your feet so you don’t stumble.

So it’s better to have the relief bearers in front of the litter. That way, when you and your partner are at the end of column of relief bearers, and you hear that strained “READY TO ROTATE!” from behind, you can step off the trail on either side. You set your feet so you’re stable. Then, as the litter passes, you grab hold of the tail end of the litter, and quickly move out into the trail. Once you’ve shifted your hands forward, and you’re carrying your share of the litter weight, you use your free hand to tap the hand of the litter bearer in front of you. Since the foot is the lightest part of the litter and we tend to go head-first, fairness requires that you move forward a bit, so you’re
not right at the tail of the litter and taking your fair share of the load.

If you’re at the back left of the litter, you’re the one designated to, once you and your partner have hold of the litter, to call "Rotate!" to let the litter team know that it’s about time to shift forwards.

The litter bearer in front of you shifts forward one position, and once securely back in control of the litter, uses his or her free hand to tap the hand of the litter bearer in front. *That* litter bearer then moves towards the front of the litter, and taps the hand of the litter bearer in front.

And, the front litter bearers peel off of the litter, cross sides, and start ahead, moving fast. There often is a long line of potential litter bearers ahead of the litter, and the litter bearers who just peeled off the litter are supposed to head to the front of the line. (The closer you get to the roadhead, the longer the line seems to get.) Now, you might think that asking the people who were just on the litter and likely exhausted to basically do a quick-march to the front of the line is a bit much.

Once upon a time, my wife and I took our toddler daughter on a hike, doing the Ferncliff Trail at Ohiopyle State Park, a short circuit hike. Usually, she rode in a Kelty toddler pack on my back, maybe walking a little bit at a time. As we started out, with her on foot rather than in the pack, we pointed out the store with the big picture of an ice cream cone on it. "See that? We’ll go there once we’re done with the hike.” “OK!” And of course, a bit more than halfway through: “Daddy, I’m tired. Pick me up.” “Well, Laurel, you remember that store with the big ice cream cone on it?” “Yeah?” “Well, we’re hiking in a big circle, so that means the ice cream store is just ahead there.” I pointed to the trail ahead. And Laurel started ahead fast enough we had trouble keeping up with her. Finished her first full dayhike without further chivvying or complaint. Motivation is key.

Same thing with peeling off of the litter and heading to the head of the line: whoever’s at the front of that line of potential litter bearers is the last to take over carrying the litter again. Motivation is key.

One observation: if you have a bunch of litter bearers who don’t know anything about this system (very common), then it’s worth doing a one-minute explanation before setting out with the litter. This will likely save time in the long run.

**OBSTACLES: LADDERING, TOENAILING, TURTLING**

Carrying a litter down a nice, wide flat trail is all well and good. For the five feet of it you will do over your entire SAR career.

But often there are obstacles, narrow trails, trails that go straight up or down, or no trails at all. And there are time-tested techniques for dealing with these problems. And you need to learn these techniques. Or you will flail, waste time, and get litter bearers hurt. Not to mention looking like an idiot.

This is not rocket science. Once you understand the rationale, and practice it a few times, you’ll have it down.

**Laddering**

Sometimes, you’ll be carrying the litter down a nice, wide trail. But it’s right after an ice storm, and you will be tootling right along, when your come to a four-foot diameter downed tree across the trail. Everything grinds to a halt.

No, it doesn’t. Because you already know how to rotate litter bearers, and you have a couple of litter bearers who’ve gone on ahead, and are on the other side of the log, eagerly awaiting their turn to lengthen their arms by carrying the litter.

Basically, this is just a brief interruption in litter bearer rotation. You stop, and then plant your feet solidly. You think to yourself "At this point, I am going to move the litter. I am not going to
move my feet. *I am not going to move my feet.*” Actually, if you’re new to this, maybe you should say it out loud.

Once everyone has their feet planted well, you shift the litter forwards as far as you can without anyone letting go of it. If you can, you set the head down on the downed tree. Once you’ve got the litter where you want it, **The Litter Captain** calls “READY TO LADDER!”

The new litter bearer to the front left of the litter will receive the litter and become the new **Litter Captain**. He or she grabs hold of the litter, and then does a quick visual check of the litter bearer across from him or her. As long as the other litter bearer looks ready, the new **Litter Captain** calls “LADDER!”

Then, without anyone moving their feet – again, **without anyone moving their feet** – the litter bearers shift the litter forwards a couple of feet. The back litter bearers peel off, and just like rotating litter bearers, they hop over the log, and head around to the front of the line, ready to take the litter when it’s their turn.

You repeat this simple process over and over until you’re past the obstacle. For a single downed tree, this only has to be repeated three times. But, if you’ve got a bunch of downed trees right together, you may do it quite a few more times.

You can use laddering for any obstacle, including rocks, and you can use it to get up or down short, steep slopes, in which case we call it…

**Toenailing**

The term **toenailing** is derived from carpentry. Toenailing, also known as skew-nailing, is when you are nailing an upright 2x4 end on to a 2x4 flat on the floor. Carpenters do this all the time, over and over, to create studs for a house wall. You drive the nail in at an angle, through the end of the upright into the 2x4 on the floor.

When you have to go up a short, steep slope, you can ladder up the slope. Except that you hammer the head of the litter into the ground – well, no, you actually just gently place the head of the litter up against the slope, then the **The Litter Captain** calls “READY TO LADDER!” and if you’re the new **Litter Captain** you call “LADDER!” once your partner is ready. And then everyone lifts the litter a bit – it takes a bit of practice not to lift it too much – and the slides it forwards, and toenails it into the slope again.

OK, I made you say it before, and this is when you really need to say it: “*I am not going to move my feet.*” Because if you move your feet while toenailing, then you will lose your balance, and you will fall, dragging the litter and the whole litter team down with you.

When you’re laddering across an obstacle, at least on the far side, you can start getting sloppy and moving your feet, and nothing bad will happen. Usually. But if you develop this bad habit, the next thing you know, you’re toenailing on a slope, and then you move your feet and kablooey, down you all go.

Say it: “*I am not going to move my feet. I am not going to move my feet.*”

**Paving, Turtling and Lap Pass**

PAVING AND TURTLING AND LAP PASSES have little to do with laddering or toenailing except that each is another way to move the litter through a difficult bit, especially in caves.

When a patient is assisting with the rescue in a cave, or in a narrow crevice with rocks at the bottom, a standard thing is to fill holes with people. Yes, we put a seat harness on the patient, even though it’s not a technical route. Yes, we put short fore-and-aft belay lines, and sometimes we pull tension on the front or back belay line to secure the patient as he or she is crossing a tricky bit. But to keep the patient from going splat, even a little bit, it’s standard to put someone in holes the patient might fall into. Sometimes, a team member’s shoulder or upper back or hands can provide a foothold for the patient. If it’s a 4-5’ deep (~1.5 m) hole you can even have people in the hole hold their hands over their heads to help pass the litter.

We call this paving. Which brings up the question: what about simply moving rocks to “pave the way”? Moving rocks is hard and takes several people if you’re moving big rocks. There are also good and bad techniques for moving rocks, and unless you move rocks on a regular basis, you may not be able to tell the difference. Consult someone who moves rocks on a regular basis, such as on
a trail-maintenance crew, if you want to learn how. But if you don’t know how, and the rocks are big, it’s probably not worth the risk of creating another patient. Modifying cave passage to make it easier to move the patient, such as using a rock saw, is an advanced topic beyond the scope of this essay.

Too, cavers tend to be rabid conservationists. Given the incidents of bat-related aerosol rabies in caves, let me reword this: they are strong conservationists. So modifying cave passage is frowned upon, unless it’s really, really needed. So for many reasons, people are used much more than rocks as rescue pavers.

Paving’s not turtling, though it’s sort of related: they both involve putting team members under the patient.

Turtling is for a litter evacuation. It’s for narrow crevices where there just isn’t room for litter bearers on each side. Someone – ideally with knee pads – gets on hands and knees with the litter on his or her back and crawls. Pretty undignified, but effective. Since you can lock your elbows and knees, you’d be surprised at the amount of weight you can carry this way. Sometimes, for a hole in the floor of the crevice, you can, just as described above, get on your hands and knees and just stay still while the litter slides across your back. Indeed, you may find two or three people’s strong backs (literally) filling the hole and allowing the litter to slide across. If the passage gets smaller, you may need to switch from a hands-and-knees crawl to a belly-crawl; we term this snaking.

Another related technique, particularly useful in canyons and keyhole passages of a certain (and common) size, is the lap pass. You get a line of rescuers to sit crossways in the passage, with their feet (or, for smaller passages, their knees) planted on one side, and their butts on the other. It’s sort of like panning, in that the rescuers bridge a hole in the bottom of the passage. However, in this case, the rescuers can use their hands to slide the litter across their laps.

Sometimes you may not be able to hold the litter directly, just due to the configuration of the crevice or cave passage. You can sometimes use load straps to stand well above the litter but still contribute to its movement; we call this a sling carry.

Littering

There are hundreds of types of stretchers and litters for carrying people. Some are suited to wilderness search and rescue, others like ambulance cots not so much. “Stretcher” specifically refers to canvas stretched between two poles, which is not a good way to evacuate someone from the backcountry, so we will henceforth talk about litters. Litter comes from the Norman French litere, which referred to a bed or couch in which people were carried by slaves or servants, popular with the rich since ancient times. They were the Lincoln Town Car limousines of the time. But they were also used to carry the ill or injured.

The standard for most search and rescue teams, at least in the Appalachian mountains of North America, is the Stokes navy wire basket litter, or “Stokes” for short. The design has morphed a bit since Stokes invented it about a hundred years ago, but not all that much.

In its original incarnation, Charles Francis Stokes, Surgeon General for the US Navy from 1910-25, designed it for evacuating the injured out of war-damaged battleships, through narrow passageways (hallways) and up narrow companionways (stairs). It was quickly adopted for land search and rescue as well.

In its original conception, it was a coffin-shaped frame of welded steel pipe, with two steel runners along the bottom. This outer steel framework (later available in aluminum, and now even titanium for rich teams) was load-bearing, and could be used to haul the patient with ropes. Inside this was a non-load-bearing inner basket of smaller solid steel stock in the shape of a basket, with steel chicken-wire fencing lining this inner basket. This provided a secure basket for transporting the patient. The wire basket had advantages for shipboard; it wouldn’t fill with seawater. And it worked pretty well on land, as well. It could be rigged for semitech evacs with a rope on the head, or via a spider for vertical hoists.

Some litters had leg dividers so you could splint the legs to the basket separately, but many teams cut these out as they made it difficult to package the patient for a cold-weather evac. And back when we thought backboards actually had a use, you couldn’t put a backboard on top of the leg divider. Some had some wooden slats under the chicken wire to provide more back support.

Bru Randall tells of a 1975 rescue in
Schoolhouse Cave in West Virginia, regarded as one of the most technically-difficult caves in North America. For a backboard, they used a 1”x12” plank, cut with a saw to fit in the divided-leg wire Stokes, and used holes drilled in the edges and 1/2” webbing to strap the patient to it.

As they became use more for land SAR than naval use, Stokes litters were modified in different ways. The first major modification I know of was the two-part Stokes; it broke down at the waist, and you could stack the two parts and carry it over a rucksack. The Appalachian Search and Rescue Conference’s Blue Ridge Mountain Rescue Group had one the first of these and we managed to break it fairly quickly.

Later, the chicken wire basket was replaced by plastic baskets. Maybe not so good for the high seas, but better for land SAR. Patients weren’t getting poked with sticks and rocks through the chicken wire. And with a plastic bottom, you could slide it on snow in the winter, or on mud and dirt in a cave. They also floated in water. Plastic Stokes also eventually came in two-part versions. I remember that the ASRC’s Shenandoah Mountain Rescue Group got one of the first of these from Ferno-Washington. It broke into its two parts the first time we used it. Two-part Stokes have since improved markedly and are now highly-reliable.

**Extras: Wheels, Akjas, ATVs**

Many devices are supposed to make it easier to evacuate a litter to the roadhead. The most common is a wheel.

Seems to me that about half the wheels I’ve seen are homebrew designs, and half are store-bought. There’s a frame that attaches to the bottom of the team’s favorite litter, with a wheel on the bottom. Sometimes the wheel is a mountain bicycle wheel, sometimes it’s smaller in diameter but thicker, like a large wheelbarrow tire.

Wheels have some advantages. Having the weight on the wheel means that, if you’re on a nice, level trail, you only need a couple of people to push the litter along the trail, and help the wheel over rocks and roots.

I know of one place where, during the busy season, a wheel is used every week or so. Shenandoah National Park in Virginia is one of the busiest national parks. It has a two-lane road, Skyline Drive, running the length of the park, fairly closely following the ridgeline of the Blue Ridge Mountains.

Near Big Meadows is one of the most popular attractions in the park, Dark Hollow Falls. The round trip to the upper falls is only 1.4 miles. Many people, including those who are quite elderly or debilitated, try this trail. As you can see from the map, it’s an ideal suck-in trail. It starts descending very gradually, and indeed the first portion of the trail is paved. But then, there’s no more paving, and it descends more steeply. So inevitably someone gets to the falls and can’t make it back up. No injury, no illness, just can’t get back up a 0.7-mile trail.

Luckily, the fire cache with rescue equipment is right there at the ranger station about a quarter mile away. And there’s a litter with a wheel. And rangers assigned to push the litter up the trail on a rotating basis. I guess if you’re counting the number of rescues you’ve done, this is a way to build up your numbers rapidly.

There are disadvantages to litter wheels as well. It’s something else you have to carry, and even the lightest ones are pretty heavy. It’s something else to break. And, despite manufacturer’s attempts to soften the ride, unless you’re on a totally flat trail, it’s still pretty bumpy compared with a litter team carryout. Try being the victim in the litter on a wheel sometime and you’ll see what I mean. If I were making recommendations for a patient with a likely spinal injury, pelvic fracture or femur fracture, I’d recommend against using a wheel.

As far as brand and type of litter wheel, search the web for online discussions. If you have something like Dark Hollow Falls in your backyard, then one of the wheels with a large frame with handles might be best. If you’re planning to carry the wheel on your back five miles into the backcountry, then one of the lighter models without handles might be best.

“Akja” is a European term, where the device originated, for a sled-stretcher designed for use by skiers. In the USA, they tend to be called “rescue toboggans.” Long used for rescue on downhill ski slopes, akjas have also occasionally been used in other SAR situations as well. Tyromont in Austria still manufactures rescue
sleds they call by the name akja. A boat-shaped sled, it has two rigid rods with handles on the ends sticking out from each end. An akja is easy for two skiers to manage down a slope. Though modern plastic Stokes litters are fairly easy to slide across the snow, akjas have actual runners underneath, designed to let the stretcher ski down the slope like a skier. Some even have special chain-brakes or other brakes that you can engage to slow the akja’s descent. Nothing works quite so well on a snow slope as a true akja.

You can get handles to attach to certain Stokes-type litters that make them akja-ish, but these are designed more for ease of carrying than for use on a snowy slope. You can also get shoulder harnesses that attach you to either end of the litter. Having played a bit with both of these, “we are not amused.” Given how often we have to rotate litter bearers even when there are six of us, and even if we’re using load straps, the idea that two people could carry a litter very far in the backcountry seems difficult to fathom. Maybe if you had two Olympic weight-lifters on the team it might be worth getting these. Load straps have the advantage that you can continuously lengthen and shorten them as you move over obstacles and through holes, up and down relative to the litter.

In addition to plastic Stokes litters and akjas, you can evacuate people down, up or across snow slopes many other ways. Simple drag sheets can work, if you rig properly with webbing, but if the webbing extends under the drag sheet, it will prevent such an improvised sled from sliding on the snow. A Sked (a heavy but somewhat flexible roll of plastic about 1/4” thick) works quite well in snow. A plastic Stokes is the most versatile, as it will slide across snow but is also easier than an akja or Sked to carry across rocks or other obstacles.

Finally, ATVs. (All-terrain vehicles, “quadrunners.”) I have to admit I’ve not been impressed with the utility of ATVs or “dirt bikes” (off-road motorcycles) for SAR. Sometimes an ATV can get a team into an area a bit quicker than walking, but at a much higher risk of injury. ATVs are simply very dangerous.

The Consumer Product Safety Commission estimates that in 2010, 726 people were killed in ATV accidents, and 115,000 people were injured enough to go to the ED. I work at a Level I Trauma Center and we get people flown in from ATV accidents all the time, and they are usually pretty mangled.

I’ve seen eager ATV users strap a Stokes litter sideways on the back of an ATV. From a risk/benefit standpoint, I would recommend against this most strongly. That is, unless a medical professional at the scene has recommended it because a few minutes might make the difference between life and death.

The one situation where ATVs shine is in body recovery. There isn’t the urge to hurry, so the driver’s less likely to get hurt, and we’re not worried about injuring of killing the patient. Using an ATV this way can actually reduce the risk of injury by sparing a litter team the carry-out.

You can get trailers to tow behind an ATV, which seems somewhat safer for a litter patient. But the ride is awful and I would recommend against it if the patient has sustained any significant trauma. The jouncing could aggravate problems such as a pelvic fracture or solid-organ injury bleeding enough to kill a patient.

In many cases where it’s tempting to use an ATV, a regular four-wheel-drive ambulance or other vehicle might be able to provide a much safer transport for the patient.

And dirt bikes? I have never even heard of an operation where there were more benefits than downsides to dirt bikes. My favorite example of this is the 72-year-old man who was hiking in the Mount Rogers Wilderness Area in Virginia, got separated from his wife in the fog, and was lost for seven days. The local sheriff insisted that the local dirt bike club be able to help. When I was talking with him after we found him, he said the only time during the whole ordeal where he was really scared, and was worried for his life, was a couple of days before we found him, when he was almost run over by one of those dirt bikes, whose rider didn’t see him. Now mountain bikes – non-motorized mountain bicycles – are different, but that is a topic for search, not rescue, and will be deferred to another essay.

I have to provide full disclosure: when working as a National Park Service Ranger along the C&O National Historical Park, in the vicinity of Harper’s Ferry, WV, I used to rid a Honda Trail 90 on patrol. As a patrol vehicle, there were advantages: I could navigate the canal towpath at a low speed, even the difficult sections, but could get out on the open road and ride at highway speeds at need. But these trail bikes made almost no noise, so you actually might hear someone calling for help before your rode past them. Or over them.
Improvised Litters and Carries

Sometimes, you may need to do an evacuation without your favorite stretcher. So you’ll have to do the best with what you’ve got.

The ASRC FTM and FTL standards don’t require you to know how to build and use improvised litters or carries, but I think any outdoorsperson and certainly every ASRC member needs to know this stuff, so here goes.

Injured or ill people have been carried on all sorts of things. Doors are often used as impromptu stretchers after a disaster, and I suppose it’s somewhat better than dragging someone by the collar across the ground. Speaking of dragging someone by the collar, I once was the recipient of such a patient.

We had a bad ice storm in Pittsburgh during morning rush hour. None of the ambulances were able to get across the bridges, and hundreds and hundreds of people fell and broke various parts of their bony anatomy. In terms of number of patients presenting to the ED in a short time, it was the worst disaster Pittsburgh had in about 50-100 years. One man was a few blocks from our Emergency Department, and found a woman who had fallen and broken her hip. He carefully used a scarf to tie her legs together, and then grabbed her collar, and then, on hands and knees, dragged her to the ED. She slid very well on the ice, and the slight traction on her legs was probably good for the hip fracture. Unfortunately, he left before we were able to get his name and thank him for such a well-done rescue.

Back to doors as improvised stretchers. Back in the 1960s, it was thought that people in car accidents needed to have their spines immobilized by being strapped to a flat, rigid board. The thought was that by hauling these people out of cars and moving their spines we paralyzed them for life.

More recently, we have realized there is no data to support the idea that backboards prevent spinal damage. Indeed, most studies show that for urban trauma, an orthopedic scoop stretcher is better in terms of immobilization, and less likely to worsen pelvic fractures than log-rolling onto a backboard. And long boards just don’t immobilize that well, either. And a door pretending to be a backboard is going to immobilize very poorly.

We also know that being on a backboard for about 45 minutes causes unbearable pain from ischemia (lack of blood supply) to the skin over the sacrum. And, after an hour and a half, the skin dies.* Therefore, since about the year 2000, there has been a movement to emphasize that “backboards are transportation and not immobilization devices” and for patients to be taken off backboards as soon as they arrive in an ED, even if a physician is not available to examine the patient right away.

Even more important, in 2013, a prehospital physician organization in Britain developed a consensus statement that people should never be transported in an ambulance on a backboard, and that backboards should only be used for extricating people from a wrecked vehicle. They recommended either an orthopedic scoop stretcher for “street” EMS or a full-body vacuum splint for backcountry evacuations.† A vacuum mattress is basically a beanbag chair in the shape of a big air mattress. When you pump the air out of it, it becomes rigid. So if you put a patient in the middle of it and then pump it out, you have a comfy form-fitted whole-body splint.

In the USA, the National Association of EMS Physicians is developing a similar consensus statement.

Bottom line? Don’t use backboards, unless it’s briefly and just to extricate someone from a vehicle. Or maybe, after a disaster, using a door as an improvised backboard, which itself is an improvised stretcher, just to get someone out of a building in danger of further collapse.

Poles and Blanket or Parkas

Are there any better improvised litters for SAR, or even in disaster settings? Yes. you can make an improvised stretcher out of two ~9’ poles and a blanket or two parkas. This actually makes a fairly good stretcher that is not all that hard to carry, and fairly comfortable for the patient. In a forested backcountry setting, you can cut down a couple or saplings (young trees) about 3-4” in diameter and use them as poles. I know that many SAR people swear by their Leatherman tools, but I’m really fond of my Victorinox Swisschamp Swiss Army knife. It has a great crosscut saw that will saw through such saplings in just a minute or two. A wire saw is also a lightweight tool that will quickly cut such

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poles, or bigger poles, and makes a good addition to that little survival kit you carry in your pack. (You do carry a little survival kit in your pack, right?)

For a blanket-and-poles stretcher, lay the blanket on the ground. Place the poles on the blanket, as far apart as the patient’s hip width or a couple of inches closer together. Leave an equal amount of blanket outside the poles on both sides. For this stretcher, you want the poles close together, and having the poles a little bit under the patient’s shoulders actually makes it more comfortable for the patient and easier to carry. Fold the sides of the blanket over the poles. The weight of the patient will increase the friction on the two thicknesses of blanket on the top, and prevent the blanket from slipping off the poles.

A few caveats about this. Again, as above, keep the poles close together. If you do as some texts recommend, and place the poles so as to divide the blanket in thirds, the stretcher may be too wide, causing the patient to roll around on it, making it very hard to carry. And, if you keep the poles close together as I recommend, you may have more than enough blanket to actually wrap around the poles a couple of times. It’s a little complicated to do this, but a bit of work will get it right.

You can carry such a litter with one litter bearer on each end, which is a great way to destroy the litter bearers’ backs. Or, you can have four litter bearers, one on each handle, which is better. If you want six litter bearers, which is optimum, then cut away a bit of the blanket over the middle of each pole to provide a handhold for the middle litter bearers, and maybe for a load strap as well.

Bru Randall tells of teaching this technique to Boy Scouts and Girl Guides at a boarding school in Kenya when he was there as part of the Peace Corps. He says they used poles-and-blankets stretchers multiple times to carry a sick or injured person to a medical clinic a kilometer away.

There is an elegant variation of this known as the parkas-and-poles stretcher. Take two parkas, turn the sleeves inside out, then zip them up. Lay them on the ground, heads apart, and about 8-10” between them. (This leaves handholds in the middle of the poles.) Pass the poles through the sleeves. Voilà! Great unless you have someone tall, in which case you can use three parkas.

Rope Stretchers

It is easy to make a stretcher out of a climbing or caving rope, though a bit time-consuming. Zigzag the rope on the ground, so that it is about as wide as the patient’s hips – a common error is to make this too wide, which makes it hard to carry. Try to make the zigs and zags precisely the same length. It’s also best to make it no longer than the patient. Your zigzags should use up about half the rope.

Next, run the rope around the edge of your stretcher, putting a clove hitch around each of the zigzag bight ends. This is where you need to take care to not make the stretcher too long. Keep pulling the outside rope taut, to judge the length.

Now, run the remainder of the rope around the edge of your stretcher, going through each of the loops formed by the slipped overhands. You now can place the patient on the stretcher and carry via that last rope you looped around the edge of your stretcher. If and when you can run some poles through the loops sticking through the clove hitches, do so, as it will make it much easier to carry.

I’ve done this with overhands tied at the end of each zigzag, but found that it works better if
you do as in the diagram on this page: no knots in the zigs or zags, but putting clove hitches around each of the zigs and zags. This allows the zigs and zags to self-equalize a bit under the patient's weight. But if you do it this way, it's quite important that the stretcher be no longer than the patient, so the patient doesn't sag in the middle of the stretcher.

Piggyback Carries

There are a variety of ways to carry someone who is not badly injured, at least for a short distance, with just one or two people. These are not required for ASRC FTM or FTL certification, but I have used these enough in SAR and disaster work that I think you should know them anyway.

The prototype of these is the fireman's carry. If you're big and strong, and the patient is small and cooperative (or limp), this works pretty well, at least for a couple of minutes. If it's a 300-lb person, forget it. Unless you have a bad back, do try this at home, but with a kid instead of an adult. You're less likely to throw out your back and kids generally think it's a lot of fun. Though if you have a bunch of kids there, I guarantee that they will spend the next 15 minutes doing it to each other.

The technique is simple. There are several variants, but here is the one that I like. Have the kid sit on the edge of a bed facing you. (You can do this with someone lying on the floor, pulling the person up to the sitting position first, but you're more likely to damage your back that way.)

Grab the kid's right wrist with your left hand. Now, stick your head under the kid's right armpit. Stand up so the kid is draped across your shoulders. Take your right arm and stick it between the kid's legs, so that your elbow is behind the kid's right knee. Now, transfer the kid's right wrist from your left hand to your right hand. You've now got the kid draped across your shoulders, with your right elbow locking the kid's right leg onto you, and with your right hand locking the kid's right wrist and arm onto you. You can now walk, and your left hand is free to steady yourself on the ladder (this is a fireman's carry, after all) or on trees or rocks or whatever.

This is clearly an “I'm going to get you out of here right now or we're both going to die” sort of carry. Are there better carries? Yes.

If you're going to carry someone for a long way by yourself, it's probably better to use some sort of piggyback carry. Indeed, a standard piggyback carry – patient on your back, with their arms around your neck, and their thighs on your iliac crests (hipbones) – is not too bad if you have an awake and cooperative small patient. But you have to hold onto the patient's thighs to keep them from slipping off your iliac crests, which rapidly becomes tiring. However, the patient is balanced on your back like a pack, which is probably the best way to carry a heavy load by yourself.

There are certain caveats – this is only suitable for a patient who is medically stable enough to be carried sitting up. That means the patient has to be reasonably well-hydrated, as sitting patients can get hypotensive (low blood pressure) from sitting up. Extremity fractures are OK, as long as it is distal to (further away from the center of the body) the elbow or knee, and you've splinted the extremity. You can do this while the patient is asleep (I've done so, and I must say, the snoring can be very irritating while you're struggling over difficult terrain) but it's probably appropriate for an unconscious patient only in a real get-out-now-or-die situation.

There are a variety of ways to fasten a patient onto your back, or at least support the patient on your back.

The most primitive is called a split-coil carry. You take a standard mountaineer's coil (discussed later), and “split” it so that it looks like a figure 8, basically two separate coils held together by the tie-off. You throw the two half-coils over your shoulders, so the tie-off is in the middle of your back. The injured climber (I've never heard of anyone except for climbers trying this) gets up on your back, and slips his or her legs through the two half-coils.

In the first draft of this essay, I said: Supposedly this is easier than a plain piggyback carry. I have tried this multiple times, with minimal success. It might be slightly better than a plain piggyback carry, but I personally don't think so. The loops of the coil keep falling off your shoulders, and the tieoff is digging into your back and into the injured climber's crotch or belly. I have given up on this as a useless technique; I just wanted you to have the advantage of my (bad) experiences with this technique. If you find it works great for you with some trick that I don't know, please let me know.
Rob Thomas, a long-time mountain rescue team member from South Africa, wrote the following:

Pad your shoulders – I get the patient into the split coils with the tie-off in the small of the patient’s back, then put them on like a backpack. That has the benefits of not trapping rope between the two people as well as helping to pull them in towards the bearer. (See attached pic)

Use webbing to create a sternum strap.

My longest evac distance like this has been about 1 km of canyon carry (14 y/o school girl). My heaviest has been a 105 kg sport climber with compound fx tib-fib (I weigh 95 kg) down the scramble portion of the approach to a climbing area (while on belay). stretcher arrived when I was 50 m further! That one was not fun! It works well if the bearer has trekking poles and is confidence-roped* on any terrain even pretending to have a slope to it.

I do know an alternate that works extremely well, but only if you have a specific kind of lumbar pack made by the company Mountainsmith. Some of their lumbar packs (“bum bag” or “buttpack” or “fanny pack”) have optional “strapettes” that add shoulder straps and a sternum strap. The patient simply sits on the lumbar pack, which provides a great seat. The hipbelt and shoulder straps/sternum strap mean that you’re carrying the patient just as if he or she were a pack. With this system, I can carry an unconscious medium-sized kid for quite a long time with no discomfort at all. I did this several times bringing a sleeping kid out of the wilds of central Florida (Disney World). The only downside is that you get drool on the back of your neck.

The next-best alternative to having this specific type of lumbar pack is tying the patient on your back with webbing, using a specific rigging. There are many bad ways to do this, and I have tried a few. I have found one that works well.

I have successfully carried a person, who weighed more than I do, up a ravine filled with large, wet, moss-covered boulders. I did have another SAR team member on either side to help me up over some of the boulders, and we did switch off carrying the patient every half-mile or so. This was during the same operation I tell of in the SAR Topics Legal Aspects essay: a girl who got separated from her hiking group on The Priest, near Tye

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*Belayed.
River Gap, along the Appalachian Trail in central Virginia. This specific rig is as good as, or perhaps better, than the Mountainsmith lumbar pack trick. I've also used it to rescue some big children, rappelling with them on my back. If doing so, a separate seat on the child, tied into your rappel rig, is appropriate.

To do this, you need to try to get the patient sitting up on something a bit higher than the ground – a picnic table, a bench, a ledge, a boulder, a stump – and then sit down right in front of the patient. I suppose you could get someone down on hands and knees and have the patient sit on his or her back. You basically need to start in piggyback position, but something needs to be supporting the patient while you do this.

You need a 20’ (6 m) length of webbing. Flat seat belt webbing is ideal and is quite comfortable for a long evac. One inch webbing is usable, but fairly uncomfortable. A 40’ (12 m) length of 1” webbing, doubled, would be better, but not as good as 2” webbing. I keep a 20’ (6 m) piece of 1.5” flat black “tent” webbing in my SAR pack. It can be used for such a piggyback carry, or as a load strap. It is not “load-bearing” webbing that can be used for climbing, but it’s fine for a backpack carry or a load strap, and less than half the weight and bulk of a similar length of 2” seatbelt webbing.

Before you sit down in front of the patient, face him or her, and place the middle of the webbing in the middle of the patient’s upper back. Run the ends under the patient’s armpits, then cross them. Now, sit down in front of the patient, and take the ends that you just crossed, and run them forward over your shoulder like shoulder straps.

Have the patient snuggle right up against your back, the tighter the better. Don’t be shy. The two of you are going to be tied tightly together for the next hour or so, and you need to tie this rig tight. If you don’t, (1) it will be uncomfortable for you and the patient, and (2) it will start slipping and you’ll have to stop to pull it tighter and retie.

At this point, the patient’s knees should be on either side of your hips, and you’ve got the shoulder straps in either hand. Run the ends down your side, through the patient’s crotch, and up the outside of the patient’s thighs. Do not cross under the patient’s crotch.

Remember: cross before putting on your shoulder straps, but do not cross under the patient’s crotch.

Take those two ends you’ve got that just came around the outside of the patient’s thighs, and tie in front of you. This is your hipbelt. The patient is now tied to your back like a pack.

The best knot to tie the webbing is a square knot, as it’s a binder knot: you can pull it tight, and it will hold while you finish the knot. I actually find that a surgeon’s knot is a bit better: as it binds a bit better, and is easier to take apart.

For ease of use, my 20’ (6 m) 1.5” flat black webbing has a Fastex side-release dual-adjustable buckle on it. You can get the 2” flat black webbing and dual-adjustable buckles from REI (rei.com); it’s harder to find the 1.5” versions, but a Google search will quickly turn up suppliers.

This is the type of buckle on large-pack hip-belts; you can pull on both of the tail-ends of the webbing to tighten. It’s light and easy to use. I can snap the buckle together, and pull both ends to tighten. As I start out down the trail, I can easily bounce the patient up a bit and retighten as needed without having to stop, and since you can tighten both ends of the webbing, you can keep the buckle centered on your belly. The buckle's not load-bearing in the sense of being suitable for vertical rescue, but for holding someone on your back like a pack when you're carrying them along a trail, it’s fine. And if you’re using this on a vertical rescue, you both should have seat harnesses on. If you absolutely had to do a vertical rescue with this and you didn’t have a seat harness for the patient, you could take the two ends of the webbing coming out of the buckle and tie them together with a knot for additional security. I would leave enough slack between the buckle and the knot that you can grab the webbing and tighten the buckle as needed. Tying such a knot might be worthwhile if you want additional security in moving over rough terrain, even if you don’t need a seat harness or belay.

Two-Person Carries

There are lots of ways to carry a patient with two people. Most of them are suitable only for carrying someone a short distance. The most well-known is a “chair” carry. Two rescuers face each other and grab each other’s wrists, left hand to right hand and vice versa. The patient climbs into the chair formed by the linked arms, thighs on one set of clasped arms, back against the other, and arms draped around the rescuer’s necks.

But carrying someone this way is awkward; rescuers’ backs are bent, and you’re trying to walk
sideways. There is a variant where you clasp all four hands/wrists together, and the patient sits on these. I'm not sure I see any advantage to this.

As long as you're on open terrain, or a wide trail, there is a quick-and-dirty way for two of you to carry out a teammate with an ankle injury who can't walk. Find or cut a pole or two about 4' long. A pair of ski poles or walking poles will work, and using two pair is even more comfortable for the patient (or, as my wife noted on proofreading, 'not more comfortable, just less painful'). If you have duct tape (you do have duct tape in your pack, right?) and you are mountaineering, you can tape two ice axes together as shown in the diagram.

The two of you should stand right next to each other, with your packs on, facing the direction you want to go. Slide the pole(s) between the small of your backs and your packs, just above where your shoulder straps attach to the pack at the bottom. The patient now sits between you on the pole. This way, the patient's weight is on your packstraps and hipbelt, using your pack’s suspension to distribute the patient's weight. Padding the pole(s) with a foam pad or article of clothing may make this easier on the patient.

There are other improvised carries, but the ones we've covered are the more well-known and useful ones.

**Rigging the Litter**

Rigging a litter for a vertical rescue is hard. Rigging a litter for a semi-tech evac is easy.

Well, it would be easy, except that there are lots of different litters, and rigging for each is a bit different.

Basically, you need a rope tied to the head of the litter. The rope needs to be tied to a part of the litter that’s not going to rip off or otherwise fail. You also don't want the rope attachment slipping back and forth, as that might put shock loads on the belay and litter. You also want the rope tie-in to be centered over the center of weight of the litter+patient load, not off to one side.

For a semi-tech evac, unlike a vertical rescue, the patient doesn't need to be in a seat harness, or be belayed separately from the belay on the litter. And, litter bearers don't need to be belayed, although on a steep semi-tech it's easier for them to handle the litter if they're clipped into the litter rail.

This really simplifies the rigging.

If you're used to rigging a litter for vertical rescue, you're probably used to rigging to points just to either side of the patient's shoulder. That's OK for a vertical rescue, but not at all ideal for a semi-tech evac. If you use those rigging points next to the patient's shoulder, and the litter gets pulled at an angle to the belay rope, the rigging may slide across the patient's head or even face. Oops.

If you’re used to vertical rescue rigging, you’re also probably used to rigging in with large steel locking carabiners. But these carabiners are heavy, and not needed for semi-tech rigging. Indeed, rigging the rope directly to the litter rail, which is larger in diameter than a carabiner, is probably significantly stronger than rigging with carabiners.

The best way to rig a litter is the way that the manufacturer recommends. That said, we will cover rigging of common litters, as you may not have access to the manufacturer’s recommendations on the side of a mountain, at night, in freezing rain.

The picture in the margin shows how to rig a wire Stokes litter for a semi-tech evac. Why do you need to know how to rig an old-fashioned Stokes litter? Simple. Many rural ambulance services and fire departments still have these
litters, and it’s not uncommon even for members of teams with the latest, greatest litter to have to make do with what’s available at the time. Not only that, some teams prefer the durability of an all-steel litter, which is why they are still made. They tend to have plastic netting instead of chicken wire, which means you (or the full-body vacuum splint) are less likely to get poked with a sharp bit of wire.

To rig, you start tying a bowline, with a loop about 2’ in diameter. Before bringing the running end of the rope back to finish tying the bowline loop, you wrap the rope around the top rail of the litter 3-4 times.

You may know, from your training in vertical rescue, that when rigging an anchor for a vertical rescue, you need to avoid big, open angles: they tend to multiply the force in the system, possibly leading to anchor failure. So that would make you want to use a bigger bowline loop, so that there is a narrow angle at the top of the bowline. All well and good, but heavy loading is not a major characteristic of semi-tech evacs, unless there’s a shock load. And, a long tie-in bowline means that the knot, which tends to get caught on trees and ledges, might be out of reach of a litter bearer tied into the litter. Simply looking at the angles, too, a knot farther from the litter is also more likely to be caught on obstacles.

This argues for a shorter tie-in bowline loop. An angle of about 60° at the knot is about right.

Why a bowline and not a figure 8 loop? Simple. The slightly greater strength of the figure 8 is not a significant consideration here. A bowline is easier to tie, and much easier to adjust. Rushing is bad, but during a rescue time is still of the essence, and faster and good enough is actually better.

One consideration about the wire-basket Stokes is that many of the older ones have a butt-weld right at the top of the head. This is a potential weak spot, so the bowline loop wraps around the main rail, but extends enough to either side to go outside the other welds where the lower litter rails join the main rail near the top. That way, if the butt weld fails, the rope is still securely attached to the litter by two other welds. Even if the litter doesn’t have a butt-weld at top, this is still the best way to rig to the litter.

There are a great variety of plastic rescue litters available, but they are generally not that different than the wire basket litters. Using a wrap as for a wire basket litter is acceptable, but it tends not to work as neatly on some of them, as there are large tabs of plastic that come up from the inner plastic basket and wrap around the outer rails. Some litters, such as the Ferno Model 71 or the Bradco, only have limited bits of the main rail exposed for rigging, so it’s simply not possible to use this wrap-rig in its full form.

For these litters it requires a bit of fancy knot-tying to do optimal rigging.

You could use a knot with two loops. Again, size it for that 60° angle between the two loops. Attach each loop to the handholds on either side of the head of the litter, using large carabiners. (Again, don’t rig to those two shoulder-area rigging points.) This in fact is what the manufacturer of the Ferno 71, in their July 2007 product manual, recommends.

A good knot for this is a bowline-on-a-bight. This is a long name for doubling the rope in a loop, and then tying a bowline with the loop. This results in a bowline with two loops.

Some teams rig a webbing harness as in the photograph on this page, through the vertical lift grommets and then also weaving the webbing through the head handholds. For a full vertical rescue vertical raise or lower, though, I would not rig to those grommets; you are rigging to grommets that are just in the plastic, and unlike with a vertical rescue spider, the rigging don’t also go directly around the railing. The grommets might rip out. While the rigging is wrapped diagonally around the rail in case this happens, I would not recommend this as a best practice; rigging just to the handholds is adequate.

If you don’t have two large carabiners, or you want to rig the rope directly you may have to do some fancy knot-tying.

Some groups tie a yoke on the litter to make it easier to clip a rope into it with a carabiner. The photograph on this page shows such a yoke, tied with a figure 8 loop, with the two ends clove-hitched through the handholds, then tied with a double-fisherman’s knot across the top of the litter.
This is certainly a bit faster when you have to attach a rope, but it does introduce additional connections that might fail, so many teams now prefer to tie directly into the head of the litter. You can tie the end of the rope into the litter just like the yoke illustrated in the photograph, but you won’t need the double-fisherman’s knot, and you will need to tie a figure 8 bend rather than a figure 8 loop. If you wish, you may use a bowline instead of a figure 8 bend, as the bowline’s a lot easier to adjust.

**Patient Packaging**

**Immobilization**

Backboards are bad. So how do you immobilize someone?

First, let’s think about this. Do you like being immobilized? Probably not. Should all backcountry litter patients be immobilized? Probably not.

Are there advantages to being immobilized? Well, yes, in certain situations. If you have a broken arm, a good splint on it immobilizes it. This keeps it from bending in the wrong place, and flopping around with those sharp bone splinters tearing up your flesh, blood vessels and nerves. And maybe skin.

Background: bone doesn’t resist infection very well. An open (compound) fracture, where bone has broken the skin (even if the bone isn’t still sticking out), makes the bone more likely to get infected. If you get a bone infection, you may have to be on IV antibiotics for months, and even then, might have to have an amputation. It’s a big deal.

An important part of treatment for open fractures is to get a dose of an appropriate antibiotic (can be by mouth or by injection) ASAP. We know from studies done by orthopedic surgeons, who create open fractures for a living (though they call it “orthopedic surgery”) that the best time to get an antibiotic is about an hour before the open fracture. The closer we can get to this, the better.

One upon a time, a patient fell in a cave called Hellhole. He broke his ankle. It was a closed fracture. Even though fiberglass splinting material was available at the scene, rescuers decided not to take off his boot and splint with fiberglass, but just wrap a SamSplint around his boot and allow him to assist with the rescue. Bearing weight on that foot.

When he got out, his initially-closed fracture was now open. And had probably been open for hours. Without him getting antibiotics to prevent infection. Oops.

Means a more complex operation on the ankle, and much greater likelihood of infection. Not good.

So, for fractures, immobilization is good. At least for that one leg or arm. But if you broke an arm, do you want a cast on your whole body? Probably not.

Are there downsides to immobilization? As discussed before, non-form-fitting backboards can cause severe pressure necrosis of pressure point, particularly the sacrum (upper butt). Indeed, people sometimes get big ulcers in this area: bedsores, also known as decubiti. These can require multiple operations by a plastic surgeon = $$$$. Even with the surgery and skin grafts, sometimes they get infected, and sometimes the patient dies of sepsis. Oops. So preventing these bedsores (decubiti) is a big deal.

Immobilization, especially of the extremities, can lead to a deep venous thrombosis (“DVT” = clot in a deep vein). When one of these clots breaks off and travels through a vein, it ends up getting stuck in the small blood vessels in the lung, cutting off the blood supply to that part of the lung, which then dies. We call this pulmonary embolism (“PE”). This can kill.

Do patients need to be immobilized for safety? Well, in vertical rescue, they need to be protected from falling out of the litter and going splat, which is why we put them in a harness connected to the belay.

But in non-technical and semi-tech evacs,
people just don’t fall out the litter and go splat. They might start slipping out a bit, I suppose, and then the litter team tucks them back in. And if the litter team drops the litter, you don’t want them falling out, even though you really don’t have to worry so much about the “splat” bit. But do you need to tie them in so tightly they can’t move? Maybe, but only if they have maybe lots of bad fractures all over. Mostly you just need some straps to keep the patient from falling out.

Full-body vacuum mattresses are good, even if you don’t pump them out to make them rigid. They insulate pretty well and feel like a beanbag chair. In fact, they’re pretty comfortable to sleep on/in. I’ve done so several times. (The plastic gets a little sweaty, so throw a blanket over it before you sack out.) If the patient needs a splint on the right ankle, you can split the ankle, then plop the patient in the vacuum mattress and not pump it out.

If you have a patient who really, really does need cervical spine immobilization – and consult with your top medical people, as very few wilderness patients will have an unstable cervical spine injury that will benefit from immobilization – use a full-body vacuum mattress. Anything else is a poor improvisation. When you use a vacuum mattress to immobilize the cervical spine, have someone hold the mattress close on either side of the patient’s head as you pump it out. Then, duct-tape the two parts of vacuum mattress across the patient’s forehead. Be careful not to tape the patient’s hair. Put another piece of duct tape on the sticky side of this duct tape, sticky side to sticky side, to keep the patient’s hair from tangling in the duct tape.

Speaking of duct tape, when not using a vacuum mattress, some people like to put a helmet on the patient and then duct-tape the front of the helmet to the litter rails. This certainly secures the helmet, but that doesn’t do a particularly good job of cervical immobilization. First, the suspension in the helmet with jack the patient’s head forwards, bending the cervical spine out of anatomic alignment. To avoid this, you can place additional padding under the shoulders, or remove the suspension from the helmet. But if you take out the suspension, you’ve also taken out any cervical immobilization this might provide. And, if you are going to immobilize the head completely in a helmet with the suspension still in, you have to do a very good job of immobilizing the rest of the patient’s body with packing and tie-ins, otherwise you’ll be torquing the cervical spine as the patient’s body moves in the litter. If you’re doing this, you also have to make sure that you have the foot supports adjusted just right, or when you tilt up the head of the litter, you may strangling the patient with the helmet’s chin strap. So, on the whole, helmets just don’t work very well for immobilization. A blanket roll and duct tape is probably much better.

And for head protection, a clear face shield that attaches to the litter is far superior to a helmet. During a semi-tech evac, another thing that protects the patient from injury from falling rocks is the litter bearers. Whenever someone screams “ROCK!” the litter bearers should bend across the patient, using their backs and packs to protect the patient.

Yes, you should have your packs on while doing a semi-tech evac. The very first question on the very first ASRC written test was as follows:

1. The first rule of mountain rescue is:
   a. don’t get separated from your pack
   b. don’t get separated from your pack
   c. don’t get separated from your pack
   d. all of the above

This is a good test question for all members, human or canine.*

So assume your medic says the patient needs to be immobilized because of possible spinal fractures. Assume further you know that backboards are evil, and you’re using a full-body vacuum mattress, which is our least-cruel whole-body immobilization device. Even with a full-body vacuum mattress, pressure on the butt can cause bedsores after a couple of hours. What do you do?

Well, when you stop, you can lean the litter to one side or the other. If necessary, you can even carry the litter on its side or even face-down for a bit. Seems silly, but given the consequences of decubiti, it’s appropriate on long evacs.

Though backboards are bad for backcountry search and rescue, there are other types of immobilization that are good for SAR patients. Splinting fractures is good, though this is not the place to go into details of splinting. However, there are two kinds of fractures that can cause enough internal bleeding to be life-threatening. Even if you are primarily a rescuer and not a medical type, you need to know about them.

First is femur (thighbone) fractures. The standard splint for them is called a traction splint,
because it uses traction (pulling) on the leg to straighten out the bones, which helps prevent bleeding, as well as decreasing pain. There are lightweight traction splints that can be used inside a litter; the Sager traction splint in particular is popular. It's basically a shock-corded aluminum tent pole with something that looks like the padded top of a crutch on one end. This goes into the patient's crotch. A hitch goes around the patient's ankle, which is then attached to the other end of the tent pole with a winch. You then tighten the winch until the leg lengthens a bit. If your team has one of these, you should practice with it.

Other styles of traction splint, not designed for the backcountry setting, tend to stick out of the litter too much, and are almost impossible to keep inside the litter packaging. Simply immobilizing the femur (thigh) inside a pumped-out vacuum mattress is better than nothing. However, if you have a Stokes litter and webbing, you can improvise a traction splint. Run a loop of 2” webbing, or padded 1” webbing, through the patient's crotch and to a rigging point a foot or two above the crotch on the side of the injury. (A seat harness will work as well, but for non-technical and semi-tech evacs, you may not have one, or it may be simpler and easier just to use a single loop.) You then tie a hitch on the ankle of the injured side, making sure it is well padded, and will not constrict and cut off circulation to the foot. You then connect the ankle hitch to the bottom of the litter with a 1” webbing loop, tied without an slack at all. To tighten, you insert a carabiner (or stick if you have no carabiners), and twist the windlass until the patient feels better, and the leg is about 1-2” longer than it was. You then secure the carabiner to the side of the litter with another couple of carabiners or a bit of webbing. You'll have to check regularly to make sure the tension hasn't changed as things shift.

Another fracture that kills from internal bleeding is an open-book pelvic fracture. Your pelvis is a combination of bones that support your internal organs and basically keeps your guts from falling out your butt. If you bind something firmly around the greater trochanters of the femur (the bony bumps on the outside of your thigh just below the hip proper), then you can close the open book. You're basically reducing the pelvic fracture. With things put back the way they are supposed to be, there is less bleeding. When you close the book, there is also less space in the pelvis to fill up with blood, which also helps decrease the bleeding.

You can get official pelvic binders, and my favorite one is made by SAM Medical Products, the same people who make SamSplints. It costs about $65, but it is cleverly designed so you can easily pull with the right amount of tightness (the buckle goes “click”) and, since it's secured by Velcro, it's almost impossible to overtighten. I keep one in my car in case I run across a bad car accident, because this is one of the few simple, easy things you can do to save the life of a trauma patient.

When should you use a pelvic binder? Basically any time you think about it. It's not going to hurt someone to put one on. If the patient fell, and has significant pain in the pelvis, put it on. If the patient fell, and is unconscious, put it on. The sooner you get it on, the better.

What if you don't have an official pelvic binder? Improvise one. A pack hipbelt would work pretty well, though you have to put it on the patient about 5-6” lower than you would usually wear a pack hipbelt. You could empty out a pack, put the empty pack under the patient, and then tighten the hipbelt before packaging.

**Basic Packaging**

Once upon a time, way before the days of body fluid concerns, one of our ASRC members, who was perhaps a bit overenthusiastic as a mock victim, outdid himself. I am ashamed to admit that I aided and abetted him in this one particular instance. This was actually a mock cave rescue that was part of training by the Eastern Region of the National Cave Rescue Commission. Many ASRC members are also involved in cave rescue, and a couple of ASRC member Groups are also official cave rescue teams.

One of the standard safety measures during any NCRC mock cave rescue is that the mock victim has a Guardian Angel. Like the other Invisible People in the cave, the Guardian Angel has a special armband for identification. (The other Invisible People are additional instructors.

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* I'm not sure where the word “ditzel” comes from but it means something tiny, something that can almost be ignored.
or observers. Students are not allowed to speak with them, or use them as footholds.)

The Guardian Angel takes a report from the student, including the actual vital signs, and then gives them the simulated vital signs. The Guardian Angel will also provide additional information on the patient, such as physical exam findings that we hadn’t been able to provide by moulage.

Another part of the safety system is the term “for real” which means whatever comes after this is not part of the simulation but a real message. It is only used when absolutely necessary.

Well, RE (name withheld to protect the innocent) and I went into the cave, and set up pretty far back, in a small dead-end passage that held a small pool of water. As the first team of students reached the patient, they noted him lying there facedown in the water, not breathing, with blood on his head. And I was standing there patiently waiting for them to do something.

The students just looked at me.

I said “Well?” and one of them said “ABCs” and another couple of students, with careful attention to his cervical spine, and with gloves on, carefully rotated him out of the water. At which point, with an explosive gasp, he started breathing. But he was otherwise unresponsive.

The students looked at me again.

I again said “Well?”

They did a primary survey, found no problems, and proceeded with the vital signs and secondary survey. They reported to me that the patient had a palpable defect in the skull and he had some drying blood in this area although they found no laceration. (They later said they could tell it was real blood.)

They reported they found one pupil dilated, (large), and unresponsive to light.

They looked at me again.

I told them “Go on.”

They gave me a strange look. Afterwards they told me that they were absolutely convinced that the patient had a serious injury and I was only staying so calm so they would stay calm and take good care of the patient.

They finished their evaluation and packaged up the patient for evacuation. As soon as they had him packaged, he developed projectile vomiting, and they quickly rolled the litter on its side to protect his airway. (Litter teams should always be ready for this, especially if they’re not doing a good job and it’s a bumpy litter ride.)

Later he had grand mal seizure, and again they flipped the litter over on its side to protect his airway.

I kept receiving real vital signs and giving out simulated vital signs.

Explanation: I had used a syringe to draw 60 mL of blood out of his arm, and we used this as moulage on a dent in his head from a prior skull fracture. I gave him a drop of cyclopentolate in one eye, which is usually used to dilate the pupil for an eye exam. Right before the students got there, he swallowed a vial of ipecac, which is used to induce vomiting. The seizure he simulated on his own, quite convincingly.

About halfway through the evacuation to the cave entrance, they gradually realized that this was indeed all a very good performance. I think they were a little bit angry at RE. OK, maybe more than a little bit.

At one point, as we were getting towards the entrance, they were moving his Stokes basket through a long crawlway only about 3 feet high, and I wasn’t able to be right at RE’s side. So I missed it when he told them several times in a row that, “for real,” they needed to let him out of the stretcher because he needed to poop. (Likely from the effects of the ipecac.) They just kept ignoring him. At which point I was able to get close to him again and hear him say “OK, it’s not my sleeping bag.”

At which point they realized they were in a very long, small crawlway with little if any airflow.

The point of which is that you need to plan for elimination. Putting a blue pad or diaper in the sleeping bag is a reasonable precaution. During a long evacuation, it may need to be changed, as dampness makes pressure sores more likely. However, for a patient who is now alert and totally with it (even if not before), there may be nothing wrong with letting the patient out of the litter for a while to take care of business. In fact, with male patients, we’ve occasionally opened up the packaging a bit, and leaned the patient, Stokes litter packaging and all, up against a tree to urinate.

For women, there is a funnel-like thing called a SaniFem (my wife calls it a “blue pee thingie”) that will allow them to do this, too. However, a certain woman I know found it just doesn’t work to let women write their names in the snow, and falling on your ass in the snow can be both embarrassing and very cold.

If we assume you are going to evacuate the patient in a litter, then you need to package the
patient. In the context of non-technical and semi-technical evacuations, packaging means that you need to:

- Strap the patient into the litter well enough that he or she won’t fall out, but is still free to wiggle for comfort (except for the bits that have to be splinted for medical reasons).
- Protect him or her from injury, such as being poked in the eye with a stick, or being hit in the head by a rolling rock. It might not be necessary for an easy nontechnical evac, but a face shield or helmet and goggles may be appropriate for a semi-tech evac.
- Protect him or her from the elements, including wind, rain and cold.
- Allow for medical monitoring and reassessment as needed.
- Allow for bodily needs: food, fluid, and, based on the story above, and what I learned from one of my daughter’s favorite childhood books (Everyone Poops), pooping and peeing.

Credit for the origin of this next bit goes to Jel Coward, a physician previously from the UK and now in Canada.* When first encountering and then evacuating a patient, you need to think of packaging in layers, like an onion.† The innermost protection layer includes things such as bandages and blue pads or diapers, to protect the outer layers from the bad effects of bodily secretions (blood, pus, pee, poop). The next layer out is the inner microclimate: insulation appropriate for the temperature, and around this, a tarp to protect the patient from wind, snow, rain, or water in a cave. Wool blankets are cheap, washable, and warm when wet, so are used on a regular basis. For insulation underneath, an old sleeping pad is commonly used. If the patient is in a vacuum mattress, this provides excellent insulation underneath. It’s common to arrange the tarp so it opens along one edge so you may easily reach the patient when needed. You may place monitoring equipment such as a BP cuff or a remote-reading thermometer on the patient before packaging.

You can apply this when first encountering a patient, as well, even before packaging in the litter, or sometimes when the litter has to stop for some reason. And in such situations, especially in cold, wet conditions,‡ you can create an outer microclimate as well.

Once upon a time, I was teaching a Wilderness Emergency Medical Technician class in the UK. I was off in the hills with a simulated patient, acting as the instructor. Teams of students would navigate to us, complete the medical problem we simulated for them, and then after a brief critique, move on to another station. A Scottish mountain rescuer team member, upon arriving at our station, immediately pulled a large piece of thin nylon (surplus parachute material, he later told me) from the top of his pack and spread it over the patient and the team. Instantly, our body heat was trapped, and the temperature inside started rapidly climbing. Even though I’d had many decades of outdoor experience in the US, this was my first experience with a bothy bag.

A bothy is a small, crude building in the UK or Irish mountains used as a bad-weather refuge by hill-walkers, climbers, and shepherds. A bothy bag is a bothy you can carry in your pack. You can throw it over your whole party when

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* He met a Canadian physician at a Wilderness Command Physician class I was teaching in the UK. She married him and dragged him back to British Columbia, not a bad place if you like the wilderness.
† Or, as my daughter says, like an ogre such as Schreck.
‡ People like to say “it’s always cold and wet.” But I cannot honestly say that as I have attended two backcountry patients on nice days. I’m not sure what fraction that represents of all the backcountry patients I’ve attended, but it’s pretty small.
1. Attach two 30-foot (10m) 1" webbing straps as shown. Cross-tie goes under patient/packaging. Two 15' (7.5m) sections may be used for the lower tie-in instead.

2. Place tarp/vapor barrier on top of Stokes litter, offset as shown. This offset puts the opening on one side, which makes it easier to access the patient.

3. Place foam pad or vacuum mattress in litter, then two blankets on top of tarp as shown, then place patient on blankets.

4. Wrap blankets around patient as shown. Arms are isolated so heat packs may be placed so as to warm the core and not the arms.

5. Run one of the upper body tie-ins diagonally across the upper back, forwards over the shoulder, then diagonally down across the chest.

6. With the other upper body tie-in, do the mirror image. Note that one finishes across the waist, and the other across the chest. Shoulder padding is essential.

7. One lower tie-in secures the pelvis. Note the blanket roll around the head and neck for insulation and shoulder-strap padding.

8. The other lower tie-in goes under the feet. Two half hitches on the other side, then run down and then loosely across the ankles and tie off.

9. Finished Eastern Region NCRC tie-in prevents shifting up or down in the litter. Upper tie-ins may easily be loosened to let patient sit up, then quickly refastened.
wind, rain or snow threaten, or someone is injured – or when you find a search subject. Those made from surplus parachutes are very light and provide a degree of protection from the elements. Fancier and more expensive store-bought versions come in silnylon,* with vents and heavier bits on the bottom inside edge on which you can sit. It’s like a tent with no stakes (your butts serve as the stakes) and your heads serving as the poles. My daughter and I have had a couple of pleasant lunches in a little 2-person bothy bag while waiting out a rainstorm. Bigger versions fit larger parties, or even a Stokes litter and several rescuers. Highly recommended for any SAR team that may be exposed to hypothermia weather. I now almost always have a small one in my daypack on any day trip, and certainly on any SAR tasks.

There are many systems for securing patients in a litter. Some combine a seat harness into the tie-in, but as this is not needed for nontechnical and semi-tech evacs, we will leave these to another place and time.

My favorite tie-in is a spider†: a length of 2” nylon seatbelt webbing, that goes down the center of the litter/patient, with 1” nylon straps that go from this to the edges of the litter. Some spiders (Allegheny Mountain Rescue Group has one) even have load-bearing buckles. Such a spider is easy to adjust if it’s too tight or too loose. You may also easily open up just one section of the spider, for example, to check sensation and capillary refill distal (beyond) a splint.

At least for wire Stokes, there is a bit of a controversy about how to tie-in a patient: do your tie-ins go around the main litter rail or not? Certainly the main litter rail is the strongest part of the litter, so tying in there would be stronger. But if your litter is being used for a vertical rescue, then the tie-in might be rubbing against rocks and getting abraded. But for our purposes here, it doesn’t matter. Some litters have alternate tie-in locations inside the basket that are also load-rated, in which case those should be used.

The simplest tie-in I’ve seen is simply to put a girth-hitch around the rail at the foot, then to lace back and forth up the litter as if you were lacing up your shoe. It works, but…

In semi-tech evacs, and sometimes in non-technical evacs even without a belay line, the litter is tilted head-up. The patient tends to slide down towards the bottom of the litter, which can be uncomfortable, and aggravate injuries. So if you have such a spider, you also should have a support for the feet. The foot support needs a loop around the ankles to keep it from slipping off the feet. If improvising a foot support from webbing, it’s important to make sure you tie it so that loop around the ankles doesn’t tighten uncomfortably. I recommend always putting in a foot support, as you never know when your non-technical evac may become a bit semi-tech, even if just for minute or so. (If you’ve got the patient in a pumped-out vacuum mattress, you don’t need separate foot support, because the patient isn’t going to move at all.)

One you’ve rigged the foot support, it’s a best practice to tighten it as much as you can, then tilt the head of the litter all the way up, and see how much the patient slips; retighten if needed.

The ASRC standard tie-in for a wire-basket litter uses three 15’ (5m) webbing pieces, attached as shown. One of the right-hand tie-ins is used to support the feet, and the other two tie-ins zig-zag between the side supports (struts). The

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*A very expensive but very light waterproof nylon.

† This is different than the spider used as a suspension for vertical rescue. One word, two meanings. Sorry.
tie-ins are can be permanently attached to the bottom struts with water knots. The patient tie-in is finished off with a secured slipped overhand knot (discussed later). The final zag is placed so as to not choke the patient; this may be a different place based on the patient’s height. For storage the tie-ins may be run to the forward strut and back a few times and tied off with half hitches, or they may be used to secure equipment in the litter.

There are other ways to lace up a litter. Eastern Region, National Cave Rescue Commission instructors developed a particularly nice combination of packaging and tie-ins for a Ferno plastic Stokes, back in the 1990s. This was modified from the earlier ASRC tie-in. It uses inexpensive and readily-available materials, and it is now widely taught. It assumes a plastic Stokes litter, as these have become standard in cave rescue, but can with some difficulty be adapted to a wire-basket type Stokes.

It is more complicated than the original ASRC tie-in, but has advantages, discussed in the text that accompanies the diagrams. It is shown on the next page.

**Loading the Patient into the Litter**

Back in the 1970s, I was taught to log-roll a patient onto a backboard. Backboards are now “out” and so is log-rolling. Log-rolling doesn’t really hold the cervical spine stable, if you’re worried about that, and it’s also very bad for pelvic fractures.

So, how do you load a patient in the litter? Well, if the patient is just dehydrated and weak, so no worries about spine or pelvic fractures, you just say “Would you please lie down in the litter?” And if the patient just has an isolated ankle injury that you’ve splinted, you say “Here, lean on me while you get into the litter.”

But if the patient has had what, in technical terms, we might call a “big splat” with multiple injuries, a different method might be better.

When I took an EMT-Basic course back in the 1970s, I was told “never step over the patient,” but I was not told why this was so. I suspect it is because you might step on the patient, though that seems unlikely. I suspect that is because, as a Russian might say, it’s некультурный. That’s “uncultured,” which in Russian is a fairly serious insult.

However, for loading a patient in a litter, stepping over the patient is culturally-sensitive for the wilderness context. Especially if the patient is in a narrow crevice, which is common in cave rescue and sometimes occurs above-ground, stepping over the patient is essential. But even better than stepping over the patient is straddling the patient, with one foot on either side. Because if you are standing right over the patient, you can use your legs to lift the patient, not your back; and if your feet are spread far enough, someone can slide the litter right between your feet and then you can lower the patient into the litter. With some practice, you can get good at this, and the patient moves minimally. Sometimes it may be more appropriate to stand beside the patient and lift, sliding the litter in from the side. At all depends on the terrain.

There are tricks for picking up a patient like this. One is to grab the patient’s belt buckle and pants with one hand, and then use your other hand to grab the patient’s pants cuffs. If you want to look very professional, you put two fingers in one pants cuff and two fingers in the other pants cuff.

Sometimes it’s not possible to get enough people on one side or straddling the patient. If so, you can use webbing slings leading up to people standing a bit too high above the patient to use their hands to lift.

Regardless of the specific arrangement of lifters, the goal is not to cause more damage as you load the broken patient into the litter. And, you should apply a pelvic binder and appropriate splints before loading the patient into the litter if at all possible. The straddle position is the best position for lifting without damaging your back, and is preferred. At an AMRG meeting a couple of months prior to my writing this, we were practicing putting on pelvic binders. Heather Houlahan asked if it would be appropriate to use the pelvic binder as a lift point. I’m still somewhat undecided about whether this is a good idea or not, but Heather laid herself down on the floor, and I stood above her with one foot on either side, grabbed the pelvic binder, and lifted with my legs, not my back. Now Heather probably weighs as much as I do, and I’m certainly no muscle-bound athlete. But when I lifted, I found I was easily able
to suspend her in midair without the slightest strain. Surprisingly, the pelvic binder was right at her center of gravity, so she balanced very nicely, with head and feet suspended at midair. Perhaps this center-of-gravity effect argues in favor of lifting by the pelvic binder rather than by hands or slings on either side of it. It's also easier to grab something on top of the patient rather than having to bend further to reach underneath the patient, and since the pelvic binder is quite wide, it provides broad support for the patient compared to narrower hands or slings. However, you also need to lift all of the rest of the patient at the same time, not solely with the pelvic binder like I did with Heather.

Packaging for Specific Injury or Illness

Patients need foot support to keep from sliding down in the litter. But what if the patient has a bad leg injury?

Well, you can put a foot support under just the good leg. But if both legs are injured, you may be better off setting up a pelvic suspension, either by running slings from the patient’s seat harness attachment point up to some struts or attachment points on the litter. If the patient doesn’t need a seat harness, or one isn’t readily available, you could simply use padded crotch slings up to a strut or attachment point.

If the patient likely has a pelvic fracture, you may have to rig up a chest harness to support the patient, though this is a double-edged sword: compression of the chest can cause respiratory distress. If you need to do this, I recommend a Parisian baudrier chest harness, discussed later in the section on knots. You can rig slings from the central knot of the baudrier up to high struts or attachment points.

The ideal solution for all these problems for keeping the patient from sliding in the stretcher is to use a pumped-out vacuum mattress. There is no need for any additional patient supports when you’re using a pumped-out vacuum mattress.

If your patient has a chest injury, or pneumonia, we know that you should position the patient on his or her side, with the good lung down. We know this from a study of ICU patients where the rolled patients on different sides and measured their pulse oximetry (the amount of oxygen in the blood). This likely works because it shifts more blood flow to the lung that’s down. If you’ve got a vacuum mattress, it’s fairly easy to position the patient on his or her side.

Positioning on the side, with the face tilted down a bit, is also appropriate for deeply unconscious patients. Then, when they vomit, they are less likely to aspirate the vomit into their lungs. Getting a bit of water or Gatorade in your lungs is no big deal, we’ve all done it. But stomach acid in the lungs is very bad. If the patient is already on the side, you just have to tilt the litter a bit to the side to let the vomit drain out. And, even if you don’t notice it happening, deeply unconscious patients tend to get acid reflux into their throats which then drains into their lungs without you ever seeing them vomit.

It’s easier with a vacuum mattress, but you can position a patient on his or her side in a Stokes basket without a vacuum mattress. It just takes lots of padding. Sometimes you can raid the litter team’s packs for spare clothing, wrapping it in leaf bags (you all have leaf bags, right?) to protect it from noxious bodily secretions.

We used to think it was good to keep head-injured patients tilted in the head-up position.* Having the head tilted slightly up is OK, but there’s no need to worry about it overmuch, it doesn’t make much difference. And, tilting in the head-up position is bad for shock, and shock is bad for brain injuries. It turns out that the most important part of packaging for the head-injured patient is the neck. Anything pressing on the neck decreases venous blood outflow from the brain, and raises intracranial pressure. (That’s bad.) So when packaging a head-injured patient, check the neck very carefully for anything that might be going across it and worsening the head injury.

Speaking of shock, keeping the feet elevated a bit is good for shock, and tilting the head up is bad for shock. So having the taller litter bearers at the foot makes sense, though you can’t do this with the standard litter bearer rotation. But if you’ve got to do a semi-tech evac with someone in shock, what do you do? People have suggested doing the semi-tech head-first. The only problem is that then all of the abdominal contents are pressing upwards, making it hard for the patient to breathe. It’s a judgment call, depending on the state of the patient’s chest and lungs vs. degree of shock. Being upside down is pretty hard on the breathing, so my choice would usually be to

* When we’re talking head-up or head-down position for a litter patient, we’re talking about a foot or half a foot of difference between the head and foot, no more.
go down feet first, but trying to keep the litter as level as possible.

Even if not in shock, tilting dehydrated patients in the head-up position is bad. And hypothermic patients get dehydrated from the cold. There is a famous “Four Inns Walk” in England (think “somewhat civilized adventure race”), and during the 1964 race, three runners got severely hypothermic and died. One of the patients were transported in the head-up position, had a seizure, and died. This doesn’t happen often, luckily, but it’s something to think about. One of the rules for wilderness patients is to always give oral fluid and food and warmth unless there is some exceedingly good reason not to. So if you can give food and fluid before the semi-tech evac, by all means do so, it might be lifesaving. While people sometimes talk about “rewarming shock” as a reason not to rewarm a hypothermic patient quickly, there’s no way to rewarm rapidly in the backcountry. (Unless you carry a hot tub in your pack; if so, let me know so I can go hiking with you.) Add as much heat as you can!

It is traditional and appropriate to place hot packs at six areas of high heat exchange with the core. These are places where big blood vessels are close to the skin. These are also the places that you curl up to protect when you’re cold: the sides of your neck, your armpits, and your groin. Remember that some brands of hot pack can cause burns if put right against the skin, so make sure there is a layer of clothing or other material between the hot pack and the skin.

A little-known and seemingly non-intuitive fact with which to amaze your fellow SAR team members is as follows. For hypothermic patients, we emphasize adding heat to the core, and not the periphery. The arms and legs are the periphery, and rewarming them first can cause low blood pressure and even shock. But there are direct deep-vein connections between the hands and feet – not the arms and legs, but the hands and feet – and the core. Which means if you’re worried about frostbite of the hands and feet – or even if you’re not, you just have some extra hot packs left over – putting hot packs next to the hands and feet is not only acceptable, it’s actually a pretty good idea. It will rewarm frostbite more rapidly than otherwise, which is good, and will help rewarm the hypothermic core.

While hot packs add some heat, a HeatPac charcoal rewarming device adds much more heat, and is recommended for rewarming hypothermic patients, and keeping patients warm in the winter. The HeatPac includes a platinum catalytic converter to prevent poisonous carbon monoxide in the exhaust, but it still produces carbon dioxide, which can interfere with breathing. Route the small black exhaust tube away from the patient’s face.

Rope and Webbing

Non-technical evacs don’t require technical equipment, and technical rescue does. Duh. But semi-technical evacs? Originally, the idea (at least in the central Appalachians) was that a semi-tech evac was something that required a rope but no other technical hardware – though now we figure that using figure 8s for lowering is still semi-tech. Another definition is that a semi-tech evac is steep or exposed enough that the litter (and presumably the patient in the litter) needs a belay to avoid that Olympic luge thing. Yet another way to look at it is the angle of the terrain. Non-technical evacs are fairly flat. Semi-tech evacs are up to maybe 45° or so, and a technical rescue is anything more than that. And yet another way is to consider the equipment needed: if you need rigging plates, pulleys, and lots and lots of hardware, it’s probably a technical rescue. If you only need a long rope, it’s a semi-tech evac. If you also use a set of three webbing slings with figure 8s, it’s still semi-tech. If you add seat harnesses and short slings to tie-in the litter bearers to the litter, it’s still semi-tech. If the angle is less than 45 degrees, but you have to set up a brute force haul to get up the hill, or a Z-rig for a bit of mechanical advantage, then that’s still a semi-tech evac. Maybe. It does involve pulleys and Prusiks so some insist that this has moved over to technical rescue. Whatever. Pursuing this question further is probably left for a discussion over beer and pizza late at night.

Steep scree evac is a roughly equivalent term for places that have lots of steep scree, in the Rockies and along the Pacific coast. (Scree is basically gravel at the angle of repose; “screeing” is sliding down this stuff, sort of like glissading down a snow slope.) Outside of some places in the Adirondacks and White Mountains, and one place in the St. Mary’s River Gorge in central Virginia where the Blue Ridge Mountain Rescue Group occasionally practices, there isn’t a lot of steep scree in the Appalachians. So that’s why we call it a semi-tech evac in the East.
**Rope**

Humans have been making and using rope for thousands, if not tens of thousands of years. One of the historical high points of rope manufacture was the Inca Empire in the Andes mountains of South America, which flourished from ~1200 CE until the Spanish conquest in 1572 CE. Much as the Roman Empire was held together by roads such as the Appian Way, the Inca Empire’s engineers created a continent-spanning web of roads. In the rugged mountains of the Andes, these roads had to cross great gorges; the greatest known span is a 148-foot gap north of Cuzco. The Inca designed ropes far surpassing designs known in Europe at the time, using them for bridges that would support mounted soldiers and livestock. These ropes were made of local vegetable fibers, woven using time-tested methods. Indeed, some rope bridges in the Andes are still replaced yearly by those living nearby.

Up until the 1960s, manila rope, also made of vegetable fibers, was the standard. Manila rope was made in ropewalks, long warehouse-like buildings where fibers of the Abacá (Manila hemp) plant, obtained from the Philippines, are twisted first into threads, then threads twisted into thicker fibers, then thicker fibers twisted into rope itself. This was known as “laid” rope. The fibers used to make Manila rope are long: 1.2 to 4.5 meters (4 to 15 feet). This length helps make Manila a superior natural-fiber rope. The rope holds together by the friction between the overlapping fibers, and the longer the fiber, the stronger the rope.

**Nylon Arrives**

When I first started climbing and caving in the 1960s, new-fangled nylon ropes were just the becoming available. Unlike the fibers in manila rope, the nylon fibers are continuous throughout the entire length of the rope. These new artificial-fiber ropes supposedly had a longer lifetime, lighter weight, and better resistance to abrasion. My mother bought me one of these “Goldline” ropes for my first climbing rope. It was a “laid” rope just like our old manila ropes. It was certainly a lot stiffer than manila rope, and very hard to coil and cast. We found that the smaller diameters of Goldline just didn’t work as Prusiks. They didn’t bend enough to grip the rope, and they ended up deforming into unmanageable twists that simply couldn’t be put on the rope. So we ended up using manila Prusiks on our Goldline to ascend static lines. They worked fine.

Rappelling on Goldline tended to untwist it, and as a result you got big twists of rope salad right beneath you, much like a twisted telephone handset cord. You had to untwist the rope beneath you as you were rappelling. And, when ascending a free drop on Goldline, one of nylon’s characteristics – it was slippery compared with manila fibers – meant that the nylon fibers would untwist as you were hanging on them. People would spin enough that some would vomit from the vertigo.

The European manufacturer Edelrid had developed something called kernmantle rope in 1953, the year I was born, and started marketing it in North America in the late 1960s. We looked at it very carefully to see if it was better than Goldline – it was certainly more expensive. The German “kernmantle rope” really should have been translated into English as “core-sheath rope.” But that word “kernmantle” had a certain cachet, and as they wanted you to pay a lot more for this rope, I guess it made marketing sense. So I ended up getting one of the early Edelrid climbing ropes. And, after using that kernmantle rope a bit, quickly consigned my old Goldline rope to the dustbin of history.

Kernmantle rope was easier to coil, easier to cast, much easier to tie knots with, and didn’t twist or spin you while rappelling or ascending. A big win all around (except for the wallet). And you could make functional Prusik loops of the thinner kernmantle!

Unlike laid (twisted) rope, kernmantle ropes contain a core of full-length fibers, making the rope quite strong. If you take a knife cut through the mantle (sheath) a kernmantle rope, you will see a kern (core) of soft, fluffy, and not-very-abrasion-resistant-looking parallel or twisted fibers.

We originally worried that, if a rock cut the sheath, then it would go through the core like butter. In practice, this doesn’t seem to happen,
but we all still inspect ropes as we coil and uncoil them… and if the sheath is significantly damaged, it’s time to retire it and cut the rope into smaller pieces, or, if lives depend on using the rope right now, maybe tie out the bad section with a butterfly knot. Don’t tell the NFPA I told you how to do this, they might soil their pants. More about the NFPA (National Fire Protection Association) later.

We also worried that, if you had a Prusik or ascender on the sheath, the sheath might slip down the core. But modern kernmantle ropes are made so as to prevent this.

**Rope Care**

**Speaking of inspecting ropes**, there are other rules for taking care of nylon kernmantle ropes. The main one is “**DON’T STEP ON THE ROPE!**” (Yes, I know that netiquette says that speaking in ALLCAPS is rude because it’s “shouting.” But someone usually is shouting at whoever’s stepping on the rope.)

Stepping on a rope with crampons on is particularly bad. And grinding a rope between your boot and a sharp rock is fairly bad.

So whenever someone steps on the rope, people yell “**DON’T STEP ON THE ROPE!**”

So whenever someone walks near the rope, people yell “**DON’T STEP ON THE ROPE!**”

So whenever a new person is anywhere near a rope on the ground people yell “**DON’T STEP ON THE ROPE!**”

Sometimes people who just bought a new climbing rope just randomly yell “**DON’T STEP ON THE ROPE!**”

This makes sense, given people’s lives will be hanging on this rope. Or perhaps it has to do with the cost of a good climbing rope, $150-$250 as I write this.

On the other hand, at the 2002 International Technical Rescue Symposium, Jim Kovach presented a paper called *Never Step on a Rope*, subsequently the topic of an article in *FireRescue Magazine* called “Don’t Tread on Me.”

He made a PMI rope into a rug, and then had it on a flat concrete floor where it was walked on, many times a day, for 8 weeks. He also took some of this rope and drove over it repeatedly, sometimes with bits of paver spread over the rope, and sometimes with a fire engine. There was no difference in pull-test strength, compared with the portion of the rope that had been stored in optimal conditions. So, at least for PMI nylon rescue rope, “**DON’T STEP ON THE ROPE!**” is a myth, at least as far as the “grinding in the dirt” bit. It would be interesting to do the same experiment with Spectra rope (discussed in the next section), which I don’t think would fare as well in this test. There is still the risk of a sharp rock under the rope. And there’s still the concern about stepping on the rope and having it roll under your foot and then you fall off the edge of the cliff and go splat.

It seems to me the people with brand-new ropes, even the ones with tightly-braided sheaths, will still scream “**DON’T STEP ON THE ROPE!**”, at least until their rope starts getting dirty. Sort of like having a new car. But there are much more important safety concerns when working with ropes. If you see someone who has been screaming “**DON’T STEP ON THE ROPE!**” and someone steps on the rope and then the owner breaks down and starts crying and screaming, please refer for professional counseling.

Ropes do get dirty, even if you’re not caving with them. (When you’re caving they seem to pick up mud equal to the original weight of the rope.) Washing them, as discussed in the later section on rope inspection, is a good idea.

While nylon ropes are fairly tough compared with manila, they do have their Achilles heels. Nylon melts easily, which is nice when you’re melting the ends in a flame to keep them from fraying. (I recommend wrapping the end of a rope with some tape or heat-shrink tubing before cutting and melting, unless you have an actual rope hot-knife cutter that cuts and melts at the same time.) But not so nice when the middle of your rope accidentally strays too near a stove or campfire.

Nylon can also be damaged by battery acid, so keeping it in a trunk with your spare car battery might not be such a good idea. Keeping it in your car is OK, even in the summer, unless maybe you’re in the Mojave desert in summertime. Ultraviolet light also causes nylon to deteriorate, so storing ropes and webbing out of the sun is a good idea.

Nylon deteriorates with age, too. It may be only a percent or two of strength lost each year, but there are recommendations (yes, from
people who want to sell you new gear) that you should replace all of your rope and webbing after ten years, even if it's never been used. It is said that nylon rope and webbing are 15% weaker when wet. Testing by Jim Kovach, in a paper presented at the International Technical Rescue Symposium in 2011 showed that some webbing was actually stronger when wet, and some rope was weaker, maximum loss about 15%.

The NFPA also says that you should retire a rope after one rescue use. If it was used hard. (That's a paraphrase. Actually it says: "Annex A (NFPA 1500) ... A.7.16.3 If a rope has been used in a situation that could not be supervised or where potential damage could have occurred, it should be removed from service and destroyed. ... The assignment of disposable life safety ropes to members or to vehicles has proven to be an effective system to manage ropes that are provided for emergency use and are used infrequently."

Most search and rescue teams use their ropes all the time, operate on shoestring budgets, and think that "disposable rope" is a bizarre idea. They rely on inspection with every use and rope logs, retiring ropes that show significant signs of wear, have sustained a large shock load, or that are 10-15 years old.

At the 2013 International Technical Rescue Symposium, John McKently presented a paper Don't XXX on Your Rope Revisited in which he reports results of various yucky things on the strength of both nylon and polyester rope. Here are the high points.

- Five samples of nylon 1" tubular webbing decontaminated with 10% household chlorine beach (recommended in the literature) three times over 76 days lost 87% of its strength. Which means don't decontaminate bloody webbing, replace it.
- Nylon rope exposed to water for 30 minutes lost 11% of its strength, and when exposed for 3 hours, lost 23%. Polyester wasn't tested with water.
- Bleach for 10 minutes, after 14 days, reduced the strength of both nylon and polyester ropes about 10-20%.
- Isopropyl alcohol reduced the strength of nylon rope 7% but had no effect on polyester rope.
- After 40 days, duct tape reduced the strength of nylon rope 5% but had no effect on polyester rope. On the other hand, a Sanford Magnum Marker had no significant effect on either nylon or polyester rope, so you can use it safely to make the middle of your rope. The Sanford Rub-a-Dub laundry marker and BlueWater Nylon marker had no effect on the strength of nylon rope.
- Unleaded gasoline for 38 days had no effect on the strength of nylon rope, and slightly increased the strength of polyester rope, but that might just be a bit of experimental error.
- There was a slight (~10%) reduction in strength of both kinds of rope from about a month of: #2 Diesel fuel, 3 in 1 oil, WD-40, hydraulic fluid, ammonia, spit (nylon only, so you can drool on your polyester rope), but not 100% DEET. But DEET dissolves lots of plastics and paints, and leaves it all over your hands. Regardless, never use 100% DEET; Consumer Reports authoritatively says that anything over 30% DEET is bad for you and there is no advantage in going higher than 30% DEET. I like picaridin, found in Natrapel, better. Picaridin is not greasy like DEET, works as well, and doesn't dissolve anything as far as I can tell.
- Common firefighting foams caused ~10% decreases in the strength of both types of rope.
- Battery acid decreased the strength of nylon rope ~50%. Polyester wasn't tested.
- Urine decreased the strength of both types of rope by ~20%, so don't pee on a hot rappel/lowering device.

**Types of Rope**

There are a half-zillion types of rope. People who are really into ropes can (and will at the drop of a hat or the offer of a beer) go into exquisite detail about the specifics of rope materials, construction and testing. If you search the Web for "Cordage Institute Publications Catalog" you will see a 3-page listing of the major types. We will not be discussing more than a fraction these.

Even within nylon, there are variations; the original nylon 6,6 (also known as 6-6) was manufactured by one specific patented process, pioneered by DuPont in 1935, and later a variant, nylon 6 (no additional comma or numeral) was developed to get around the patent, and was itself patented as Perlon. For primarily historical reasons, nylon 6,6 seems to be used in American ropes, and nylon 6 (Perlon) seems to be used in European ropes. Though there are important differences to chemical engineers, and rope manufacturers will passionately defend their choice of nylon type (especially if you buy them...
a beer) there are no significant differences that search and rescue types should care about. So if someone insists that you should prefer Perlon rope to plain nylon rope just ignore it.

Nylon is the main material used in search and rescue rope, but there are two other materials that are used in certain types of rescue ropes: polypropylene and ultra-high-molecular-weight polyethylene (UHMWPE, UHMW) available under the brand names of Dyneema and Spectra.

Polypropylene ("polypro") ropes are used primarily in water rescue. They aren't quite as strong or abrasion-resistant as nylon ropes, but they have one great advantage: they float. White water kayakers and canoeists (yes, they are distinct; aficionados will tell you about the differences in great detail) tend to carry throw bags with a 50-100’ length of polypro rope for when things go bad. Longer polypro ropes are sometimes used by whitewater rescue teams.

Dyneema and Spectra rope are used for some accessory cord (for pre-tied/sewed rope or webbing slings, or on chocks or other devices for lead-climbing), and is available in longer lengths as well. This stuff is, weight for weight, and diameter for diameter, significantly stronger than nylon. Sounds great! However, it also has very poor energy absorption. That means that if you’re tied into a Dyneema or Spectra rope, and there is slack in the rope, and you fall … well, instead of a nice little bounce at the end that absorbs some of the shock-load, you stop. Just like that. No bounce. No energy absorption. (Well, not much.) So, even if the rope is quite strong, maybe the shock load breaks the rope. Or the anchor, or the anchor sling. Or maybe you. Sort of the exact opposite of bungee-jumping.

In lead climbing, one climbs above one’s belayer. (The use of the impersonal – and numerical – “one” here is your clue that some math is coming up and you’d better pay close attention.) And the potential distance one can fall is twice the distance above the belayer or last “protection.” One places protection in the form of chocks or Friends or other brands of protection in cracks in the rock. And one clips the belay rope through a carabiner attached to the protection, so that one can theoretically fall only twice the distance above one’s most-recently-placed protection. The shock load on one’s system (and one’s body) is smaller if one falls a shorter distance, and larger if you fall a longer distance. The shock load is smaller the more rope there is to absorb the energy of the fall. See the figure for a graphical explanation.

Wikipedia’s entry on Fall Factor has a wonderful derivation of an equation that describes the maximal force given a particular fall factor and a particular rope. Then it goes on to say that this equation doesn’t work and you actually have to test ropes. Reminds me of the mathematician’s recipe for fried chicken. It starts “First, assume a spherical chicken.”

However, this fall-factor stuff assumes that one’s protection doesn’t pull out in a dramatic zipper fall. A zipper fall is where your weight is caught by a piece of protection, but then the protection pops out; one falls further, then one is caught by the next piece of protection briefly before it pops out, and so on down to the bottom. Once in Camp 4 in Yosemite Valley my climbing partner was about 50’ up an aid climb from the ground when he did a zipper fall all the way down. He landed on his feet without any injury. After a second of shock, he bowed and took applause from bystanders. (David said it didn’t hurt a bit. But not all zipper falls end so well.)

OK, enough math. The point is that with lead-climbing there can be a long fall before you’re caught by the rope. If you’re using Goldline, you will bounce up and down for about a minute

\[
F_{\text{max}} = mg + \sqrt{(mg)^2 + F_0(F_0 - 2m_0g)\frac{m}{m_0}f}
\]

\[\text{Fall Factor} = \frac{\text{fall length}}{\text{rope length}}\]

\[\text{Length of Fall} \quad \downarrow\]

\[\text{Length of Rope} \quad \downarrow\]

\[\text{Fall Factor 1} \quad \downarrow\]

\[\text{Fall Factor 1/3} \quad \downarrow\]

\[\text{The longer the fall, the worse the shock load. The longer the rope to hold the fall, the smaller the shock load.}\]
and get lots of abrasions from being scrubbed against the rock. (I may exaggerate slightly.) But: not much shock-loading.

But, Goldline would stretch and stretch and stretch when you loaded it. Which means when you were rappelling over an edge, you had to lean back slowly and let your body weight stretch out the rope. If it was a fair way from the anchor to the edge, it would stretch several inches as you applied your body weight. Which is a scary feeling when you're right at the edge; what is worse, if you started rappelling without accounting for the stretch, you might fall over backwards right as you were going over the edge. And ascending? You'd have to spend a minute or two with your ascenders just pulling the stretch out of the rope before you finally started moving up the rope.

Whereas, if you're using Dyneema or Spectra as your rope while ascending, you don't have to pull out any stretch as you're rappelling over the edge, or starting to ascend. But if you're using Dyneema or Spectra as your belay while lead-climbing, and you fall, your harness stops abruptly, cuts you in half, and the two parts of your body land on your belayer. This is the ultimate "static" rope, and Goldline is the ultimate "dynamic" rope. Or perhaps bungees for bungee-jumping are the ultimate "dynamic" rope.

A paper from the 2009 International Technical Rescue Symposium by Jim Kovach entitled *Fall Factors: Do They Apply to Rope Rescue and Rope Access?* however showed that the shock load on static rope is actually much more a factor of the actual distance of the fall, more than the fall factor. Since static rope has poor energy absorption compared with dynamic rope, this intuitively makes sense, though it contradicts a traditional doctrine of "don't use static rope if there might be a fall factor of more than 1/4 (0.25)." Indeed, the data Kovach presented shows that the shock load is a function of the weight and the distance of the fall, and not the fall factor.

Dyneema and Spectra are used in slings, where you assume the dynamic nylon rope you're using will provide adequate energy absorption. These slings have some advantages over nylon: they're strong and light, and better at resisting ultraviolet light damage. Actual Dyneema and Spectra ropes are, as far as I can tell, used only as an alternative to steel cable for helicopter hoist operations, and for some river rescue uses, where shock loading is very unlikely.

Really, if you think about it, an ideal rope would be both static and dynamic. Static in the sense that it doesn't elongate at all under standard loads; dynamic in the sense that if you fall and shock-load it, the rope stretches and keeps the shock-load low. Manufacturers have been toiling in their R&D shops for decades to achieve this rope-Nirvana, and they keep decreasing static stretch and increasing dynamic energy absorption. But they are still far from done, and so they've come up with compromises.

The compromise that emphasizes energy-absorption we call *dynamic* or climbing rope. There is a European standard EN 892, which states that dynamic ropes must sustain an 80 kg load falling with a fall factor of 1.77 with no more of a shock load than 12kN, and it must sustain five such falls before it fails. It also must stretch less than 10% under a static 80 kg load. If, for example, you look at rei.com for information on choosing a climbing rope, every rope sold there meets the UIAA (Union Internationale des Association d'Alpinisme) standards which reference that EN892 standard. They are rated in terms of the number of UIAA falls they can take before they must be retired.

Used to be all dynamic climbing ropes were 7/16" (11 mm). But now, as rope manufacturers are producing better rope, you can now buy 11 mm ropes rated for 10-17 falls (a lot more than early kernmantle ropes), or slim and light 8-9 mm ropes that are still rated 6-16 falls.

The compromise for caving (and later for rescue) the rope manufacturers came up with is called static or caving (or rescue) rope. In 1969, inspired by German kernmantel dynamic climbing ropes, a Georgia caver named Richard Newell bought out a Manila rope manufacturer and started making a core-sheath rope specifically for caving. Known in the caving community as BlueWater II (though the company insists it was named BlueWater II Plus+), this brown rope with a dark-blue stripe on the sheath immediately became the standard for cavers worldwide. But in 1976 Steve Hudson, another Georgia caver, started up rival Pigeon Mountain Industries to manufacture PMI rope, and the competition between the two continues to this day. Steve has been very active in the NCRC (National Cave Rescue Commission) over the years, as well as in the wider search and rescue community.

What is this about Georgia cavers and caving rope? Well, Georgia is famous for its deep caves. Surprise Pit in Fern Cave is particularly well-known example, with its 437-foot free drop. And when you want to rappel or ascend such a length
of rope, elongation is a big deal. You can imagine how using Goldline in such a cave might be a spur to developing better rope. And for cavers, who seldom if ever lead-climb (climbers start at the bottom, cavers start at the top), strength, resistance to abrasion, and low elongation at working loads are key for ropes.

We also use the term “static” rope to refer to the type of rope we use in search and rescue. Given those key characteristics of caving rope – strength, resistance to abrasion, and low elongation at working loads – caving ropes from BlueWater and PMI were quickly adopted for rescue ropes, both by the wilderness search and rescue community, and later by “street” and industrial rescue services. Other rope manufacturers caught on and started making static ropes for this relatively big rescue market. Indeed, the market for static rescue ropes now dwarfs that for caving rope. It’s interesting that many of the techniques now used in mountain and even street rescue started with cavers: rappel racks, for example.

But if you think about it, cavers are more focused on vertical ropework technique than climbers, who tend to focus on the actual act of climbing, or perhaps belaying. For climbers, rappelling and ascending fixed lines are epi-phenomena: necessary evils to allow the act of climbing itself, things that don’t deserve all that much attention. For vertical cavers, this is the core of what they do.

According to the Cordage Institute Standard 1801, a “static” rope has less than 6% elongation at 10% of maximum breaking strength. In Europe, static ropes must meet the EN 1891 standard, which includes surviving 5 falls with a fall factor of 1, Type A with a 100 kg weight, and Type B with an 80 kg weight; static ropes are tested with a 2 meter rope length, whereas dynamic ropes are tested with a 1 meter rope length. As a very, very rough approximation, you might take this as an indication that static ropes have some energy absorption capacity, but maybe about half of a good dynamic climbing rope. This is important – these “static” rescue ropes we use all the time do have some energy absorption capacity, even if it’s less than a dynamic climbing rope. It’s still a lot more energy absorption than a Dyneema or Spectra rope. Rescuers still have a justified fear of shock-loading a static rope, especially with rescue loads, but this energy-absorption capacity of “static” ropes provides a small margin of safety. PMI and BlueWater static ropes (and those of many other manufacturers) meet these standards.

It’s even a bit more complicated than that. Cordage Institute (CI) standard 1801-98 specifies “low stretch” (medium elongation) and “static” (low elongation). Some ropes used for rescue meet one specification, some meet the other, but all tend to be unofficially called “static rope.”

**Size Matters**

The fire-rescue community, represented by the NFPA (National Fire Protection Association) adopted the use of nylon kernmantle rope from the mountain rescue community, which had adopted it from the cave rescue community, which had adopted it from the sport-caving community. More or less. However, when the NFPA finally codified this use in its NFPA-1983 standard, it deviated from the standard 7/16” (11 mm) rope used by the mountain rescue community. It demanded the use of 1/2” (~13 mm) rope. This may have had to do with the memory of the death of two firefighters in New York in 1980 when the 1/2” nylon “general utility” rope to which they were attached failed. This may be because the NFPA wanted a 15:1 safety margin, and a firefighter loaded with an air pack and turnout gear can be pretty heavy. (I have been repeatedly assured by firefighters that this is not because mountain rescue types tend to be skinny and firefighter types tend to be fat.) At the time, this caused great consternation in the mountain- and cave-rescue communities. Half-inch rope is a lot heavier (~30%) than 7/16” rope. A bunch of mountain and cave rescue people got together under the auspices of ASTM (the organization formerly known as the American Society for Testing and Materials) to set up their own competing standard (ASTM F2116) so that the mountain and rescue communities could continue to use their lighter and thinner rope. In defense of the smaller rope for wilderness rescue, proponents noted that weight, while not significant for fire departments, is a big issue for wilderness rescuers, and that a heavier rope could slow rescuers enough that a victim might die while waiting longer for the rescuers to arrive.*

* NFPA later amended the standard to specify that it was not for wilderness use, and to allow 11 mm rope, provided it had the very high breaking strength they specified.
Nylon, Heat and Weld-abrasion

Nylon is great stuff for climbing, caving and rescue ropes. But, unlike Manila rope, it has one sneaky but major danger that must be zealously guarded against: weld-abrasion. Nylon has a relatively low melting point: that is why I have seen rescuers urinating on an overloaded descender in a desperate attempt to keep the metal cool. (Bad idea: urine reduces the strength of nylon rope.)

A better approach was a rappel/lowering device I encountered circa 1970 and got to use at a National Speleological Society (NSS) convention once: A rappelstein (or rappel-e-stein). This was invented by Don Shofstall, a caver from Evansville, Indiana. The original is in the National Speleological Society museum. It was a cylinder of thick aluminum with a bottom attached to it, just big enough to take a beer can. An aluminum carabiner was welded into the side of it. To use it for a long drop, you would place a frozen can of beer in it, then attach it to your harness. You would then wrap the rope around the cylinder several times and rappel. At the bottom, the beer would have thawed while keeping the rappel device cool, and your beer was ready to drink. Frankly, it was not a very good rappel device, which makes it hard to understand why it was so popular for a while. I think most of them were used for partying at the Old Timer’s Reunion, a very big caver’s get-together held in West Virginia each year since 1950. But it wasn’t that good of a beer stein, either.

Yes, rope running over a rappel or lowering device will, by friction, make the rappel/lowering device hot. But as long as the rope is moving across the metal device, it doesn’t have much time to get heated up. It’s when the rope stops that one gets worried about damage to the rope. This is a concern for people doing very long rappels, such as during Bridge Day at the New River Gorge near the Virginia/West Virginia border. Rappellers try to get the rope clear of their rigs as quickly as possible after the 876’ (267 m) rappel.

The real problem, though, is nylon-on-nylon friction. If both bits of nylon are moving – for example, if you’re rappelling on a Münter hitch, there will be little damage to the rope. But, if the running nylon is going across stationary nylon, it will cut through the stationary nylon like a hot knife through butter. Well, not exactly like a hot knife through butter, because what happens with running nylon on stationary nylon is called weld-abrasion. This is a bit tech-y but anyone working with nylon rope and webbing needs to know all about this.

The moving nylon heats the stationary nylon to the melting point of 428°F (229°C) for the most common nylon (nylon 6,6) or 509 °F (265 °C) for Perlon (nylon 6). The stationary nylon melts, and the melted nylon then welds itself to the moving nylon. This exposes fresh stationary nylon to be heated and welded away. This can cut through a bit of rope or webbing very fast.

As a demo (yes you should try this at home), I take a 2 or 3-foot tied loop of half-inch tubular nylon webbing and loop around my right foot. I then take a 3- or 4-foot length of parachute cord (or shroud line if you want to sound like a really part of the rope-cognoscenti) and loop it through the webbing loop. I then hold the ends of the shroud line wrapped tightly around each hand, and ask the audience: “How many strokes of this shroud line will I need to saw through this webbing?” I then saw back and forth with the shroud line and ask the audience: “How many strokes of this shroud line will I need to saw through this webbing?” I then saw back and forth with the shroud line as hard as I can. It usually only take five or six saws to cut completely through the webbing. Yes, I cheat a bit by using shroud line and half-inch webbing. But it’s OK, I’m aiming for a dramatic presentation to get the principle across, and this works quite well and throws the proper scare into the audience. Speaking of drama, if you do this yourself (which I highly recommend): as soon as you cut through the webbing, quickly take the shroud line and throw to one member of your audience, then grab the severed webbing loop and throw to another audience member. A dramatic flourish is required.

Weld-abrasion may occur when you are rappelling, and the rappel rope is running across your harness. This is particularly likely if you do a carabiner-wrap rappel (discussed later) using a single carabiner attached to your harness, which is an old-style military rappel from World War II; with Manila ropes of that era, weld-abrasion wasn’t a danger, but with nylon ropes, it certainly is. Though less likely, running nylon on stationary nylon might happen in rescue lowering, too, and is to be assiduously avoided!

Weld-abrasion on harnesses is enough of a concern that the ASRC has an official tied seat harness. The ASRC Seat was designed by Gene Harrison, one of the ASRC’s four founders, around 1975. Unlike some tied seats, this one requires that it be cut in at least two places
before it fails and you go splat.

**Rope pads**

Where a stationary rope goes over a sharp edge, a shock load can break the rope. Where a moving rope goes over a sharp edge, abrasion can quickly destroy the rope. And, sometimes, you just have to route a rope over a sharp edge: thus, rope pads. I have seen all sorts of rope pads: carpet samples, old firehose, and many types of specially-constructed pads. Rope bags that also double as a rope pad are a clever design, but any rope bag can be used in a pinch.

Rope pads, like other physical objects, tend to go to ground. We call this gravity. Having a leash on the rope pad helps keep it in place over the edge. The most clever rope-pad leashes I’ve seen are for rope pads in locations where you really have to leash them to the rope itself: a length of shroud line is attached to a standard binder clip of the appropriate size to attach to a 7/16” rope. As people rappel or ascend past the rope pad, they can take the binder clip off the rope and then reattach it once past. Some of these rope pads are made from 2” seat belt webbing and Velcro, so they surround the rope on all sides. These are particularly useful in caving and cave rescue, where ropes may rub against sharp rocks halfway down a drop.

There are also a variety of other plastic plates and edge rollers you can buy. These specifically address the concerns during vertical rescue, where the stress on the rope at the edge is extreme.

**Stacking and Casting**

*Note: for this and many of the following sections, complex procedures are described. These are manual skills that are best learned by guided hands-on practice. Next best is seeing the procedures done, either in real life, or via a video. Search YouTube for the appropriate technique or knot, and you will find rope videos of how to perform the procedure, some of which ASRC members have posted there. As a supplement to these methods, here you will find pictures and text descriptions.*

Rope salads used to be a big problem with Goldline, but even with the most supple Perlon kernmantle ropes, it can still happen. Keeping rope salads from happening, while making it look easy, is a key way to look experienced.

One of the ways to look good is to always keep your rope in a rope bag rather than a coil. There are many different styles of rope bag. My favorite is a design used by many cavers. It has a couple of webbing straps so it can be carried like a pack, or the straps can be used to tie the rope bag onto a pack. The bag is made of tough Cordura nylon that can be used as a rope pad. (Some have additional padding or flaps, often of cotton duck or corduroy, which better resists abrasion from nylon rope, specifically to enhance their paddiness.) There is a drawstring on the top, so you can open fully to randomly “stack” rope inside when putting it away. There is also a large hole with a brass grommet at the bottom, so you can feed the end of the rope through it.

It’s traditional, more or less, to use such a bottom grommet to feed the rope through and tie a backed-up figure eight loop there. And, on the end that’s left when you’re almost done packing the rope in the bag, you tie another figure-eight loop, and clip it to the rope bag’s drawstring or haul loop.

When a rope is placed in a rope bag this way, you can deploy it as a static line quite quickly. You unclip the biner from the haul loop or drawstring, pull out about 10 or fifteen feet of rope, wrap it around a good anchor tree three or four times, and clip the end-biner back onto the main rope. You then can simply throw the rope bag over the edge of the cliff, trusting that the randomly-stacked rope in the rope bag will pay out neatly.

You of course yell “ROPE!” before you throw the rope bag over. Why do you yell “ROPE!” instead of yelling “ROCK!”? Indeed, some insist that you should indeed yell “ROCK!” but I think it’s persuasive that “ROPE!” is better, as (a) rope is less dangerous than a rock or other large object, and (b) the people below can pause for a minute, and then check to see if the rope has made it all the way down. If it’s tangled, those at the bottom can signal those at the top to pull it up or recast it. And if the rope doesn’t reach the bottom of the drop, it’s only polite to let the people at the top know before they rappel off the end of the rope and go splat.

The weight of the rope bag will assist the rope in reaching the bottom of the cliff. Providing the person who put the rope in the bag did it properly – which means randomly – this almost always works perfectly.
Stacking

Stacking the rope is an essential skill. If you want to tie a rope salad (see diagram) all you need to do is take a coiled rope, untie it, and throw it over the edge. Then pull it back up and spend the next hour untangling it.

To prevent this sort of public embarrassment, you stack the rope. While this sounds like a neat-freak sort of thing you actually stack rope randomly, just like you randomly push rope into a rope bag. Surprisingly, this is the best way to get rope to pay out neatly. If you are uncoiling a coil and getting ready to cast this line over the edge of a cliff or into a pit, you start by uncoiling the rope carefully, to avoid knots or tangles, but then you just throw it on the ground randomly. A random stack like this will easily pay out, without tangles, whether pulled from the bottom or pulled from the top.

A few caveats: if you stack rope not on the ground but on or in a sticker bush/bramble bush (“jagger bush” in the dialect here in Pittsburgh) such as blackberry or greenbrier, it won't work. Indeed, if you try to stack it on an area of ground with loose sticks, it will tangle in the stack. And, when surveying a spot to stack a rope, it's probably a good idea to avoid areas with unpleasant objects such as sharp rocks or dog poop. (In my Allegheny Mountain Rescue Group, our dogs learn how to rappel with their handlers, so the dog poop is not there for comic relief. Well, maybe a little bit.)

If you are uncoiling and casting a rope, and you've now stacked it on the ground, the next step is to throw the rope over the edge so it gets to the bottom. This may not be as simple as it sounds.

Casting

Cliffs and pits may be encumbered by rock projections, bushes, or even whole trees that will do their best to prevent you from throwing that rope to the bottom. A rope bag does a pretty good job of getting past such obstacles. The best way to cast it is overhand. It's also a best practice to be tied in so you don't cast yourself over the cliff. Ideally you should be tied in at the back of your harness, adjusted precisely so you can lean forward a bit over the edge while some of your weight is on your tie-in; this way you have a good view of where you are casting the rope.

Don't laugh about the "casting yourself over a cliff"; if you peruse the decades of material in Accidents in North American Mountaineering and American Caving Accidents lots of fatal falls occur not because of equipment failure but because someone, not tied in, trips and tumbles over the edge.

To cast a line down through brush, without a rope bag, there are two main options. First and most common is gather up about 20-30' of the soon-to-be-bottom of your stacked line. Loop it back and forth across your dominant palm, so that there are 4-5 loops, each 2-3 feet in length, on either side of your palm. We call this a speed coil. Grasp in your hand then cast this, overhand, directly down that little hole in the brush where you want the line to go. The weight of this line you cast should be enough to pull the rest of the stacked rope down that little hole after it.

If you've tried this a couple of times and it's simply not working, try this alternate method. Stack your line into two separate piles, each with half the rope. Take the middle of the rope, and cast as described above. Once the middle seems to be in good position, let the other half of the rope slither down past it.

It's a good idea to have visual confirmation that the rope reaches all the way to the bottom before rappelling down it. Yes, people have died from rappelling off the end of a rope. If you're not sure the rope reaches the bottom? You can tie a figure-eight loop in the bottom of the rope, and size it so that someone nearing the end of the rope can put a foot in it. Rappelling with an ascending rig already on might be a good idea as well.

Coiling a Rope

Rope bags are handy, and frequently used by cavers and search and rescue teams. But sport climbers and some "street" rescue teams prefer to coil their ropes.

There are disadvantages to having a rope in a coil: you have to uncoil and stack the rope before using it, which takes time. On the other hand, compared to a rope bag, you can more easily throw a coil over your shoulder, or strap it on top of a pack. And, a coil is lighter, which may make a difference if you're heading deep into the
backcountry. This may be persuasive if you’re one of those ultralight climber/backpacker types who cuts the handle off your toothbrush and trims the margins off your maps. (But then you don’t have a rope bag to pad your rope, either.)

There are several YouTube videos with quick-and-dirty ways of coiling rope. If you’re just climbing at an indoor climbing wall, or walking a quarter of a mile from your car to a cliff to climb, and then walking right back to the car, these methods are fine. But if you need to carry a rope a longer distance, these coils tend to fall apart, and so neater but more labor-intensive rope coiling are part of the skill set of any caver, mountaineer or SAR team member.

To prepare a rope coil for storage or carrying, the first step is to coil it, and the second step is to tie it off. If you’ve ever learned to coil stiff cables and hoses, you may need to unlearn one thing: alternate twists. When coiling something stiff like an electrical cable, it’s customary to loop the cable once, then to flip the cable backwards the next time. This is known as “over/under” cable coiling. This prevents the twists to the cable from tangling the coil into a series of twisted loops instead of a neat coil. It also means that, when you uncoil the cable, it has no twists in it.

A video of this technique is available at http://stagecraft.theprices.net/gallery/cablewrap/. Kernmantel rope is twistable enough that you don’t need to use this technique; when coiling as described below, the half-twists in the rope are spread out through each loop without making the rope appear twisted.

To get all the loops in a coil the same length, it’s common to use two different parts of your body as a frame to make sure the loops are all the same. You can do this between your palm and your elbow, between your knee and the bottom of your boot, or between both knees. You should be prepared to do all of these. The neater and faster you can do them, the more style points you get.

The most important way to make your coiling go smoothly is to neatly stack the rope randomly on the ground before coiling. A faster alternate is to have a helper untangling and stacking the rope right next to you as you’re coiling.

**Elbow Coil**

For short lengths of rope, it’s easy and fast to make a small coil using your hand and your elbow. You grab one end in your left hand (if you’re right-handed) so that the rope is across your palm, which is facing up. The short end of the rope should be hanging out about a foot beyond your little finger. Lift up your arm so that your forearm is nearly vertical, with your hand with the palm up, your wrist bent back at an uncomfortable angle, and your fingers pointed away from your body. It makes you look like an ancient Egyptian pictogram but it works quite well.

Now, you use your right hand to wrap the long end of the rope down the outside of your forearm, under your elbow, then up the inside of your forearm and across your palm. Do this over and over until you run out of rope. Shake the rope off your elbow. This is the tricky bit. Practice in front of a mirror until you can flip it off in a single graceful shake of your arm. Peeling it off your elbow with your right hand works but is not as cool. The trick is to be able to bend your wrist back really far to loosen the coil from your elbow. Now you’re holding a nice little coil in your hand, ready to tie off.

**Knee Coil**

The knee coil is probably the most common search and rescue coil. The process with a knee coil is very much the same as with an elbow coil. But the knee coil produces a bit bigger coil, and is suitable for longer ropes, up to maybe 200’. Again the instructions are for right-handed people. If you’re left-handed, you can try holding the paper up to a light and reading from the back side of this page, though I doubt it will work.

You start down on the right knee, with your left foot on the ground. You place the short end of the rope across your left knee, with a couple of feet of the end hanging off the right end of that left knee. You then pull up some of the rope with your right hand, run it down the outside of your lower leg, under your boot, then back up the inside of your lower leg, and across the knee to the outside. Repeat over and over. Keep your foot pointed down so that when done, you can flex your ankle to get out of the coil.

It is important that you maintain good posture while you do this. It’s probably good for your back, but most importantly it makes you look good in photographs and videos.

There is also a tendency for the first loops you do to be longer than the later loops, resulting in an uneven coil. Therefore, it’s good to start with the loops quite tight, then to loosen them up as
you go along.

It is also important that you keep the rope right at the very front of your knee, so the coils don't get shorter and shorter as they slip up your thigh. If that happens, you become trapped in the coil and have to ask for help to get it off your knee. Very embarrassing.

**Lap Coil**

For longer ropes, such as 300' ones, it's quite hard to do a knee coil, so a lap coil is what you want to use.

Sit down on the ground, with your legs crossed. Start with the rope across your left knee, just like with a knee coil, with a couple of feet of the short end lying in your lap. Coil the rope around both knees, then tie off. You can look pretty professional heroic doing an elbow or knee coil, there's just no way that sitting in a yoga posture looks good on-screen, especially when you're sitting in the mud. That's probably why most people use rope bags for their 300' ropes.

**Coil Tie-Off**

I have seen someone do a beautiful knee coil, with all the loops the same exact length, and all of them lined up neatly. And then put the coil over his shoulder and walk off, and a few minutes later the coils were all uneven and about 10 feet of rope was trailing him on the trail. That's because he did a great job of coiling but a not-so-good tie-off. There are a couple of tricks that will help you avoid this.

A standard tie-off – called a “mountaineer's coil” on Wikipedia though the article's really talking more about the tie-off – is not hard to do, but it definitely takes practice. There are several ways to do a good tie-off; this is the one I use successfully all the time. It uses the two ends of the coil to create a wrap around the top of the coil. You will be wrapping one of the free ends around the coil, then snugging the end of that wrap down using a bight (uncrossed loop) in the other end. That bight will be inside your wrap.

Grab the coil in your left hand, so that it is hanging down from your hand.

One of the free ends, the one that forms the loop, can be fairly short, but at least a foot. The other end needs to be longer, at least 2 feet for a standard 100-150' rope, maybe 3’ for a 200-300’ rope. If you don't have an end this long, flip a loop off of the coil to make the end longer. Longer than the minimum, even way longer, is fine. The short end should be pointing away from you, the long end pointing towards you. Flip the coil around in your left hand if necessary.

Bend the shorter end back on itself to form a bight. Stick the tip into between your hand and the coil, but so that there is a good-sized loop sticking out of your hand, at least 5”. Keep the two ropes of this bight right next to each other.

This is the hard part: while still holding the bight and the coil in your left hand, use your left thumb to hold the rope right where it leaves the coil to go to the long free end. Now, using your right hand, tightly wrap away the long end around the coil, starting away from you around the coil, spiraling towards the loop. Note that you are wrapping this end of the rope back on itself, which is why you need to hold it with your left thumb.

I prefer to wrap away from me on the top, then towards me on the bottom, though Yorke's diagram here shows he likes to do it the other way.

Once the wrap gets close to the end of the bight, stop wrapping. Stick the remainder of the long end through the bight.

Gently pull the other end, which will tighten the bight.

But you're not done yet. You need to use your right hand to twist the wrap, several times, to tighten it up, and push the slack through that little loop. Now, tighten the loop firmly by pulling on the other end, and you've got a nice, tight tie-off.

**Rescue Coil, Chaining**

Speaking of looking heroic, there's nothing better for this than walking to the edge of a cliff, taking a coil off your shoulder, doing a quick tree-wrap anchor, then throwing the coil off the edge without taking time to stack it.

Of course if you do this with any of the coils we just discussed, you then look over the edge and about ten feet down you see a massive ball of tangled rope. But wait: there is a solution that will work for that next mountain rescue movie. It's called a Rescue Coil. (Just had to capitalize that.)

I've seen a couple different version of rescue
coils, including one that requires you to do it very neatly on the handles of an Army stretcher, then folding up the Army stretcher. Of course that one frequently turns into a massive rope salad when you cast it, so we won’t discuss that one further.

The one that I have used with 100% success is not actually a coil in the traditional sense, it’s a chain. We will digress briefly to discuss chaining, as it’s the most common way to store flat webbing. There is no way to look heroic while chaining webbing. The object here is to chain the webbing so that it is easy to unchain with a flick of the wrist (now that looks professional if not heroic) as opposed to producing something that looks like a failed macrame project. You can also chain short bits of rope, and in fact we routinely chain the tails on load-releasing hitches.

There are many different ways to chain webbing, but this is not macrame class, so we will just learn one adequate way.

It’s possible to chain either long pieces of webbing, or pre-tied or sewed webbing loops. The process is the same, though the results look a bit different. For simplicity, we will consider chaining an untied length of webbing.

Warning: this needs to be practiced at home before you try doing it in front of others. First, fold the webbing in half. Now, where the doubled webbing forms a loop, make a girth hitch. To do this with style takes a bit of practice. Stick your right hand through the loop, with your palm facing down, so the webbing is dangling from the back of your wrist. Bend your hand down slightly and grab the two dangling pieces right below your wrist. Hold onto them, and with your left hand, pull the loop over your fingers. Now pull your right hand up, bringing the closest parts of the two dangling pieces of webbing right below your wrist. Hold onto them, and with your left hand, pull the loop over your fingers. Now pull your right hand up, bringing the closest parts of the two dangling lengths of webbing up through the loop. Voilà! Now you have a girth hitch in the middle of the webbing. You need to practice this until you can do it without looking at your hands, and while talking about your plans to summit Annapurna next year. (My wife says this is nothing more than crocheting, or what Waldorf schools call finger-knitting.)

Once you get really good, you can do this entirely with your right hand. It is simple but takes a lot of practice, and is prone to embarrassing failures. While you have the webbing across the back of your wrist, you quickly jerk up your hand to get the loop to rise off your wrist a bit. While the loop is in mid-air, you grasp the two lengths of webbing, which leaves the loop a bit loose on the top of your wrist. Then you give your right hand a sort of sinuous shake so that the loop falls over your hand, forming the girth hitch. Good if things are being recorded but a bit risky for live video.

To be truthful, I usually just use the fingers of both hands to create the girth hitch, and usually while talking about something interesting one of my cats did.

Once you’ve got the girth hitch, you should take a few seconds to neaten the webbing so it’s not twisted too much, though some folding of the webbing is inevitable.

Hold the girth hitch in your left hand, so that the two tails of webbing are dangling. With your right hand, grab the two tails, together, about four inches below the hitch. Carefully fold this in half – now you should have four thicknesses of webbing in a loop – and stick this loop through the girth hitch. Tighten the girth hitch a bit, but not too tight. Adjust the webbing loop you just pushed through the girth hitch so it’s just big enough to push another loop through. Then, reach down, grab another doubled loop of the tails, and push through the loop.

Continue doing this over and over until you don’t have enough to push another loop through.

Finish the chain by grabbing the tails, and push them through that last loop. Voilà! You’ve chained webbing! That’s all there is to it.

Well, no, it’s not. How does your chain look? Does it have that failed-macrame look? Then experiment with different ways of chaining. Try to keep the webbing as flat as possible. (No, ironing a chain is not a good idea. But maybe a Corby pants press?) Many find that alternating the direction from which you push the webbing through the loop results in a neater chain.

Now, back to the rescue coil. This is tricky, and takes a bit of practice. Take the end of a stacked rope, do an overhand in the end, and chain the rope singly until you have enough to be the circumference of your coil. I find I tend to make this part a bit too long, so make it about 4 feet. Chain loosely.

Now for the tricky part. You loop your rope chain around so that now, instead of chaining the rope, you are chaining around the first chain. I’ve found it easiest to do this with the rope I’m chaining with under the already-chained rope. Unlike the initial single chains, these chains around the already-chained rope should be tight.

Again, to get this to pay out perfectly, do the
first chain *loose* and the chains around the first chain *tight*.

As with a rope stacked in a rope bag, you can throw this down a cliff, or you can rappel while carrying it. Time-consuming but stylish and handy.

**Inspecting and Washing Rope**

You inspect rope as you take it out of the rope bag, and as you put it back in. If coiling, you inspect it as you uncoil and stack it, and as you coil it back up.

There is even an ASTM F1740 Standard Guide for Inspection of Nylon, Polyester, or Nylon/Polyester Blend, or Both Kernmantle Rope. Here are some generally-accepted guidelines for inspecting rope.

Run your hands over the rope. The entire rope. You feel every inch of the rope, and you look at every inch of the rope. It's sort of like belaying, where your braking hand never leaves the rope; your hands must feel every inch of the rope. One hand (usually your left hand, if you're right-handed) pulls the rope up from the stack and shoves it into the rope bag. The right hand stays fairly firmly on the rope and feels every inch of the rope as your left hand pulls it through your right.

Look for wear in the sheath (mantle). If a rope is very fuzzy all over, that makes you a bit suspicious it is about time to retire it, if for the simple reason that fuzzy ropes are hard to handle, and they absorb water and mud. Caving ropes that are used for lots of rappels tend to get this way.

But what really is important is to look for local areas where the sheath is damaged. If you can see the core, it's time to retire the rope. If more than half of the sheath fibers are gone, it's time to retire the rope. Yes, I suppose you could cut out the bad section, and if someone in crampons stepped on a place a foot from the end of a brand-new rope, it might make sense to simply shorten the rope a foot. But if it's a well-used rope, maybe it's time to bite the bullet and get rid of the rope.

Feel for stiffness. A rope that has been heavily loaded will often be a little stiff all over. Sometimes, the rope even seems to fold up not like a rope but like a set of tent poles connected with an elastic cord. But that stiffness disappears quickly as you handle the rope. For that matter, some ropes are stiff all the time, though newer ropes tend to be a bit more supple than older designs. But if most of the rope is soft, and you feel a single small hard area pass through your hand, and it doesn't go away when you wiggle the rope a little, it's bad news. It may mean heat damage from where the rope stopped in a hot rappel or lowering device. Look for telltale glazing of the sheath that might be a clue to this. Even without the glazing, though, a stiff area like that means "retire the rope."

Feel for dents. Even if the sheath is intact, a dent may indicate damage to the core (kern). Another clue to such damage might be white core fibers sticking out through the sheath. Time to retire the rope.

Discoloration usually is just patchy dirt. Mountain rescue ropes get dirty on a regular basis. Cave rescue ropes get dirty all the time. But if the rope may is pretty dirty, it's time to clean it anyway, and you inspect the color as you wash it.

The best way I know of to wash a rope is with a commercial rope washer. Not as expensive as it sounds, a PMI or similar rope washer costs less than $50, and basically is a mostly-hollow T tube about twice the size of a rope. You hook the bottom of the T to a garden hose or similarly-threaded faucet (I use the one on my utility sink in the basement). You turn on the water, and small orifices in the inside of the top T squirt water into a central tube. You pull your rope slowly through the rope of the T and it gets washed. Elegant. Simple. No washing-machine tangles. No need for soap. And, as you're pulling clean rope out of the washer, you are inspecting it for color as you pull it out.

There are many opinions (expert and otherwise) about how to wash ropes, but little or no science. If you want to use soap, a mild soap is recommended: Woolite, PMI rope soap, or NikWax TechWash. You can hand-wash it in a bathtub. Or you can put it in a washing machine and wash with cold water. To prevent tangles, either (1) put it in a pillowcase and tie the pillowcase with a twist-tie (for front-loading washers) or (2) chain it and carefully place the chained rope evenly around the bottom of the washer tub (for top-loading washers). Some people say to not use pressure-washers, but Bruce Smith of On Rope 1, the best rope expert I know personally, even has a web page showing a good way to wash ropes with a pressure washer (search for "rope washing on rope 1").

All in all, I still favor pulling the rope through
a dedicated rope washer, as long as you’re just washing a couple of ropes. If I had a bunch of ropes to wash, I think I would use Bruce’s pressure-washer methods. In fact, I could probably get my daughter to do it; she loves playing with the pressure washer.

The only problem with the pressure washer method is it needs to be above freezing and you need a clean driveway or patio. In the winter, in the North you need a large, well-drained, clean indoor area. But the indoor rope-washer method works regardless of the weather outside, and all you need is a laundry sink.

As mentioned earlier in the Rope Care section, bleach damages rope and webbing. For bloody webbing, I recommend replacing it. For bloody rope, I recommend washing it twice. I think that the chance of anyone catching a blood-borne pathogen from a rope that has been washed twice asymptotically approaches zero. If a rope is used in a cave, decontamination is also a concern due to White Nose Syndrome, a fungal disease that is decimating bats in North America. As with blood, I simply recommend washing twice. You may use one of the gentle soaps recommended above, but soap is not required. I have no evidence for this whatsoever. I guess as I am a physician and user of lots of ropes who follows the rope literature, you may cite this as “expert opinion.”

If, after you wash it, a rope still has a discolored patch, that’s bad. Time to retire the rope. You start worrying about something having gotten on it that dissolves nylon. Like battery acid.

**Webbing**

*Webbing is interesting stuff.* It’s like you pulled the kern (core) out of a big rope, and then ironed the mantel (sheath). Sort of.

Webbing has some advantages over rope: it’s much more supple (flexible) and easier to work with in many applications. It’s also flatter (duh) and flatter means when you use it to rig to a tree, it’s less likely to dig grooves in the tree. When your wrap it around you, it’s less likely to dig grooves in you, which is why people prefer webbing over rope for harnesses and litter tie-ins, whether commercial or tied.

Most of the webbing we use in search and rescue is made of nylon. There are two major types of webbing we use: flat and tubular. Flat webbing is just as it says, flat, and mostly we use what is called seat-belt webbing, which is 2” across. It’s sort of heavy, but for certain applications – seat harnesses, litter spiders, tying someone on your back, litter load straps – it’s superior.

However, there is one significant disadvantage to flat webbing: it’s not nearly as abrasion resistant as rope. In fact, the threads that form flat webbing go from one side of the webbing all the way to the other side, which makes it fairly easy to abrade through the thread enough that the webbing fails.

Tubular webbing addresses this by being, well, tubular. It has a hole in the middle, though it’s a flat hole, if you follow. In olden days, it used to be made by taking flat webbing and folding it over and sewing the edges together. But these days, most tubular webbing is produced on a loom that makes a continuous spiral. The advantage compared to flat webbing is that you have to abrade 3/4 of the way through, rather than half-way through, to make the webbing fail.

Two-inch flat nylon seat-belt webbing is load-bearing, which means it’s strong enough to hold a person or a rescue load. However, you can also get non-load-bearing flat black webbing, sometimes called tent webbing for reasons that escape me, as it’s used much more often on packs, for hipbelts, shoulder and sternum straps, and for accessory straps. You should never use this stuff to hang a human life, but it’s useful for many other things, including piggyback carries, which we discussed before. I have a box in my basement with lots of this in the standard 1” and 3/4” width, and a bunch of the buckles that go with it. You never know when you might need to make up another accessory strap.

One-inch tubular nylon webbing is also load-bearing. You can also get different widths, which may or may not be load-bearing; check first.

As with rope, webbing should be inspected, and retired when it shows signs of damage, or after 10-15 years.
If you want to rappel, or lower a litter, or delay a litter coming uphill, or haul a litter uphill, then you need an anchor.

The subject of anchors is quite extensive. We won’t go into excessive detail, but we will run through a bit about anchors in general, coming from the climbing and caving perspective, and then focus in detail on anchors for semi-tech evacs.

In emergency services training these days, there are three levels of training/competence for almost every discipline: HazMat (hazardous materials), whitewater rescue, whatever. There are various official definitions, but I will give you my take-home impression.

- **Awareness Level** means you have at least a clue about the hazards involved. You know enough to not get yourself killed right away, even if you can’t actually do any rescue work. You will at least not get in the way and actually might be able to help a competent rescuer a little bit.

- **Technician Level** means you know what you are doing, and can accomplish standard rescue tasks competently and efficiently.

- **Operations Level** falls between the two.

The goal of this section is to give you Awareness Level for the field of anchoring in general, and when combined with some practice, Technician Level for the simple anchors usually used for semi-tech evacs.

Anchors include “protection” (sometimes “pro”) for lead climbing, which are anchors you place on a cliff as you’re climbing up it.

The simplest protection is to take a loop of webbing or rope and flip it over a rock spur as shown in the diagram. Webbing loops are usually sewed or pre-tied with a water knot. Rope loops are usually sewed or pre-tied with a double fisherman’s knot (barrel bend). However, it’s important to use the right size loop of webbing or rope. If the loop is a bit too small, the angle $\theta$ (Greek lowercase theta), as shown in the diagram on the previous page, may be wide rather than narrow. And, once the angle $\theta$ gets wider than 60°, it starts multiplying force significantly. Indeed, at an angle $\theta$ of 180° (straight, no angle at all) even the slightest pull on the carabiner should be enough to snap the webbing loop. Therefore, with any anchor rigging, it’s important to make that angle $\theta$ acute (<60°) to avoid this force-multiplying effect.

When I first started rock climbing in 1960s, I used Chouinard pitons (metal spikes) that I would hammer into cracks in the rock. These are now considered некультурный (or as they say in Pittsburghese, "ignorant") as they damage the rock.

I also used nuts – originally nuts (as in nuts and bolts, not as in walnuts) with rope threaded through them, that you placed in cracks in the rock. These were eventually replaced by hexagonal blocks of aluminum with rope threaded through them, later in many other shapes. Today, lead climbers tend to use devices usually called Friends (after the initially-dominant brand), which are spring-loaded camming devices that are much easier to place and remove, and fit in a greater variety of cracks. While such anchors are widely used in sport climbing and sometimes in vertical rescue, they are seldom needed for semi-technical evacuations.

For climbing, you may want to protect a popular route from damage from temporary anchors by placing a single permanent anchor. In caving, you may need to create an anchor at one particular place to rig a rope down a pit so it people on the rope are not immersed in the waterfall. For such situations, you need to put in a bolt. Unlike setting climbing protection, putting in a bolt is much more involved. Although there are hand drills you can use to put in bolts, most experienced bolters tend to use Hilti or other industrial rock drills to place the holes. Placing the bolts in the holes drilled in the rock is itself somewhat of a black art, requiring judgment of the quality of the rock and the quality of the placement. Hangers are attached to the bolts to allow a carabiner to be clipped to the bolt. Since bolts tend to pull out if you pull them in an out direction, it’s important to only load them parallel to the surface of the rock, that is, perpendicular to the bolt itself. It’s also common practice to place two bolts side-by-side and to anchor to both of them.

**Anchors**

Anchor: Runner with carabiner over rock spur. The angle $\theta$ must be acute to prevent multiplication of force resulting in failure under load.

**Picket and Deadman**
for security.

Snow and ice anchors represent another complex area of anchor-expertise. Ice screws are rarely used as anchors for semi-tech evacs, even in alpine areas. But deadmen (flukes) and snow pickets are indeed sometimes used for lowering on steep snow slopes. And, deadmen and snow pickets may also be used in mud in caves as anchors. Commercial deadmen and pickets are available, but they can also be improvised from logs or rocks buried in snow or mud. A bollard can also serve as an anchor in hard snow or mud.

To make a bollard, you dig out a hole in the shape of a doughnut, leaving the doughnut hole sticking up. A very big doughnut hole: it needs to be about 6 feet across. And it actually should be a bit teardrop-shaped, with the point of the teardrop aiming at the expected load. You then wrap a rope or sling around that doughnut hole.

Does this sound a bit scary? Good. Learning snow anchors and bolts, and protection in general, is best learned by apprenticing yourself to an expert, not reading about it here.

OK, now that we've had an overview of anchors in general, let's look at those anchors very commonly used for semi-tech evacs and rappelling.

Especially in the hardwood forest that covers most of the Appalachian mountains and nearby rolling hills, there's no better anchor than a big, well-rooted hardwood tree such as an oak or hickory or maple. And, such trees are usually available. (Coniferous trees such as white pines can be quite strong, but the sticky sap tends to get on your rope or webbing, so pick a hardwood if you can.)

A paper from the 2010 International Technical Rescue Symposium by Rick Weber entitled How to Determine Tree Strength and Build Tree Anchors (search the web for Build Tree Anchors to find) provides detailed information about how to select tree anchors, based on actual testing of different species of trees. Weber concluded:

If an anchor can be affixed to a tree at a point on the trunk no higher off the ground than a distance equal to the tree's diameter, then the trunk diameter at that point should be no less than 6.5 inches (16.5 centimeters). A typical rescue helmet is 8 inches wide and can provide a convenient measuring means.

The testing included both hardwoods (Beech, Hickory, Maple, Oak, Poplar, Sycamore) and coniferous trees (Eastern Hemlock, Virginia Pine, White Pine). The hardwoods tended to be a bit stronger than the conifers but the variation within a species was larger than the variation between species.

That conclusion above was for full vertical rescue loads. Weber gives a list of principles for selecting trees for anchors; while most of them are for rigging for vertical rescue, three apply to selecting tree anchors for semi-tech evacs:

- Use only live trees or ones that have recently died.
- Avoid trees with dead snags that could break off and drop onto rescuers.
- Use the largest diameter trees available in the vicinity.

What if you are in an area without any big trees? A 2012 ITRS paper, Are Scrub Oak Shrubs a Viable Anchor Source for Rescue Sized Loads? looked at using a particular species of scrub oak, found in the Denver area, as anchors. They used a wrap-2 pull-1* anchor, but given the failures were of the shrubs and not the webbing, a girth hitch would likely work as well and would be much quicker to set up. They recommended using multiple anchors, and only using healthy-looking bushes with a base more than 10” in diameter. It is hard to generalize from this study of one particular species, but if push comes to shove and no other anchors are available, having girth hitches (or wrap-2 pull-1 webbing anchors if you want to take more time) around several bushes might be a reasonable anchor. This brings up the question of how to combine multiple low-quality anchors into a single reasonable anchor by distributing the stress.

It is possible to use anchors in series, so that each anchor is backed up by another.

* This is a webbing anchor just like a wrap-3 pull-2 anchor, only with two wraps instead of three. Keep reading to find out more.
We know that tree anchors tend to fail by the tree tilting, and the anchor slipping up the tree. Have you ever seen a tree being transported to be transplanted? The tree roots and a big ball of dirt are wrapped up in burlap. Trees fail the same way; a big ball of roots and dirt rotates.

This suggests a method for backing up a tree that is in the perfect place for an anchor, but is a bit questionable. You anchor to the bottom of your perfect-position but questionable tree. Then, you wrap a sling around this tree, a few feet higher, then run that back to the bottom of another but more-solid tree. To make this work, you will need to tension this backup anchor sling a bit. A short rope or long webbing sling with a tree wrap on both trees can be tensioned by attaching a Prusik and having several people haul on it. A mechanical advantage system should not be needed for such tensioning. Theoretically, you could have a backup for the backup, and then a backup for that... while this technique is sometimes used by engineers, for rescue work, a single series backup is usually enough. This may be called a tie-back or back-tie.

It is also possible to arrange anchors not in series, but in parallel. There has been much written on the use of multiple marginal anchors, and perhaps the best is a paper published in issue #51 of The Nylon Highway (the newsletter of the Vertical Section of the National Speleological Society) in 2006, entitled “Multi-point, Pre-equalizing Anchors.” The analysis is exquisitely detailed, including both theory and pull-testing.

The take-home messages are as follows:

Three anchors are better than two.

Four anchors are not significantly better than three.

“Self-equalizing” anchor rigging (where the slings can slide under load, but also slide a lot if one anchor fails) are inferior to “load-sharing” anchors where you have manually adjusted the lengths of the slings.

The easiest way to create a load-sharing anchor is to use a Frost Knot, which is described in the section on knots.

Shock loads for a semi-tech evac should be significantly less than for a vertical rescue. Therefore doing a tree belay a few feet up a tree is acceptable, provided it's less than about twice the diameter of the tree above the ground. Since the belayer usually stands below the tree, and you're on a slope, it's seldom hard to do this.

Sometimes, instead of tree belays, a semi-tech evac will use Figure 8 descenders as lowering devices. This requires a webbing anchor on the tree. There are three main ways to rig webbing to a tree: wrap-3 pull-2, a doubled runner, and a girth hitch.

Wrap-three-pull-two is a standard way to rig to trees when there may be heavy loads, as in vertical rescue or a Tyrolean traverse (highline). It's seldom used for semi-tech evacs, though, because it takes a while to tie, and is overkill for the loads of a semi-tech evac. However, if you're rigging a single-pitch semi-tech evac that's really steep, steep enough that you want to use a rack for lowering rather than a Figure 8 – in other words, a semi-tech that could almost be considered a technical rescue – then you might use a wrap-3 pull-2 anchor.

The rigging is quite simple. You take a length of webbing (not a pre-tied runner) and wrap it around a tree three times. You tie it with a water knot, and back up the water knot on either side with either two overhands or a barrel knot. You pull two of the three loops, and rig into them with a carabiner. Done.

It is traditional to place the knot away from load-bearing limbs, that is, on the one loop you didn't pull. It is also traditional to place the knot on the side of the tree facing the load.

But a 2013 International Technical Rescue Symposium paper, Causal Mechanisms of Webbing Anchor Interface Failure by Thomas Evans, Sherrie McConaughey, and Aaron Stavens, found it made no significant difference where the knot was. A wrap-3 pull-2 breaks at the carabiner attachment, not at the knot. A wrap-3 pull-two is also significantly stronger than 11 mm rope. So it really, really doesn't matter where...
the knot is. But tradition is very strong, and if you don’t put the knot where it’s “supposed” to be, you will lose points for style. The illustration on the next page is tied with 30’ (10 m) of webbing and barely makes it around a small-to-medium tree. This anchor uses lots of webbing; you may need to tie two pieces together, but given what we know about where these anchors a break, the placement of the second knot is not a safety concern.

But there is also something to be said for this tradition. The original motivation – placing the knot at the point of minimum stress to make the rigging stronger – is clearly false. But having the knot always in the same place, and in a place that is easily visible to those checking the rigging – still makes sense. So be traditional.

On semi-tech evacs, you shouldn’t be working near the breaking strength of your rope, as may be the case with a technical rescue. And, you’re trying to move fast. So, let’s consider a couple of alternative ways to quickly rig webbing and a lowering device to a tree: doubled-runner and girth-hitch. Given what we know from the study of how wrap-3 pull-2 rigging fail, these two are likely just as strong as your rope, so there should be no concern about using them as alternatives.

The simplest rig is to have a locking carabiner and a Figure 8 descender/lowering device on a long, pre-tied or sewed webbing sling. You double the runner, with the carabiner and Figure 8 on one end. You hold onto the end without the 8, then (carefully) fling the end with the biner/8 around the top of the tree. You then clip the biner into the other end of the runner, thread the rope through the Figure 8, lock the biner, and get ready to lower. This has the advantages of rapid rigging and extreme simplicity. If you think about the testing of the wrap-3 pull-2 rigging, this actually has four strands of nylon.

Sometimes, you may need to “chain” an additional runner to the existing runner make it long enough to go around a particularly big tree, and allow the angle at the carabiner θ to be acceptably acute (<60°). This daisy-chaining does decrease the strength of the rigging slightly, but this should not be a major concern for a semi-technical evac where very high shock loads are very unlikely. With this rigging, it is important to keep the θ angle acute, not only to prevent multiplication of forces in the rigging, but to prevent cross-loading of the carabiner, discussed later in the section on carabiners.

A variant, for when you want the sling to stay at the same point on the tree, and not to slide up or down, is to girth hitch the runner around the tree. You might want to do this to get a better position for the belayer, or to keep the rigging out of some poison ivy. It does decrease the strength of the rigging somewhat, but again, this should not be a concern for most semi-tech evacs.

Let’s assume you want to rig a rope to a tree and cast it down a cliff as a static line on which to rappel.

Static line in this context does not mean the same as static rope. A static line means a rope that is just hanging there, as opposed to a rope that is moving up and down, as in lead climbing, or as in vertical rescue. You can use a dynamic climbing rope as a static line, or your can use a static caving/rescue rope as a static line. Yes, it’s confusing. No, I’m not responsible for this terminology.

Anyway, if you want to rig your rope (dynamic or static) as a static line, say for rappelling and ascending, and there is a good tree near the top of the cliff, a tree wrap is by far the best way to anchor the rope. As I type this, I am thinking back to last weekend, when I demonstrated a tree wrap anchor to some medical students from the Wilderness Medical Society Student Interest Section at the University of Pittsburgh Medical School. I’m their faculty advisor, and they’d wanted a class on knots, so we had them over to my house. I and some Allegheny Mountain Rescue Group members ran the knots class for them. We also discussed rigging and anchors, and Powell, who is a nuclear engineer as well as long-time Mountain Rescue Association member, was drawing diagrams of the way logarithmic curves on Friends’ cams worked. I decided to do something simple and physical to let their brains rest a bit. We went outside, up to the top of my driveway, and I took a short rope and rigged it to a Japanese Maple there. It’s a small tree, only about 10’ high, and the trunk is about 10-12” in diameter. I wrapped the end of the rope around the trunk four times, left the end hanging there without tying it off at all, and handed
to the other end of the rope to the students. I dared them to, all pulling at once, pull it off the tree. Of course, the friction around the tree was so high that the rope didn't budge, and neither did the tree. Great party trick, but it illustrates a great way to rig a static line to a tree: a tree wrap. The main advantage of the tree wrap is that it is as strong as the rope. There are no knots or carabiners to weaken your rigging. And it's incredibly simple. "Nothing is foolproof, as fools are so ingenious" as Robert Heinlein reputedly said in The Man Who Sold the Moon, but a tree wrap anchor is pretty hard to get wrong. I suppose you could wrap it around a tree only once or twice and not have enough friction – more of a problem with small-diameter trees – or you could pick a long-dead tree – but it takes talent to mess up a tree wrap.

In fact, since they're so high-strength, tree wraps are the preferred anchor for Tyrolean traverses (highlines).

Another advantage of the tree wrap is that, if someone gets stuck on the rope, you can tie another rope to the upper end of the rigged rope, and then use the tree wrap and lower the person just like you do when lowering a litter on a semi-tech evac.

That's why we wrap tree wraps up. It's easier to get a knot around the tree if you wrapped up in the first place.

The only real worry is that a squirrel might grab the end of the rope and unwind it from the tree. I admit this sounds pretty far-fetched, and I think that the only reason we tie off the end is solely for psychological reassurance. It's become common to tie a figure 8 loop in the end of the rope, then clip that to the standing part of the rope. I suspect this is because a lot of SAR teams keep a figure 8 loop in the end of their ropes and it's convenient. Unless you only use a couple of wraps around the tree, or it's a small tree, it's extremely unlikely that the figure 8 loop and carabiner will become loaded and impossible to get off.

However, the official ASRC 1974 tie-offs, shown in Yorke Brown's sketches, are slightly superior. If a taut-line hitch or clove hitch becomes loaded, you may be able to slide it along the rope enough to get some slack and be able to untie the hitch; you might not be able to get the figure 8 loop and carabiner off the rope. But, it probably doesn't matter. as long as you wrap around the tree enough times, and you've checked the area for homicidal squirrels.

**Knots and Hitches**

Knots are good, because we often have to tie things together. Knots are bad, because they weaken the rope or webbing. Knots are bad, because sometimes a knot will come untied. Knots are bad, because then can get jammed so tightly that you have to cut the knot instead of untying it. The 1944 Ashley Book of Knots has more than 3800 entries. Don't worry, we only need to know a few for search and rescue. One of the best places to learn to tie knots is the website animatedknots.com, which even has an animation of how to tie a Purcell Prusik rig.

The same knots often have several names, even in a single language, and the same name may apply to different knots. Knots have been around for a long time, so none of these knots' names are likely original. Even if you found an account of the knot on 5000 year old Sumerian or Akkadian clay tablets, the names there were probably not original, as ropes and knots were around long before there was written language. The names here reflect the most common English usage.

**Knot Basics**

To speak about knots, we have to first have some language in common.

The running end of a rope is the part that runs around and ties the actual knot. It's the end that is left hanging out when you've finished tying the knot. It's also sometimes called the working end. It's the part you have to tie off with a backup knot or someone will yell at you.

The standing part of a rope is the end that leads away into some distant place. For example, assume you have one end of a rope wrapped around tree as an anchor. Assume further that you are tying a loop in the far end of the rope, the one you are going to throw over the cliff. The rope leading back to the tree-wrap is the standing part of the rope.

A bight is a U-shaped bend in the rope.

A loop is a bight that is twisted once. It's a full circle formed by passing the running end over itself.

An elbow is a bight that is twisted twice. It has
two crossing points created by an extra twist in a loop. The only time I can think of that you need to create an elbow is when tying a butterfly knot. Well, one way of trying a butterfly knot, and probably the easiest. If you are totally confused by elbows simply learn the other way to tie the butterfly.

To get the good results of knots while minimizing the bad points of knots takes knowledge and practice. We will next consider knots in terms of their strength, their security, and their proneness to jamming.

**Strength**

Knots weaken a rope or webbing. The percentage a knot weakens the rope is a function of many things: the rope material, rope diameter, the specific test set-up, and perhaps ambient humidity and the phase of the moon.

In some tests Tom Moyer and Chris Harmston did on knots in accessory cord and reported in 2000, a figure 8 knot reduced the strength of 7 mm nylon kernmantle rope by only 6%, but the same knot in 5.5 mm Spectra/Dyneema type cord decreased strength by 29-47% depending on the brand.

So if anyone says: “Don’t use a bowline because it reduces the rope strength xx%!”, you answer:

“For this test result you quote:

“I assume this was kernmantle rope? if so:

“Was this nylon 6, or nylon 6,6? Or Dynenea or Spectra?

“What was the diameter of the rope?

“Was this a shock load or a constant load?

“What was the ambient humidity?

“Given the high variability of test results, I prefer to simply class knots as high-strength, intermediate-strength, and low-strength.”

The main thing that determines the strength of a knot is how sharp of a bend the standing part of the rope makes as it enters the knot. For instance, a bowline almost always breaks right where the standing part enters the knot.

In search and rescue, even just considering semi-tech evacs, we sometimes stress our systems pretty highly. And, though it’s not part of this essay, technical rescues stress systems even more. So, compared with sport climbing and caving, we emphasize high-strength rigging. We also emphasize the use of high-strength knots.

**High-strength knots** we tend to use in search and rescue include:

- Figure-Eight Bend
- Figure-Eight Loop
- Double-Fisherman’s Knot (Barrel Bend)

These all reduce the strength of a standard search and rescue rope by about 20%.

**Medium-strength knots** we tend to use in search and rescue include:

- Butterfly
- Bowline
- Water Knot

These knots reduce rope strength by about half or a bit less.

**Low-strength knots** we use in search and rescue include:

- Square Knot
- Slipped Overhand
- Surgeon’s Knot
- Taut Line Hitch

The last three are not officially-required ASRC knots, but they are so useful for search and rescue that I teach them all the time.

Why do we include low-strength knots? Because they are useful in certain situations, and there are no high-strength knots for those situations.

**Security and Proneness to Jamming**

In the setting of knots, security refers to how easily the knot comes untied when you don’t want it to. Proneness to jamming refers to how easily the knot comes untied when you do want it to.

Almost everyone likes the figure 8 knot, because it rarely comes untied when you don’t want it to, so it’s secure and not prone to jamming.

If you’re tying rope (or, after reading the story about water knots above, webbing) into runners, people like to use a double fisherman’s. It is a very secure knot; it basically never comes undone, so it’s quite secure. However, once you’ve put your body weight on it, you can almost never get it untied. But for a runner that you want to stay permanently tied? That’s where the double-fisherman’s proneness to jamming is actually a plus. Knots vary quite a bit in their security and proneness to jamming.

We’re going to start with the hitches and low-strength knots first, as they’re the easiest to tie.
Half Hitches and Backup Rules

A **half-hitch** is *not* a knot that the ASRC wants you to know. It is *not* particularly useful in search and rescue. However, some people think a half hitch or two is a good way to back up a knot. It’s *not*, and you should *not* use it to back up a knot. However, you *should* know what it looks like just to avoid it. (OK. Yes. You can use a half-hitch to initially tie off a load-releasing hitch, and it’s acceptable. But then it’s backed up with an overhand. *Do I contradict myself? Very well, then I contradict myself, I am large, I contain multitudes.* —Walt Whitman)

Which brings up a point about terminology. For hundreds of years, knot experts have been pushing the idea of standard terminology: a **hitch** is something in one rope that is not self-tightening when loaded, a **knot** is something in one rope that is self-tightening when loaded, and a **bend** is something that can tie two ropes together, and is self-tightening when loaded.

Not unsurprisingly, given that even in English many knots have multiple names, and some English knot names apply to different knots, and some knottish things are called hitches and some hitchish things are called knots, and we won’t even consider other languages… as you can imagine, the purists have failed big-time. But the idea of classifying knots this way is useful, at least in a sort of theoretical sense, as you’re learning knots and hitches.

And in particular, backing up a knot that’s going to hold your life with a hitch – which won’t self-tighten when pulled on – seems quite stupid. You can instead back up the knot with an overhand or two, or half of a double-fisherman’s knot (a barrel knot). When I see search and rescue people (or firemen, or any other rescue or climbing/caving types) backing up a knot with a half hitch, or even two half hitches, I say “could you tell me more about your death-wish?”

Indeed, the standard from the very beginning of the ASRC was: **back up all knots in rope with a barrel knot on either side, and all knots in webbing with two overhands on either side.**

Why two overhands in webbing instead of a barrel knot? A barrel knot is a bit harder to inspect compared to two overhands.

I won’t argue with someone who uses a barrel knot instead of two overhands to back up a knot in webbing.

I *will* argue with someone who tries to back up a knot in search and rescue rigging with a single overhand instead of two overhands or a barrel knot. I may not win the argument, as many in SAR think a single overhand on either side is adequate.

I will suspend from a training or operation anyone who tries to back up a knot with half hitches until they have completed remedial knot training. My experience with the water knot, discussed later, may have mentally scarred me for life.

It is considered acceptable to *not* back up a double-fisherman’s knot in a loop of webbing or a Prusik loop, provided an inch or more of the tails are sticking out. This is such a secure knot, which is not known to creep under stress or when wet, that it’s the one exception to the backup rule in red above.

Once upon a time, the Allegheny Mountain Rescue Group was training at the the cliffs at McConnell’s Mill State Park. The Group was at the bottom, getting ready to do a vertical raise. They had the litter on the ground there, ready to load a mock patient. On the cliff next to them was an unrelated group getting ready to rappel. The first person started rappelling and the rope anchor tie-in at the top came untied and he went splat. (If only they had moved the litter over a bit he would have landed right in it…) I don’t know what kind of knot they tied at the top, but I bet it was backed up with a half-hitch. He was injured, but not fatally. It was only a matter of a few minutes to load him in the litter, haul him up the cliff, and hand him off to the local EMS service.

**Specific Knots and Hitches**

This section includes all the ASRC-required knots and hitches, but also other ones I think all SAR people should know. Each required knot has FTM (Field Team Member) or FTL (Field Team Leader) after it. Page 2 has a complete listing of the standards.

**Girth Hitch (FTM)**

You can use a girth hitch when rigging a runner to a tree, and specifically when you don’t want the rigging to slip up or down the tree. It’s good for quickly rigging to a tree when the extra strength of a doubled runner or wrap-3 pull-2 isn’t needed, as in semi-tech evacs.

If you can’t figure out how to do it from the diagram then there is no point in continuing to try to learn how to tie any of the other knots here.
Clove Hitch

The clove hitch is the standard way to tie off a tree wrap in the middle of a rope, and it’s used for rope stretchers, so I include it.

And, if you ever need to rig to a pole, as in a for a semi-tech evac with an improvised blankets-and-pole stretcher, you will need to use a clove hitch. Nothing else works quite so well to rig to a pole and then keep on going to secure the patient. It’s also a high-strength knot. (I know it’s officially a hitch, but it tends to tighten when you pull on it… remember what I said about the knot terminology purists failing?)

When Yorke Brown drew the diagrams for the original ASRC training materials, they ended up being used for the Virginia Wing Civil Air Patrol Ground SAR Training Program as well. And the CAP members needed to know how to rig an Army stretcher (it was the CAP, does that make it an Air Force stretcher instead?) for a semi-tech evac.

To me, this sounds like a last-ditch act of desperation, but they wanted us to teach this to CAP cadets. So Yorke drew some diagrams of how to rig an Army stretcher for a semi-tech evac. I was going to leave them out of this essay, but since I discuss quite a few “do this only if someone’s going to die unless…” improvisations, I am including these diagrams.

A modification I made, after trying this, uses a clove hitch instead of the half-hitches Yorke originally drew. If you actually do a real semi-tech evac with an actual patient (not a mock victim) using this rigging, please let me know how it worked, and more importantly, why you did it.

Taut Line Hitch

You can use a taut line hitch to create an adjustable loop in the end of a rope. The classic use is for the tie-outs for your tent. I’ve tried a variety of those little hardwar tent-line-adjusters, some of which even came with the tent. None of them are as good as a taut line hitch.

A taut line hitch is a little like taking the end of the rope, looping it around, and tying a Prusik knot on itself. Yes, you can actually do this with a Prusik knot, and if you’re building a Purcell Prusik set, you do so.

But for quick-and-dirty non-loadbearing use, such as for tent lines, the taut line hitch is great, is easier to tie, and the fact that it’s a bit asymmetric seems to make it grip better than a Prusik. The original ASRC way for finishing off a tree wrap anchor uses a taut line hitch.

I’ve also see people use it to finish off the webbing tie-ins holding a patient in the litter. That’s fine if you want your tie-ins to completely immobilize your victim; it holds well on a taut line. But if, as I advised earlier in this essay, you want to give your patient some wiggle-room and not make the victim of your over-eager tie-ins, use a slipped overhand (discussed later) and leave some slack in the tie-ins. If you use a taut line hitch on a line that’s not taut, it isn’t at all secure and will likely fall off.

Overhand Knot (FTM) and Frost Knot

The overhand knot is the simplest knot you can tie. You twist a loop, and then stick the running end through the loop.

As far as I know, a simple overhand knot by itself is useless in search and rescue. However, as a backup to another knot, when tied in the running end around the standing part, it’s very useful.

Let’s imagine you just tied a knot. And you are cold, exhausted, stressed-out, and distracted by lots of other things going on. (Sounds like many SAR operations, right?) Further, let’s imagine that you tied a garbage knot. A complete garbage knot that will fall apart as soon as there is any stress on it.

But, because you were trained to back up all your knots, and you do this all the time, you backed up the knot with an overhand in each running end coming out of the garbage knot, tied around the standing part. In fact, if you had not tied a garbage knot but no knot at all, the two overhands by themselves form a fisherman’s knot. A complete garbage knot that will fall apart as soon as there is any stress on it.

BAD: Rigging an Army stretcher for a semi-tech evac

BAD: Details of Army stretcher rigging

BAD: Patient tied onto Army stretcher.

Clove Hitch

On blackthorn walking stick.

European Death Knot

BAD: 1: Rigging an Army stretcher for a semi-tech evac

BAD: 2. Details of Army stretcher rigging

BAD: 3. Patient tied onto Army stretcher.
even when it's a nice, sunny day: you want to get into the habit of backing your knots up, all the time, so when you're so tired you can't even think, you will still follow your habits and back up your knots.

A fair number of climbers, cavers and even rescue people consider a knot adequately backed up with a single overhand on either side. The ASRC is a bit paranoid about this, and prefers two overhands, or better, a single barrel knot (discussed later). The safety margin for this practice is minimal, but the time and effort to accomplish it is also minimal.

The Frost Knot is a variant of the overhand knot. Take a piece of webbing, and make it into a coil with two or more loops, with the free ends overlapping slightly. Tie an overhand knot in the entire coil, so that one side of the overhand makes a small multi-layer loop, and the other side makes a large multi-layer loop. This can be used to rig multiple marginal anchors together to make a single better anchor. It's easiest if you adjust the size of the loops of coil to the right size to reach the anchors before tying the knot.

**Frost Knot**

Creating three loops for distributed anchor.

**Water Knot (FTM)**

Also known as the tape knot, ring bend, grass knot, overhand bend and overhand follow-through, the water knot is a medium-strength knot long used to tie rope, but more often webbing. It's a common way to tie a piece of webbing into a pre-tied loop, also known as a runner.

Traditionally, we call these single-length runners and double-length runners. A single-length runner is big enough to slip over your head and one arm, so as to be able to clip carabiners and other equipment on it, so it all hangs conveniently at your side. A double-length runner is twice as long. (There are standards lengths from some manufacturers, but measuring based on your body size makes a lot more sense.)

To make a webbing loop with a water knot, you tie an overhand knot in one end of the webbing. Then, you feed the other end through this knot, backwards.

If you feed it forwards, then you get the same thing as if you doubled the webbing tied an overhand knot in the two ends at the same time. This is a very low-strength knot. It is known as the one-sided overhand bend, offset overhand bend, flat overhand bend, thumb knot, thumb bend, creeler's knot, and openhand knot. It is also known as the European Death Knot, so perhaps you should not use it.

I'm not a fan of the water knot, even tied properly, for pre-tied loops. It's OK for doing a quick "wrap-three-pull-two" anchor, but it's not a good knot for a pre-tied runner. Why? Because it fails.

Even though a water knot tends to jam so hard you can't even untie it, it's not that secure. It's not insecure in the usual sense that jiggling it will make it fall apart. Instead, as shown by Tom Moyer in some testing he presented at the International Technical Rescue Symposium in 1999, it slips. It doesn't slip much under stress, but each time it's stressed, it slips a little bit. And if you keep loading and unloading it, the tails slip through a little bit each time, until the end slips through and the runner fails. Some people recommend that if you tie your runners with a water knot, you leave 3" tails on either side and check them regularly for creep. This sounds really stupid. How about if you back it up with an overhand or barrel knot on either side? Tom's testing shows this prevents creep and failure. So, tying a wrap-3 pull-2 with a water knot and backing it up is OK. More or less. But I think that you have to back it up with two overhands on either side, or a barrel knot.

I had an interesting experience with a water knot once. This was in the early 1970s. I was at a campground in West Virginia for the Old-Timer's Reunion (OTR), which is a humongous private long-weekend caver's get-together at an undisclosed location in West Virginia. I could tell you the location for OTR but then I would have to kill you.

Anyway, I was checking a new caving harness for comfort. I went over to an unused swing-set, girth-hitched a pre-tied runner around the top of the swingset, clipped a biner into this, then clipped the biner into my new harness, and ended up my legs. The harness was fairly comfortable, but I thought I might be able to figure out a way to modify it to make it even more comfortable, so I was sitting there for quite a while. It started raining, but it was warm, and the clothing I had on was muddy from caving and could do with a little rinse, so I figured I'd just sit there and keep fiddling with my harness. I looked up at the now-damp water knot in my runner. I suddenly became very frightened. Because I could see the webbing visibly creeping through the water knot.
just with my body weight on it.

I immediately went to my vehicle and retied all of my runners with double-fisherman knots. The etymology of “water knot” is lost in the mists of antiquity, but to me it means “knot that comes untied under load when you apply water.”

Square Knot (Bend) (FTM) and Surgeon’s Knot (Bend)

The square knot is the first knot we learn. As kids. A variant of the square knot, called a double-slipped square knot, is how we learn to tie our shoes. Tie your shoes (no Spectra or other pull-laces allowed). Do it right: under and over, and then over and under. (You were taught this as a kid, right?)

Now, grab the two loops and pull on them until the ends come through. You now have a square knot. And you will now have a devil of a time untying your shoes (sorry).

But that does indicate why a slipped knot is good: it’s easier to untie, you just pull on the ends.

And it shows why, even though the square knot is not very strong, we use it to tie our boots: it’s a binder knot. When you tie that first twist and pull it tight, it stays tight while we finish off the knot with the two loops.

Here’s a useful variant. Next time you go out for dinner and have leftovers, and get one of those little plastic bags, start tying it like you’re tying your shoes, with a double-slipped square knot, only you should pull through just one of the loops. That longer end has a hole in it by which you can carry it, and when get home, you can just pull the shorter end to untie the knot. Clever trick I learned from Frank, the owner of the Little Tokyo Japanese restaurant we have been going to for >20 years.*

There is a possibility that you tried to do what I said and you ended up with a granny knot instead of a square knot. (A granny knot is tied over and under, and then again over and under.) A granny knot is justly despised, as it’s neither strong nor secure, but in this particular case, it might make it a bit easier to untie your shoes.

There is a really cool variant called the thief knot or thieves’ knot. The running ends come out on opposite sides of the knot. Clever party trick: tie a thief’s knot in a bit of climbing rope. Leave it a bit loose. Hold the knot so that the running ends are hidden in your hands. Show it around. Ask people what kind of knot it is. (If you’re lucky, nobody screams out “THIEVES’ KNOT!”) Regardless, quickly hand the one of the standing ends to someone then pull on the other standing end. The knot quickly unravels. Then you show the difference between a thief’s knot and a square knot and everyone goes “ooh, cool.” If you really want to do a bad job of tying a square knot, see the diagram of the “grief” knot: a combination of the granny and thief knots.

And the trouble with this monofilament suture is that it’s hard to tie. It’s stiff, sort of like tying a knot in steel wire. And that first twist of the square knot that’s supposed to bind the wound closed? Well, if you do it with monofilament sutures, you could just use a square knot and then back it up with another square knot on top. But braided suture is more likely to get infected, so for sewing up the skin, we now tend to use monofilament fishing line. Or something that is so similar as to make no difference.

And a variation of the square knot called a surgeon’s knot. Whenever I’m sewing up someone’s skin (which I do all the time, it’s part of my day job), I use it. With the old braided silk sutures, you could just use a square knot and then back it up with another square knot on top. But braided suture is more likely to get infected, so for sewing up the skin, we now tend to use monofilament fishing line. Or something that is so similar as to make no difference.

And I teaching you this? Well, it’s a good thing to know how to put an extra twist in a square knot if you can’t get it to bind with a single twist. An excellent application of this is when you’re tying somebody on your back with the piggyback carry discussed earlier. I find it takes two or three twists to get this to bind on my belly when I’m trying to get someone firmly attached to my back.

Another application of this surgeon’s knot principle is what I will call the “upside down double-slipped surgeon’s knot.”

Have you ever been out on a climb or a SAR task, with your gaiters on, and had your boots come untied under your gaiters? Have you ever gotten in to a cold-weather camp, and found your fingers were too cold, numb and clumsy.

* It also works on those similar and terrible plastic grocery bags. If you live in an area with those grocery bags, though, I recommend you buy ~8 reusable canvas grocery bags and keep them in your car, so you always have them when you stop by the grocery store. One of the best purchases I’ve ever made.
to get your boots untied from that #$%%$!* (double knot you tied in the loops? Well, someone who works at an REI store once showed me how to eliminate both those problems with an upside-down double-slipped surgeon’s knot. Well, actually he just said “Hey, let me show you a cool way to tie your bootlaces!”

It’s easy in principle but takes a little practice. Actually, it’s quite hard to learn, but more than worth the effort. You know how with a surgeon’s knot you add an extra twist? Well, you start tying your bootlaces just like normal, with a single twist. But when you start tying the loops, you add an extra twist. That’s it. This will stay tied all day. And you can still just pull on the ends to untie your boots.

It took me a couple of weeks to learn how to do this reliably. I will try to describe what I do that makes this work reliably. It may or may not help you learn how to do this faster, but here goes.

As I tie my shoes, I get to a stage where the twist is done and I’m tying the two loops.

I have the a loop between my right index finger and thumb. I then bend this loop to the left, and flip the other end over this loop away from me, I then use my left index finger to push that end up through the center of the knot towards me to form the second loop. After I’ve pushed just a little loop through, I then stick my left thumb into this loop and pull it out just a bit more. My left thumb then pushes this over the top of the knot, away from me. And then my left index finger pushes it through the center of the knot towards me again. At this point, my hands grasp the two loops and then pull them taut. Easier done than said.

After all this talk of square knots and their variants, let me give the best example of where such a knot is useful: the ASRC Seat Harness. There are a variety of ways to tie 1” webbing into a seat harness, and the ASRC way is arguably the best. With any tied seat harness, loose is bad and tight is good. A loose harness slips and binds, putting lots of pressure on certain areas = pain. A tight harness distributes your weight across the harness better. So how do you get it tight? As with your bootlaces, a binder knot. And the square knot is arguably the best binder knot.

The slipped overhand knot is not well-known in the climbing, caving or SAR communities, which is a shame. It’s one of my favorite knots, and I use it all the time. I’ve been teaching it for ~40 years. There is a related knot called a double-slipped square knot. As described above, this is the standard way to tie your shoes. So if you can tie your shoes, you can tie this knot.

It is a superior way to finish off a patient tie-in, whether with rope or webbing. It is also a superior method to tie off when on a rappel, as when you’re doing a “pick-off”: rescuing someone hanging on a rope. It’s also a superior way to tie off a rack, figure 8 or other device for a semi-tech or technical lowering.

Why is it superior for these uses? First, it is a knot and not a hitch. That means that if it’s tensioned, it tightens rather than slips. Good if your or someone else’s life depends on it not slipping. Yet, even if it’s tight from being tensioned, you can always pull on the end to pull out the loop and pop it loose.

If you’re rappelling, and you want to secure your rappel device (tie off) with a slipped overhand, here is the sequence I use. If there is a way to jam the rappel device, such as drawing the rope across the top of a figure 8, I do that first. If it’s a rappel rack, I simply move my right (braking) hand up and pull the bars together.

Once my right (braking) hand is holding the braking portion of the rope above my rappel device, I then grab both ropes with my left hand: both the rope from which I’m hanging and the braking rope that I’ve pulled up. I then use my right hand to tie the slipped overhand.

There are two ways you can orient your slipped overhand. If you tie it with the bight coming out perpendicular to the standing line this is known as a halter hitch, for tying your horse’s halter to a hitching post, for quick release. However, I prefer the bight to come out right along the standing line. It’s easier to tie while you’re hanging on rappel, and a bit easier to untie when you’re on rappel, because you pull down, rather than out, to release it.

For additional security, I clip a carabiner through the bight of the slipped overhand and onto the rope from which I’m hanging. This is called a “biner jam” (not sure why, doesn’t sound edible to me).

Since you usually don’t have a biner when
horseback riding, instead of a biner jam, you can pass the end of the rope through the bight. This is also a good way to finish it off when using it to tie a patient into a litter.

If you're tying off a rappel or a lower, and you don't have a carabiner handy for a biner jam, you can pull the bight coming out of the slipped over hand, make it longer, and tie an overhand in the bight. This is a standard way to tie off a lowering device during technical rescue. This slipped-overhand-plus-overhand-on-a-bight-method (if I were writing in German I could make this into one word) also is handy if you have a lot of rope beneath you; the weight of the rope keeps trying to pull out the bight from the slipped overhand, making it sometimes hard to get the biner out when you're done. (In this case, I guess the biner is jammed for real.)

If you're tying off a lower device, the same technique works as well, only it's done upside down. When concerned about shock loads, as in vertical rescue, you can take the bight and tie an overhand in the whole bight, around the standing part of the rope, before adding your biner jam. When this method is used to tie off a Münter hitch it's called a "Münter Mule."

This technique can also be used to tie off a load-releasing hitch, and is superior to the method made popular by Conterra, which involves tying a half hitch rather than a slipped overhand.

**Double Fisherman’s Knot (Barrel Bend, Grapevine) (FTM)**

When the double fisherman’s knot was first touted by Yvon Chouinard as a safer way to tie runners back around 1970, he was accused of picking a knot that used up lots of rope since he was selling rope. I don't think anyone took this seriously, but the knot certainly does use up a fair bit of rope. So if you're going to cut some rope for a Prusik loop, remember to allow for a lot of rope in the double fisherman's knot.

The double fisherman's knot is one of the most secure knots around, though quite prone to jamming. Once it's tied and been stressed with body weight a couple of times, it's simply not going to come untied without major effort. Like a serrated knife or a pair of paramedic shears.

In fact, it is so secure that it's the one exception to backing up knots. Yes, that's right, you don't need to back up a double fisherman's knot. It is considered prudent to leave somewhat more than an inch of tail protruding from each side of the knot, in case the knot creeps a bit. But unlike the water knot, I've never seen, or even heard of, a double fisherman's creeping.

A properly tied double fisherman's has a characteristic look that gives it the alternate name "grapevine knot." To tie it properly and rapidly, I recommend the method shown in the picture: tying the knot around your left index finger, wrapping back towards your hand. Then you pull out your finger and feed the rope through where your finger was, going the way your finger was pointing. You then flip the ropes 180° and do the same thing. This makes sure you have a nice symmetric knot.

The double fisherman's is also a high-strength knot. The main use for SAR is to tie Prusik loops. It's also useful to tie your own runners from 1” tubular nylon webbing, though more and more people are using commercial sewn runners instead.

If you're buying pre-sewn runners, I recommend getting nylon rather than Spectra or similar "high-strength" runners; that high strength may be somewhat of an illusion, the strength of those runners decreases rapidly with age and use, and they have poor energy absorption.

As discussed in the section on the water knot, I recommend a double fisherman's knot instead of a water knot for pre-tied webbing runners. However, I don't recommend it for a wrap-3 pull-2 anchor. Why? If tied correctly, a wrap-3 pull-2 anchor should have no stress at all on the anchor. However, even minor stress will make a double fisherman's jam, whereas it's much easier to untie a slightly-stressed water knot.

Indeed, that's another reason to place the knot in a wrap-3 pull-2 anchor where it traditionally goes, even though it makes no difference in
strength. It may make a big difference in how easy it is to de-rig and untie that water knot.

*Figure 8 Knot, Loop and Bend (FTM)*

The Figure 8 Bend is one of the best ways to tie two ropes together. It’s strong. It’s secure. It’s not prone to jamming. So what’s the downside? Learning to tie it is hard. But not that hard, which is why this knot and its variants are used all the time in climbing, caving and SAR.

Tying a simple figure 8 is easy. Take a bight of rope. Twist it once to form a loop; continue twisting the same direction another 180° to form an elbow. (Yes, I said the only time you need to form an elbow was for a butterfly. So I was wrong.) Stick the running end through the loop.

A simple figure 8 in a rope is not particularly useful. But once you’ve got this knot in the rope, and enough length of running end, you can loop it through the attachment point of your seat harness, then feed it back through the figure 8, and finish off with a barrel knot. This is the standard way to tie into your harness for climbing.

It’s easier to tie a figure 8 loop in the end of a rope. Simply make a bight (leave it long enough for a backup; at least 2’ for a small loop for a carabiner attachment) and tie a figure 8 in the bight and then back it up.

A figure 8 bend, to tie two ropes together, is tied just like you tie a figure 8 loop to tie into your climbing harness, except that you’re using it to tie two ropes together.

If your figure 8 looks sloppy, you won’t get style points. And, it may well be a bit weaker. So how do you make it neater? You go through the knot, flipping the two ropes over, until you get something that looks like the picture. You want to eliminate any twists. The two ropes should not cross over each other with respect to the center of the knot. We know that knots tend to break where the rope enters the knot and makes its first turn. And, when there is a twist in the two ropes, with one over the other with respect to the center of the knot, this concentrates force there, and makes the knot just a bit more likely to break there. For SAR, even though it’s mostly a problem with high-tension vertical rescues, that little bit of extra strength might make a difference, so we want our figure 8s contoured.

It’s also true that a contoured knot is easier to inspect. If it’s neat, it’s easy to tell with a glance that it’s tied correctly. If it’s sloppy, it’s a bit harder to tell that it’s tied correctly, if, indeed, you consider a non-contoured figure 8 “correct.”

*Extra Credit:* With a Figure 8 Bend, or any other Figure 8 variant, you can make it slightly stronger by “making the standing ends go to the far outside of the knot.” Let me explain. You now know that knots break where the rope enters the knot and first turns. And the tighter this turn, the weaker the knot. So if you contour your figure 8 so that the standing ends enter the knot, then go right into the center where they make a tight turn over each other, you’re creating a weak spot right there. But if you then twist the ropes once, and then push this twist all the way through the knot, the standing ends go to the *far outside* of the knot. The radius of curvature is less, so the knot is stronger. You can think of the running ends of the knot providing padding inside the knot for the standing ends.

*Trick:* teach someone how to contour a Figure 8 Bend in rope and to get the standing ends to the outside. Then give them two pieces of webbing and ask them to do the same thing. Watch as they keep twisting the webbing over, and over, and over. It’s impossible to both contour a Figure 8 Bend in webbing and get the standing ends to the outside. Just can’t be done, unless you can twist it through a couple of extra dimensions like a Klein Bottle (look it up).

*Girth Hitch (FTM), Prusik Knot (Triple Larksfoot) (FTM); Hedden (Kreutzklem) Knot*

I love seeing people experiencing a Prusik knot for the first time. I had some medical students over recently for a knots class. Most had not experienced a Prusik before. The idea that you could tie this on a rope, slide it up...
easily, and then hang your body weight on it just seems magical. The students watched, amazed, as Ben McCandless of Allegheny Mountain Rescue Group used his Purcell Prusiks to ascend a rope hanging in my 2.5-story-high Great Room. (Yes, I have a way to rig a rope in my house. Are you surprised?)

Mechanical ascenders don't seem nearly as magical, even if they're much faster.

Kudos to Karl Prusik, professor of music at the Imperial Academy of Music and the Performing Arts in Vienna (since 1998, University of Music and Performing Arts Vienna), and served twice as president of the Österreichischer Alpenklub.

He developed this knot during World War I to fix strings on musical instruments, and published it as a rope-climbing technique in the newsletter of the Austrian Alpine Club in 1913.* It is likely that this knot has been used prior to Prusik, but he certainly introduced it to climbing. Since it's named after him, it should always be capitalized. And it's not “prussik” or “prussic.”

Prusik was an expert in the music of Silvius Leopold Weiss, who during his life, was more famous than Johann Sebastian Bach, with whom he used to jam. (Think “dueling banjos”; they used to have contests to see who could come up with the best variations on a tune.) If you like the music of Bach, you’ll doubtless like the many lute sonatas of Weiss. (Sorry, I can’t help myself, one of my degrees is in music.)

The usual way to use a Prusik knot in SAR is to have a loop of nylon kernmantel rope – usually a millimeter or so smaller than the mainline onto which you’re going to place it. For your Prusik loop, you don’t want to use too small of a rope, then it wouldn’t be strong enough. And you don’t want to use too big of a rope, as then it won’t grip the mainline very well.

For tree-climbing, for sailing, for construction and for other trades, there are a great variety of variants similar to the Prusik knot. We have already discussed the taut-line hitch.

There are three Prusik versions you should knot: the Girth Hitch, the two-loop Prusik and the three-loop Prusik. The girth hitch we covered as a way to rig a runner to a tree for an anchor. You can also do it around a mainline rope, but I’m not sure why, as it won’t grip the mainline rope, it’ll slide. But if you wrap it around another time, you end up with a two-wrap Prusik, which, depending on what you’re using as a mainline and for your Prusik loop, may work well to hold you while ascending a rope. Indeed, those who routinely use Prusiks as ascenders prefer a two-knot Prusik, as it’s easier to get loose from the mainline over and over as you ascend the rope.

If you wrap it around the rope three times, you get a three-wrap Prusik, which is preferred for SAR. It’s a bit more difficult to get loose than a two-wrap Prusik, but it’s stronger in that it’s less likely to slip under load, particularly shock loads. For a ratchet or “progress capture device” for hauling up a litter, for mechanical-advantage pulley systems such as a Z-haul, or for belaying a litter on a vertical rescue, three-wrap Prusiks are the standard, and rightfully so. They are stronger than any mechanical ascender. In some situations, particularly belays, we use tandem Prusiks: two Prusiks, with slightly different loop lengths, so they sit easily on the mainline next to each other.

A sidebar on terminology. We used to call a Prusik at the anchor of a mechanical-advantage hauling system a “ratchet.” It’s short, and has an accepted definition you can find in any dictionary, but then some tech-rescue types decided that “ratchet” wasn’t quite precisely the right term, so changed the name to “progress capture device.” That certainly is a bit more specific, but also certainly doesn’t roll trippingly off the tongue. So then people started shortening this to a TLA (three-letter acronym): PCD. And people started talking about, not ratchets, but PCDs. And those new to rescue training were totally bewildered by this new term, which now, by being shortened, completely defeats the original intent. Call it a “ratchet Prusik” to avoid confusing people. You won’t sound as fashionable, but the new people will appreciate your clarity.

Once upon a time, my family went to Acadia National Park to spend a week hiking. We stayed in a bed and breakfast. To my surprise (not my wife, she found the place and knew this a head of time), the husband of the couple who owned the bed and breakfast was one of the NPS Rangers there. So he and I spent some evenings swapping SAR stories and tricks. One he taught me was a quick-and-easy way to make sure you always get the Prusik loop’s double fisherman’s knot in the right place.

You don't want the double fisherman's knot in the Prusik where it turns around the mainline, because then the Prusik won't grip. You don't want the double fisherman's knot at the very bottom of the Prusik loop, as then your carabiner will be right on the knot. You want it a little offset from the bottom of the Prusik loop.

Grab the Prusik loop's double fisherman's knot in your right hand. Take the part of the loop hanging beneath your hand, and pull up a bight just big enough to fit in your palm, and place it beside the double fisherman's knot in your palm. Now, when you tie the Prusik loop onto the mainline, pass this bundle of knot-and-rope around the mainline and through the loop to tie the Prusik knot. This should keep the knot just a bit off center near the bottom of the Prusik loop.

There are many knots similar to the Prusik knot for gripping a rope or cylindrical object. The generic term for these is friction hitch. In French, the generic term for such knots is noeud autobloquant. From this, some tend to call friction knots autoblocks (or autoblocs) in English; others reserve the term autoblock for a particular type of friction hitch, but nobody seems to agree which one. Some recommend using a Prusik or similar knot for a safety during a rappel, which is discussed further in the section on belaying. The ideal knot for this is a knot that will grip as soon as you lose control of the rappel, but that once you've got your weight on it, you can press down on the top of the knot and break it free of the main rope. None of the knots that have been tried for this, some of which people refer to in English as an "autobloc," have proved satisfactory. Either they fail when tested as a rappel safety, or you can't break them loose once your weight is on them.

There are quite a few of such knots, just as there are many variants of the basic Prusik, for example, the Bachmann knot, where you tie your Prusik around a carabiner as well as the mainline. Why? It holds pretty well, and it's easier to loosen and move up the rope while ascending. If you're really interested, find the out-of-print book by Bob Thrun, an old friend of mine, called Prusiking. It's chock-full of such knots.

What if you desperately need a Prusik, but you don't have a Prusik loop or any spare rope from which to fashion one? Can you make a Prusik out of a webbing runner? You can, but it won't hold on the rope, and it's very, very ugly.

However, there is a knot that you can use that serves the purpose that will work with a webbing runner. The best ascender knot in webbing is the Hedden knot (Kreutzklem) knot. It's incredible easy to tie, and very hard to tie wrong. In fact, if you get it upside down, it's a Klemheist knot which is almost as good, though a Klemheist often takes another wrap or two to hold on the rope. I have ascended a couple of times with webbing Hedden knots and they worked almost as well as Prusiks, though a bit harder to loosen. Chet Hedden developed this knot back around 1959. The Klemheist is more popular these days, but it's not quite as good as the Hedden knot.

I think all SAR team members, climbers and vertical cavers should know this as an emergency backup technique.

You offset the knot (or sewed splice) of the runner as described above. You then take the other end of the runner, and hold it next to the mainline with the loop of the other end sticking out to one side of the mainline. You then loop the webbing, neatly, around the mainline, spiral upwards, two or three turns. (With rope, you only need two turns, but with webbing, you may need three.) You then take the end of the runner with the knot, and stick through that little loop at the top, and pull down to set. I've ascended a 100' free drop using this knot, and though it's not as easy as with a rope Prusik, it's not bad at all.

One important point with the Hedden (or Klemheist) knot: when you have wrapped the Prusik or sling around the rope, you want to stick the long end through the short end from inside to outside. Going from outside to inside will cause the knot to bind; it'll be hard to get it loose to move it up the rope. (See the green arrows in the diagram.)

We will discuss how to use ascender knots along with other hardware and slings to create an actual ascending system in a later section.

**Bowlie (FTM) and variants**

For many people, the bowline is first knot they learn after learning how to tie their shoes. Over the decades, there have been regular arguments over whether ASRC members really need to know how to tie a bowline. After all, a figure 8 can do anything a bowline can do, and is stronger, right? But always there is just enough

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* A German by that name showed Chet's knot in Europe, and his name stuck to it there.
sentiment to leave it in.

Some of this may just be tradition; after all, before there were climbing harnesses, we used to tie a bowline-on-a-coil around our waists with the end of the rope for a belay. Indeed, the bowline-on-a-coil used to be required for ASRC members.

One of my fondest memories of the Blue Ridge Mountain Rescue Group, one of the first ASRC Groups, is something that you’ll probably only find in a college group like BRMRG. There used to be (and perhaps still are) knot-tying contests. To see who can tie a knot quickest. To make it sporting, there were certain encumbrances. Such as being blindfolded. And having one hand tied behind your back. With mittens on. And with someone carefully drenching you with cold water from a hose held over your head.

I’m not so sure I’m still fond of participating, but it’s a lot of fun to watch. And there was a particular skill set to tying a bowline-on-a-coil around your waist, blindfolded, with one hand. It’s somewhat dangerous to bystanders, who need to be about 20’ (6 m) away.

You hold the rope in your right hand at a point about 20’ (6 m) away from the running end. You swing the rope, quite hard and fast, so it whips around your waist about three times. As soon as it’s whipped around your waist, you let go, and grab the coil around your waist, feeling for the running end. Once you find the running end, you grab it a foot or two from the end. You then bend forwards, dip your right hand across the standing end of the rope, push your hand in against your belly button, then up through the coil around your waist, and then do some clever finger work to tie the bowline.

Alas, like some languages now spoken only by a few elderly people in some remote village, this clever method to tie a bowline-on-a-coil is heading for the ash-heap of history. Why? Because a bowline-on-a-coil is a perfectly sucky way to tie yourself into a belay line.

I say this with some assurance, because I’ve been an emergency physician at a Level I Trauma Center for about 30 years. So I know quite well that the most commonly-injured organs in the abdomen are your liver (right upper quadrant) and your spleen (left upper quadrant). Blunt trauma to the upper abdomen commonly causes lacerations in these organs. And, it’s easy to bleed to death in your abdomen (“internal bleeding”) from such lacerations. And falling and being caught by a bowline-on-a-coil around your waist is a just perfect mechanism for lacerating these two solid organs.

There are different ways to teach how to tie a bowline. The classic way is to twist the rope to form a loop, and then “the rabbit goes in the hole, runs around the tree, and goes back into the hole.” The caver’s variant is “the rabbit goes in the hole, around the root, and then back out the hole.” The trouble with these methods is that there are two ways to twist the rope to create the loop (“hole”), and these methods only work if you’ve twisted the loop the right way. Or looking at it another way, your rabbit has to figure out which way is out and which way is in.

To avoid this problem, I tell people to look at the loop they’ve just twisted. One side has the running end on top, and if you look at the other side, it has the standing Take the running end, and stick it through the standing end side of the loop, around the standing end, and the back through the loop the way it came. This will work whether your initial twist to form the loop is to the right, or to the left.

Regardless of how you choose to remember how to tie a bowline, it is traditional to go around the standing part of the rope (the “tree” or “root”) from the outside to the inside, so that the running end comes out on the inside of the large loop you just formed. If your running end comes out on the outside of the big loop, others will correct you and think you are некультурный. And perhaps the knot is a bit weaker.

It is traditional to backup a bowline with a barrel knot on the large loop, right where the running end comes out of the knot. There is a variant called a Yosemite backup where you take the running end and feed it up through the knot next to the standing part, and then backup with a barrel knot on the standing part. This works OK, but there isn’t much if any advantage to it. And if you loop the running end through the knot wrong you untie the knot instead of backing it up. So back it up on the loop instead. And it’s hard for people to inspect a bowline with a Yosemite backup to make sure the knot looks OK. So, even if you like the Yosemite backup for personal use, backup on the main loop for SAR.

If you absolutely need to tie someone into the end of a rope and there is no alternative to using the rope, don’t use a bowline-on-a-coil around the waist, instead use a triple-loop bowline. It’s a plain old bowline tied with a long, long bight...
instead of the end of the rope. The running "end" doesn't need to be backed up as it forms one of the three loops; this running-end loop goes around the person's waist, and the other two loops form leg loops. (There is a variant of this called a bowline-on-a-bight, where you take the running end loop and flip it around the big loop, then tighten it. Very cool, but not very useful.)

That said, there are still quite a few legitimate uses for a bowline, even for a bowline-on-a-coil. A bowline on a coil is a useful way to tie into three or four anchors without needing separate slings and carabiners, and also can be used to rig to the top of a plastic Stokes litter. And, for rigging to the top of a metal Stokes, a bowline is superior to a figure 8 as it's much quicker to tie and far, far easier to adjust to the right size.

Another application for the bowline is in tying the leg loops of the:

ASRC Seat Harness (FTM/FTL)

Back in 1974 when Rita Cloutier, Ray Cole, Gene Harrison and I started the Appalachian Search and Rescue Conference, we all used seat harnesses tied from 1" tubular webbing. A few diehard vertical cavers sewed their own harnesses from 2" seat belt webbing, but commercial sewed climbing harnesses remained an expensive item, rarely imported from Europe, for a decade or two after this.

So for climbing or caving, almost everyone used a tied harness, but there were different designs. The simplest (and likely the worst) was called a diaper seat. You take a double-length runner, or one a bit smaller, and clip a carabiner into the runner. You then hold this in front of your belly button. With your right hand, you reach around your right buttock, and through your crotch, and grab one strand of the runner. You bring this around your right hip, and clip it into the carabiner. You then do the mirror image with your left hand. You're sort of sitting in the runner as if it were a diaper.

The diaper seat has one advantage: it's quick. But it falls down if you don't have the length of the runner just right. As you rappel in it, it shifts and pinches in different and sometimes very important anatomic areas. And, if it fails anywhere, for example from weld-abrasion from the rope running over it, you go splat.

There are a variety of other, somewhat superior tied harness designs. After careful analysis, Gene Harrison designed a tied harness that seemed to be superior to other tied harnesses. After due consideration, the ASRC adopted it as the official ASRC harness, and the ability to tie one has been an ASRC certification requirement for some 40 years.

If you're a climber or a caver, or have done urban vertical rescue, you may consider a tied harness archaic and déclassé.

But a tied harness still has a place in SAR. Consider: we often spend many hours, or sometimes days, tromping around in the woods, and up and down mountains, or crawling through cave passages, with a pack. And the bigger and heavier that pack, the slower we go, and the less we can do. But sometimes, after these hours or days, we have to rappel. Or ascend. Or, more commonly, do a semi-tech evac where we need to be tied into the litter. Do you really want to carry that big, heavy, padded climbing harness in your pack all the time just in case of such a rescue? When a 20' (6 m) length of 1" tubular webbing will do the trick?

I have a minimum equipment bag, a small batch of technical equipment clipped to a single-length runner that doubles as an over-the-shoulder equipment sling, that goes in my pack if I'm searching in possibly-steep-semi-tech or technical terrain. And on that sling is a 20' (6 m) length of webbing with the leg loops of an ASRC harness pre-tied, and the ends chained. If I need that sling for something else, I can untie the two bowlines and voilà, there is a 20' (6 m) sling. If I need a seat harness, it's a matter of a couple of minutes to get it on and tied.

So what are the specific good elements of the ASRC harness? First, safety. You have to cut it in two places, or more likely three places, to have it fail and make you go splat. Second, lightweight and versatile: high usefulness-to-weight and usefulness-to-bulk ratios. Third: comfort. While not as comfortable as a much bigger, much heavier, and much more expensive commercial harness, it's more comfortable than any other tied design.

It would be possible to tie an ASRC seat harness with figure 8 knots instead of bowlines. However, the figure 8s are a real bitch to adjust. And, unlike the bowlines, they have pointy bits that dig into your groin. Stick with bowlines.

The technique for tying the ASRC seat harness is simple, but it takes time and a bit of practice to get it right.

Start with a 20' (6 m) length of 1" tubular webbing. Tie a bowline around your left thigh with about a 2' running end sticking out to the left.
SEAT HARNESS

R-VR/CL(20JUL74GLH)

Semi-permanent seat harness using 1" wide tubular webbing:

1. Tie a firm hawline high on the left thigh with an excess of 12" to 18" on the short end.
2. Tie a second hawline high on the right thigh with a 2" to 3" crosspiece separating the leg looms. Hand over and rotate the loops to move the crosspiece high in front.
3. Wrap the remaining webbing around the hipbone, just below the crease, passing the end under the crosspiece each time. Tie the ends on the left hip with a squareknot backed up with overhand knots. Secure excess.

STEP 1

12" to 16" excess
Firm hawline

STEP 2

Firm hawline
2" to 3" crosspiece

STEP 3

Wraps below crest of hipbone
Pass wraps under crosspiece

FINISH

Squareknot with overhand knots
Get it up close to your crotch and tie it pretty tight. Make sure the running end comes out away from the center of your body. Again, leave about 2’ of a running end. Don’t back it up.

Now – and here’s the hard part – about 2-3” (~ 6 cm) to the right of the bowline in your left groin, tie another bowline, this time around your right thigh. The tricky bit is that you’re tying this with the running end being very long, so you’ll have to fight to get the entire length out of the hole, around the tree, and back through the hole. Make sure that there is only 2-3” (~6 cm) between the bowlines. And that the bowlines are really pretty tight around your thighs.

Take that long end on your right, and wrap it around behind your butt. Keep it flat; twists will be a pain in your butt. Keep it low, on the bony pelvis. If you get it up above the pelvis, on the soft part of your waist on either side, it will dig in and hurt you. Bring it around your left hip, keeping it below your anterior superior iliac crest, wrapping the bony pelvis and not the soft bits of your belly.

Stick the end under and through that little 2-3” (~6 cm) section between the bowlines. Pull it firmly to the left to tighten it around your butt. Pull it again. Harder. The tighter you get it around your butt now, the more comfortable it will be later. Now wrap it around your right hip, across your butt, and then around your left hip.

Stick it under that little cross-piece between the bowlines, just like you did the first time. then around the right hip, across your butt, and then around the left hip. Pull tight each time. Repeat until you run out of webbing.

Some tied harnesses wrap the webbing around your waist instead of tucking it under that cross-piece. No! No! No! That is bad in so many ways! First, when you clip a biner through the waist loops as well as the crosspiece, you are almost guaranteed to cross-load the carabiner. Bad, bad, bad. Not only that, if you wrap the webbing around your waist, when you fall, it’s going to compress and squish all of your internal organs.

Squishing your giblets is bad.

Take the right and left ends, and on your left hip, tie them with a square knot. A surgeon’s knot is an acceptable variation. When you make that first twist, pull tight. Should I say this again? Pull tight. Back when we used to all use these all the time for vertical rescue, I can remember people asking others to help pull their butt-wraps tight, and I’ve even seen people put a foot up on someone’s left hip so they can pull those butt-wraps tight.

Finish off the square knot with overhands on either side (just around one bit of webbing, not the whole stack), and either (1) stick the leftover ends in a pocket, or (2) tie enough overhands to use up the leftover webbing.

Rig to the crosspiece.

When taking off, you can leave the leg loops tied, ready for another use.

The diagram here is Gene’s original; you can see his initials and the date. The “R-VR/CL” references an early ASRC Reference for Vertical Ropework and Climbing.

**Butterfly (FTL)**

The butterfly is a beautiful and useful knot. Not that we’re doing macrame, but we might as well appreciate the beauty of the knots we tie.

I learned the butterfly as a way to tie into the middle of a rope for glacier travel. Originally, I learned to tie a butterfly, throw the loop around my waist, then adjust the loop so it fits snugly. It’s now more common to make a small loop and clip it into your harness with a biner. But still we use a butterfly. Why?

It’s a knot that is load-bearing in three directions. It is strong when stressed from both ends, when stressed from the loop and one end, and when stressed from the loop and the other end, or even when stressed from all three directions at once. In addition to tying into the middle of a rope, it can be used to tie out a bad section of a rope. For example, assume a rock fell on the middle of your rope, and damaged the rope badly in one small section… and it’s you’re only rope. By tying a butterfly that makes this damaged section into the loop, the rope is again usable, at least as a belay line, until you can get home and retire the rope.

In addition to the standard method for tying a butterfly, shown in the diagram here, there is another method that is hard to show in a diagram here, but is well shown in a series of animations at animatedknots.com.
I love the Münter hitch. I learned to rappel using a Dulfersitz (a technique described under rappelling, below, that likely qualifies as cruel and unusual punishment), then an unsafe double-brake bar rappel that we will discuss in the section on carabiners below, and an even unsafer carabiner wrap rappel discussed later under rappelling. So when I discovered I could rappel safely and fairly easily with a single locking carabiner on my harness using a Münter hitch, I was overjoyed. Today we have figure 8s, rappel racks and other fancy rappel devices, but back then, the Münter hitch was my favorite means to rappel. (Why, you may ask, are we discussing a rappel technique in the section on knots rather than the section on rappels? Because you need a Münter hitch to tie a load-releasing hitch. Which is a knot. Sort of.)

Once you tie a Münter hitch, you need to pull on first one end of the rope, and then the other. And then do it again. And again and again, until you’ve satisfied that there are two configurations, called “raise” and “lower” and that they both are exactly the same, except that the hitch is on the other side of the biner.

Not only can you rappel on a Münter hitch, you can use it as a belay method. Swiss mountain guide Werner Münter introduced this hitch to climbing in the 1960s as an improvement over a standard hip belay. He gave talks about it in the USA which firmly attached his name to it in North America. In Britain, it’s known as an Italian Hitch. In Europe it’s known at the UIAA belay method, or as the Mezzo Barcaiolo technique or MB hitch. It’s also known as a HMS knot, which is short for Halbmastwurfsicherung (“half clove hitch belay”).

It works best on pear-shaped carabiners, and in Europe, these are known as HMS carabiners. You can use it on D shaped carabiners, but it tends to jam a bit in the narrow portion of the D. This can make a rappel bumpy. When belaying, it also makes it hard to switch from taking in rope to paying out rope, as again it tends to jam. In the event of a fall, it will still hold, though. Some locking modified D carabiners have a less acute angle, and work fairly well, without too much jamming.

For safety, it’s standard to use a locking carabiner. There is some concern that the rope will run across the gate and roll the ferrule around so as to unlock the gate. You can avoid this by using an autolocking carabiner. Or by making sure that the rope doesn’t run across the gate. You do this by making sure that the carabiner gate is on the side away from your braking hand.

There are multiple ways to tie a Münter hitch, and all work. The easiest I have found is to twist the rope in a loop. Start clipping the carabiner through the loop, from the standing end side, then clip around the standing end. It is also commonly taught to form a loop, then twist it a bit more until it is in the shape of a Münter hitch as shown in the picture, then clip the carabiner through it. It it possible to tie it one-handed on a biner hanging from a sling: clip the rope through the carabiner, then form a loop and clip it into the biner as well.

Rappelling with the Münter hitch is quite easy. If you have rappelled on a figure 8 descender, try a Münter hitch, and you’ll find little difference, except that you may have a wider range of control. It does twist the rope a little, but it’s not usually a problem except on really long drops.

Belaying takes a bit more practice; the hitch flips back and forth as you alternate between paying out rope and pulling it in. However, even when reversed, a Münter Hitch is still a Münter hitch. It can be used clipped into an anchor sling, which is the preferred method. Assuming you are right-handed, rigging the anchor so that the Münter hitch is right behind your right flank allows you to use standard hip-belay hand motions (discussed later) to belay.

A Münter hitch is a suitable (and many feel, the best) belay for a lead climber, or for top-belaying
a climber or rappeller. However, it’s not considered adequate for belaying a full vertical rescue load. If you can’t find a tree for a tree-belay, and don’t have a figure 8, it might be suitable for a semi-technical evac, provided the slope is not too steep, and you take your time and monitor the carabiner for overheating.

There is a variant called a Super Münter or Monster Münter (officially, a dopplealbmastwurfsicherung; no, I am not making this up) that involves tying a Münter hitch and then adding another pass of the rope through the carabiner. This provides more friction than a standard albmastwurfsicherung… sorry, I just can’t help using that word. Perhaps we should just use “Münter” from now on despite how the Europeans despise the term.

The Super Münter has two advantages over a standard Münter. First, it doesn’t twist the rope. Second, it is strong enough to handle rescue loads. The only reason it’s not a standard method for lowering rescue loads is heat dissipation. Lowering a rescue load on a Super Münter can get the biner hot enough so that, when the rope stops for a minute, the heat melts the rope. Not likely a problem in a winter semi-tech evac, since semi-techs have lower loads than a full technical lowering. But for summer semi-techs, and technical rescues in even temperate weather, it may be necessary to dribble water on the biner to keep it cool. Which is why we generally prefer other lowering devices.

To tie a Super Münter, you first tie a standard Münter. It is easiest to tie a Super Münter when you have it hanging from an anchor, which is appropriate; the Super Münter has too much friction to use as a rappel or belay device.

You then take a bight from the running (braking) end, bring it around the standing (load) rope, and clip the bight into the carabiner again. You do this so that the rope you just wrapped around the standing (load) rope forms a nice U around the standing (load) rope.

I have been trying very hard to make this essay about non-technical and semi-tech evacs, and not about vertical rescue. For broader situational awareness, I’ve included bits here and there that apply more to technical rescue than semi-tech evacs, such as in the section on anchors.

ASRC FTMs and FTLs are not really expected to be competent with vertical rescue (though many of them, especially from the Groups that are certified by the Mountain Rescue Association, are). And, to be truthful, a load-releasing hitch is a technique used all the time in vertical rescue. But it rarely needs to be used in semi-tech evacs. In fact, I can think of many ropework skills I would like to see ASRC FTLs know, ones that are not in those FTL standards on Page 2, more than a load-releasing hitch. I’ve included a number of them in this essay. But it’s in the standards, so here goes.

For any vertical rescue where you may be doing a raise, you really should use a load-releasing hitch. Why? Duh. To “release the load.” If needed.

When you do a vertical raise, you have to pull the rope quite hard. And you use a set of tandem Prusiks as a ratchet/progress capture device. So, if the you are pulling up hard, and the edge of the litter gets caught under an overhang, and the Prusiks get set, then you are stuck with the rope under a lot of tension. Releasing Prusiks under tension is impossible. What do you do?

You use your load-releasing hitch. You untwist the rope wrapped around it, and inside you find a Münter hitch, as well as a 3:1 mechanical advantage haul system, tied with doubled 6 mm rope. (The 3:1 haul system uses biners, not pulleys, but that’s fine as it adds a little friction, and you’re using the advantage for lowering and not raising.) So you lower the litter a few inches, get it unstuck, and you’re ready to haul again. A load-releasing hitch will let you lower roughly 8-9’ (~3m).

There are other uses for a load-releasing hitch, such as in switching between raise and lower, and for passing knots, which don’t apply to semi-tech evacs. But perhaps the most important use for the load-releasing hitch is when belaying a vertical rescue. A Münter hitch, while fine for belaying a climber or rappeller, just won’t hold a
rescue load. So a standard way to belay a rescue load is to use tandem Prusik knots. This has one great disadvantage compared with methods such as a Münter hitch: once the Prusiks are set, you can’t undo them. So, for this kind of belay – used for technical rescues but not semi-tech evacs – a load-releasing hitch is absolutely essential.

For a semi-tech lowering, you do not need to use a load-releasing hitch. You rarely if ever need to pass knots or switch from lower to raise with a semi-tech evac. But for a semi-tech raise with a brute-force haul, or a Z-rig, some argue that you need a load-releasing hitch, just in case the litter gets stuck on a rock or a tree, the Prusiks get stuck, and you need to lower the litter a bit.

It’s not a strongly persuasive argument. Others argue that any raise needs to be rigged with a load-releasing hitch as it’s a good habit. I’m not sure I find that a persuasive argument either. When you are raising a litter up a cliff via rigging a Münter hitch and a variety of other wraps and when you’re raising a litter up a semi-tech slope, without a load-releasing hitch, I would not see it as a safety problem and ask that it be called out as a safety problem and ask that it be restricted two steel locking D carabiners, preferably either pearbiners (pear-shaped ones), or locking modified Ds (that’s what I use, and they seem to work fine), so that the Münter hitch will get stuck on a rock or tree is much, much less.

If you are doing a lowering or raising, even if rigged to the head of the litter, that requires a separate belay line, then that is defined as a technical rescue. (I just defined it that way; it’s arbitrary, I know, but you have to draw the line somewhere.) For semi-tech evacs, the hassle to usefulness/safety margin ratio is so high that a separate belay line should not be used. In fact, if you need a separate belay line, I think that by definition is a technical rescue.

If I see someone rigging a vertical rescue hauling system without a load-releasing hitch, I’ll call it out as a safety problem and ask that it be re-rigged. If I see a brute-force haul up a slope that has trees but no rock ledges, and it’s rigged without a load-releasing hitch, I would not see any safety concerns, and would allow it to proceed. If it were a steeper slope with rock ledges on which the head of the litter might hang up, a load-releasing hitch might be appropriate.

Strictly speaking, the load-releasing hitch isn’t a knot, and it’s not a hitch. It’s a device made up of two locking carabiners and a 10-meter (33’) length of 6mm nylon kernmantle rope, using a Münter hitch and a variety of other wraps and a tie-off. They are often stored pre-tied, ready to rig.

But if you want to be an ASRC FTL, you are expected to be able to tie one from scratch.

For many knots, the origin and etymology of the name is lost in the mists of antiquity, likely before the era of written language. But for the load-releasing hitch, we know who invented it, and when and where. Arnor Larson, a British Columbia rope rescue maven, developed it in the 1990s, and in 1999, Kirk and Katie Mauthner, whilst soaking in the Radium Hot Springs in Kootenay National Park in British Columbia, came up with a variant called the Radium Hitch, which is the most popular version of load-releasing hitch, and is what is described here.

Details of the load-releasing hitch, and a great amount of additional vertical rescue material, is available online in a document called Considerations for Rope Rescue in 2012 by long-time cave and mountain rescue instructor Ken Laidlaw. This document has become an essential text for those doing vertical rescue. (Available free online.)

To tie a load-releasing hitch, you start with the requisite two steel locking D carabiners, preferably either pearbiners (pear-shaped ones), or locking modified Ds (that’s what I use, and they seem to work fine), so that the Münter hitch will work without jamming. The load-releasing hitch is directional. It’s important not to tie it upside down, or if it’s pre-tied, to clip it in upside down. The Münter hitch always goes on the end toward the anchor, and the end with the figure 8 knot goes toward the load. Keep the gate openings of your carabiners “down and out.” The open end of the gate should be toward the load ("down"), and the gate should be away from things it might bang into, such as the ground or the cliff face.

You take the end of your 10m (33’) piece of 8 mm nylon kernmantle rope and tie a figure 8 loop in it; back it up with a barrel knot. Make sure the loop is quite small, just big enough to fit over the carabiner. Clip the figure 8 loop into the load carabiner. Now, run the rope through the anchor carabiner, back through the load carabiner, then once more up to the anchor carabiner; tie a Münter hitch on the anchor carabiner, oriented so that the end you pull on is next to the gate.

You’ve now got a tiny 3:1 mechanical advantage system backed up with a Münter hitch.

Pull on the rope coming out of the Münter hitch to tighten up your little haul system. (This flips the Münter hitch into the “raise” configuration.) You only want 3-4 inches (8-10 cm) between the two carabiners.
Now, pull the carabiners apart just a bit so that the Münter flips over into the “lower” configuration. Now, you should have about 5” between the carabiners. (There are diagrams that say it should only be 4”, which was easy to do with the original load-releasing hitch, but almost impossible with the new, improved Radium hitch.)

Make sure the Münter hitch is in the release position (ready to lower) with the in-feed cord towards the gate side of the carabiner.

That's the basic Radium load-releasing hitch. There will be a lot of rope left over, so you need to neaten it up.

It's somewhat traditional to take a bight of this leftover rope, tie a half-hitch around the middle of the assemblage, and the further use the bight to tie a square knot around the assemblage. There will still be rope left over. You can stick this in a little ditty bag, or chain it.

As a best practice, however, I recommend the following tie-off, which has a few superior features, instead.

Tie a slipped overhand around the three center strands of the load-releasing hitch, with the bight coming out down towards the load carabiner. Pull out the bight in the excess rope, until the bight is about a foot (30 cm) long. Using the bight, tie a simple overhand again around the central three strands. There will still be excess rope left over.

Tie a figure 8 loop in the end of this excess rope, and back it up with a barrel knot. As with the figure 8 loop on the other end, make the loop just big enough to clip into a carabiner. Clip a non-locking carabiner into this figure 8 loop. (You can hang it on the anchor locking D carabiner if this makes it easier; the illustration shows this.)

Start chaining at the figure 8 loop, chaining back towards the tied-off load-releasing hitch. Once you can't chain any more, take the non-locking biner that's on the end, and also clip it into the end of the chain closest to the hitch proper. This jams the chain and keeps it from unchaining. Clip this biner, a third time, into the anchor locking D carabiner.

If you need to lower, unclip the non-locking biner from the chain, but leave it attached to both the end of the excess rope and the anchor locking carabiner. This way, you can't lower the end through the Münter hitch and have everything go splat.

As reported in John Dill's reports in the NASAR Response magazine and reprinted in the NSS Vertical Section newsletter, Nylon Highway,* having a load-releasing hitch in the system acts as a shock-absorber, allowing a tandem Prusik belay (discussed under belaying later) to better hold shock loads. In Dill’s report, it decreased shock loads 14% in a simple tied-off configuration and a 25% reduction in the standard tandem Prusik belay configuration discussed in the later section on belaying.

Since we tend to use pre-tied load-releasing hitches, remember: Münter hitch on the anchor carabiner, figure 8 loop on the load carabiner.

Chest Harnesses (FTL)

The ASRC Training Standards say that an FTL must be able to tie the “knot” of a “cross chest harness.” To be truthful, I’m not sure exactly what this means. I know of multiple ways to tie a chest harness. I’ve tried all that I know and most tied chest harnesses suck. If you’re hanging by your seat harness, and the rope is routed through a carabiner on most of these chest harness designs, the carabiner slides up to your throat, and the back part also slides up to the back of your neck. Your back hurts and you choke. Not recommended. If you don’t believe me, try it yourself.

I’ve used (and still use) a variety of special-built sewn chest harnesses for vertical caving, and in particular, I use the Petzl “Torse” strap as part of my three-ascender system; I’ve also used several different types of chest harness with what are called “roller boxes” that clip onto the rope, with other types of ascending rigs. The Torse and the rest of the Petzl Frog Ascending System are by far my favorites (search the Web for Frog Ascending System to see pictures).

To figure out what “cross chest harness” officially meant, I did a Google search, and reviewed multiple pages. The vast majority of hits were for ~$300 commercial safety harnesses for window cleaners and the like. There was a smattering of exotic lingerie. And one hit in Mountaineering: The Freedom of the Hills that mentioned using a chest harness (diagram of what looks like a twisted runner shown) for glacier travel when you might fall in a crevasse. It unrealistically shows the carabiner right in the center of the climber’s chest, where it never stays.

So let me mention the “crossed runner chest harness,” also sometimes known as a figure of 8

chest harness, only to condemn it. There is no diagram, as that might encourage you to try this. You take a single-length runner. (You do remember what that is? If not, reread the Water Knot section again.) You twist it once into a figure 8. You put an arm through each of the halves of the figure 8. You flip the crossed center over your head. You clip together the two parts in front with a carabiner. You then realize that this is really more of a neck harness than a chest harness and you abandon the attempt. If you really don’t believe me, hang in your seat harness from a short rope tied to a swingset or tree branch. Put on this chest harness, clip it the rope, and hang back and relax.

You now should concentrate very carefully on the following instructions on how to tie a Parisian Baudrier chest harness.* It’s a little complicated but definitely worth learning.

First, you need a double-length runner. Hang the runner, from your left thumb. Slide the runner around until the knot or sewed join 3 inches (8 cm) below the base of your thumb. (You don’t want a knot digging into your back.)

Hold your left hand up against your chest. With your right hand, reach around behind your back, and grab both strands of the runner. One strand of it goes over your shoulder, one goes under. Yes, you can move your left hand a bit to make it easier to grab with your right hand, but then bring it back to your chest. Bring the two strands in your right hand around the right side of your chest. Using the single loop over your left thumb, and the doubled strands in your right hand, tie a sheet bend. A sheet bend is basically a bowline tying two ropes together. See the picture.

The steps to tie this knot are as follows. First, take the doubled end in your right hand, and push through the loop on your left thumb, in the direction opposite to the way your thumb is pointing, and let the end drop down in front of you. Take your left hand out of the loop it was in, and use your left hand to grab that dangling doubled end. Your left thumb should be against your chest. Keep holding onto that doubled part with your left hand, and with your right hand, pass that doubled end back up behind all the webbing on your chest, so it comes up to your neck. Your left thumb should be in the loop you just formed with the doubled part. With your right hand, flip the doubled part forwards, away from your chest. Now feed it through where your left thumb is, this time in the direction that left thumb is pointing.

Adjust the knot you just tied so that the harness is fairly tight around your chest, and there are no painful twists in the webbing. Make sure that the knot in the runner is not going to dig into your back.

The loop resulting from the sheet bend should hang down, and for additional security, you can clip it into your seat harness. If you want to clip this chest harness into the line from which you’re hanging, clip the carabiner around the sheet bend, from upper left to lower right.

Over the decades, I’ve spent a fair amount of time just hanging on a static line, waiting to be picked off of a “rappel accident” as part of cave or mountain rescue training. (I guess I have “sucker” printed on my forehead.) Having a Parisian Baudrier clipped to a Prusik or ascender just above you makes this much more comfortable. Especially because it always seems to take 30 minutes before I finally get rescued.

I sometimes also attach another ascender or Prusik to the line and run a single-length runner under my knees. Almost like lying in a hammock. Well, not really. But much more comfortable than just sitting in a harness and hanging onto the line with my hands, which can be quite tiring, both to your arms and even aerobically.

* Nobody’s quite sure where the name came from. Baudrier in French means a broad sash, and at some point maybe the person who invented this thought it looked something he saw some Parisian official wear at a ceremony.
Hardware: Carabiners and Pulleys

Carabiners

Most non-outdoorsy people call carabiners snaplinks. Outdoorsy people call them biners, and sometimes call locking carabiners lockers. The term is derived from Karabinerhaken, German for “spring hook for a carbine” (a carbine is a short rifle for cavalry) and have been used by climbers and cavers since 1911.

Regardless of what you call them, carabiners are an essential part of caving, climbing and rescue equipment. Originally designed for snapping the rope to a piton for protection for a lead-climber, they quickly found many other uses.

The gate on a carabiner is spring-loaded, so it will stay closed. Carabiners are designed to be loaded along their major axis (see diagram).

The earliest basic form of carabiner is the nonlocking oval, as illustrated in the diagrams. Later, Bonaiti in Italy produced “D” shaped carabiners, which became popular as they transferred more of the load to the solid side of the carabiner, and away from the weaker gate side. More recently, a modified D shape has become popular; the gate opens as widely, and it’s as strong as the original D carabiners, yet lighter. Another modification replaces the gate with a spring, which lightens the biner even more, without sacrificing strength.

For situations where speed is more important than security – for example, clipping your rope through a piece of protection while you’re lead-climbing and balanced on nearly-invisible hand- and footholds – nonlocking carabiners are the type of choice.

But for situations where you’re not hanging by your fingernails, we tend to use locking carabiners. The classic locking carabiner is a locking D, but they now come in all shapes and sizes. In rescue, we tend to use locking Ds all the time. In fact, a large modified locking D is perhaps the most versatile locking D to have in your pack, as it’s big enough to snap onto a litter rail.

One of the most useful types is a locking pearibiner, which means it’s pear-shaped. The large rounded end of one of these biners (Petzl makes a nice one) is perfect for a Münter hitch.

Carabiners come in aluminum, steel, and for all I know, gold. (Though I wouldn’t hang my life on a gold carabiner, the metal’s too soft; I’d rather have light and strong titanium carabiners, but nobody makes them.) Large steel locking Ds, because of their strength, are often used in vertical rescue. But if you’re not doing vertical rescue, they are overkill and overweight; get a few of those locking Petzl pearabiners and a few non-locking modified Ds, preferably the lighter spring-gate ones. Having at least one large aluminum modified D that will clip over a litter rail is a plus.

There are different types of locking gates. The first was a locking screw gate. There is a ferrule (metal sleeve) that has screw threads on the inside. You can rotate the ferrule to move it over the gate opening.

Some concerns about a rope running through such a carabiner unscrewing the screw gate ferrule (which has happened a few times, but not very often) led to other types of gate closure, and in particular, auto-locking carabiners. For some of them you twist the sleeve at the same time you open the gate. These aren’t too hard to open. But they are certainly harder to open than a locking biner with a screw gate with the screw gate open. I have seen a few auto-locking biners that are designed to sort-of-lock open until you clip into someone and then push on the ferrule. I was not impressed.

I recently got a CMC pick-off strap (designed to quickly clip a person hanging on a line or cliff into your harness) which had a carabiner permanently attached to it. It is an auto-locking carabiner. However, you have to twist the sleeve and pull the sleeve back, and open the gate at the same time.

I am certain this gate will never accidentally come open. However, I suspect that, when I’m hanging upside down on a tied-off rappel, and trying to hook this carabiner onto someone’s harness, while wearing gloves, I will not be able to get the gate open. While sitting here at my
desk, without gloves, I can barely get it open.

Sometimes, excess safety is dangerous. This is an example of it. When I'm lead-climbing or doing a pickoff, I do not want to be so safe that I can't accomplish the task at hand. In search and rescue, sometimes it's safer to ignore certain safety rules, or subvert certain hardware “safety” design, designed to protect against extremely rare risks, in order to expeditiously accomplish a potentially life- or limb-saving task. For many bad situations, you have to make an assessment of risks of benefits, including the risks of following certain safety rules.

Buy any long-experienced SAR team member a beer and ask for stories about this principle and you will probably get an earful.

Carabiners are good companions, but you must use them with care. Used appropriately, they serve their function; used incorrectly, they break and you die. Or, worse, someone else does.

There are several ways to misuse a carabiner. If you're using a non-locking carabiner, the gate can press against a ledge (or whatever) and come open. This is potentially bad; your rig may come apart, and with the gate open, the biner is weaker. Therefore there is a very long-standing traditional saying to orient the gate down and out. Out means away from whatever might bang into the gate and open it. If you're doing vertical rescue, and your clipping a biner to the rail, you have the gates down and in, in the sense of facing in to the patient. On the other hand, this out compared to the cliff, so the down and out rule still applies. You just have to realize what it means in the context of clipping to a litter rail.

"Out" in this context means away from things that might bang the gate open, which means away from the cliff.

Yes, you can use a locking biner. But locking biners sometimes unlock, and it's a best practice even with locking biners.

What if you don’t have a locking biner? Well, you can use two non-locking biners, in true opposition. That means that you have the gates oriented so that, even if one of the biners rotates, the gates open the opposite direction. This is as reliable as a locking biner.

Another way to misuse a biner is to cross-load it. Biners are designed to take a load along the major axis. If you side-load a biner as shown in the diagram, it doesn't take much to pop out the gate and thence to break the biner in half.

Yet another way to misuse a biner is to cross-load the gate. Basically, this means that if you pull hard on the gate, you can rip it out. This is why we don’t use a carabiner to clip into a harness while being belayed – at the precise moment you fall, the biner may be oriented so that the rope rips out the gate. Indeed, some tied harness designs almost guarantee you will cross-load the carabiner. As we discussed before, clipping a carabiner into a doubled runner with a wide angle not multiplies forces so that the webbing is more likely to rip when you load it. Not only that, a wide angle can make it much likelier that you will cross-load the gate and rip it out. Bad on many levels.

There is another way to cross-load a carabiner, and I am afraid to say I used to do this all the time. When I was first learning to rappel, I was taught the Dulfer'sitz, but then shown how to use a tandem brake bar carabiner rappel. This was a caver’s (slightly) safer alternative to a climber's method of using a piton like a brake bar. This is a really, really stupid way to rappel, as you're cross-loading the gate of the carabiner. If the gate comes open a bit, then there is a shock load (quite common when rappelling a broken slope), it would be quite easy to have the gate and the brake bar go “ping” and fly away, and then you go splat.

The illustration of a double-brake-bar rappel here is from Gary Storrick's website (storrick.cnc.net), which has a massive collection of pictures of rappel, ascending and belay devices.

If you want to get some locking biners for rescue use, get ones that are rated 25 kN (5620 lbs), which should be stamped on the biner.
Pulleys

The load-releasing hitch uses a 3:1 mechanical advantage hauling system. We use it for lowering, not for hauling. That's a good thing. The friction around the carabiners negates much of the mechanical advantage if you were to try to use it to haul up a load.

But if you do want to use a mechanical-advantage system, you will want to use pulleys instead of carabiners, to minimize friction.

There are hundreds of types of pulleys and blocks (groups of pulleys), dating back millennia. There are several types used in search and rescue. There are little plastic things that slip onto a pearibiner. I carry a couple of these on my minimum gear sling; they're slightly better than just using a carabiner. Not very good, but they weigh almost nothing. I string them on a 6” length of shroud line (parachute cord) with a loop on either end; both ends are clipped onto a biner on the gear sling. Beware other ultralight pulleys; they may not be strong enough to deal with rescue loads.

At the other end of the spectrum are big multi-pulley blocks for hauling vertical rescue loads, and special “jiggers”: a couple of small multi-pulley blocks pre-rigged with small-diameter rope, just for pulling something up a few feet. The most famous of these is the Aztec edge kit, which is a small buttpack with a length of smaller-diameter rope with a jigger on one end; the other end serves a a safety line when working near the edge. But those things are for vertical rescue, not semi-tech evacs.

The kind of pulleys we use for hauling up a litter for a semi-tech evac – or for a technical rescue – are pretty standard. They have aluminum sheaves (the flat plates on either side) and seem to come in mostly red and blue. I have no idea why these two colors. (But my wife does. "Easiest to see against wood, stone, snow & foliage. More commercially viable than hot pink or chartreuse.")

You can get them with brass bushings (cheaper) or stainless steel ball bearings (less friction). They look exactly the same.

You can also get standard pulleys (smaller, lighter) or Prusik-minding pulleys (some call them PMPs; these are the same people who call ratchets PCDs). Standard rescue pulleys have rounded sheaves; Prusik-minding pulleys have larger, almost-triangular sheaves. The basic idea of a Prusik-minding pulley is as follows. If you’re pulling up rope through the pulley, and there is a Prusik on the downhill side, then the Prusik will press up against the sheaf and release, allowing you to pull up the rope without encumbrance. But, if you start paying out rope, the Prusik will catch and prevent any significant return of rope back downhill. At least that’s the theory. It usually works. But it’s still a good idea to have someone tending the Prusik to set it when needed, just to make sure.

Belaying

Belaying a climber

The simplest belaying situation is when someone is climbing up a cliff, and you’re at the top providing a belay. Climbers call this “top-roping.”

The first belay technique for such a situation reportedly was when mountain guides in the Alps would take a client up the mountain, and use a rope to help pull up the client over the hard bits. Later, this morphed into using the rope more as a safety line, and guides developed a method of looping the rope over the shoulder, pulling it in as the client climbed. It wasn't particularly effective, given how it was draped over the guide’s shoulder, but it was said that a guide could then, at need, flip the rope off the shoulder and let the client go splat. This lost you a client but at least kept you from going splat along with your client.

The next development was the sitting hip belay. The guide would get into a good sitting position, perhaps on a small ledge, and brace his feet (back in those days, guides were always "him"). He would wrap the rope around his hips, which was a much better way to use the rope to catch a fall.

When the client fell, you would hold on tightly with the hand on the opposite side of your body from the rope leading to your client. So it was important for you to keep this hand – this brak-ing hand – on the rope all the time.

A variant of this top belay is very common in sport climbing on small cliffs. Instead of sitting
at the top and belaying, you just hook a sling to an anchor at the top, and clip the climbing rope through a locking biner on this sling. Then you belay from the bottom. This is better in some ways, in that you’re standing and watching the climber, so it’s easier to pass calls back and forth. And it’s easier to catch the fall as you will be pulled upwards, so gravity is on your side. It’s worse, I suppose, in that if you don’t catch the fall, the climber lands on top of you.

When the client was downclimbing, it was easy enough to shuffle your hands to pay out rope. But when the client was climbing, you really needed to do some fancy handwork to pull up the rope rapidly, without your braking hand leaving the rope. A standard three-movement technique evolved, as shown in the diagram. This requires practice. Lots of practice. It’s not a natural way to haul in rope, so it takes practice.

There are tricks that will help you learn this technique. First, you gotta have rhythm. It’s ONE TWO THREE. It’s a waltz rhythm, which is appropriate, since this likely evolved in the Austrian Alps, where the waltz originated. Think Johann Strauss, Jr., “The Waltz King” (Vienna: October 25, 1825 – June 3, 1899). Keep in your mind a waltz such as The Beautiful Blue Danube.

ONE TWO THREE ONE TWO THREE ONE TWO THREE!

You need to practice over and over, and over and over. If you’re teaching this to a bunch of others, a clever technique is to get them sitting down in two lines, facing each other, with about a yard between their feet. Snake a rope back and forth, so each person is holding the rope in a belay position. Then have everyone practice “up-roping” together. Count out the waltz rhythm: “ONE TWO THREE ONE TWO THREE!” A nice slow waltz is best to start with, after that perhaps Johann Strauss’s Accelerations to build up speed.

Another trick that helps learning how to “up-roping” while belaying is to make sure that when you do two that your feeling hand (that’s the one that’s not your braking hand) always reaches out farther than your braking hand.

When you set up a hip-belay position it’s good to have a solid place to put your feet, so that, when your client falls, you don’t get pulled off and go splat. It’s even better to have a harness on, and have the back of your harness (many harnesses have something called a “belay loop” specifically for this purpose) tied back to a nice, solid anchor. As shown in the diagram, you want to keep your anchor, your body, and the expected force of your client’s fall in line. As shown in the diagram, you can even use a “redirect” to make sure the force of your client’s fall is in line. Why this emphasis on being in line? Simple. When you client falls, and you catch it with your hip belay, you will be lifted up off your butt by the force. And if things aren’t in line, you might suddenly get pulled to the side by 500 pounds of force, and break an arm. Or worse.

Speaking of “or worse” Dave Templeton, a long-time climber with the Potomac Appalachian Trail Club Mountaineering Section, taught me to climb safely – he was a big proponent of safe climbing – and how to do some basic rescue techniques. Once made a bad mistake. He was belaying a climber from above, and forgot to clip his belay loop into the anchor line. The climber fell, pulling him off his belay stance. He fell over the edge and went splat. And died.

So even experienced climbers can make simple mistakes that can kill. That’s one of the
reasons we have a rule in rescue: someone else always checks your rigging. Whether it's for a vertical rescue, a sport climb, or a caving rappel, you should always ask someone else to check your rigging before you use it. Even if it's a pleasant, sunny day, and you've just had a nice lunch and a full night's sleep the night before, you always get someone else to check your rigging. So that when it's cold, and wet, and you're starving and exhausted and short on sleep, you'll follow the habits you developed in better times and places.

People are always searching for a better way to belay; either making it easier to take in rope, or less likely you will lose control of the rope (a significant potential problem with big falls and a sitting hip belay). We've discussed the Münter hitch, which is the most popular way to belay in Europe. Another European invention was the Sticht plate. A round steel plate a bit smaller than a hockey puck, the Sticht plate had a rounded slot in the middle. You stuck a bight of the rope through the slot, and clipped the bight into a carabiner either on your harness or attached to a bombproof anchor. When your climber fell, the rope pulling taught would pull the plate up against the biner, pinching the rope and stopping the fall. I don't think Sticht plates have been made for many decades, but I see echoes of them in various devices, such as "Rescue 8" descend devices, which have a slot in the middle that allows it to function like a Sticht plate.

A number of "tubular" Sticht variants evolved, which provided more surface area for the rope to rub against, and generally providing a better belay. There are many different such devices, but the Black Diamond Air Traffic Controller (ATC) seems to be the most popular in North America as I write this. As with a Münter hitch, you can use these for rappelling as well. They also are lighter and easier to use than the original Sticht plate. Indeed, I use one for sport climbing with my daughter, though I'm not a fan of it as a rappel device.

There are many other belay devices, most of which also double as a rappel device. They all have advantages and disadvantages. For example, one popular belay device – though not as popular as an ATC – is a Petzl GriGri. However, I have seen, multiple times, where someone is trying to rappel with a GriGri and got a thumb in the wrong place and fell a few feet before controlling the rappel. Seems to me that if you have a good belay device that is a makeshift rappel device, you're better off using something separate for rappelling, even if it's just a Münter hitch.

**Belaying a Rappeller**

It is possible to provide a rappeller with a bottom belay, also known as a "fireman's belay."

This is quite different than the bottom belay of a climber described previously. The idea is that mechanical rappels work by friction. If the rappeller pulls hard on the rope with the braking hand, the rappeller slows down or stops. If a person standing at the bottom of the cliff or pit pulls hard on the rope, the rappeller slows down or stops.

In 1998, Jim Kovach tested bottom belays at Bridge Day, a yearly festival to celebrate the New River Gorge Bridge in West Virginia. Rappellers routinely rappel the 800’+ drop off the bridge. In his report on the NSS Vertical Section website entitled *The Effectiveness of a Bottom Belay on Long Drops*, he found that bottom belayers couldn't stop a majority of simulated out-of-control rappellers.

That said, ASRC Groups routinely have bottom belayers stop actual rappellers. Ralph Brigham of the Eastern Region of the National Cave Rescue Commission, tells a story from the 1990s when he was at Three Caves Quarry in Huntsville one weekend. He observed some young men practicing rappelling down the 90’ (30 m) quarry wall. As Ralph says "they were freely partaking of a well-known non-nutritious beverage that does not lend itself to clear cognitive mentation. " When one of them lost control and started a free-fall, he grabbed the rope, stopping and quite surprising the young man, as well as likely saving his life.

Why the difference? If you're rappelling a long drop, you have to have very little friction on your device, due to the heavy weight of all of that rope hanging below your rappel device. So if you have a rappel rack, you may start with only three bars, and gradually add bars as you get lower. So, compared to the weight of all that rope, the incremental addition of one human body weight won't make much difference. But for 200’ rappels or less, a bottom belay works fine.

To work, a bottom belay needs to do two things well.

• First, you need to be able to pay out and take up rope rapidly as the rappeller moves. You don't want to tug on the rope and make it hard for the rappeller to use his or her braking hand.
• Second, if the rappeller loses control, you want to rapidly (a) pull out all the slack in the rope, and (b) pull on the rope with most of your body weight.

I see people trying to bottom-belay with the rope around their waists, like a sitting hip belay. Nope, doesn’t work. I also see people holding the rope under their butts, just like they might do while doing a bottom belay of a climber on a cliff, through an anchor and biner at the top. Nope, that doesn’t work either. Don’t believe me? Try it. Make sure there is a nice pad at the bottom and see if you can catch a falling rappeller that way.

Gene Harrison, one of the ASRC’s four founders, teaches a bottom belay method that seems superior to all others. So here’s Gene’s method. Wear a helmet. Wear eye protection, as you’ll be looking up to keep an eye on the rappeller.

Stand facing the cliff or the wall of the pit with the rope in front of you. Flip it over your right shoulder, so the stack of extra rope is behind you. Bring up your right hand to about shoulder height, with your fingers and thumb extended upwards. Catch the rope in the V between your thumb and your index finger. Don’t grab the rope with your hand. Resist that urge!

Bring up your left hand with the fingers and thumb similarly stretched upwards. Place it under the rope farther away from you than your right hand.

As you have to pay out and pull in rope, do it by shuffling the rope forward and back with your (open) hands. This way, if the rappeller suddenly pulls up on the rope (happens all the time) it doesn’t snag on your hands and make the rappeller snap at you. But you can still keep a minimum of slack in the line.

So, when the rappeller loses control you can:
• Grab the rope with your right hand, and pull back hard to pull out all the slack.
• With your left hand, reach up as high on the rope as you can and hold on for dear life (the rappeller’s, not yours).
• Fall down.

This will rapidly take out all the slack and put a sizeable portion of your body weight on the line. As long as this isn’t an 800’ rope this should stop the rappeller dead. Well, alive, but not moving down the rope. I think everyone who learns rappel should learn to belay this way.

And people should practice: get a belayer to take over control while you’re rappelling, and then lower you to the ground. It’s not only a it’s good practice for when something happens for real, it’s also good confidence-building exercise.

What if you’re rappelling and there is nobody at the bottom yet? Well, your choices are a top belay – which is a royal pain as the two lines usually get twisted up and in the way – or to try a self-belay (“safety,” “autobloc”). You can attach a Prusik above your rappel device. Or any one of the other 35 or so ascender knots; people tend to experiment with rappel safeties for some reason, likely trying to find one that can be loosened under tension. The Penberthy knot I used a few times works this way, sometimes; you can press down on the top and loosen the knot. Maybe. The problem with this is as follows. If you are inexperienced and you lose control of your rappel, where do you instinctively put your hands? On the rope above you. Which means (a) your braking hand is no longer braking, i.e., no longer multiplying the friction in the rappel device, and (b) now that you’ve grabbed the Prusik, it’s going to start slipping. Sizzle as the Prusik slips and melts in your hand. Then splat.

You can also fasten a Prusik safety to the rope below your rappel device, and attach it to a leg loop. But then you may have to insert a biner or a little sling to get your rappel device up high enough that the knot doesn’t get caught in it. But then your rappel device is far away from you, so it’s hard to control. And it makes it harder to get over edges or ledges when your rappel device is so far away from you. And it’s a lot harder to tie off when it’s that far away.

I tried both kinds of Prusik rappel “safeties” 45 years ago. (Actually, on my leg loop I used a knot called a Penberthy knot. Even then, people were experimenting with their rappel safeties.)

In the space of about 6 months, I firmly convinced myself that these “safeties” cause far more danger than rappelling without one and I have refused to use one ever since.

A more recent study of Prusik safeties for rappels by Dr. Ron Farmer called A scientific study of common friction knots, available online with a search on this name, found that Prusik (and related knot) rappel safeties worked less than half the time.

Gary Storrick has a web page devoted to the evils of Prusik style safeties for rappelling, including reports of Prusik failures, and even
of a death directly caused by a Prusik safety. (Search for “Post on Rappel Safeties.”)

To ensure a safe rappel, I recommend: (a) tie a figure 8 loop big enough to hold a booted foot in the end of the line you’re throwing over, (b) triple-check the first rappeller’s rig, and (c) have your most experienced rappeller go over first, and be rigged into an ascending system that can be put on the rope if needed, and (d) do a bottom belay for everyone after the first rappeller.

**Belaying a litter for semi-tech Uphill**

Belaying a litter on a semi-tech uphill carry is a lot like belaying a climber:
- the belay is there just in case the climber falls, or the litter team falls and drops the litter,
- you keep your braking hand on the rope all the time,
- the climber and the litter team are moving upwards on their own, and
- you have to keep the slack out of the belay line, but pay out and take in rope as the climber or litter move, mostly up but occasionally down to pick a different route.

Note that we are now discussing belaying a litter. We will discuss lowering a litter in the later section on rappelling and lowering devices. We will discuss hauling a litter uphill in the even-later section on ascending.

I suppose you could use a sitting hip belay to belay a litter. It might even work. On the other hand, we know that some people just can’t hold a single-person fall with a sitting hip belay. Surprisingly, it’s not always the big, muscular guys who hold a belay the best. Big guys sometimes have big hands and just can’t grip the rope that well. But I wouldn’t advise a sitting hip belay even if you’re good at holding big falls with it. A semi-tech fall isn’t going to be as bad as a vertical rescue fall, but it’ll be worse than a falling climber.

Luckily, as with rigging anchors for a belay at the top of a cliff or pit, we often find trees, and can use a tree-wrap as a belay. In the Appalachian Mountains (except for a few areas in the White Mountains of New Hampshire, and in Maine), and in hilly areas throughout much of North America, you can find trees. And for 40 years, the ASRC’s member Groups have belayed quite a few litter patients uphill using tree belays, and there are no reports of any problems catching falls. And tree belays are so, so simple. You need a litter and litter team, a rope, a belayer with a pair of gloves, and a tree. Not much equipment.

You simply pick a tree, stand uphill a bit from the tree, with your back to it and the rope across the small of your back, then back around the tree a couple of times. There is no need to tie in or wear a harness, as the tree is taking the load for you.

That said, there are some tricks to using a tree to belay a litter, at least if you want to remain attached to your fingers. And if you want to efficiently use tree belays, over and over, to move up a slope. First, let’s deal with the fingers.

Assume you have the rope in your hands, and running across your lower back under your back, and back around a tree enough to hold a fall. If there’s enough friction around the tree to take a fall, there’s enough friction that you won’t be able to pull up the rope. Problem.

Solution? We need not just one Belayer, but two, dividing the duties between them. If we called them both The Belayer, things would get confusing. So we call the person who backs around the tree and is in traditional hip-belay stance The Belayer. And if you’re person who helps by pulling up the rope? You’re The Downhill Ropehandler. Why “downhill”? Because the Uphill Ropehandler has the end of the rope and is walking uphill, looking for the next belay tree.

As The Downhill Ropehandler, you have two important jobs.

The first job is to pull up the rope, since the belayer can’t. This sounds simple, but it’s not. In a traditional one-person belay, the rope between the belayer and the climber (or litter captain) not only provides a belay, it serves as a communications device.

There is a reason we speak of a belayer’s “brake hand” and “feeling hand.” With your feeling hand, you are continually pulling gently on the rope to see if you should pull out more of the slack. Slack in the belay line is bad. It means if the climber or litter falls, then they might fall enough to go splat, at least a little bit. This is bad. On the other hand, you don’t want to pull so hard that you pull the climber off of his or her holds, or pull over someone on the litter team, or be so tight that
the climber or litter can’t move sideways or even down just a bit. (Yes, there is a call “TENSION!” that may be used by climber who is about to fall, but that’s different.) But if you are insulated from the litter by the rope going around the tree, your feeling hand is simply not going to fell the litter. That’s where **The Downhill Ropehandler** comes in. **The Downhill Ropehandler** pulls in the rope, making sure that there is no slack between the tree and the litter. But wait, it’s even more complicated than that. What if **The Downhill Ropehandler** pulls in the rope faster than **The Belayer** can take it up? Then there is a pile of slack between the two. Which means that the litter captain sees a taut belay rope, and thinks that there is a good, tight belay. Whereas if the litter slips, suddenly all of that slack gets pulled out before the belayer catches the fall, and the litter falls a long way. Ouch.

So, when using this kind of belay, you as **The Downhill Ropehandler** must not take in rope faster than **The Belayer** can move it through.

The second job when you’re **The Downhill Ropehandler** is to not lose any of your fingers. This is somewhat incompatible with the first job, in that to protect your fingers, you have to pull up the rope in an awkward way.

**Never get your fingers between the rope and the tree.** If you do, you may lose those fingers.

Just think. What happens if your fingers suddenly get crushed between a tree and an 11 millimeter object that has the weight of seven people suddenly pressing on it? As an emergency physician at a Level I Trauma Center, I see a fair number of similar industrial accidents.

You may have heard about the possibility of microsurgery, replanting fingers? Well, that’s possible if the injury is right at the base of the finger, it happened within the past hour or two before the surgery, and there is no major crushing. But from the kind of crushing we’re talking about, those fingers are complete losses and will very likely have to be amputated.

So how do you protect those precious fingers? Well, you wear leather gloves, which provides some minor protection against abrasions. But no protection at all from a massive crush injury.

So what you do is to grab the rope between your thumb and the radial side of the proximal interphalangeal joint of your index finger. If that standard anatomic language doesn’t make sense to you, look at the diagram. In simpler terms, you use the knuckle of your index finger, not the finger itself.

This way, if the rope suddenly tightens against the tree, it snaps out of your hands, rather than whapping your fingers against the tree and crushing them to a bloody pulp. It’s not easy to do this. It takes practice. I recommend practicing with someone on the end of the rope (just a single person) who repeatedly simulates a fall by pulling on the rope. The pull should not be enough to seriously crush a finger, but enough to bruise it and make it hurt for an hour or two. Pain is a very, very good teaching tool. No pain, no gain.

Now, for **The Belayer**: while taking a fall while tree-belaying a litter, there are tricks that will help you do a better job of holding such a fall. First, foot position: your foot that is nearest to the tree should be forwards. Why? A fall will pull you into the tree and this will brace you and keep you from falling over.

Second: if you are doing a tree belay, and you take a fall, and you’re not able to hold it – the rope is continuing to slip – what do you do? You should move further around the tree. This requires a bit of prior planning. You need to position yourself so that you can easily move further around the litter. This means that the rope to the litter should not block you from moving around the tree. Even if it’s a bit too much friction, it’s probably a good idea to step across the rope so you have room to move. It’s also nice if you can step downhill to increase friction around the tree, but that’s not always possible.

What if you’re in an Alpine area in New England, or say at Spruce Knob or Dolly Sods in West Virginia, or a Southern Appalachian bald, where the trees are only as high as your knees? Well, as discussed in the section on anchors, you might be able to take one or more pieces of webbing, put girth hitches around three of those small trees or some hardy-looking bushes, or maybe include a very large rock, connect them with a custom-fitted Frost Knot, and fashion a reasonable anchor. But, as we already discussed, you can’t use a sitting hip belay tied into this anchor, or a Münter hitch. So what can you use?

A Super Münter hitch would be ideal in such a situation. A Super Münter may or may not be adequate for a full-on technical rescue, but it works quite well for semi-tech evacs.

An alternative would be to use Tandem Prusiks just like you do when you are:
Belaying a Litter for Technical Rescues (FTL)

Even if you don’t do technical rescue, as an FTM or FTL, you may end up at the scene of a technical rescue. You will be pressed into service. Your choice will likely be (a) be on the haul team or (b) to belay. If you know how to belay, you may get to avoid being on the haul team. If this sounds like a plus to you, then learn how to belay for a technical rescue. It’s not hard. Let me clarify. It’s a bit tricky to learn, but not hard to do once you’ve got it down.

There is no perfect belay for a rescue load. A perfect belay would allow the belayer to rapidly and easily switch from “Up Rope!” to “Slack!”, yet would always be able to catch and hold a rescue load, such as a litter with patient and two tenders (say 200 kg) falling with a fall factor of 0.3, falling a meter on three meters of rope. This, in fact, is the the British Columbia Council of Technical Rescue (BCCTR) Belay Competence Drop Test Method (BCDTM). To pass, the maximum impact force must be less than 15 kN (3,340 lbs) and the litter must slide less than a meter. Only two methods have been formally tested and passed this test as far as I know: Tandem Prusiks and the 540° Rescue Belay device.

Some say we need to test bigger loads (300 kg), some say we need to test a failure on a longer length of rope. We need more such testing, and a good place to publish such test results so they are available to all and sundry.

The perfect belay needs to do a good job of “catching” the fall: the litter should not fall very far before it is caught. But it must not be too good at catching the fall; the litter needs to fall a little bit, dynamically decreasing the impact force, both to protect the anchor and to protect those on the end of the rope.

Many rappel and ascending devices have been tried as a belay for a rescue load, and have failed. Some, particularly ascenders, have failed miserably and spectacularly, with shredded rope ends flailing about and ascenders exploding (just search YouTube).

The Super Münter hitch shows promise, but has not yet been validated in scientific testing, nor has it been widely-adopted enough for it to become a standard technique. But it shows promise; stay tuned.

Despite its limitations, the accepted standard technical belay these days is called a Tandem Prusik belay.

To set up a Tandem Prusik belay, rig to a bombproof anchor; if it’s a tree, use a wrap-3 pull-2 with 1” tubular webbing.

Clip a pre-tied load-releasing hitch to this, or tie one on the spot. (We reviewed in the Knots section how to tie a load-releasing hitch.)

Tie a long Prusik loop and a short Prusik loop onto the rope leading to the load/belayee. This is a rescue application, so use three wraps for each Prusik. First, clip the long Prusik, and second, clip the short Prusik, into the load carabiner (lower biner) of the load-releasing hitch.

Some people say you should place the Prusiks and pulley on the carabiner in this order: short Prusik, long Prusik and then pulley. This places the Prusiks, the short Prusik in particular, which is most likely to take a shock load, next to the stronger (non-gate) side of the carabiner. Even though it seems natural to put the pulley on first, it makes more sense to put the Prusiks on first so they are closer to the strongest side of the carabiner. However, in trying to put the short Prusik first, I’ve found the long one always slips over the short Prusik on the carabiner, resulting in Long, Short, Pulley. Given the short Prusik is tied onto the main rope closest to the pulley, it’s natural for it to gravitate to next to the pulley even if you put it on first. I’ve decided to let Nature have its way, and to recommend that you place them in this order: Long, Short, Pulley as a best practice. But I don’t think the order in which you load them makes a significant difference. If someone has evidence (not anecdotes) to support a particular order, please let me know.

It’s also traditional to make sure that the Prusiks are oriented the same way. I am aware of no data or even any good anecdotes to support
this, but neatness counts, and standardization is good, so let's all do it this way.

Remember the mnemonic LSP or just chant “Long... Short... Pulley” “Long... Short... Pulley” over and over the next time you are meditating. Or maybe just remember the reason we place them in this order. Whatever works for you.*

Third, clip a rescue pulley to the load (bottom) biner on the load-releasing hitch. Run the rope through this. Having a pulley is not absolutely necessary – you could you could make do with another locking biner – but the pulley makes it a lot easier. And a pulley is the standard way to rig this, so do it the standard way to avoid confusing others.

Usually a SAR team that does technical rescue will have a kit made up with properly-sized Prusiks for a tandem Prusik belay. If you need to make up such a set, how you make them is in the sidebar.

If your pulley were a Prusik-minding pulley, then theoretically, all you have to do then is pull rope in, trusting that the Prusik-minding pulley will make sure that the Prusiks catch if and only if there is a fall. Of course the Prusik would catch if you needed to pay out rope, but you could hold onto the Prusik with one hand to keep it loose as you pay out rope.

There have been reports of failure with this system. But, in 2009, as reported by Mark Miraglia in a paper at the 2010 International Technical Rescue Symposium, he and his colleagues did 23 tests of their system (year-old 11.5 mm New England KM III static rope, 4-year-old Sterling sewn 8 mm nylon kernmantel Prusiks, Petzl Mini Prusik-minding pulley, 190 kg cargo bag of sandbags). They used wet ropes, they used ropes that were wet and left out overnight to freeze, they sometimes used Prusiks that were soaked in water, and at one point, they deliberately left the Prusiks too loose; they even dropped the load when someone was taking in rope. In no case did the Tandem Prusik/Prusik-minding pulley system fail to catch the load. The only way they got a failure was to use two-wrap Prusiks and leave them loose; when they dropped the load the Prusiks failed and the sandbags crattered (= splat). So, Alaska Mountain Rescue Group still uses tandem three-wrap Prusiks and an untended Prusik-minding pulley for belays.

However, back in 1997, Corvallis Mountain Rescue Group did some drop tests (posted on their website), but with a heavier load: 300 kg, to simulate a litter with patient and two attendants, with a 0.33 fall factor of one meter. Although the tandem Prusiks all held in their prior 210 kg drop tests, they all failed with the 300 kg load. Since tandem Prusiks are the best we’ve got right now, I guess this means that litter tenders all need to go on a diet.

As far as I know, we have nothing that is known to be better for holding 300 kg loads. Luckily, this essay is about semi-tech evacs, and if you’ve got a 300 kg load free-falling on your semi-tech evac, you’ve badly misjudged the slope of the hillside. For semi-tech evacs, you can have solid confidence in the ability of tandem three-wrap Prusiks to provide a reliable belay.

* There is a bit of a consensus to load the Prusiks first, but there is some dissent; the PMI Tandem Prusik Kit instructions shows the Prusiks closer to the carabiner gate than the pulley.

Tandem Prusiks: Belaying a Lowering

Over the past decade or two, a standard method has evolved for paying out rope during a lowering. This is for when you are belaying a lowering that is done on a technical rescue. You won’t be using this on a semi-tech evac, but if you’re belaying for a technical rescue, you need to have this down cold.

In paying out rope through tandem Prusiks, there are conflicting principles that needs to be balanced. If the litter falls, you don’t want too much slack in the line. On the other hand, you need some slack in the line, or the Prusiks will keep seizing, you’ll have to untension the belay line using the load-releasing hitch and then unset the Prusiks. Over and over. So, as in Zeno’s Paradox, perhaps the litter will never reach the bottom of the cliff. Or maybe you’ll just run out of rope in the load-releasing hitch.

So, to balance these two conflicting principles, you need to pull slack through the Prusik, and have just a little bit of slack in the line, but all the time. How much is a little bit of slack? Depends on who you ask – there is no one right answer, at least in scientific terms. But informed opinion says you need to keep a maximum of 12” (30 cm) of slack in the line. And, over the past decade or two, a standard method for performing this technique has evolved, and is described in an online paper called Considerations for Rope Rescue in 2012 by Ken Laidlaw. Despite its modest title, this (and its predecessors) is a major reference for anyone doing technical rescue. He describes the technique there, and I will attempt a different description of it here.
You stand, or more commonly kneel, at the tandem Prusiks. You wear leather gloves. You place your uphill hand on the lower Prusik – the one closer to the litter. You place your downhill hand on the rope, closer to the litter.

Your thumbs should be pointing towards each other. The amount of rope between the little finger of one hand and the little finger of the other hand should be up to about 12" (30 cm) but never more than this.

As you pay out the rope, you use a particular sequence, over and over again. The sequence is as follows. Unlike the regular waltz rhythm of "up rope" while belaying a climber, this is a series of twos, with the two beats always taking the same amount of time, but the time between those paired beats sometimes varying widely depending on how fast the litter is moving. Not The Beautiful Blue Danube but something more like Stravinsky's Rite of Spring.

You fix your downhill hand on the rope, then pull about 12" (30 cm) of rope through the Prusik in your uphill hand. (That 12"=30 cm is from little finger to little finger.) With that uphill hand, you'll have to push the Prusik uphill, towards the anchor, just a wee bit to keep it from seizing on the rope.

Next, you grip the rope with both hands, and bring your hands together, thumbs up, so that there is a 12" (30 cm) bight between them, pointing straight up in the air. You slowly loosen the downhill hand and let the bight start slipping through, pulled by the weight of the rope and litter. When the bight is almost gone, you fix your downhill hand on the rope, use your uphill hand to push the Prusik uphill just a bit, and pull out another 12" (30 cm) of rope. You then bring your hands together as before, and repeat.

As you pull through rope for your bight, your hands will naturally rotate inwards by about 45°. This is OK.

Why do you keep your hands with the thumbs up? One reason: it increases the friction on your gloved hands and makes it easier to hold the rope without it slipping. It actually makes the process less tiring. But the main reason is because holding the Prusik at 90 degrees makes it more likely to grip under a shock load. John Dill did some testing in the late 1980s that showed that Prusiks that were loose (meaning you could stick a finger inside the Prusik next to the rope) would not catch, unless the rope bent as it was entering the hitch.

A sudden load on the belay line will make it instantly go taut. This can hurt your hands, badly – we’re talking possible fractures here, maybe requiring surgery to fix them. There are two things you can do to make this less likely.

First, keep your hands always in line with the load. Don't get off to either side.

Second, some people say you should keep your thumbs off the rope. There's a saying "two thumbs up": as you're making your loops over and over, keep your thumbs pointing straight up in the air. Perhaps a more anatomic but less memorable way to say this is that your thumbs should never be below the rope. Remember that if a fall occurs, the rope will suddenly straighten. I suspect this evolved because someone hurt their thumbs this way, but I don't know the details, or how serious the injury was.

Opinion is divided on the “thumbs out” vs. “thumbs in.” It certainly is much easier to grip the rope with thumbs in. I think the answer depends on the structure of your belay stance. Look carefully at where the rope runs out from the pulley. Before you start belaying, have someone hold the rope on the uphill side of the pulley. Now, suddenly pull the rope from the litter end. If the rope whaps against the ground or a rock, then maybe you don't want your thumbs in the way. Moving the pulley up a little bit higher, if possible, should allow you to belay with "thumbs in" and still not lose a thumb if the litter falls.

When such a fall occurs, you're supposed to tighten your uphill hand, so that the Prusik tightens. I really don't think it's possible for you to react fast enough, but it's what you're supposed to do. Luckily the Prusiks seem to catch by themselves just fine.

Some people say that they can't understand why the Prusiks are on the load side of the pulley. Think about it this way. This is quite different from a sitting hip belay, or a Super Münter belay, because your uphill hand that's on the Prusik, controlling it, is your braking hand. Yes, it's on the load side of the pulley.

If you think in terms of the pulley being the belay device, this is just plain wrong. But think about it. Think about it some more. No matter how much you think about it, a pulley just cannot be a belay device. The pulley is just there to make it easy, in case you have to "up rope," for you to take up rope, by pulling down rather than having to pull up through the Prusiks. It also keeps the rope nicely lined up with the Prusiks when you're paying out rope.
Belaying a litter moving up a slope with tandem Prusiks is simpler than belaying a technical lowering with tandem Prusiks.

Some say that it's quite simple. You pull the rope uphill through tandem Prusiks attached to an anchor. No pulleys, no other hardware. If the litter falls, the Prusiks catch. Ken Laidlaw calls this the “manly” method. That's because hauling up the rope this way takes a lot of upper body strength and is quite tiring.

But most people prefer Ken's “wimpy” method: pulling the rope through a pulley. This means you can pull down on the rope, through the pulley, to “up rope.” For semi-tech evacs, where the litter may be moving uphill fairly fast on the easier bits of the slope, the wimpy method is a best practice, as it allows you to “up rope” faster.

There is some discussion — I'll not call it dis- sension — in the tech-rescue community about what kind of pulleys to use for such belays.

The problem is that, once upon a time, tandem Prusiks and a Prusik-minding pulley (without a Prusik-minding human) failed a drop test (reported in John Dill's 1990 article). When repeated the same exact way, the tandem Prusiks held.* As discussed above, Alaska Mountain Rescue Group did its own testing and, convinced of the safety of tandem Prusiks and an unattended Prusik-minding pulley, use this system for belaying an ascent. Others, such as Ken Laidlaw, suggest that using a non-Prusik-minding pulley gets the Prusik closer to the center of the pulley, and thus is more likely to catch on the rope in the event of a fall. Without a Prusik-minding pulley, though, a human has to keep a hand on the Prusik to prevent if from binding as the rope is pulled up.

I don't think there is enough evidence to say that one of these two conflicting viewpoints should rule. For belaying a semi-tech ascent, either tandem Prusiks with a Prusik-minding pulley, or tandem Prusiks with a non-Prusik-minding pulley but with a human hand on the Prusik next to the pulley, are acceptable. Perhaps human hands and a Prusik-minding pulley, as shown, is a best practice.

Belay Calls

Belay calls are the same for belaying a climber or belaying a litter. There's a slight difference for belaying a rappeller.

Remember the rule: “the belayer always says the word belay first.” So: belayer says “BELAY ON!” And the climber, or litter captain, or rappeller, says “ON BELAY!” Some climbers and cavers say that the right call is not “ON BELAY!” but “ON BELAY?” with that upward tonal inflection at the end, meaning that it’s a question: “are you on belay yet?” (Who says English is not a tonal language?)

But the ASRC and all right-thinking people instead know, deep in their hearts, that “ON BELAY!” is the only proper call: “I am on the rope and ready for you to belay me.” It’s a statement, not a question. If that’s so, then the inescapable conclusion is that the belayer and the belayee (is that a word? now it is) can exchange these calls in any order.

“BELAY ON!” means “I am in a proper belay stance, and I am now ready to take your fall if it happens.”

At the end of the climb, litter-carry, or rappel, though, there is a irrevocably set order. The belayer should never say “BELAY OFF!” until they belayee is secure and doesn’t need a belay any more. Even if you’re standing right next to the other person, you exchange the calls. And, to improve situational awareness for all at the scene, you exchange your calls loud and clear!

So, at the end of the climb, carry or rappel, the belayee first says “OFF BELAY!” meaning “I am no longer expecting you to catch me if I fall.” It doesn’t mean that you’re necessarily disconnected from the rope; we have a separate call for that: “OFF ROPE!” That means that you, or the litter and litter team, are disconnected from the rope.

If you’re belaying a litter up the hill, and you are THE BLEYER, when the litter gets to your tree, you receive an “OFF BELAY!” from THE LITTER CAPTAIN (again LOUD AND CLEAR for the situational awareness of those farther away). You then step out of your belay loop, clear the rope loop from around the tree, and then call “CLEAR!” This is the signal for THE UPHILL ROPEHANDLER to quickly back around the tree and get into belay stance and call “BELAY ON!”

Among teams who practice these

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procedures regularly, it is a matter of pride that is is only a matter of a few seconds between that “CLEAR!” and the subsequent “BELAY ON!”

It’s also a matter of pride for The Belayer to say “BELAY OFF! ... CLEAR!” in a single breath. Perhaps this is a good time to bring up one of those usually-harmless but quite embarrassing things that sometimes happen when you’re belaying a litter uphill. When you transition from being The Uphill Ropehandler to The Belayer, it is very important to keep the litter’s path in a straight line. That is, you do not want to call “BELAY OFF! ... uh ... uh ... uh-oh ... sorta CLEAR” because the rope is now looped around the tree, and because The Litter Captain is now throwing handfuls of mud at you because the litter has to go completely around the tree before heading on uphill. You may laugh, but I have seen this happen more than once. Including the mudslinging (but only during a practice). So, in your haste to transition from The Uphill Ropehandler to The Belayer, make very, very sure that the rope coming up the hill and the uphill end of the rope stay on the same side of the tree as you back around the tree. Ideal is to have the new Uphill Ropehandler take the end of the rope and hold onto it as you back around the tree, so it can’t possibly end up tied around the tree.

The other use of a call similar to “CLEAR!” is when you have finished rappelling, gone off belay, and unclipped from rope. This means someone at the top can pull up the rope to rig in to rappel on the same line. The call is “OFF ROPE!”

Speaking of “the same line” you may have multiple static lines rigged on a cliff or into a pit. If you have different color lines, it’s easy to expand the calls a bit to avoid confusion: “ON BELAY RED LINE!” “ON BELAY BLUE LINE!”

This is an argument for having ropes that are all different colors. I’m not being facetious: I think different-color ropes is a best practice and may well prevent a fatal accident someday.

If all of your ropes are the same color, you can number them from left to right, looking up from the bottom of the cliff. This is going to be more accident-prone: what if you add a new rope on the left? Does everyone get that you’ve renumbered them?

“ON BELAY LINE ONE!” “OFF ROPE LINE THREE!”

In addition to “BELAY ON!” and “ON BELAY!” and “OFF BELAY!” and “BELAY OFF!”, and “CLEAR!” and “OFF ROPE!”, there are a few other standard calls used during belaying.

“ROCK!” refers to any object other than a rope (for which the call is “Rope!”) that is traveling downwards and might hurt someone below. This applies not only to vertically free-falling objects, but to big things that might hurt someone rolling downhill. The proper response is not to look up. but to hunch your neck, bringing up and tightening your shoulders to protect it. This is a fairly instinctive response; you just have to get rid of that other instinctive response to look up.

If you’re carrying a litter and someone calls “ROCK!” you have an additional responsibility to protect your patient. You bend over the litter, protecting the patient’s vulnerable belly with your helmets, your packs, and your strong backs. (If you don’t have a strong back, you probably shouldn’t be carrying the litter.)

Another standard call is “FALLING!”; it is considered a distinct lack of savoir-faire and sangfroid to instead call “AAAAAEEEE!”

There are a few other calls that are commonly used in belaying a climber or a litter, though they don’t make sense, except maybe “TENSION!” when you’re bottom-belaying.

“UP ROPE!” is a call from the climber or The Litter Captain. It’s used in two contexts. Right after the belayer and The Litter Captain have exchanged their “BELAY ON!” and “ON BELAY!” calls, it’s common for The Litter Captain to immediately say “UP ROPE!” and The Belayer to echo “UP ROPE!” It’s not really necessary, but people do it all the same, and it’s not wrong. Climbers instead tend to call “CLIMBING!” which also is a bit of politeness that’s not required. Sometimes the belayer even responds with “CLIMB AWAY!” which to me just sounds like an excess of politesse.

Speaking of which, my wife and I were once
taking a hill-walking holiday in Wales (translating this into North American English: “a day-hiking vacation”). One day, we were climbing Tryfan, Wales’s most picturesque peak, via a fairly exposed route up a wide, slanting ledge system up the east face. We had a group of about 12. About halfway up the face, suddenly, with no apparent direction from anyone, everyone but us sat down, finding a secure place on the ledge, maybe wrapping a knee around a little bush or nubbin of rock (see arrow on picture). Unsure of what was happening, we sat down too. All the others opened up their packs, took out a thermos and poured a cup of tea and ate a scone or some biscuits (North American English: “cookies”) and had polite conversation for a few minutes before packing up and heading back up the ledge to the summit.

For the British, when it’s time for elevenses (North American English: no translation*), it’s time for elevenses, even if you’re on a ledge halfway up a thousand-foot face. Now that’s climbing politeness for you. If you’re ever in North Wales, I highly recommend this trip. The peak is a beautiful pyramid with a variety of rock types, including rhyolite and quartz, sitting off to the side of the main ridge by itself, much like Old Rag Mountain in Shenandoah National Park. The views all along the climb are spectacular.

“Up Rope!” is also used when you are climbing, and you see slack developing in the rope. If you are climbing fast, or carrying the litter uphill fast, maybe The Belayer just can’t take up rope fast enough. In which case, it is not considered polite to call “Up Rope!” “Up Rope!” “Up Rope!” “Up Rope!” “Up Rope!” “Up Rope!” “Up Rope!” “Up Rope!” like a three-year-old throwing a tantrum. If you are indeed getting ready to fall, a more proper call is “Tension!” which not only means for The Belayer to pull up on the rope firmly, but without jerking, it also describes the psychological situation of the climber or the litter team.

In sport climbing, “Tension!” is reserved for total wimps. Or at least that’s the prevailing attitude. But during a rescue operation, “Tension!” is a legitimate call; if a little tension from the belayer may help prevent a bit of a fall, that’s all to the good and not, in this situation, a sign of wimpiness. After all, rescue is a team sport, not an individual sport like sport climbing, and anything we can do to make the overall operation safer, faster and more effective is fair game.

Slack in the belay line might well mean The Belayer can’t take in rope fast enough. This is common when you’re using a tree belay for a litter, and the belaying job is shared between The Belayer and The Downhill Ropehandler. If the patient is light, the day is pleasant, the litter bearers are fresh and strong, and the slope is not steep, it’s quite possible for the litter team to “overclimb the belay.” There is one simple solution: the litter team just has to slow down.

“Slack!” means just that. When The Belayer hears this, The Belayer echoes “Slack!” and pays out a foot or so of rope. A climber or The Litter Captain may call for “Slack!” to downclimb a bit to choose a different route or to negotiate some sort of obstacle. “Slack Three Feet!” or similar is sometimes used, and is acceptable, but in noisy environments might not be well-understood.

**Rope Team Rotation:**

**Uphill**

The key to efficiency in any evacuation is to keep the litter moving. The challenge in any evacuation is pre-planning and practicing and maybe even having someone scouting the route and pre-rigging anchors so you can keep the litter moving.

Sometimes, for example during a cave rescue, it requires multiple teams to pre-rig a route, placing anchors such as bolts, starting an hour or two before the patient is likely to arrive at a difficult point. But for the majority of evacuations in the Appalachian Mountains and similar areas, there are long stretches where it’s all uphill, or all downhill, and there are lots of trees. For such areas, we can automate the process.

Given such a scenario, we found it takes a

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*Sort of like English afternoon “tea” but in the mid-morning. The English aren’t into siestas, but they go in for elevenses, tea, and even “high tea” which is usually Sunday afternoons, with enough cookies and cakes to give you diabetes from just looking.
minimum rope team of three people to provide belays while we keep the litter moving. In fact, we found it takes a maximum of three people on the rope team to keep the litter moving. More than three just confuses things and does not keep the litter moving. I will now describe the rope team rotations using a tree belay, going uphill. We will discuss going downhill later, but not unsurprisingly, the same optimum team of three works for going downhill, too. We keep the same names: The Uphill Ropehandler, The Downhill Ropehandler, and The Belayer, though the duties and locations are a bit different going downhill.

Assume you are starting off from with the patient in a valley, and the best route out is to go straight up the ridge to a wide and almost-level trail on the ridge. Assume further that the slope is fairly gentle; enough that the litter needs a belay, but the litter bearers don’t. Assume further that the slope up the the trail is 1500 feet (0.5 km) which means your 200’ (60 m) rope requires you to switch belays every 150’ or so, given the rope used in rigging to the head of the litter, and in belays, and the availability of good tree-anchors. (I think you will agree that this is a very reasonable scenario that could easily happen to any SAR team.) That means you will have to switch belays 10 times during the evac up to the trail. If you want to keep the litter moving then efficiently switching belays is key to keeping the litter moving.

Occasionally stopping the litter for a minute or two, for the medic to recheck the patient, or to tilt up the litter for the patient to pee, is OK. But stopping the litter 10 times during a 1500'/0.5 km evacuation is entirely too much stopping if your goal is to efficiently get the patient to definitive medical care and to keep the litter moving.

So, from starting off: the first of the three members of the rope team stare at each other until someone says “I’ll take the first belay.” This person then becomes The Uphill Ropehandler. He or she grabs the end of the rope, and heads uphill. He or she can do this even as others are still rigging the rope to the head of the litter. He or she picks a good route for the litter – no zigzagging between and around trees – because the litter will have to follow wherever he or she routes the rope. (In training, this position is sometimes misused for revenge on The Litter Captain. Once I even saw a rope routed through a knothole in a tree.)

So The Uphill Ropehandler walks up the hill, accompanied at this point by the other two members of the rope team, clearing out loose rocks and flipping aside downed branches. At about 150’ (50 m) – you don’t have to measure this, you can usually see you’re about to run out of rope – The Uphill Ropehandler hands off the end of the rope to another member of the team. It’s sort of a “tag, you’re it”: whoever gets the end of the rope takes over the role of The Uphill Ropehandler. Going uphill, it’s quite easy to remember who’s The Uphill Ropehandler because he or she always has the end of the rope and is heading uphill.

The previous Uphill Ropehandler then magically turns into The Belayer, backs around the tree the requisite number of turns, or she drops the rope, and starts heading uphill, ready to become the new Uphill Ropehandler. The Belayer calls out “Belay Off! ... Clear!” as he or she steps out of the belay loop and quickly clears the belay loop from around the tree. The Belayer then heads uphill to assist the new Belayer as his or her Downhill Ropehandler. The calls go out again:

“Belay On!”

“On Belay! Ready ... Lift! Forwards! Up Rope!”

“Up Rope!”

“Ready ... Down! Off Belay!”

“Belay Off! ... Clear!”

... und so weiter und so fort, over and over, ten times, until you reach that nice, wide, flat trail on the ridge. Yes, the litter has to stop for long enough for the old Belayer to get 150’ (50 m) uphill to the next tree belay and become the Downhill Ropehandler, but at this point, the litter team needs a little breather anyway. It’s a lot faster than having to set up 10 separate
belay from scratch each time, because you have an efficient system, and if you’re practiced at this procedure, it works very smoothly.

Practice makes perfect.

The ideal place to practice is on a slope such as described above. But even if practice makes perfect, practice doesn’t have to be perfect to be effective.

You don’t need to have a patient in the litter; you don’t even need a litter. All you need is four people and a rope. One person can tie a bowline around his or her waist (makes it easier to pull hard when you fall) and be the Litter Captain. And you don’t even need trees. You just need a bunch of vertical anchor-objects in a row. Streetlights work quite well, at least as simulated anchors. My ASRC Group, Allegheny Mountain Rescue Group, meets at UPMC Mercy Hospital. Sometimes we go out on the street right outside the ED and use a short rope to practice this way, up and down the street. It helps that the street is sloped a bit, but you can use a flat street and just designate an up and down. Any team that does non-technical and semi-tech evacs would do well to schedule such practice on a regular basis. You may get some strange looks, but your practice now may save a life or a limb later.

**Rappelling and Lowering: Descent Devices and Technique**

Rappelling and ascending are not required of ASRC FTMs or FTLs. But it seems to me that every SAR team teaches this. Almost every SAR team member wants to know how to rappel and ascend. Rappelling is just lowering a litter backwards. Every SAR team member ought to have at least a passing acquaintance with these techniques, so here goes.

**French Arm Rappel**

The French Arm Rappel is probably as French as French Fries. (Though the French lay claim to having invented them on the Pont du Neuf in Paris in 1789, the Belgians have a better claim with a 1781 manuscript dating them to the before 1680 in the then Spanish Netherlands.)

First, safety. Trying to use a French Arm Rappel on a vertical or free drop is incredibly stupid. It’s not designed for that. I’ve seen people try to do this and then treated them for second-degree burns of their arms. Even through a thick shirt and a parka. Speaking of which, you should always wear thick padding on your arms when doing a French Arm Rappel.

That said, I use a French Arm Rappel all the time at McConnell’s Mill State Park in Pennsylvania, where Allegheny Mountain Rescue Group trains. There’s a place where there is about an 8° fairly gradual drop to another part of the top of the rocks. There are no good footholds, and it’s a long way to walk around, so people tend to rig a handline there.

But sliding down hand-over-hand using a handline is just, well, *undignified*. And awkward. And sliding down gracefully using a French Arm Rappel shows quite a bit of style. It’s also easier and safer as you’re a lot less likely to lose your balance.

It does require that you have on a thick long-sleeve shirt or jacket or even better two layers. (Have I said this before?) With a thin shirt, or a short-sleeve shirt, there is no way to even do a short French Arm Rappel without getting bad abrasions or rope burns.

The technique is simplicity itself. Rig a rope to an anchor, at about shoulder-height, above a drop that is steep but less than 45 degrees. I think the maximum 45° slope I’d rappel this way is about 20-30’.

If the drop is considerably less steep, you can use it on a longer drop. There is one place at Harper’s Ferry National Historical Park where there is a granite slab slope that’s a bit less than 45° and about 50’ long. It’s a great place.

You could use it on an extremely short drop, say 5’, that is steeper, but it doesn’t work nearly as well.

Cast the rope down the slope. Grab the rope in your left hand, with your thumb pointing at the anchor. Stand so that you are sideways to the slope, with the rope passing in back of your waist. Now grab hold of the rope with your right hand, with your thumb pointing away from the anchor, that is, down-slope. If you were to slide down the rope this way, it would probably work (maybe, I haven’t tried it) but there would be a lot of friction on your hands.

Did I mention that you should do this
with gloves on? Come on, who would try to slide down a rope without gloves on? Do you know how long you would be disabled with bad rope burns of the hands? A painful two weeks minimum. Wear gloves.

Anyway, to decrease the friction on your hands, use your arms. Let go of the rope with one hand at a time. With that hand, move your hand backwards, scoop up the rope over your elbow, with a forwards motion of the hand. Then, continuing in a circular motion that’s like spinning your arm around in circles backwards, flip your hand in front of the rope, around your arm, then behind your back and thence to the other hand.

Now, all you have to is twist your body just slightly so your right hand is a bit in front of your body, and your left hand is a bit behind your body – to keep your feet from bumping into each other – and walk sideways down the slope. To slow or stop, bring your right arm across your body, as this adds friction on your side as well as your back.

It takes much, much longer to read this than to do it. It only takes one or two times to be an expert at this. It’s very quick, as well; no equipment to rig, and people get on and off the rope quickly. In fact, if you have someone who hasn’t done it before, you can just have them rappel last and by the time they’ve seen two people do it, they’re ready to give it a try and seldom need even minimal coaching.

Dulfersitz

What if you have to get people down a drop that’s greater than 45° and you have no equipment but a rope? Then it’s time for a dulfersitz rappel. When I was a young whippersnapper, this is how I learned to rappel. The excuse for you to learn this is as an escape technique for emergencies. Or just to show that you have balls. However, given that the other name for this is “hotseat” you may not have any balls when you’re done.

Even with thick winter clothing on, doing this on a free drop is only recommended for extreme masochists and those looking for an interesting method of suicide. When I was a kid, it was de rigueur to have a leather patch sewn on your parka’s left shoulder and neck to protect the parka and provide better friction for the rope. I think most of those people were the same kind of people who now get multiple nose ring piercings for fun.

I will now try to describe this rappel in words rather than a thousand pictures. You really should also look at a thousand pictures, which means a video on YouTube.

To perform a hotseat, you straddle the rope, facing the anchor. You grab the rope between you and the anchor in your left hand.

You then reach down behind you with your right hand. You then bring right hand and the rope in it forwards, across your right hip, then across your chest. Now, dipping your head forwards and to the right, you then drape the rope across your left shoulder and neck. Let go with your right hand.

The rope now comes from your front, through your left hand, under your crotch, and then around your right hip. It proceeds across your chest and abdomen from bottom right to top left, then back across your right shoulder and down your back.

Grab the rope below you with again with your right hand, with your thumb pointing toward the anchor. Hold firmly. The right hand is your braking hand. The grip of your right hand is what multiplies the friction around your body. Resist the overwhelming urge to let go with your right hand, and to grab the rope above you. That is the route to a screaming fall to your death.

Did I mention this is an extremely hazardous method to rappel? Did I mention that, unlike the French Arm Rappel, the Dulfersitz is an escape technique, only to be used when the alternatives are worse? Like you are rappelling to escape certain death at the hands (paws) of a grizzly bear? I suppose you could use a Dulfersitz on the sort of gradual slope where you might use a French Arm Rappel and it might be sort of safe.

For a hundred years or so, this was the standard way to rappel down a cliff. That was back when men were men, except those who were very flat things at the bottom of a cliff.

When I first started climbing this was what I was taught and used until (slightly) better forms of rappel were developed. I will also say that we did this with large-diameter manila rope, which provided much more friction than today’s nylon ropes, and the bigger diameter meant that it didn’t cut into your crotch and shoulder/neck as badly. However, I did make the mistake of using this technique to rappel using nylon Goldline
over a short free drop. Once. I would say I still have scars from this experience, but this was back when I was young and healed faster.

Now, if you are still willing to give this a try, turn your body slightly so that your right side angles down the slope or cliff at about 30-45°. Spread your feet a bit more than shoulder width. Walk backwards down the cliff, keeping your right arm straight and your right hand pointed down the cliff. If you need additional friction, keep your right arm straight, and bring your right arm across your body until it points uphill. Do not bend your elbow.

Keep your knees straight. This is very, very important. If you bend your left knee, the rope will slip up from your crotch to behind your knee and you will then be rappelling with your left knee in your mouth and the rope wrapped around the back of your knee and your neck. Not only is this likely to kill you, it looks really awful on the video your teammates just posted on YouTube.

If you have read this far, let me reassure you that being able to do a hotseat rappel is not, as far as I know, required by any search and rescue teams, including the Appalachian Search and Rescue Conference. However, it’s of historical interest, and as an escape technique, might save your life someday. Or kill you.

One final note: don’t use a bottom belay with someone rappelling with a dulfersitz. The rappeller will likely show his or her disapproval by Screaming and then landing on you headfirst.

**Carabiner Wrap**

A more commonly-taught escape rappel is a carabiner wrap. All you need is a seat harness, a carabiner, and a rope to rappel with. If you just have a rope, you can even cut a bit off the end and create a diaper seat.

Do you know how to create a diaper seat? If you only have a small bit of webbing or rope, it might save your life, so it’s worth knowing.

Tie your rope or webbing in a loop. Hold the loop in front of your belly button. Clip your carabiner through it.

It should be a locking carabiner, but as this is an escape technique, you might not have one, and it’s possible to do this with a non-locking carabiner. In fact, the military taught this exact method for many decades.

While holding the biner in your right hand, reach around behind you with your left hand. Lift up your left leg like your are a dog getting ready to pee on a fire hydrant. Grab one strand of the webbing, bring it around front, and snap it into the biner. Lift up your right leg, reach around your right leg, and bring a strand of webbing around the right side and clip into the biner. You’re done.

A diaper seat, unless it’s exactly the right length, tends to fall down, so you’ll have to walk around with a hand holding it up. And if you pause on a ledge while rappelling, it may fall down. Oh, yes, if you get weld-abrasion and the webbing gets cut in one place, the harness fails and you go splat.

Clearly this is a technique that should be used only when absolutely necessary.

Back to the carabiner-wrap rappel. You clip a carabiner into your diaper seat. The standard World War II military method used a non-locking carabiner.

WARNING: Don’t try this at home. Or anywhere else. Unless you are rappelling a short distance over a very large pile of soft pillows.

Clip the rope through the carabiner. Take the rope below the carabiner, twist it around the solid side of the carabiner, then clip back through the carabiner. If you feel suicidal, rappel like this, with the rope running right across your harness… a perfect way to cut through your harness with weld-abrasion.

I suppose if you used a locking carabiner, and another locking carabiner to connect to your seat, this might not be as suicidal. But it’s still a very, very poor way to rappel. The biner wrap tends to bind up, resulting in a bumpy rappel; this is especially true if you use a locking D carabiner. It also twists the rope a lot, even more than a Münter hitch. And the twists, when they form below you and then pass through the biner wrap, can cause you to lose control.

Speaking of twists, in ~2005, Scott McCrea, a North Carolina caver, did some backyard tests with a 23’ free rappel to see how different rappel methods twisted the rope (numbers are the number of twists at the end of the rappel; some methods tested more than once):

- Figure 8: 5, 5, 5, 3, 1, 5
- Micro-Rack: 1, 5
- Standard Rack: 1
- Münter Hitch: 7
- Biner wrap: 9

Nobody has done a comparative test of a
Slipped into a Girth Hitch.

resulting in bumpy rappel; shown, may twist (shown on right) and untwist, holding braking hand up may help prevent.

Figure 8, Locked Off.

How to tie a Münter hitch you already learned in the section on Knots.

Unlike the Carabiner Wrap, you can use a Münter hitch on a single locking pearabiner on your harness; there is no significant danger of the rope running over your harness and causing weld-abrasion, as the rope stays up at the top of the carabiner. You control a Münter hitch in the same way as most other mechanical rappel devices; you hold your braking hand at your right hip.

Unlike other rappel devices such as a figure 8 or a rappel rack, there is no simple, easy way to lock off a Münter hitch. You can take a bight of the running (braking) end of the rope and push it through the carabiner, but even then, it’s not secure without tying it off as well. Tie this off with a slipped overhand, as described in the Knots section, and then clip this bight to the tensioned standing part of the rope with a carabiner (“biner jam”) and you’ve got the hitch both locked off and tied off. If you now unclip the biner jam, and slowly pull on the running (braking) part of the rope, moving your braking hand up close to the hitch as you pull out the rope, suddenly your bight will pop out and you’ll be back on rappel.

The hitch provides a fairly wide range of control. Most people find that a little tension with your braking hand will slow the rappel quite a bit. This is the meaning of the term “wide range of control”: a small amount of tension on the braking hand results in a large increase in braking force in the rappel device. A rappel rack is similar in its wide range of control.

However, some rappel devices have a fairly narrow range of control, meaning that holding hard with your braking hand doesn’t increase the friction in the rappel device all that much. A good example of that is the:

**Figure 8 Descender**

Max Pfriimmer, a physician attached to a mountaineering regiment in Austria, invented the figure 8 descender during World War II.*

I didn’t count all of the figure 8 descender variations Gary Storrick has on his web page devoted to the topic, but even if you discount the ones that are really just figure 8-shaped bottle openers, there are about a hundred of them. Enough that at the bottom of the page he has a nice bar graph of the weight distribution of the 8s.

Some are aluminum. Some are steel. Some are machined, some are drop-forged. Some are so small as to look like toys. Some are designed for rescue work, and are bigger and heavier.

The basic design is simple: a chunk of metal with a big hole and a small hole, and a narrow neck between them for the rope to run around. The small hole clips into your harness. The rope goes through the big hole, around the neck between the two holes, and then back through the hole.

The 8 has one big advantage: it’s almost fool-proof. It’s very simple to rig properly, and even with all the fools I have seen rappelling with an 8, I’ve never seen one rigged into the rope wrong. However, there are quite a few disadvantages.

Some 8s have ears. The ears are designed to prevent a rare but catastrophic problem: the rope slips up off the neck of the 8, and suddenly you’re not rappelling, you’re tied to the rope with a girth hitch. So, for rescue use – for any use, really – you should use an 8 with ears. I admit this is a very rare problem, but enough of a concern that one should use an 8 with ears if you’re going to use a figure 8 for rescue work. If you have to rappel with an 8 without ears, push the bight of rope down through the large hole, rather than pull it up; that means the rope around the neck is on top, not on bottom where it can get pulled up on the edge or a ledge.

Another problem with the 8 is that the friction isn’t variable, much, while you’re on rappel.

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* Pit Schubert, Bergsteigen 3/06, as quoted by Gary Storrick on his website.
Yes, you can do a double wrap on the figure 8, as illustrated in the diagram. This actually works pretty well for lowering, as both ropes come out in the direction of the top (larger hole) of the 8. However, if you’re rappelling on an 8 with a double-wrap, your braking hand is usually down at your right side — that’s the comfortable place to keep it, and many recommend it, as you can purportedly get a little extra friction by running the rope around your hip. But if you do this, then the rope on the braking hand side tends to twist where it goes around the 8, and this makes your rappel quite bumpy; you suddenly stop when it twists, then suddenly go when it untwists.

Another problem with the 8 as a rappel device is that you have to take it off your harness to rig into the rope. I can’t tell you the number of times I’ve seen people drop their 8s, sometimes to bounce all the way to the bottom of the cliff or pit. When I first tried an 8 for rappelling, I tied a bit of parachute cord (call it “shroud line” if you want to be more classy) to the very top of the 8 with an anchor hitch (a knot which you will be surprised to find I did not include in this essay) and then to a loop on my seat. It did prevent me from dropping the 8, but it kept getting caught in the rope no matter how I tried to rig it. This is not a problem with a rappel rack (discussed next), which stays on your harness — or rigged into the anchor for a lowering — while you’re rigging in.

To lock off a figure 8, you bring the rope across the top of the 8, snapping the rope between the top of the 8 and the tensioned portion of the rope.

I have to admit I’m not a big fan of the 8 as a rappel device. Given a choice, I will always pick a Münter hitch over an 8, though my microrack is my favorite rappel device. The Münter may twist the rope more, but it gives a broader range of control. A little bit of tightening of your braking hand with a Münter hitch slows you down quite well, while on an 8 it doesn’t seem to make much difference.

In the early days of the ASRC, our standard semi-tech lowering bag had three slings made up from about 15’ (5m) of 11 mm static rope, three locking D carabiners, and three figure 8s. With this gear, using the 8s with double wraps, we accomplished a large number of semi-tech lowerings flawlessly. However, having a rappel/lowering device with a bit more control would have been nice; sometimes on a steep section, the double-wrap on the 8 just wasn’t quite enough and it stressed the belayers who had to hold a lot of friction around their rear ends. I remember one evac when the Rescue Specialist on the team girth-hitched a sling around a nearby tree, and then threw a carabiner wrap into the lowering line, after a brief brute-force haul to get some slack.

So, if you’re going to put together a semi-tech kit to place into your litter — which makes a lot of sense, as the vast majority of the evacs in the Appalachians that require a rope are semi-tech lowerings (think about it, the roads are usually in the valleys) — so if you place a semi-tech kit in your litter, prepare a kit like we used to do in the early days of the ASRC, but replace each of the 8s with a:

**Rappel Rack**

"The Rappel Rack is the best rappel device in the world." —Bill Cuddington, vertical caving pioneer.

Much of the technical equipment used in rescue in the later 20th century was developed by cavers, not climbers. (Dialect note: in the UK and Ireland, cavers are cub scouts with flashlights,* and spelunkers are experienced and well-equipped cave explorers. In the US, the terms are precisely the opposite.)

Why? Climbers are focused on the physical act of climbing, and ropes, rappelling and ascending are seen as necessary evils. But for cavers, single rope techniques — rappelling and ascending — are the primary means for exploring vertical caves. And some of the pits that cavers want to explore have very, very long drops that need to be negotiated. For an extreme example, the pit in Sótano de las Golondrinas in San Luis Potosí, Mexico, has a minimum 1092’ (333m) rappel. Fern Cave in Alabama has Surprise Pit at 404’ (123m). My first date with my wife was back in the early 1970s, and we went on a caving trip to Cass Cave in West Virginia, which has a 130’ (40m) rappel down a pit next to a waterfall. The rappel was great, the ascent back up not so much.

The rappel rack was invented by caver John Cole in 1966,† specifically to deal with long rappels. For such rappels, you need only a little friction at the top, due to the weight of the rope, but need to add friction as you descend. That requires the ability to continuously vary the

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* No offense meant to cub scouts, some of whom are cavers in the US sense. But it gets the idea across succinctly.

friction while on rappel, which is what the rappel rack delivers.

Gary Storrick's web pages on rappel racks (one for J racks, one for O and U racks) list 89 different designs, but they all share certain characteristics. I should note that I have an all-titanium micro-rack that Carroll Bassett of BMS Rescue made for me that Gary doesn't have in his collection/list; Carroll said machining the titanium damaged his tools and he wasn't going to make any more.

Rappel racks have two parallel rods, at a fixed distance; between the rods are bars, and the rope wends its way between the bars. The bending of the rope between the bars provides friction. Most racks allow you to move the bars closer together, for tighter bending of the rope and more friction, or spread the bars apart, for less friction. Most racks also allow you to rig the rope to all of the bars, or take off a bar or two to reduce friction. Most racks have an upside-down U shape, with one leg longer than the other, and a welded attachment loop at the end of that long leg. Others, like my BMS titanium microrack, have a symmetrical U shape, with the bottom of the U serving as an attachment; the bars are retained by nuts on the top, which have been individually tested to take very large loads. Some racks have spacers to hold some of the bars in particular position.

Many rappel racks, especially the smaller ones, have one or more hyperbars, usually at the top. A hyperbar sticks out to one or both sides of the rack, and has a small pin sticking out of one or both ends. You can take the rope where it comes out of the bottom of the rack and then flip it up and over the hyperbar. This not only adds friction around the hyperbar, but compresses the rest of the bars together.

Brake bars come in many different shapes and sizes; square with slots for the rope, oval with notches for the rope, round, or pipe-like with a hole in the middle to allow better heat dissipation. They come in aluminum, steel and titanium. Some brake bars are permanently mounted on the rack – they may slide up and down, but both ends stay on the rods of the rack. These bars have a hole drilled in both sides, through which the rods of the rack fit. Other bars can be half-detached from the rack; there is a hole drilled in one end, but the other end has a slot, usually cut as a bit of an angle. If you squeeze the rack's rods together a bit, then you can pop one end of one of these bars off of one of the rods, then rotate it out of the way. Indeed, this is how you move the bars out of the way to rig the rope through the rack.

This brings up the one big safety concern with a rappel rack – it's not as foolproof as a figure 8. It is possible to rig the rope through the rack backwards; that is, with the rope on the wrong side of the partially removable brake bars. And, since those bars usually snap on the rack, it might even look right to a cursory glance.

Which is why, when someone asks you to check a rack that's rigged for a rappel or lowering, always take a close look to see where the rope is: which side of those partially-removable bars it runs over.

If you try to lower on such a wrongly-rigged rack, it holds the first 30-50 pounds of weight, then "ping" "ping" "ping" as the brake bars pop off, "whizz" as the rope slides rapidly through the brake-bar-less rack, and then "umph" as the top-belayer takes the load. If you're rappelling, even with a bottom belay, I'm afraid it's just splat.

Some people file off the edges of the slots on their brake bars, so they won't snap into place; they will only stay if the rope holds them there. However, this has its own downside: if you take the load off the rack for a minute, as when rappelling and standing on a ledge, or when lower a litter and it catches on a ledge, the rope unloads, and it's possible that these filed bars might flip out of place, leaving you with no friction, and again splat. (Or an "umph" from the belayer.)*

I am aware of no deaths from rigging racks backwards, but there are numerous reports of close calls, including near-death experiences. If you're going to use a rack for rappels or lowering, practice it putting it on the rope. Over, and over, and over. Make sure you practice rigging it the wrong way a few times, so you get a feel for doing it wrong, so you can avoid this feeling. But practice doing it right at least ten times more often, so that's the habit you develop.

When you rig a J rack for a rappel, you want to have the short end of the "J", depending on how you have the rack oriented, either down or on the side of your braking hand. This makes it easier to add or remove brake bars. With a U shaped rack, you usually have the slots of the brake bars down, so you pull bights of rope up through the

* My large J rack has, as its second brake bar, a hollow steel bar that was designed without a lip. To take the picture of this rack rigged the wrong way, I had to insert a paperclip to hold the bar closed, then airbrushed it out with Photoshop. I have accepted the risk that this might flip open when unloaded, but as it's only the second bar that is this way, the risk is lower.
rack. This keeps your braking hand down at your side, rather than up in the air, which would be more tiring.

Locking off a rappel rack varies depending on the design. You may need to combine one or more of the following to lock off your rack.

For a J rack without a hyperbar, you can bring your braking hand up, and then jam the braking part of rope between the top of the rack proper and the portion of the rope above you. For a rack with a hyperbar, you simply loop the rope over the hyperbar. Adding a twist in the bight of rope before you loop it over the hyperbar makes it more secure and higher-friction. In the case of a U rack, you can stick a bight of rope through the bottom of the U before bringing it up to loop around the hyperbar.

In all cases, you want to bring the rope up so that it compresses all of the rack’s bars.

Most racks are rated for rescue loads, but it’s worth checking before you get one. If you might be working with NFPA half-inch rope, make sure that your rack can deal with it. If your team just wants racks for semi-tech evacs and not vertical rescue, then one of the smaller racks with a hyperbar might be best, as they’re lighter.

At this point, a rescue-rated rappel rack is the standard for lowering during vertical rescues, and for semi-tech evacs that need more than a tree-belay. As new devices are developed, this may change, but we aren’t there yet. Stay tuned.

**SCARAB**

There are zillions (well, maybe just hundreds) of descent/lowering devices, most of which won’t be covered in this essay, as they have no compelling advantages over the others. Browse Gary Storrick’s web pages if you are really interested.

But one of these new-fangled devices, the Scarab, seems to have really caught on.

The company Conterra developed the Scarab in ~2008. The Scarab is basically a single-bar rappel rack, with the equivalent of a two-sided hyperbar on the top and another on the bottom. As the equivalent of the hyperbar pin is bent inwards, and it’s part of the metal plate, it’s referred to as a “horn.” And one speaks of wrapping the rope around the horn, rather than wrapping it around a hyperbar, but the principle is the same.

It’s machined out of a single piece of metal, except for the brake bar, so no welded bits or nuts about which to be concerned. It’s available in a stainless steel version that will take 1/2”/12 mm NFPA rescue rope. If you are going to use it solely on 7/16” (11 mm) rope, you can get the slightly smaller, much lighter, and more expensive titanium version. Both are rated for rescue loads. Perhaps because of the size of the hollow brake bar, the company’s tests found no problems with heat dissipation. They also ran a mile of dirty rope through the stainless steel version with no visible signs of abrasion.

If you’re using it as a rappel device, you wrap the rope around the one brake bar, then around one of the top “horns”; add a wrap around one of the bottom horns if you need additional friction. For a rescue load for a semi-tech evac, you need to wrap around the brake bar and at least two of the four horns.

The titanium scarab is smaller and lighter than even my titanium micro-rack, and for mountain and cave rescue use, is starting to find its niche. If your team were to have a semi-tech kit with three scarabs rather than racks, I think any tech rescue geek would be happy with this. I would recommend springing for the extra expense for the titanium ones.

When rigging, it is standard to bring the bight of rope up through the scarab; the slot on the brake bar thus needs to be down. This makes it easier to control with your braking hand down at your side, rather than up in the air.

To lock off a scarab, you loop the rope around all the horns. Unlike a rack with a hyperbar, there is not enough room to twist the rope between the horns.

If you want a personal rappel device that can also be used to lower a rescue load, get a BMS microrack ($100; better if you’re planning to do long drops), a stainless steel Scarab ($130), or lightest but most expensive, a titanium Scarab ($250). I have no financial relationship to either BMS Rescue or Conterra, though I’ve known Carroll Bassett of BMS for decades.

**RAPPEL SAFETY AND TECHNIQUE**

Rappelling can be dangerous. Let’s look at some data to see where the danger lies and consider countermeasures for the dangers, then discuss technique general, to make rappelling safer and more efficient.
If you look at reports of rappelling injuries and deaths – good places to look include the US Occupational Health and Safety Administration (OSHA), Accidents in North American Mountaineering, and American Caving Accidents – patterns emerge.

Improper rigging is one of the most common causes. On July 21, 2009 a firefighter was practicing rappelling from a helicopter and his rappel rig was connected to his harness only with a rubber ring. He fell to his death.

Prevention: a religious dedication to the principle that rigging always needs a formal double-check by another person. And when asked to do a double-check, take it quite seriously, and take the time to do it right. Pay careful attention to the proper rigging of brake bars on rappel racks, Scarabs, and similar devices.

Losing control of a rappel is another common source of injury and death. On October 20, 2005, another firefighter was rappelling off a balcony at the fire station, and his single-wrap figure 8 descender stuck on the edge of the balcony; in trying to free it, he let go with his braking hand, and when he cleared the 8 off the railing, he was no longer in control and slid rapidly down, injuring his elbow.

Prevention: train yourself and your team members that, while on rappel, your braking hand leaves the rope only after you’re or locked off and then tied off. Use bottom belays whenever possible.

An uncommon cause of rappelling deaths is rappelling off the end of a rope. On October 7, 2008, Dennis Luther, a 54-year-old experienced climber, was in the Adirondack Mountains, and rappelled down a doubled rope, with a Prusik safety. The rope ends were not tied, and were not even. He rappelled off one end of the rappel rope and pulled the other end down with him, resulting in his death.

Prevention: tie a figure 8 loop, big enough for a booted foot, in the bottom of the rope unless you are absolutely sure it reaches the bottom.

By far the most common cause of death from rappelling, however, is from not being clipped in or tied in at the top of a drop, and slipping or tripping and falling over the edge.

Prevention: Act fearful of heights, even if you’re not. When appropriate, establish a “hot zone” or “safety zone” at the edge of the drop; people in the safety zone have to be tied in to a safety line, and wear helmets with chin straps secured.

All of this needs to be taken in context, and with a very large grain of salt. OSHA collects reports of work-related rappelling injuries and deaths, and tabulates them. And for the twenty year period 1989–2009, there were a grand total of... wait for it... six rappelling deaths. And nine injuries. If we add outdoor recreation, perhaps we can double these numbers.

On a related note, Tod Schimelpfenig of the National Outdoor Leadership School showed that NOLS courses were safer than golf. Really. Those golf carts are dangerous. And just think about lightning strikes when you’re playing golf, or even more commonly while fishing or at the beach. In the USA in 2012, 28 people were killed by lightning strikes, and 139 injured.

Which means that rappelling may be dangerous, but you are on the order of maybe 10,000 times more likely to die on the way to or from the rappel in an auto accident. This doesn’t mean that you should take the safety rules lightly, because those are what make us safer on the rope than we are on the golf course.

**Rappel Technique**

Good rappel technique likely makes rappelling safer.

Good stance makes you less likely to fall over and lose control. On a free rappel (no cliff or pit wall to put your feet against), there’s not much choice; your harness keeps you in a sitting position. Your left hand grasps the rope above you, loosely, to control your position. This prevents you from leaning back too far. If you find you always have to hold on hard with that left hand, to keep from falling backwards, you need to consider a different harness design, one that supports you mostly upright on a free drop; usually this means a higher attachment point.

If your feet are on the cliff face or the side of the pit, there is a tendency for you to fall to the right or the left. You can counter this by keeping your feet fairly wide apart. Sometimes you are rappelling on a cliff that has ledges and indentations. One way to deal with this is to keep your knees flexed, and extended on the indentations. It’s sort of like walking backwards on uneven ground.

Often, the hardest part of a rappel is getting over the edge. While this may be true psychologically, the physical act itself is difficult. Part
of this is due to the simple geometry. Play mathematician/physicist/engineer. Imagine a rope going over the edge of a perfect cube; the edge is a perfect 90° and the rope is flat against both the top and the side. Now, imagine a heavy bipod – an A-frame if you will – lifting up the rope on top. Further, imagine this bipod moving to the edge and then over the edge. As the bipod approaches the edge, it is stable: the weight of the rope and the bipod assure this. But there is a certain point, as the bipod is transitioning over the edge, where the bipod is no longer stable. Suddenly, the bipod flips over the edge, and the rope whaps down on the top of the cube.

The bipod is your legs, and that sensation of suddenly falling over the edge and the rope whapping down on the top of the cliff is a sensation that few people enjoy. Some, who are not expecting it, panic, let go with their braking hand, and put both hands on the rope above the rappel device. An understandable instinctual response, but, in terms of survival of the fittest, maladaptive. Recognizing that this problem exists is the first step in compensating for it.

The easiest way to compensate for this is by rigging. Rig the static line so it doesn’t go over the edge of the cube (cliff or pit edge) at 90°. If there’s a 3’ (1 m) diameter solidly-rooted tree right at the edge, rig it up a bit high on it. If the nearest bombproof tree is a bit far away, but there’s a somewhat wimpy-looking tree right near the edge, throw a tree-wrap on that big far-away tree, and then rig a redirect high up on the tree at the edge. This can be a wrap of 1” tubular webbing with a carabiner to clip onto the rope. If you’re short on equipment, you can even do another tree wrap high up on the semi-wimpy tree.

Sometimes there’s just no way to rig high at the edge. In this case, getting over the edge without a shock load (in both physical and psychological terms) presents more of a challenge.

One technique is to get on your knees as you go over. You can even, while on your knees, roll over to one side and go over on the left hip (keeping our braking hand away from the edge and free). This certainly will get you over the edge without that loud “whap” as the rope suddenly hits the ground. But it’s pretty undignified, and hard to do.

An option that takes more practice, but I find I prefer, is to “preload” – get right before the edge, get your feet on the edge, and then slowly put your weight on your rappel device, keeping any rope from slipping through. If you judge this just right – and it takes practice to figure out that “just right” – then you will slowly bend over backwards, slowly and gently laying the top part of the rope on the ground. Keep your knees straight as you do this; that seems to be one of the keys to success. This may a bit scary at first, but with practice you’ll find it is actually less scary than creeping over the edge on your left hip, which I now find scary. The bipod stance, with your knees locked and your feet wide-spread, will eventually start feeling quite natural.

I find that, right after I bipod over the edge, one of my legs automatically moves down just a bit, even before I let any rope through the rappel device. It seems to provide a little extra stability, just like a the common karate stance where one foot is back just a bit and turned a little bit out.

Another thing to think about: the closer your rappel device is to your body, the less likely it will get caught on an edge. So the practice of extending your rappel device away from your body – usually to accommodate a Prusik or other belay knot below the rappel device, attached to a leg loop – makes it more likely that your device will catch on the edge.

This brings up the design of seat harnesses. If you’re a lumper rather than a splitter, there are just three types of seat harnesses.

The most common used in SAR is a climbing harness. It is well-padded, has gear loops on the sides, the waist loop rides high, and has an attachment point that is fairly high, a few inches above your pelvic bone. This type of attachment means that it’s hard to invert (turn upside down). This is an advantage, unless you want to invert, for example, to reach a patient hanging on a rope, to attach your pickoff strap. Having a high attachment point, though, makes it harder to rappel over an edge. But climbers are interested in climbing, not rappelling over an edge.

Caving harnesses rarely have gear loops (though you can add them if you wish). The Petzl Super Avanti is the classic example; I use one of these for caving and for vertical rescue. Caving harnesses are not padded, so not quite as comfortable as a climbing harness, but still pretty comfortable. A caving harness is lighter and packs much smaller. The attachment point is lower, making it easier to invert – and to rappel over edges, which is something that cavers do all the time. If you think about it, a caving harness is more suitable for SAR than a climbing harness, though not as cool.
The third type of harness is a full-body or OSHA harness. This meets the requirement for doing work on towers, washing windows, and other work-related ropework. It incorporates a seat harness and chest harness all in one. It has attachments front and back. It is much heavier than climbing or caving harnesses. The only person I know who wears one for SAR uses it all the time for work, so he’s comfortable with it and willing to carry the extra weight. Like climbing harnesses, the attachment point is high, making it hard to rappel over an edge.

Since getting over the edge is by far the most dangerous part of a rappel – more loss of control occurs there than elsewhere on a rappel – lengthening the distance to your rappel device to have a Prusik below the rappel device is a bad safety bargain. The benefit of the Prusik below the device is far outweighed by the risk of losing control fighting to get your device over the edge. There is a device known as a Petzl Shunt that is specifically designed to be used as a safety below a rappel device, and it works, fairly well. If you want to rappel with a safety below your rappel device, consider getting one.

Once your rappel device is stuck on the edge, there is an almost overpowering need to use your braking hand to help pry the rappel device free. Even if you bring up your braking hand with the rope still firmly grasped in it, you won’t have the braking part of the rope under tension. And your hand won’t be in the right orientation to take the shock as your rappel device comes free. You probably can’t lock off your rappel device, as it’s stuck on the edge, and locking it off won’t help anyway, as you need to get that rappel device down the rope a bit.

This is the most dangerous part of a rappel, when people tend to lose control. In his book Rappelling, Tom Martin devotes an entire chapter to this problem. Anything that minimizes this danger makes your rappel safer. One of the keys is keeping your rappel device as close to your crotch as possible. Another is to keep your knees relatively straight as you’re bipoding over the edge; this gets enough slack in the rope so that when you go over the edge, your rappel device ends up below the lip. You can also try to go over the edge gently by preloading as your bipod stance starts gently going over the edge. This means you have to get to that exact sweet spot where you’re standing on the very edge with your legs pretty straight, then gently bend your knees slightly to lower the rope gradually to the edge. Takes practice. So practice. With someone you trust providing a bottom belay.

If you have to rappel over a fairly sharp knife-edge, consider attaching an etriér (set of foot loops) via a Prusik to the rope above the edge, or directly to the anchor if it’s close. This way, if your rappel device is stuck on the edge, you can put a foot in the loop and lift up a bit to get it loose.

When you are over the edge and you’re in the midst of your rappel, you may need to stop and let go with your braking hand. For example, you may need to connect your pickoff strap to the person you’re trying to rescue.

As you may have noticed from the diagrams provided for the various rappel/lowering devices, I distinguish between locking off and tying off a rappel device.

Locking off a rappel device means jamming the rope somehow – different methods for different devices – so that your body weight will not cause you to continue down the rope, even if you take your braking hand off the rope. This is a quick-and-dirty way to secure your rappel or lowering device.

Tying off a rappel device is an additional step after locking off. It means securing the rope so that a tug on the rope, or banging the rappel device against something, won’t accidentally unlock it and make you go splat. If you’re doing a third-man rescue of someone in the middle of a rope, and you’ll be hanging upside down, I strongly recommend both locking off and tying off. My favorite way to tie off a rappel is with a slipped overhand on the main line, secured with a biner jam; see the Knots section for more on this.

One final note: bouncing. Bouncing on rappel looks great on a video, but is frowned upon by all right-thinking SAR people. It increases stresses in the system, so makes anchors, harnesses, ropes, and rigging more likely to fail. Other than looking good on video, there is really no good reason for bouncing.

It’s beyond the scope of this essay, but switching over from rappel to ascend and back again is a very important and difficult task for anyone doing technical rescue. If you want to go beyond simple rappelling and ascending, then this is the next skill to master, before you start learning third-man techniques for rescuing someone on a rope. Practicing, over and over, on a rope hanging from a tree in your backyard (or in my case, a rope hanging from the rafters of
my Great Room) is essential. Also, if you're planning to rappel as part of vertical caving, this is an important skill.

Lowering yourself down a slope or cliff by rappelling is a good way to get down. We won't discuss lowering a litter down a cliff, as that's technical rescue, and a subject for another time and place. But lowering a litter down a slope with a rappel device – now that's definitely within the scope of this essay. And, as with the story this essay started with (can you still remember that far back?), semi-tech evacs downhill can be very efficient.

I suppose you could anchor a rope to a tree, and then attach a rappel device to the top of the litter and have The Litter Captain “rappel” the litter down the rope. In fact, this “traveling brakes” technique has been used extensively in the past, and I’ve done it before. Twice, if memory serves. It has justly gone out of fashion these days. For one thing, when you’re tending the litter, you’ve got enough to worry about without trying to control the rappel device, too. And when the rappel device is up out of your reach, it’s quite hard to vary the friction very much.

As in the opening scenario of this essay, you can use tree belays very efficiently to get down a long slope, if you’ve got a rope team of three people who are expert at the jobs of The Belayer, The Uphill Ropehandler, and The Downhill Ropehandler, and who are also expert at the:

**Rope Team Rotation: downhill**

The rope team rotation for belaying a litter uphill necessarily involves a delay as The Belayer moves uphill to become The Downhill Ropehandler. However, the rope team rotation is different going downhill, simply because The Belayer doesn’t need a ropehandler to pull the rope around the tree; the weight of the litter pulls it around the tree just fine. As long as the rope is stacked, or laying out in a nice straight line up the hill, it should feed to the belayer without any problems.

This has a couple of implications. First, the rope team positions need to have different duties. The Uphill Ropehandler, instead of having to help get the rope around the belay tree, can head downhill to the next belay tree, to become The Downhill Ropehandler, picking and clearing the path below the litter, and looking for a new tree anchor for becoming the next Belayer.

Second, this means that the only delay is in getting the old Belayer out of belay stance and giving an “BELAY OFF!” and clearing the rope from around the tree and giving a “CLEAR!” and, a rope-length down the slope, the new Belayer backing around the tree and giving a “BELAY ON!” This is much shorter than going uphill.

Since, in most mountainous areas, the roads tend to be in the valleys, most semi-tech evacs are downhill. And, with this three-member rope team rotation – as with the opening story of this essay – this can go very fast, without need for the litter to do more than briefly pause during the downhill evac.

Perhaps at this point, you’re happy with a rope team of three for downhill; it sounds like a highly-efficient way to get a litter patient down a long, wooded hill. But, you may ask, why a rope team of three for going uphill? Why not four?

If you have a long uphill, it might make sense to set up a rope team of four. But long uphill semi-tech evacs are, thankfully for our lungs and legs, rare.

What is more common is a mixture of uphill and downhill, much more downhill than uphill; usually there will be lot of downhill with scattered bits of uphill. A three-member team is optimal for downhill semi-tech evacs, and works fairly well for uphill as well.

Let’s take time out to discuss something known as operational friction. If you have had any significant experience in SAR, then you know what this is, even if not by that name. When members all know what they’re doing, and everything is going like well-oiled clockwork, we speak of low operational friction. When members are not sure what they’re doing, having to ask for guidance all the time, and making frequent minor or
even occasionally major mistakes, we speak of a period of high operational friction. Actually, we tend to use more colorful language: “SNAFU”; “train wreck,” “nuclear train wreck,” “cluster.”

Switching from a rope team of three to a rope team of four introduces a lot of operational friction. In fact, in training ~40 years ago, we found that the operational friction of switching back and forth from a rope team of three to a rope team of four far outweighed any potential speed advantages. So we settled on a rope team of three, with the same names, for both uphill and downhill. It simplifies training quite a bit, and reduces operational friction during real evacuations. So, rope teams of three, downhill and up.

To summarize the roles for semi-tech downhill:

**The Belayer:**

- While serving as The Downhill Ropehandler, you sought out a belay tree where you will then set up as a new Belayer. Once you've picked the tree, wait for the “**Belay Off! ... Clear!**” from above, then back around the tree in proper belay stance and call “**Belay On!**” and once you hear an “**On Belay!**” from The Litter Captain, belay the litter. One additional thought, and a couple of calls that we have not discussed up to now: “**Two-Oh!**” and “**One-Oh!**” These are time-honored climber’s calls that are particularly useful for downhill semi-tech.

  The thought: how does The Downhill Ropehandler know when to pick out a specific tree for the next belay? The answer:
  - “**Two-Oh!**” translates as “you've got about 20’ (6 m) of rope left.” This is information both for The Litter Captain – to look for a good place to stabilize the litter to switch belays – and for The Downhill Ropehandler to pick out a new belay tree. For the downhill rotation, the Litter Captain and The Downhill Ropehandler are right next to each other, so there can be a bit of informal communication to pick out a place that’s good for both belaying, and for setting the litter down, or at least temporarily anchoring it to a tree during the belay change.
  - “**One-Oh!**” was not originally a standard call, but it spontaneously evolved. It seems to be a better call than “**I AM ALMOST OUT OF ROPE AND YOU ARE GOING TO STOP VERY, VERY SOON BECAUSE I CAN’T BELAY YOU ANY FURTHER!**” I suppose we could translate it as “you've got about 10’ (3 m) of rope left,” but the verbose call above is probably a better translation.

**The Uphill Ropehandler:**

- as the last Belayer, you gave a “**Belay Off!**” and then cleared the rope from around the tree and called “**Clear!**” Now, as Uphill Ropehandler, you head downhill. You follow the untensioned rope below you down the hill, clearing any snags you might notice. But mostly you just keep moving downhill at a rapid pace. One you pass the new Belayer, you follow the tense rope that is carrying the weight of the litter, and you use it as a handrail as you speed down to the litter. You keep an eye on the rope, to make sure it’s not snagging on trees or rocks. The prior Downhill Ropehandler should have picked a nice route down the fall line (the route a ball would roll down the hill), free of any obstructions. But sometimes the rope snags on something.

  I’ve never seen a snag in the sense that it prevents the rope from lowering the litter, that would require it getting caught in a crack of the right size. It’s not impossible, it’s just that a different kind of snag is more common: the rope bends a bit around a rock or stump or tree.

  If the rope is bent a bit around a big, solid tree, that’s a different matter. It could slip off the rock or stump and suddenly drop the litter a few inches or more. It’s a judgment call what to do about this. In some cases, with just a slight bend, and judging the geometry carefully, it may be unlikely the rope will slip off, and appropriate to continue the eva as is.

  On the other hand, it may be better to get the rope off the offending object. There is no standard way to do this. You can ask The Litter Captain to move the litter to one side to make the bend into a safer straight line. In rare cases, you may need to flip the rope off the rock or stump. The Litter Captain may be able to stop, go off belay, and untension the rope, at which point you can easily flip the rope off the offending object. If it is necessary to flip a rope off under tension, which should be a last resort, the knuckle-thumb grip used by The Downhill Ropehandler during an ascent would be the safest way to flip the rope off the offending object, presuming you wish to stay
attached to all your fingers.

Once you get to the head of the litter, you stay there above the litter, continuing to monitor the line, and perhaps lending a hand with the litter. Once The Downhill Ropehandler turns into the next Belayer, you turn into:

**The Downhill Ropehandler:**

you head down below the litter, scouting the route, clearing it of loose rocks and logs as needed. You communicate and consult directly with The Litter Captain about the best route. “Head to the right of this next big tree to avoid a drop.” “There's a nice big Tulip Poplar about 20' below you, keep to the right of it and about 5' past it is a good place to set the litter down for a minute while we switch belays.”

The technique for belaying or lowering a litter with a tree-wrap or a mechanical lowering device is fairly straightforward; it's just like rappelling only upside down. If you consider that all motion is relative, then you're rappelling your anchor and the Earth while the litter stays still.

Whether it's a tree-belay or a mechanical device, your job is to give the litter a smooth ride. It does take a bit of practice, as you have to learn to control the descent gently, making no sudden changes in friction. We've covered how to change the friction on common mechanical devices already. For a tree belay, you just need to move one way or the other around the tree to control the friction. Remember to keep an eye on your rope! Give “Two-Oh!” at the right time.

As with belaying a litter uphill, you keep the foot closest to the tree or lowering device a bit ahead, and keep your braking hand always on the rope. Mostly you just need to adjust the friction up or down to keep the rope running at the appropriate rate for "Down Slow!" or "Down Fast!" What's the right rate? You'll have to learn from experience. In the words of Supreme Court Justice Potter Stewart, it's hard to define but “I know it when I see it.”

If the litter is going over a bit of a breakover, where the slope becomes more steep, it may be appropriate for The Litter Captain to call “Stop! Preload!” (echoed by The Belayer) which means for The Belayer to prevent any rope from slipping through, and to increase friction in preparation for a harder pull.

In many semi-technical evacs, it's possible for the litter team to put the litter down securely so that they may be off belay. If the slope is too steep for this, then a short rope attached to the head of the litter, with a figure 8 knot on the end and a locking carabiner, can be passed around a tree, several times if needed, and clipped back into itself to secure the litter during the belay change.

I have heard some people say that The Belayer should stay on belay until The Downhill Ropehandler is in position. However, if the litter falls while The Downhill Ropehandler is just into position as a new Belayer, and the old Belayer holds the fall, The Downhill Ropehandler could suffer a significant crush injury to the abdomen, resulting in potentially-fatal liver or spleen lacerations. No. The litter should briefly go off belay, secured in an alternate manner, as the belay is changed.

The Litter Captain has gotten the litter to that good place right below that Tulip Poplar you want to use for a belay tree. You're already in position above the Tulip Poplar, ready and waiting… As soon as you hear the “Belay Off! … Clear!” from above, you back around the tree enough times to provide adequate friction. As the new Belayer, you call “Belay On!”

And then we repeat the process, over and over, until we're done.

Tree belays can “girdle” a tree, removing the bark all around the tree, which kills it. You shouldn't do tree belays on trees with thin or delicate bark, such as Paper Birch, American Beech, Black Cherry or Ironwood. Large oak trees are ideal for a tree belay. As a conservation effort, some SAR teams have moved away from tree belays to always using slings and lowering devices. However, I think every SAR team member needs to know how to do a tree belay, so this requires practice. Many SAR teams tend to practice on the same hillside over and over. If you're just doing this with one person tied onto the end of the rope, rather than a full litter and litter team, you can do this on thick-skinned trees without worry. But if you've got thin-skinned trees, or are doing this with a full litter, then a bit of conservation-mindedness suggests scouting out good trees on the fall line up and down the hillside, and padding those trees with nice thick cotton duck pad wrapped completely around the trees at the appropriate height.

If you're doing a tree-belay semi-tech evac downhill during a real time-sensitive rescue, I recommend against padding the trees. Considering how much paper and wood we consume every day, a few trees can sacrifice their lives to potentially improve the medical outcome of the patient.
Speaking of time-sensitivity, if you're doing a semi-tech descent with racks or Scarabs or 8s instead of tree belays, there is no need to take the time to tie a wrap-3 pull-2 anchor around a tree. A doubled runner or girth hitch around the tree is quite sufficient for the load, and quite a bit faster.

So we've discussed how to carry a litter up a hill with a tree belay, and how to slide one down a slope with tree belays or another rappel/lowering device. We've also discussed rappelling to get you down to a bottom of a cliff. Now we need to discuss how to get you back up that rope hanging on the cliff, and how to get a litter up a slope that's just a bit too steep for the litter team to carry the litter. So that means:

**Ascending Devices and Systems, and Hauling**

### Ascending Devices

You can't do rescue these days without being intimately familiar with Prusik knots. We use them for tandem Prusik belays, we use them as ratchets for haul systems, we use them in Purcell Prusik systems; they're everywhere. This came after testing in the 1980s showed that mechanical ascenders failed low shock-loads, spectacularly, by either shredding the rope or exploding.

If you're new to SAR, you may therefore get the impression that Prusiks are good and mechanical ascenders are bad. But it's not that simple.

When, as a pre-teen, I first started ascending fixed lines in the 1960s, with Prusiks made of manila rope, we called it Prusiking rather than ascending, because people always did it with Prusik knots. In fact, the definitive book on ascending systems, by caver Bob Thrun, is even called *Prusiking*.

Of course, back in those days, manila Prusiks worked a bit better than nylon Prusiks, at least as far as ascending. They were easier to break loose from the static line, so you could move faster than with nylon on nylon Prusiks. But once we moved to nylon Prusiks on nylon rope, Prusiking was harder. So we tried things like Bachmann knots: putting a carabiner through the middle of the Prusik, so it was easier to break loose from the rope. A bit better, maybe as good as those old manila Prusiks. But people are ingenious and started working on even better ascending devices. There were tens of different ascender knots – we discussed the Headden knot, and its upside-down variant, the RBS knot, in the section on knots, as an improvised technique for making an ascender knot out of webbing – but none was really much if at all superior, and the Prusik is the knot that survived this period of climbing and vertical caving.

The first mechanical ascender I tried, in the mid-1960s, was the Hiebler ascender, created by European climber Toni Hiebler. This is described, with pictures, at verticalarchaeology.com/. After using them on one free ascent, I went back to Prusiks. They worked pretty well, in that they moved up the rope well, and gripped the rope well. Despite the fact that mine had the little safety clip shown in model (B) at verticalarchaeology.com/, I realized that if you wiggled them as moving them up the rope, or even looked at them wrong, they would fall off the rope. I later found out that they had been colloquially renamed “European Death Hooks” by North American vertical cavers.

The next ascenders I tried were called Jumars. They'd been made in Switzerland since 1958, but didn't arrive in North America until the late 1960s. I got a pair and liked them. They didn't fall off the rope! The Hieblers got tossed in the trash, but the Jumars are still in my vertical rescue bag. I read the instructions that came with them and rigged them as recommended, an experience I will relate in the next section, on ascending systems. Jumars used a spring-loaded cam, which means that the toothed cam is being pressed up against the rope all the time. This means you don't have to worry about the cam coming loose and the Jumar slipping down the rope. It also meant a bit of friction as you pulled up the Jumar; and, if you were right at the beginning of the ascent, you needed someone to hold the bottom of the rope for you, else the Jumar would simply drag the rope up instead of moving up the rope. Either that our you had to get your thumb on top of the cam and press it down as you lifted the Jumar up the rope.

But once you got going with Jumars, they were fast. Really fast. Prusiks you had to loosen and then push up. Jumars you just pushed up. With Jumars, you could go four or five times...
faster than with Prusiks. For climbers ascending fixed lines, or even more for vertical cavers coming up out of deep pits, life was good. To this day, European climbers don’t talk about ascending a rope, they talk about Jumaring it, regardless of what brand of ascenders they use.

The only problem with the Jumars is that they were clearly designed to be used in your hands. They had handles. There was no real way to attach them to different parts of your body.

And so, in 1965, Charlie Gibbs, a vertical caver, developed the Gibbs ascender. Designed specifically to be attached to parts of your body, not operated by your hands, the Gibbs ascender had no handle. It also had no spring (later you could get spring-loaded versions, but you could still easily disable the spring). The cam was held against the rope by the weight of your body hanging on it. When unweighted, the Gibbs would slide freely on the rope, meaning less effort to pull it up.

I remember seeing Gibbs first demonstrated with an ascending rig called the Ropewalker, at one of the annual conventions of the National Speleological Society. I think Don Davison did the demo for Charlie. Now Don was in great shape and an experienced vertical caver. But still, seeing Don moving up a rope twice as fast as a Jumar rig would allow. And with his hands free, using just his legs. I was impressed. I got a set of Gibbs and a ropewalker rig and started using it right away. For long drops in caves, this was far superior to Jumars. For one thing, your legs are much stronger than your arms, so letting your legs do most of the work makes sense; you move faster and you’re a lot less tired at the top.

We’re getting a little ahead of things by discussing systems rather than ascenders, but when I first starting using Gibbs for vertical caving, we used a simple system for using lengths of 1” webbing to tie a Gibbs onto the right foot, another one onto the left foot with a sling that brought the Gibbs at knee level, with a loop of webbing above the knee to hold it in place, and the tail tied to your seat harness for safety. A third Gibbs was tied to a length of webbing that went from your seat biner up and over your right shoulder, where the the Gibbs was tied in place, then down your back to where it was tied onto the back of your seat harness. A variant we quickly learned to use was to run a bungee cord from the knee Gibbs to the shoulder webbing, rather than relying on the wrap around the knee to bring up the Gibbs. This crude ropewalker rig got me up any number of 100’ and sometimes 200’ pits.

Today, there are many brands of ascenders, though it seems that Petzl, a French company that started out manufacturing caving equipment, tends to dominate. Spring-loaded ascender seems to predominate over the old Gibbs free cam design. You can get ascenders with or without handles. Though handles are handy for some applications, they also encourage you to pull yourself up by your arms, rather than using your legs.

To some degree, now that we have lots of good brands of ascenders available, what matters more than the brand of ascender is how you attach them to your body and use them as:

**Ascending systems**

Back in the old days, when we were using manila Prusiks, and even with nylon Prusiks, once those were available, the standard rig was a three-knot system.

Attach one Prusik to your seat harness, so that the Prusik is on the rope at a low chest height.

Attach another Prusik to your right foot. The Prusik on the rope should be well below your seat Prusik, at about the knee level.

This Prusik is not a simple loop, but a bowline or figure 8 loop with a long tail, and in this tail is another bowline or figure 8 loop sized to fit your foot. Some people would tie a slip knot instead, so the loop would cinch around your foot. Others found this painful on their foot, so would tie a bit of rope onto the loop to go around the back of your heel, or a bit of elastic to go all the way around your boot. These are sometimes referred to as “chicken loops” though most people put them on not out of fear, but more out of frustration with having to put the loop back on a foot while ascending a rope. The third Prusik attaches to the rope above your seat Prusik, at about shoulder height, with a long tail down to your left foot.

Some variants have both foot Prusiks attach to the rope below the seat harness. Where you attach the foot Prusiks seems a matter of taste, not a matter of safety or efficiency.

To use this system, you stand up on both your foot Prusiks while quickly sliding up your seat Prusik at the same time; as soon as the seat Prusik’s up a foot or two, you sit back down in your seat harness. You then move one foot Prusik up, then the other. Your then stand up on both foot Prusiks, while quickly sliding up
your seat Prusik at the same time; as soon as the seat Prusik's up a foot or two, you sit back down in your seat harness. And you repeat, over, and over, and over...

Now that we’re talking about ascending systems, let's combine this thought with a thought from the last section, the European Death Hook. What happens if you’re using European Death Hooks instead of Pruskis. What if, just as your moving the seat Hiebler up, it falls off the rope?

If you are lucky, and don’t fall to your death, you may be hanging upside down by two broken ankles. Thinking about it a bit more, perhaps the quick splat death would be a better outcome.

Redundancy is a core principle for ascending systems. Double-redundant, as in the double-redundancy of the ASRC Seat Harness, is what you want for your ascending system. Or, since this is a three-knot system, how about triple redundancy.

How? Simple. Just run a sling, or another tail with a figure 8 loop in the end, from each of your foot Pruskis to your seat harness. It takes a bit of work to get the lengths just right, so you can pull the Pruskis up without being limited by your safety, but it’s not hard to do this. So now, any two of your knots could fail, and you're still sitting in your seat harness and able to recover.

There are many variants on this ascending system. One of the most popular is the Texas inchworm system. You set up one Prusik for your seat harness, and a single additional one that goes to both feet. So, you’re moving just two Pruskis up the rope: more efficient. Faster.

When I got my first set of Jumars, I eagerly looked at the little piece of paper that came with them that described how to use them.

The first rig I tried was what was shown in picture on that little sheet of paper. You take two long loops of small-diameter kernmantel rope and girth-hitch each around the bottom of the handle of the Jumar, then tie a slipped overhand in the other end. You slip these over your boots. The loops are adjusted so that the Jumars are at chest height or a bit above. You tie a chest harness (that crossed-loop chest harness I dissed in the knots section) and clip a carabiner into the front of the chest harness, and around both of those rope slings from your Jumars to your feet. I kid you not, this was how the instructions told you to use them.

After trying this once, I realized it didn’t work too well. In fact, it sucked royally. It relied on your arm strength to keep you upright. If you leaned back on your chest harness, your feet went far forwards, and you were hanging from the Jumars by your hands. And when your arms tired out, you ended up sliding down your slings, still clipped to your slings by your chest harness carabiner. You ended up curled up in a little ball, with your feet under your chin, and the Jumars far out of reach overhead. Perhaps this is why this became known, by North American cavers, as the “Jumar death rig.”

Now, unlike the Hiebler “European Death Hook” ascenders, there’s nothing wrong with Jumars as ascenders. It’s the rig, the system, that’s the problem in the “Jumar Death Rig” and not the ascenders.

So if you want to ascend safely and efficiently, you need good ascenders and a good ascending system.

And since Jumars are good ascenders, let me tell you a story about how to use Jumars the right way. First a digression. Have you heard about Speleo-Olympics? These are games that pit cavers against each other in games of caverly skill.

They occur at the annual National Speleological Society convention, and at Old Timer’s Reunion (“OTR” to caver-cognoscenti) in West Virginia each summer. (That’s the thing that’s held at an “undisclosed location.”) However, the OTR games also sometimes include unofficial contests like jousting while sliding across a Tyrolean traverse.

Some of the contests are pretty tame, like being given a bowl of parts, and assembling them into a carbide lamp (uses calcium carbide and water to generate acetylene gas for a flame inside a reflector; it was a standard caving light for almost a hundred years) and getting the light going, as fast as you can. While blindfolded. And cable ladder climbs – my daughter won that one for her age class at Old Timer’s Reunion a couple of years ago.

But others are a bit more challenging, such as obstacle courses. Just imagine what a caver’s obstacle course would be like. While working in the OTR medical tent, which is actually a pavilion with a roof, concrete floor and tarp walls) I saw one guy who dislocated his shoulder during the obstacle course. But being a tough caver, he finished the course. And won. And only then he came to the med-tent. I had another guy who managed to get a corneal laceration from being dragged through a gravel crawl on his face (that one you could have an assistant for). He wouldn’t go to the ED, so I sterilized the scissors on my
Swiss Army Knife and used it to trim off the little flap of corneal epithelium that was hanging off his eye so it would heal better.

At the Speleo-Olympics, the vertical contests are the big deal. Cavers actually train for years, and tweak their ascending rigs over and over, so that they can get the best times ascending various lengths of rope the fastest.

I’m not talking about the vertical hell contest, which is different. The vertical hell is a bunch of – well, long things – tied or clipped together to simulate a vertical rope. There have been lengths of chain, and even a kitchen sink. Needless to say, Prusiks work better on this than mechanical ascenders.

But the big contest is the 30 meter rope climb. And now to the story.

Once upon a time, the University of Virginia Cave Club was having a vertical practice in the gym. A rappel rack was rigged to an anchor in the gym floor. A 300’ (100 m) rope was run through this rack, up to a pulley on a girder on the ceiling, thence down to the floor. So as you climb up with your ascenders/ascending rig, someone could lower the rope through the rappel rack. This way you could simulate climbing a 300’ (100 m) pit.

Well, this same weekend, Gene Harrison, one of the ASRC’s founders, was in Charlottesville for a conference. And none of the UVA cavers in the gym knew Gene - who was not only an experienced caver, but also a leading contestant in the 30 m vertical climb at the Speleo-Olympics. And Gene had his truck with him. With his vertical racing rig.

Now, his racing rig was a kind of hybrid system, a Mitchell-ish sort of system (search the Web for “Mitchell ascending system”) with Jumars but with double rescue pulleys on the shoulder rather than the chest.

Thirty-five years later, Gene says he still has this rig. Great for racing as long as you have strong arms, but a real bitch to get over an edge. It won him multiple races.

So we worked out a plan. When Gene got a lunch break, he wandered over to the gym. In his coat and tie. So Gene was standing there with his mouth open, looking at people practicing with their rigs. I was sitting there getting into my rig (actually Gene’s racing rig) when Gene said “Gee, guys, that looks like fun. Can I try?”

So I offered to let Gene use my (his) rig to try to ascend the rope. So Gene fumbled as I showed him how to rig onto the rope. And then started very slowly and unsurely up the rope. “Gee, this is hard. Hang on, I think I’ve got the trick now…” and Gene started moving up the rope so fast the person on the rappel rack could barely let out the rope fast enough.

Seeing the expression on the faces of all those experienced vertical cavers was wonderful. The points being (1) cavers put an insane amount of thought, time, effort and money into their ascending rigs, (2) a good ascending system can let you move up a rope quite efficiently, and (2) a good ascending system is one where you’ve adjusted everything to be just right for your body, and with which you’ve practiced.

There are a couple of other principles that apply to ascending systems. The ones that are best for long free drops tend to be cumbersome to get on and off the rope. But the ones that are easy to get on and off the rope tend to be not so good if you’re facing a long drop, or if you’re out of shape.

If you’re a dedicated vertical caver now getting into SAR, you probably have an ascending system that has been tweaked over and over and that’s what you’ll use. If you’re a dedicated lead climber who also ascends fixed lines, you likely also have an ascending system that’s been tweaked over and over and that’s what you’ll use. The two systems are likely to be quite different.

If you’re about to invest in ascenders and an ascending system, you would do well to search the web for “John Charles Woods ascending.”

You will find John’s page devoted to discussion of, and testing of, the currently most common ascending systems, the Mitchell and Frog systems.

But if you’re new to SAR, and you need an ascending system, and you want to start with something cheap (Prusiks) before you consider investing in fancier systems or more expensive ascender, you should build yourself a:

**Purcell Prusik: Lanyard and System**

The Purcell Prusik was developed by Arnor Larson and named after the Purcell Mountains.
of southeastern British Columbia. The term Purcell Prusik now seems to be used in two ways. First, it can refer to a complete three-knot Prusik system.

Second, it can refer to a specific way of tying a lanyard. Let’s deal with the second meaning first.

Purcell Prusik Lanyard

The Purcell Prusik (lanyard sense)* is a 16' (5 m; though some say the original specified 3.5 m) length of 6 mm nylon kernmantle rope, tied with a figure 8 loop in one end, and the other end doubled back on itself into the figure 8 knot. That long bight is tied back on itself with a three-wrap Prusik. This makes an adjustable tie-in/lanyard that, because the Prusik is tied onto doubled rope, can even be adjusted under a bit of tension. It also tends to slip a bit under a shock load, which provides a bit of protection against shock loads. In 2005, Mike Gibbs presented some information at the International Technical Rescue Symposium drop-testing existing lanyards: daisy chains and the like.† Conclusions: never, ever use Dyneema or Spectra or the like for a lanyard for rescue. And, no commercial climbing lanyards are good for rescue. In 2006, Mike presented another paper, in which he presented testing of a Purcell Prusik as a vertical rescue lanyard.‡ Conclusions: a Purcell Prusik is an acceptable lanyard for vertical rescue shock loads, but commercial alternatives are not.

If you’re looking for a general-purpose lanyard, for example, for tying into a safety line at the top of a cliff or the edge of a pit, or for vertical rescue to tie in as a litter attendant, this is what you want. Tie the Prusik-loop end onto a safety line or clip into the vertical rescue litter rigging, and clip the small figure 8 loop into your harness. The theory is that if you panic and grab the lanyard, you’ll grab the figure 8 instead of grabbing the Prusik and loosening it. This reasoning seems a bit sketchy to me. But it’s good to have a standard way to use this. And, if you’re trying to shorten the lanyard with one hand while holding onto something with the other hand, it’s easier to pull down on the Prusik to shorten the lanyard.

As you’re tying this only to use as a lanyard, remember to make the figure 8 loop small, just big enough to clip into a carabiner. This allows you more room to adjust the Prusik loop and make it smaller. On the other hand, if you’re making two to use as foot Prusiks as well as maybe a lanyard, as described below, make the figure 8 loop big enough for a double-wrap Prusik on the static line.

Purcell Prusik System

The Purcell Prusik system, in the sense of an ascending system, is the basic three-knot ascending system that I used to use with manila Prusiks back in the 1960s, with the seat Prusik above the two foot Prusiks. The seat Prusik is a simple Prusik loop, but the two foot Prusiks are Purcell Prusik lanyards; if you’re using your Purcell Prusik lanyards this way, you need to make the figure 8 loop at the end big enough that you can tie it onto the rope as a Prusik knot. You use the Prusik end of the lanyards to adjust the loops firmly around your boots. This has the advantage over slip knots that they won’t constrict further and squish your foot.

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In the National Cave Rescue Commission, this is called a Quick Attachment Safety.

† Daisy Chains and Other Lanyards: Some Shocking Results when Shock Loaded.

‡ Lanyards Part II: An Examination of Purcell Prusiks as Personal Restraint Lanyards.
A note about using a Purcell Prusik system; since this is used for personal ascending, not for rescue loads, the Prusiks you tie onto the static line as two-wrap Prusiks. These hold a body weight just fine and are much easier to loosen and move up than a triple-wrap Prusik. However, the Prusik adjustable loops are always tied back onto itself with a triple-wrap Prusik. This Prusik is tied back onto doubled 6 mm rope, and experience shows that a two-wrap Prusik just won’t hold for this adjustable loop.

Tie the two foot Prusiks with 6 mm nylon kernmantle rope. Even though you will tie one shorter and one longer, so that one Prusik is above the other on the static line. You tie the foot Prusiks with equal lengths of 6 mm rope. (Which is not what some people will tell you.) Tie one full-length, and the other shorter as in the picture. For the shorter foot Prusik, use the extra length as a long tail coming out of the big figure 8 loop, and tie a single small figure 8 loop on the end, just big enough to clip into your seat harness. The original version didn’t have this extra tail, but this is what gives you double redundancy.

You can use the lanyard standard of 16’ (5 m) for each, or you can cut them to fit your height per the length tables in the sidebar (adapted from swiftwaterrescue.com); I’d recommend the latter. Rick Weber’s diagrams, reproduced here, also show you how to fine-tune the sling sizes for your body size. This will make you significantly more efficient ascending a rope.

You tie the seat Prusik as a single loop of 6 mm nylon kernmantle rope, tied with a double fisherman’s knot.

Although animatedknots.com has some excellent diagrams of how to tie a Purcell Prusik, you should ignore two things on this page.

First, their drawing of the Purcell Prusik system does not show the redundant safety to the seat harness that is required for this to be a safe ascending system.

Second, the list of lengths they provide advise using a shorter length for the short foot Prusik, but this does not consider the extra tail needed for double-redundant safety.

Of course, even if you’re making a set of Purcell Prusiks as an ascending system, you’ve also got two lanyards that will serve well for vertical rescue.

So now we’ve discussed personal ascenders and ascending systems, used to get you up a cliff or out of a pit. Now let’s discuss how to get a litter up a slope that’s too steep for a litter carry, using:

### Haul Systems: Brute Force, Z-Haul, 4:1

Haul systems are a big deal in technical rescue. Cave rescue, mountain rescue, fire rescue, EMS rescue, industrial rescue, all emphasize haul systems. You are expected to memorize the setups for different strengths of haul systems, and regurgitate the theoretical and actual mechanical advantage for each. There are T-shirts that have common haul systems on them, upside down, so you can look at them as you’re setting up the haul system. Being able to estimate the stresses in such systems, given the angles involved, especially for an operation involving a Tyrolean traverse ("highline" but that’s such a boring term in comparison) can be important: tension a Tyrolean traverse too much, put even a small weight on it, and the stress can rip out a 4-foot diameter, 300-year-old oak tree. While this may be a safety concern, it’s also a conservation issue; we don’t have that many 300-year old oak trees. But, we don’t use haul systems for nontechnical evacuations, and we only use very simple haul systems for semi-tech evacs. If it needs a complicated haul system, or a Tyrolean traverse (highline), it’s technical rescue and not a semi-tech evac. So no T-shirts, no complex calculations, we’re just going to do some very, very simple haul systems here, and leave all that esoteric technical stuff for another time and place.

Yes, even in the simple haul systems you will learn here, you can get fairly high stresses, and you need to notice this. But it’s not a big worry like it is in technical rescue.

For our consideration of semi-tech haul systems, let’s consider a very simple for-instance.

### An Illustrative Example

A big man (250 lb = 115 kg), a tourist from Kansas, was driving along Skyline Drive in Shenandoah National Park with his wife. They stopped at the Timber Hollow Overlook in SNP’s Central Section (see map and pictures). With some effort, he clambered over the very short rock wall and ambled over to the flat rock you see in the picture. While taking a picture of the Shenandoah Valley below, he lost his balance, and rolled over the grassy edge, and down onto the Appalachian Trail below. He rolled down a 45 degree grassy slope, about 100’ (30 m) and is
lying on the flat but narrow trail below. Medically, he seems stable, without any obvious injuries other than scrapes and bruises all over. But he does have some abdominal pain and mild right upper quadrant tenderness, and he says he can’t walk, just because he hurts so much “all over.”

You look at the options. You could do a carry along the Appalachian Trail to the nearest road crossing, using the wheel on your litter. But it’s about a mile (about a kilometer and a half) north to the nearest direct road access to the Appalachian Trail. You look at the narrow trail, and you look up the grassy slope about 100’ (30 m) up to the overlook. Neither way looks all that good, but this guy has abdominal pain and probably needs a CT of his abdomen. So you need to get him out soon. There’s a park ambulance responding, and you’ve got a Stokes, several ropes, and about 50 pounds of rescue gear in the truck. You think wistfully about simply using the winch on one of the maintenance trucks but none are anywhere nearby. You think about getting a tow truck. Tow trucks are great for this sort of thing. But you know from experience that getting a tow truck to this point on Skyline Drive will take a couple of hours. And you look around. You’ve got three other NPS Rangers right now, and you will have a few more in just a few minutes. But there’s an entire Student Conservation Association trail crew working a tenth of mile south on the Appalachian Trail, with about 15 very fit young people who love nothing more than a challenge. Indeed, they hear the commotion and just wandered over to see if they could help. They are already covered by insurance and worker’s comp, so there’s no reason you can’t use them to help.

You get the overlook blocked off so that you can have the entire area to work with. The island between the overlook and the Drive proper has a couple of just perfect anchor trees about 30’ (10 m) apart, about 50’ (15 m) from the edge.

You start at the southernmost of the two big trees on the traffic island. You walk a straight line, perpendicular to the wall and the edge, right to the edge. You look below, and straight down below you is the patient. You turn to the other NPS Ranger. “This,” you say, “will be easy. And fast. We’re going to do this the minimalist way.”

You go to the rescue truck, and grab the following:

- A 300’ (100 m) rope,
- Two locking D steel carabiners,
- Two rescue pulleys,
- Two lengths of webbing for anchors,
- One set of tandem Prusiks,
- Eight extra Prusiks,
- Four rope pads,
- Some leather gloves,
- Four lengths of webbing for load straps,
- and nothing else.

You figured it’s time to do a brute force haul and get this guy up the slope, into the ambulance, and out of your park as soon as possible.

You get a couple of your fellow Rangers to rig a wrap-3 pull-2 anchor on each of the trees, with a carabiner and rescue pulley on each, and the set of tandem Prusiks on the southernmost tree. You send the litter down the slope with the end of the 300’ (100 m) rope rigged properly into the head of the litter. Given the size of this man, you pick your four strongest people as litter bearers, and send them down with the litter.

You rig the rope through the pulley on the southernmost tree, and attach the tandem Prusiks. You assign the most experienced of your fellow Rangers to tend the Prusiks. You then route the rope through the rescue pulley on the northernmost tree, and then cast it down the slope, about 30’ (10 m) north of the patient. You place rope pads both on the wall and on the edge; you decide to move some large rounded rocks to be under the rope pads at the edge, as it’s just dirt and grass. The SCA kids volunteer to do this “We’ve had lots of experience moving big rocks!”

You pick eight of the SCA volunteers as a haul team. Thoughtfully, they’ve brought their own leather gloves so you don’t need to get any more out of the truck. You spend a few minutes briefing them.

“Listen up! We’re going to be doing what’s known as a brute force haul.”

“You are going to pull on this rope, and that’s going to pull the litter up this slope. See that
set of Prusiks there? If you slip, those Prusiks will keep the litter from slipping back downhill. Jenny there will be tending the Prusiks to make sure they don't jam and to make sure they set if and when we need them.

"All of eight of you will be holding onto this rope here, and as you pull down on it, it will pull up the litter over there. You could all hang onto the rope and pull down, then set the Prusiks, climb up the slope, and then repeat it. But there's a more efficient way to do this.

"We'll divide you into two teams of four; you four and then you four. Bill, you will be the top hauler in the low team, and we refer to you as THE BELAYER. Don't worry about the title, I'll explain what your job is in a minute.

"You all know about Prusiks, from your trail work, right? Good. So all eight of you start spaced out about 20 meters up this rope, a couple of feet apart – just enough so you're not trampling on each other's feet. Good.

"Now, attach your Prusiks and hang onto them with your hands; remember to wear your gloves. "Good. Everyone in position?

"Now, Bill and the three of you below him will hang onto your Prusiks, leaving the locked on the rope, and haul down until you're hitting the Appalachian Trail, that's about 20 meters, yards, whichever you prefer. Bill, you keep an eye out behind you, and when the bottom person hits the trail, you will call "READY ... SWITCH!" nice and loud.

"The four up you up top, while they're hauling down with fixed Prusiks, you'll be sliding your Prusiks up the rope and using the rope to haul yourselves up the slope.

"When you hear Bill call "READY ... SWITCH!" those of you on top will fix your Prusiks and pull on the rope with your whole body weight.

"Bill, you and your three will at that point be hauling yourselves up the rope, sliding your Prusiks as you go. And when you're about to run into Jennifer there, you call out "READY ... SWITCH!" and all of you on the bottom fix your Prusiks and start riding downhill. And of course those of you on the top start climbing up the rope with your Prusiks.

"Frank, once the litter gets to the edge and jams there, call "STOP!" and Jenny will set the Prusiks. Then all of the extra people at the edge will help muscle it up and slide it over the edge.

"Any questions? No?

"Jenny, you ready on the Prusiks? Good.

"Frank, are you and the litter team ready? Yeah, just let the haul team do all the work of getting the litter up this hill. You just have to keep it up off the slope. Did you show everyone how to use the load straps? Good, that'll make it a lot easier for you. Just hang onto the litter and allow the rope to pull you up. Don't try to lift the litter up until the rope takes most of the weight.

"Haul team, start hauling!"

And in a matter of a few minutes, the litter is at the edge, muscled over, and then the patient is placed into the waiting ambulance.

Mechanical Advantage

The brute force haul can be an effective technique when you have plenty of room, and plenty of people. It requires minimal equipment, and minimal knowledge of rigging. Even if people haven't done it before, some "just-in-time training" usually suffices. It works a bit better if your haul team can affix their Prusiks to seat harnesses, but simply hanging on the Prusiks works pretty well. In this case, if you found that your haul team didn't have enough oomph to overcome the friction in this system, you could fix the Prusiks, and take a couple of minutes to get them all into seat harnesses; even a quick-and-dirty diaper seat would work for this. This particular haul used a haul team of eight, and four litter bearers; the diagram shows a haul team of six and a litter team of three. Depending on the angle of the slope and the weight of the patient, you'll need to adjust your numbers. You can also
Nontechnical and Semi-Tech Evac Calls

**Clear!** A call by The Belayer during semi-tech evacuations, uphill or downhill: the rope is clear of the tree or belay device and ready to switch over to the next tree or belay device.

**Down Fast!** Lower the litter down somewhat faster. Usually a call from The Litter Captain to The Belayer.

**Down Slow!** Lower the litter down slowly. Usually a call from The Litter Captain to The Belayer.

**Falling!** I am falling, or the litter is falling.

**Haul!** Pull on the haul line. Call from the member who has just reset the haul Prusik to the haul team.

**Ladder!** In the context of toenailing a litter up a short steep bit, or across an obstacle, from the new Litter Captain to the litter team: keep your feet planted, and lift the litter a short distance up the hill or across or around the obstacle to where the two new litter bearers can grasp the litter rail.

**Off Belay!** From The Litter Captain, or a climber, or a rappeller, to The Belayer. I no longer need to be belayed. Paired with a call from The Belayer: Belay Off! (The Belayer always says the word Belay first.)

**Off Rope!** I am no longer attached to the rope. May be qualified, such as Off Rope Red! or Off Rope Line 3! May be used after a rappel, an ascent, or after being belayed.

**On Belay!** From The Litter Captain, or a climber, or a rappeller, to The Belayer. I am attached to the belay rope and ready to be belayed. Not a question. Paired with a call from The Belayer: Belay On! (The Belayer always says the word Belay first.)

**On Rope!** I am attached to the rope. May be qualified, such as On Rope Red! or On Rope Line 3! Used mostly for rappelling and ascending.

**One-On!** In the context of a downhill semi-tech evac, from The Litter Captain to The Belayer.

**Preload!** In the context of a downhill semi-tech evac, from The Litter Captain to The Belayer; do not let any rope slip as we load the rope. The Belayer echoes.

**Ready!** Prepare to lower; sound off if not ready; pull out and squat to gently set the litter down.

**Ready to Ladder!** In the context of toenailing a litter up a short steep bit, or across an obstacle, from The Litter Captain to the litter team: front four bearers, plant your feet, shift your hands back a bit, and the back two bearers peel off and move up the hill or across or around the obstacle to the head of the litter.

**Ready to Rotate!** During a nontechnical evacuation, from The Litter Captain to the next set of relief bearers: step off the trail and be ready to grab the back of the litter when we come through.

**Reset!** Drop the haul line and move the Z-haul Prusik back toward the load. Call from the member who checked that the ratchet Prusik has gripped the rope to the rest of the haul team.

**Rock!** Something is falling; something other than me (see Falling!). All echo.

**Rope!** I am casting a rope over a cliff or into a pit. Watch out, and also if you can, check to see if the rope made it all the way to the bottom.

**Rotate!** During a nontechnical evacuation, from the new back-left litter bearer to the litter bearers ahead: I and my partner have hold of the litter and it’s time to start shifting forwards on the litter.

**Set!** Gradually release tension on the Z-haul line until the ratchet Prusik is engaged. Call from the member best able to see that the team can make no more progress.

**Slack!** Let out some rope. May be quantified as, for example, Slack One Foot! The Belayer echoes. (Sometimes used instead of Reset! in cave rescue)

**Stop!** Meaning 1: In the context of a technical rescue or semi-tech evac, from anyone to everyone: major safety issue, everyone stop! Everyone echoes. Whistle equivalent: 1 Short Whistle (NCRC standard, ASTM rope rescue standard) Meaning 2: In the context of a nontechnical litter carry, from The Litter Captain to the litter team: stop walking.

**Stop, Stop, Why Stop?!** Why has movement stopped? or, Why is progress delayed? Usually a question from The Litter Captain to The Belayer. Concern is that the lowering has stopped; the lowering rope has snagged, and a dangerous amount of slack may be developing in the upper portion of the lowering rope if The Belayer lets out more rope. Everyone echoes. Developed by the National Cave Rescue Commission but appropriate to above-ground rescues as well. The series of four words, even if the actual words cannot be made out, is an easily-recognizable call for a potentially fatal safety problem. Whistle equivalent: 4 Whistles (not NCRC standard but should be)

**Tension!** Take any slack out of the line but don’t lift or move the litter or climber. Usually a call from The Litter Captain to The Belayer. In technical rescue, may be Tension Main! or Tension Belayer! The Belayer echoes.

**Two-On!** In the context of a downhill semi-tech evac, from The Belayer to The Litter Captain and The Downhill Ropehandler; you’ve got about 10’ (3 m) of rope left.

**Up Fast!** Haul the rope/load up faster. Usually a call from The Litter Captain to the haul team. The response No can’t- Way! is not an accepted call. The leader of the haul team echoes.

**Up Rope!** From The Litter Captain or a climber: take in the belay rope; or, take in the belay rope faster if you can.

**Up Slow!** Haul the rope/load up slowly. Usually a call from The Litter Captain to the haul team. The leader of the haul team echoes.
have the litter bearers wear seat harnesses and tie into the litter rail with a Prusik loop. This provides a bit more security if the slope is particularly steep or exposed.

Since the Prusiks won’t be holding more than a fraction of body weight, you could easily substitute any ascender of your choice for your haul team.

There’s a tradition in vertical rescue that the haul team never attaches anything to the haul line, using only their gloved hands. But for a brute force haul like this, Prusiks (or ascenders) are both safe and effective.

Sometimes, though, you need to haul a litter up a slope and you have plenty of equipment, but not enough room on the slope for a brute force haul. But you can use pulleys and Prusiks to create a simple haul system. We won’t get into the details of how to, for example, create a 16,000:1 haul system, we’ll stick with a simple system known as a Z-haul.

The Z-haul is a straightforward 3:1 (theoretical) haul system, meaning if there were no friction, the force with which they effectively haul is three times as much as if they were hauling with a brute force haul. Thus a haul team of three is the equivalent of a brute-force haul team of nine.

As a consequence, though, everyone on the haul team will have to haul three times as much rope as they would with a brute force haul.

There are two variants of the Z-haul. The simplest is done with a single rope.

You tie the rope onto the head of the litter as usual. You place a wrap-3 pull-2 webbing anchor on the tree anchor. You attach a locking carabiner, rescue pulley and tandem Prusiks to the webbing anchor rig. If you have a load-releasing hitch and want to put it between the rescue pulley and the webbing around the tree, that’s OK. It’s the standard way we rig hauling for a vertical rescue, and with good reason. However, if you’re just hauling a litter up a slope with no cliffs or ledges, then the chances of you needing to use the load releasing hitch to lower is nearly infinitesimal. So rigging this without a load-releasing hitch is fine from a safety standpoint. If your team doesn’t do anything more technical than a Z-haul, I’d say forget the load-releasing hitch, it’s just something that is likely to confuse people, or get rigged wrong.

But if you are from a team that does technical rescue and says “always rig any mechanical advantage system with a load-releasing hitch” to form good habits, that’s OK. Forming good habits is important. But if you’re from one of these “always use a load-releasing hitch” teams and you’re working with a team that does Z-hauls without one, don’t start screaming about how unsafe it is. You’re wrong, it’s not significantly safer, and you’re might get flat-rocked. That’s a technical cave rescue term that I won’t explain except to say that hitting someone on the head with a pointy rock usually leaves visible evidence. Just kidding. I hope.

As in the diagram, the rope comes up, through the tandem Prusiks (“Prusik #2” in the diagram) and through the rescue pulley, then down to and through a second rescue pulley that’s attached to a single Prusik on the haul line (“Prusik #1” in the diagram) then off to your haul team.

The one major disadvantage of this system is that your haul team is pulling uphill. You can fix this by adding a third rescue pulley on your anchor tree. This is called a direction change pulley. We will not get into details of how to analyze the exact mechanical advantage of such a system, so just take my word that this is still a 3:1 haul system with a direction change.* If you have a hard time figuring this out, join a vertical rescue team or get one of the technical rescue references out there. Or better yet, get that T-shirt with the upside-down mechanical advantage systems on it, and wear it on a regular basis.

If you need the entire length of your rope for the slope, and you have a second rope, you can set up a Z-haul just as described and shown in the diagram. But instead of attaching it to the load, you attach it to a Prusik on a separate main line. You’ll need a rescue pulley and tandem Prusiks for the main line, to capture progress in the main line, and allow you to reset the Prusik you’ve attached to the main line. You’ll also need

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* If you just can’t stand it, and really, really need to know how to analyze such systems, search the web for and read “Understanding Mechanical Advantage in the Single Sheave Pulley Systems Used in Rescue Operations.”
a person to tend the pulley/tandem Prusiks. For such a piggyback Z-haul, you can omit the tandem Prusiks shown as Prusik #1 in the diagram.

If a 3:1 Z-haul isn’t enough to lift your load, you can set up a 4:1, 5:1, 6:1, 8:1... If your SAR team does technical rescue, you’ll need to know these. But the only one of these that is required of an ASRC FTL is a 4:1, and so that’s all we’ll cover here.

The principles are the same as with a 3:1 Z-haul, but you need additional equipment. While you can rig such systems with special rescue pulleys that have an attachment point at both the top and at the bottom, I will assume you don’t have them, and are just building a system from rope, Prusiks, carabiners, and standard rescue pulleys.

You will need two ropes, or perhaps a single long rope tied to the anchor with a figure 8 knot in the middle of the rope, which effectively gives you two ropes with which to work.

You will need to rig the pulleys as shown on the diagram this page. While this gives you additional mechanical advantage – useful if you are short on haul team members, or don’t have room for more haul team members (common in cave rescue), this will help you. But you have to realize that you will be doing Set! Haul! Reset! much more often, which slows down the haul process.

**Haul Calls**

There are several standard calls to use during a haul.

One rope team member is assigned to set the Prusik closest to the litter (Prusik #1 in the diagram). If this is you, you make sure the Prusik is set, and then you call “HAUL!” This tells the haul team to pull. As this is a mechanical advantage haul system, even if a weak one, it’s traditional for the haul team to not be attached to the haul line by Prusiks. The haul team can move, but usually, they stay in place and simply pull on the rope.

One member of the rope team, usually the same person who set the Prusik on the line (Prusik #1), is in the best position to see when that Prusik is getting close to the pulley and tandem Prusiks on the anchor (Prusik #2). When you see this, you call “SET!”: this is a signal to the haul team to slowly and gradually release tension on the haul line. You’ve usually got another member tending those tandem Prusiks: THE BELAYER. Once THE BELAYER is sure that the load is on the tandem Prusiks, he or she calls “RESET!” and the haul team drops the haul rope, and you grab that Prusik #1 and slide it back down the main line, as far as you can given the terrain. You set that Prusik #1 and call “HAUL!” and the sequence repeats, as many times as needed.

**Evacuation Route Selection, Urgency, and Operational Friction**

We discussed operational friction earlier: what differentiates a smooth-running operation from a SNAFU. As an emergency physician, and in particular as an emergency physician at a Level I Trauma Center/Burn Center/Stroke Center/Cardiac Cath Center, I have spent ~30 years dealing with and thinking about operational friction. All emergency physicians do; we have to.

The nature of our practice, involving unknown volumes of unknown patients with unknown problems, presents a worst-case situation for managing medical operations. Other parts of the hospital, such as the Operating Room, and other physician practices, worry about operations, and work hard to maintain a smooth flow. But they don’t feel the same pressures we do in...
the Emergency Department. Given in SAR we face emergency time-urgent operations, but rarely, perhaps we can learn some lessons from the ED.

There are many things you can do in the ED to decrease operational friction. One of them is moving from a serial process to a parallel process. It used to be the standard process all across North America that if you came into the ED walking or in a wheelchair, you first went to Registration, where a clerk would obtain information about your complaint, your insurance, your address, and have you sign a bunch of forms. Then you would be seen by a "triax" nurse who "triaged" you. Actually the way this evolved, it had almost nothing to do with triage. Nurses were forced to do a full "nursing assessment" gathering all sorts of useful but non-emergent information, such as when you had your last flu shot, and whether or not you smoked, and your fall risk. Then you got taken to a room where you waited to be seen by a doctor.

Now our ED does this in parallel. You come in, you're seen by a triage nurse who actually triages you. If you've got something bad, you go to a high-acuity area of the ED. If you've got something not so bad, you go to a lower-acuity area of the ED. But as long as there's a room available, you go back to a room right away.

The next person to see you might be the registration clerk. Or the nurse. Or the doctor. It all depends on who's free. Sometimes it's all three. It's done in parallel. This really speeds throughput. Can we use parallel processing in SAR evacuations? Certainly. If it's a long evac, we can have a small team well ahead of the litter, figuring out the best route, clearing it a bit, and flagging it with flagging tape, maybe even flagging good belay trees, or perhaps setting up belay anchors ahead of time. For cave rescues, we can preplan how many people we need to "pave" or "turtle" an area, and make sure they are standing by, briefed, and ready to pave or turtle right before the litter gets there.

As I type this, there is a focus in the media on emergency care for stroke.* There are different kinds of stroke. One is a hemorrhagic stroke: bleeding in the brain, commonly from untreated high blood pressure. But the more common kind is what we call an ischemic stroke. Ischemia means lack of blood to an area. Like in your butt when you're on a backboard. So an ischemic stroke is blockage of an arterial blood vessel. This can come from disease of the arteries in the brain, for which old age, diabetes mellitus, and smoking are big risk factors. You can also get an ischemic stroke from an embolism – a blood clot in your heart that breaks off and travels to your brain, common with an irregular heartbeat called atrial fibrillation. Young, otherwise healthy people with "holes in the heart"† can get this as well. If you have an ischemic stroke, giving you a clot-busting medication such as recombinant tissue plasminogen activator (r-tPA) can cure you – or kill you. The quicker you give tPA after an ischemic stroke, the more likely it is to make you better – often lots better – than to kill you. But after about four hours,‡ it's more likely to kill you than make you better. And it's best to give it in the first hour.

But getting tPA to patients with strokes in the first hour is hard. Very hard. And much of the delay occurs in the ED. And we're not doing too well with these times, for multiple reasons. So efforts to improve these times have been ongoing for the past several years. Reducing operational friction, just like we try to do in semi-tech evacs by drilling the rope team rotations, over and over and over.

One simple thing we did was to have EMS call ahead so we could get the CT scanner cleared and ready for the stroke patient; you need a CT to see if this is an ischemic or hemorrhagic stroke. This has parallels in our scouting the evac route and preparing it for the litter.

Whether to start thrombolysis for stroke (that's a fancy word for clot-busting; remember, doctors get paid by the syllable, with extra charges for Greek and Latin roots), was, in the early days, considered by the powers-that-be to be a decision that could only be made by a super-specialist, called a stroke neurologist, after seeing the patient. Trouble was, there were only a few of these stroke neurologists, and they're not there in the ED, or even maybe in the hospital, when a stroke candidate arrives. So finally we realized that this is a decision that can and should be made by the emergency physician seeing the patient. Simply due to operational friction, we had to have emergency physicians make these decisions. So that's now the way we always do it, and our times to tPA have gotten shorter,

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* Also known as cerebro-vascular accident or CVA, though the term "stroke" seems to be a lot more popular these days.

† Atrial Septal Defect (ASD) or Ventricular Septal Defect (VSD); the small blood clots that form in the legs are normally filtered out in the lungs, but with a hole in the heart, they can get past the lungs into the brain and cause a stroke.

‡ In certain situations, such as embolic stroke, this can be extended a bit.
with no worse outcomes.

A parallel to SAR would be the question of who makes decisions during an evacuation. If the Rescue Specialist (someone in overall charge of the evacuation) is out scouting the route, and a decision needs to be made by The Litter Captain, does The Litter Captain have to stop, get on the radio, and request a decision from the Rescue Specialist, regardless of how small a decision this might be? Distributed decision-making, where leaders at all levels are expected to make decisions when needed, decreases operational friction, as long as those decisions are communicated.

In another parallel, during World War II, the German and Russian armies had very different leadership styles. The Germans used distributed leadership, whereas the Russian army was a totally top-down model. There was a lot of operational friction in the Russian army, a lot of waiting around for orders. If they had emulated the German army’s leadership style, they likely would have won the war much sooner. This means the Rescue Specialist has to accept that his or her power is not absolute, that The Litter Captain or a member of the rope team may have to make tactical changes in the Rescue Specialists plan; whereas the Rescue Specialist has to concentrate on strategy, the overall big-picture view. Are we going to do a semi-tech evac down the slope, and then Tyrolean high-line across Passage Creek, or are we going to do a carryout along the Buzzard Rocks trail?

Speaking of The Rescue Specialist: in a complicated rescue, say with bits of technical or difficult semi-tech, it’s standard for The Rescue Specialist to stay off the litter, and off the haul team to be free to supervise. If the rescue’s just some simple semi-tech and non-technical the Rescue Specialist can help carry the litter.

Similarly, if the patient has significant medical issues, it’s better for The Medic (the member who is attending the patient, usually whoever has the best medical training) to stay off the litter, maybe darting in from time to time, such as at belay changes, to check the patient. That way The Medic isn’t too exhausted to stay close to the litter and can concentrate on the patient. If the patient has a sprained ankle, though, there’s no excuse for The Medic to stay off the litter.

I have heard people say that “The person in the front right (passenger seat) is always The Medic.” This is stupid. Yes, The Litter Captain is busy, and the person in the passenger seat is ideally situated to speak with the patient. But if you’re rotating litter bearers, your Medic will keep changing, and you may have someone there with nothing more than Red Cross non-wilderness First Aid, whereas right behind him is a board-certified emergency physician. Reminds me of the time we found a 72-year old boxing coach who’d been lost for a week off the Appalachian Trail in a wilderness area. The story is in SAR Topics: Legal Aspects. Andy Peet and I were standing, in ASRC uniform, next to the patient that we had examined and treated. We were pretty dirty and maybe a bit smelly, which may be an extenuating circumstance. The local EMS agency’s ambulance arrived, and one of the local EMTs came up, and literally pushed us aside: “move aside, I’m an EMT!” she said. Andy and I looked at each other. I said “Hi, I’m Dr. Keith Conover, and this is Dr. Andy Peet. Would you like us to tell you about our patient?” Oops. After apologizing for her gaffe, she was quite competent and enjoyable to work with as we prepared him for transport in the ambulance and gave her a report.

I suspect this “passenger seat is Medic” is a corruption of something that was originally an excellent idea, and I think all SAR teams should adopt this idea. In the Laurel Caverns cave rescue that you will read about in a few paragraphs, one thing the patient said to me, once she got to the ED, was how confusing and frightening it was having so many different people coming up the litter and talking with her. I’ve seen this in many other rescues as well. Everyone on the litter team, and everyone in the rescue as well, wants to talk with the patient. I’m sure this is all well-intentioned, people after all are there because they care about the patient. But make a rule that there are only two people who talk to the patient – The Medic, and the person on the front right. If you need a name, call this person The Speaker. The Speaker can say “How are you doing?” but nobody else should.

* The pictures of Massanutten Mountain was during that exact decision-making process.
The patient can talk to anyone of course, and people should reply appropriately. But only **The Speaker** or **The Medic** start a conversation with the patient. When a team acts this way, it can create a strong sense of professionalism and trust in the patient and others at the scene. It also reduces operational friction by keeping people focused on their tasks rather than interrupting them to check on the patient.

Picking an evac route is an art and not a science. The more experience, the better you will be able to pick a good route. If you know land navigation route selection (that will be the subject of another SAR Topics), then you're way ahead. Even when you're just orienteering, it's often faster to contour around a hill rather than to go over it. This applies double, or more, when you're carrying a litter. And with a litter, doing down with a tree belay is easy and fast. Going up with a tree belay is difficult and slow. Going up with a haul system is faster, but the operational friction is higher, and delays things. Pre-rigging a route may save time but uses up a lot of skilled people. If you want to learn more about evac route planning, find some experienced SAR people who are free for an evening, buy them beer and pizza, and ask them to tell stories about past evacs.

Once upon a time,* there was a National Cave Rescue Commission (NCRC) Orientation to Cave Rescue (OCR) class at Laurel Caverns. Laurel Caverns is a commercial cave on the top of Laurel Hill, which is the easternmost edge of the Allegheny Plateau, which extends from central Pennsylvania through Maryland to central West Virginia. It's about an hour's drive southeast of Pittsburgh. It's sort of unique, in that the cave is owned by cavers with NCRC training. (Makes it a handy place for OCR classes.) They have commercial tours along prepared paths that last an hour or so. But is unique in that you can also rent helmets and go "wild" caving there in relatively safe portions of this non-vertical cave, though with an experienced caver guide.

NCRC OCR classes are the most common classes offered by NCRC. An OCR is a one-weekend class, accepting both cavers and fire-rescue-EMS people as students. The Saturday morning is devoted to classroom sessions; cave environment for the rescue types, basic first aid and rescue for the caver types. Saturday afternoon there is some above-ground litter humping, practicing laddering and litter bearer rotation. Sunday is a mock cave rescue underground.

I taught some sessions Saturday, but had to go back to Pittsburgh that night as I had to work in the ED on Sunday. I have a deal with the ED that I will not take off for searches, but for rescues where a cave rescue doctor is needed, we'll call in backup and I'll head out.

During the mock rescue on Sunday, the students were heading into the cave, when they were passed by one of these wild-caving groups. A 17-year old girl with the group said in passing "I hope you don't have to rescue me!" An open invitation for Clotho, Lachesis, and Atropos to intervene. (That's the three Fates by their Greek names; Nona, Decima and Morta if you prefer the Roman names; Urðr (Wyrd), Verðandi and Skuld if you prefer the German Norns.)

Of course, when she got back to a room known as The Post Office, she climbed up a big rock and fell on her head. The OCR students and instructors responded. Now this was an OCR and not one of the NCRC weeklong classes, so there were no field phone lines strung. So after assessing the patient, Julia Smith, a long-time cave rescue instructor and Ohio paramedic, sent a runner with a note out to Jackie Bannerman, who was the Incident Commander for the operation.

The note said the patient had fallen onto her head, had altered mental status, was bleeding from the mouth, had one unresponsive pupil, and had injured her hip/thigh and right leg.

Jackie took one look at this, read it again, and called me in the ED and asked if I could come assist with the rescue. Bruce MacLeod was on backup call and started driving into the ED to cover. I called STAT MedEvac, our helicopter service, who agreed to fly me out to the cave. As I was making these arrangements, I noticed the unhappy puppy-dog look on the face of Eric Swanson, the emergency medicine resident who was working with me.

Now in those days, the emergency medicine resident working this shift worked in the ED, in his or her flight suit, ready to fly off on a scene run at any moment. This was sort of a scene run, an interesting-sounding one. And Eric was a climber, had been caving, had done mountain rescue work in his native Utah, and had helped teach Wilderness EMT classes before. So I said "Eric, I have some spare polypro you can put on under your flight suit, and we can find a spare helmet and light. Wanna come along?" Big smile.

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* actually, 7/11/93
So we flew out there in the helicopter, went into the cave, and worked together just like we were in the ED. (That means he did all the work and I just stood there.)

When we got to the patient, she was already loaded in a KED (short spine board) and in a plastic Stokes litter. She had a SamSplint on her right arm. Eric talked with her and with Julia. He and I then discussed the case as we accompanied the litter, being managed by the OCR class and members of the local fire department who had responded. We asked for a brief stop for Eric to examine her.

It seems she had indeed fallen, and was initially hysterical and uncooperative; later she calmed down. Because she was uncooperative, they had immobilized her spine. She was now cooperative and said the immobilization was hurting and she wanted out of it. She had indeed bruised her left thigh, but there were no signs to suggest a fracture there. She had slight tenderness over the radial head of the right elbow but not elsewhere, and a fracture there is not splinted, but simply put in a sling for three days and the patient encouraged to move the elbow as much as possible, to prevent stiffness.

She was alert and oriented, and Eric did a brief neurological exam that was entirely normal. Her pupils were now normal, and we concluded that the prior unresponsive pupil was simply a stunned pupil from the fall, not a sign of brain injury. As far as the blood from her mouth, she had a bruise of the right cheek, and a tiny abrasion on the inside of the mouth that was no longer bleeding and needed no stitches.

We were able to clear her cervical spine clinically, and get her out of the spinal immobilization for which she thanked us profusely. The remainder of her exam was entirely unremarkable.

We then explained to the rescuers that the urgency, which was initially thought to be quite high, was now quite low. She had already had the same evaluation she'd get in a Level I trauma center except for an X-ray of the elbow and a CT of the brain, and as a low-priority patient in the ED, would probably wait an hour or two for those anyway. So there was no need to hurry; we wanted rescuers to take their time and avoid injury.

However, rescuers, mostly from the local
Fire department, started grumbling about how the doctors were interfering with the rescue. And despite our entreaties for them to take their time as the urgency was now much lower, the fire department members kept rushing things. And one sprained his ankle badly enough he had to be helped out of the cave. And another fell and injured himself somehow, not too seriously as I remember, but I don’t remember the details.

Perhaps this was due to some of the rescuer’s narrow mindset: “our job is to get the patient out of the hazardous environment to an ambulance and anything that interferes with this job is bad.” No real thoughts that the overall goal is the well-being of the patient. No, that’s “patient” and not “victim” even if you’re a first-aider or just a non-medical rescuer.

The pilot had maneuvered the helicopter to right outside the old entrance, which made the takeoff pretty tricky as it’s in a narrow, winding ravine. And even though the rescue was now low urgency, the helicopter was going back to the hospital anyway so we all got a helicopter ride. Once in the ED, we got the CT and the X-ray, confirmed our initial diagnoses, and discharged her home. We did get some looks when Eric and I came into the ED in muddy coveralls.

This story illustrates two important points.

First, the level of urgency of an evacuation helps determine things such as the speed of the evacuation, and the risk of rescuer injury; sometimes the route of evacuation, taking a riskier or safer route; whether staff should arrange for ground transport, or air transport, and whether to a local ED or a trauma center. Certainly the EMS crew of the ground or air ambulance should be involved in this decision, but those who have been caring for the patient for a long time should have major input into this decision.

Second, that of the many factors that influence the urgency of the evacuation — listed in the form on this page for cave rescue — the one that is the most susceptible to modification is the assessment of the patient’s medical condition.

The more advanced the medical care at the scene, the better will be the medical assessment. This can make big changes in the urgency. The cave rescue presented above is an example of down-grading the urgency, which, if acknowledged by the rescuers, could have prevented two significant injuries.

On the other hand, consider this case. On a search, a Field Team Member (FTM) falls and does a belly flop on the ground. She hits her left upper quadrant on a rock, and has some mild pain there. After a minute to catch her breath, she gets up and continues with her task. However, she starts getting lightheaded, and develops pain in her left shoulder. The team Medic, a Wilderness EMT, examines her, finds left upper quadrant tenderness, and a tachycardia with an elevated heart rate. The Medic correctly suspects a subcapsular hemorrhage of the spleen, which can be fatal, and calls Base to arrange helicopter transport to a trauma center, thus saving the FTM’s life. Again, medical knowledge not only determines the urgency of the evac, but in this case, it changed an FTM into a patient.

I may have a warped view of this, as I’m a doctor, but ask other experienced SAR medical people and I think they can all give you cases where medical assessment changed something about an evac. Big-time. If you think about it, medical condition is the one urgency factor in which subtle clues can make a big difference in the calculation.

So I’m a big fan of SAR people calling a doc for advice. Not medical direction, but advice. So the senior medical person at the scene can combine this advice with what he or see knows from being on-scene, to make the best decision about the urgency of the evac. My mountain rescue group members are supposed to know, if I’m not in the field myself, to call me any time of day or night with such consults. If needed, I can even sub-consult to a neurosurgeon, orthopedic surgeon, or trauma surgeon.

**Making Future Evacs Better**

Of everything covered in this entire essay, choosing an evacuation route and urgency is likely the most important. Unfortunately, it is the subject you are least likely to learn from reading. Experience is key, but listening to tales of past rescues is probably just as important. In the great scheme of things, evacs don’t happen that often to SAR team members. If it’s a big search, hundreds of SAR team members may be involved, but only a few take part in the evac once the patient is found.

Before written language, oral traditions were
the human race’s extended memory. But as with the Iliad and the Odyssey, you can later record oral history. Yes, such stories may “grow with the telling” and, over time, the precise details may become smudged. Nonetheless, for evacs and for SAR in general, such stories are sources of wisdom.

I’ve written down a few such stories for this essay. But we need more. Search out experienced SAR team members. Write down their stories about rescues. Publish them, somewhere people can find them online. You may thereby save a life.

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- Bolt Anchor: Lane Holdcroft.
- Hedden Knot, Klemheist Knot, Carabiner-Brake-Bar Rappel: Gary Storrick
- Knot Diagrams: from Knots, Splice and Rope Work, A. Hyatt Verrill; and from Knots, Bends, Splices, with Tables of Strengths of Ropes, etc., and Wire Rigging, by Captain Jutsum, Cardiff; in public domain, posted at Project Gutenberg; and from Army Mountain Warfare School, Military Mountaineer Course Knot Guide, public domain.
- Climbing harness tie-in: New Mexico Climbing Club
- Alternate Method for Tying Münter Hitch: Lee Trowbridge
- Münter Hitch Rappel, Scarab, Rigged Properly for Rappel, Edge that Tends to Trap Rappel Devices, Rappel Device Extended for Prusik Below Catching on Edge: Ben McCandless
- Laurel Caverns Map: Laurel Caverns.
- ER-NCRC Urgency Chart: ER-NCRC, public domain.