Acute pulmonary edema (APE) is a common Emergency Department (ED) presentation requiring admission to an intensive care unit (ICU). This study was undertaken to examine the effect of ED management on the need for ICU admission in patients with APE. ED records of APE patients were abstracted for patient age, prehospital and ED pharmacological treatment, diagnoses, airway interventions, and ICU length of stay (LOS). Statistical analysis was through multiple regression, logistic regression, chi-square, and ANOVA. One hundred eighty-one patients composed the study group. Pharmacological treatment included nitroglycerin (NTG), 147 patients (81%); morphine sulfate (MS), 88 (49%); loop diuretics (LD), 133 (73%); and captopril sublingual (CSL), 47 (26%). Use of CSL and MS were associated with opposing needs for ICU admission. MS use was associated with increased ICU admissions (odds ratio, 3.08; P = .002), whereas CSL use was associated with decreased ICU admissions (odds ratio, 0.29; P = .002). Morphine sulfate use also demonstrated an increased need for endotracheal intubation (ETI) (odds ratio, 5.04; P = .001), whereas CSL demonstrated a decreased need for ETI (odds ratio, 0.16; P = .008). Ninety-three patients required some form of respiratory support. Forty received noninvasive pressure support ventilation (NPSV) from a bilevel positive airway pressure system (BiPAP), and 60 received endotracheal intubation. Some patients received more than 1 form of respiratory support; all other patients received supplemental oxygen only. The ICU-LOS associated with different airway interventions were supplemental oxygen, 0.72 days; BiPAP, 1.48 days; and ETI, 3.70 days (P < .001). Specific ED pharmacological interventions are associated with a decreased need for ICU admission and endotracheal intubation in acute pulmonary edema patients, whereas use of noninvasive pressure support ventilation correlates with a reduction in the ICU length of stay for patients who do require critical care admission. (Am J Emerg Med 1999;17:571-574. Copyright © 1999 by W.B. Saunders Company)

Acute pulmonary edema (APE) is a common Emergency Department (ED) presentation requiring intensive care unit (ICU) admission. Multiple studies have focused on the effects of individual treatments on patients with this problem by examining the responses of isolated physiological parameters to specific interventions. None of these reports addressed specifically the impact of such interventions on patient outcome and resource utilization. This study attempts to establish a correlation between ED management and admission to the ICU.

METHODS

The site for this study was Our Lady of Lourdes Medical Center in Camden, New Jersey, a tertiary care university-affiliated community teaching hospital. Records of ED patients with a diagnosis of either acute pulmonary edema or congestive heart failure with respiratory failure presenting to the ED between December 1, 1992 and October 31, 1996 were examined. Inclusion criteria required clinical evidence of acute pulmonary edema and severe respiratory distress as evidenced by treating personnel’s descriptions of marked dyspnea, diaphoresis, use of accessory muscles, or notation of impression of acute respiratory compromise with no associated primary lung pathology and no other evident cause for the patient’s respiratory distress. Vital signs were not employed as part of the inclusion criteria because of their lack of correlation with illness severity. Some of the most critically ill patients had near normal vital signs as they passed from tachypnea and hypertension to agonal respirations and hypotension. In addition, many of the most severely ill patients had therapeutic interventions initiated before obtaining vital signs or placement of any monitoring equipment.

Accepted ED charts were abstracted for patient age, diagnoses, prehospital and ED pharmacological interventions, possibility of myocardial infarction (MI), and airway management. Hospital records were reviewed for ICU length of stay (LOS) and discharge diagnoses. Patients not admitted to the ICU were assigned an ICU-LOS of 0. Airway management was divided into those patients receiving no ventilatory support, those receiving noninvasive pressure support ventilation (NPSV), and those undergoing endotracheal intubation (ETI). NPSV was provided through a nasal mask with a bilevel positive airway pressure system (BiPAP) (Respironics-SPD, Murraysville, Pa.). In patients receiving more than 1 form of therapy, airway assignments were based on the highest level of support required.

Pharmacological agents studied included use of loop diuretics either furosemide or bumetanide, morphine sulfate (MS), nitroglycerin (NTG) either sublingual, intravenous, or transcutaneous, and captopril sublingual (CSL).

Statistical analysis was performed, using logistic regression, multiple regression, ANOVA, chi-square, and Student’s t-test with the JMP statistical software package from SAS Institute (Cary, NC).

RESULTS

A total of 2,466 patient records with a diagnosis of congestive heart failure or pulmonary edema were screened with 181 identified for analysis. The mean patient age was 69.7 years (+/- 1.0 years), with a median of 73 years. Forty-seven (26%) patients were dialysis-dependent chronic
renal failure patients, and 28 (15%) patients had an additional ED diagnosis of rule-out MI. Four patients had a discharge diagnosis including myocardial infarction, all of which were subendocardial.

ED pharmacological management is summarized in Table 1. Table 2 lists the regression analysis for the need for intensive care admission, ETI, and ICU LOS for each agent. One hundred two patients (56%) were admitted to the ICU, 58 (32%) patients were admitted to a floor or stepdown unit, and 21 (12%) patients were discharged. Use of CSL and MS were associated with opposing needs for ICU admission. MS use was associated with increased ICU admissions (odds ratio, 3.09; P = .002), whereas CSL use was associated with decreased ICU admissions (odds ratio, 0.29; P = .002).

The uses of different airway interventions are summarized in Table 3. Ninety-three (51%) patients required some form of respiratory support. Forty (22%) received NPSV from a BiPAP, and 60 (33%) underwent ETI, 27 (45%) prehospital and 33 (55%) in the ED. Some patients received more than 1 form of respiratory support. The ICU-LOS for airway interventions were supplemental oxygen, 0.72 days; BiPAP, 1.48 days; and ETI, 3.70 days (P < .001). There was also no statistical difference in ICU-LOS for those patients intubated in the field and those intubated in the ED. ICU admission was required for 27% of the supplemental oxygen group, 61% of the NPSV group, and 97% of the ETI patients (P < .001).

Six (15%) of the BiPAP patients failed NPSV and required ETI. Twenty (50%) of the BiPAP patients were successfully weaned from the BiPAP system in the ED. Three (5%) of the intubated patients were extubated in the ED. Four (10%) of the BiPAP patients were discharged from the ED after weaning. There were no significant differences in hospital discharge diagnoses of MI in the BiPAP group compared with the other 2 groups.

A total of 47 patients were hemodialysis-dependent chronic renal failure (CRF) patients. Sixteen (51%) CRF patients were discharged without admission after interventional dialysis, compared with only 5 (4%) of the non-CRF patients (P < .001). ICU admission was required for 38% of CRF patients compared with 63% of non-CRF (P < .004). Intubation rates were not significantly different between the 2 groups, with 26% of CRF patients and 36% non-CRF patients requiring ETI (P = .2).

**DISCUSSION**

Intensive care unit utilization by ED patients has been reviewed for a number of cardiocerebral diseases, but not for acute pulmonary edema.12-13 In addition, no studies on

**TABLE 1. Summary of Prehospital and Emergency Department Pharmacological Therapy**

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitroglycerin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NTG sublingual</td>
<td>82</td>
<td>45.30</td>
</tr>
<tr>
<td>NTG intravenous</td>
<td>27</td>
<td>14.90</td>
</tr>
<tr>
<td>NTG topical</td>
<td>109</td>
<td>60.20</td>
</tr>
<tr>
<td>NTG total*</td>
<td>147</td>
<td>81.20</td>
</tr>
<tr>
<td>Captopril sublingual</td>
<td>47</td>
<td>25.90</td>
</tr>
<tr>
<td>Morphine sulfate IV</td>
<td>88</td>
<td>48.60</td>
</tr>
<tr>
<td>Morphine sulfate (ED)</td>
<td>61</td>
<td>33.70</td>
</tr>
<tr>
<td>Loop diuretics</td>
<td>133</td>
<td>73.00</td>
</tr>
</tbody>
</table>

*Represents total number of patients given nitroglycerin (NTG) by any route. Patients receiving NTG by multiple routes counted only once.

**TABLE 2. Regression Analysis for Multiple Pharmacological Treatments, Prehospital and Emergency Department**

<table>
<thead>
<tr>
<th>Variable</th>
<th>ICU Admit Odds Ratio</th>
<th>P</th>
<th>95% CI</th>
<th>ETI Odds Ratio</th>
<th>P</th>
<th>95% CI</th>
<th>ICU LOS P</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI</td>
<td>2.7</td>
<td>.064</td>
<td>0.99-8.35</td>
<td>1.2</td>
<td>.62</td>
<td>0.49-3.27</td>
<td>2.71</td>
</tr>
<tr>
<td>Age</td>
<td>0.14</td>
<td>.046</td>
<td>0.02-0.94</td>
<td>0.08</td>
<td>.03</td>
<td>0.01-0.72</td>
<td>0.96</td>
</tr>
<tr>
<td>Captopril</td>
<td>0.29</td>
<td>.002</td>
<td>0.13-0.63</td>
<td>0.16</td>
<td>.008</td>
<td>0.05-0.44</td>
<td>1.90</td>
</tr>
<tr>
<td>NTG</td>
<td>1.78</td>
<td>.23</td>
<td>0.69-4.67</td>
<td>0.72</td>
<td>.54</td>
<td>0.24-2.08</td>
<td>3.17</td>
</tr>
<tr>
<td>MS</td>
<td>3.09</td>
<td>.002</td>
<td>1.54-6.30</td>
<td>5.04</td>
<td>&lt;.001</td>
<td>2.31-11.76</td>
<td>2.09</td>
</tr>
<tr>
<td>Loop diuretics</td>
<td>1.06</td>
<td>.89</td>
<td>0.46-2.39</td>
<td>0.9</td>
<td>.81</td>
<td>0.36-2.27</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Age was stratified as a continuous variable; NTG use was included as positive if administered to the patient in any form.

**ABBREVIATIONS:** LOS, length of stay (days); NTG, nitroglycerin; MS, morphine sulfate.
the efficacy of individual treatments for APE have examined their effect on ICU admissions. Use of CSL was associated with a significant decrease in both ETI and ICU admissions. CSL's efficacy was probably due to captopril's multiple physiological actions. Captopril decreases peripheral vascular resistance, reduces left ventricular (LV) afterload, and improves LV diastolic dysfunction by dampening the adrenergic crisis associated with severe dyspnea and CHF. Prior studies looking specifically at captopril also have shown a reduction in ETI in patients receiving the drug, an improvement in myocardial oxygen consumption, and improved outcome in acute MI patients.

Morphine sulfate's use in acute pulmonary edema is difficult to justify based on the data in this and other studies. Its use resulted in higher intubation rates, probably through respiratory depression and consequently higher ICU admission rates.

NTG use itself did not show a significant impact on patient outcome. Because some form of this drug was used in such a high percentage of patients (81%), it may have been difficult to detect a significant difference in the data analysis. Subgroup analysis did show that patients receiving NTG in more than 1 form, and thus a greater amount of NTG, were less likely to require ETI (P < .03). This is consistent with other reports showing the advantages of NTG in APE patients.

The use of loop diuretics also did not show any correlation with ICU admission rates or need for intubation. This absence of any effect from these agents probably reflects the fact that blood flow to the kidneys is reduced during the hyperadrenergic state of pulmonary edema. It is not until the respiratory crisis is resolved that blood flow to the kidneys returns and the loop diuretic's beneficial actions begin. This might explain why the CRF patients in whom diuresis was delayed for hours had as good or better outcomes than those patients with intact renal functions who were pharmacologically diuresed. Furosemide is known to increase both pulmonary and peripheral vascular resistance, although these effects are probably clinically not significant.

The lack of immediate efficacy of the loop diuretics is also supported by other studies on the acute care of APE patients.

Airway management in pulmonary edema patients directly impacted on ICU use. As expected, patients undergoing ETI required the most ICU resources, whereas those receiving no ventilatory support used the least resources. Patients with respiratory failure managed with noninvasive pressure support ventilation required significantly fewer ICU admissions than intubated patients (P = .001) but more than those patients requiring no respiratory support (P = .001).

The most obvious explanation for the increased ICU use for intubated patient is that these patients were the sickest. However, a comparison with those patients intubated by paramedics does not necessarily support this premise.

Because paramedics do not have access to the BiPAP system, they must intubate all respiratory failure patients. A subset of these patients should comprise the supposed less sick respiratory failure patients who would have received NPSV in the ED. These patients should then have an ICU-LOS similar to that of the ED NPSV, not ETI patients. The combination of these 2 patient groups should produce a shorter ICU-LOS for prehospital ETI patients than ED-ETI patients. This difference is not present in this study population. The ICU-LOS for ED intubations was 3.6 days, compared with 3.7 days for prehospital intubations (P = NS). Previous studies have shown NPSV to be very effective in the management of CHF patients.

Six (15%) patients failed NPSV. This failure rate is higher than that of previous reports for NPSV in pulmonary edema patients. This drop in success rate may indicate our department's trend toward attempting NPSV on patients with more severe respiratory failure than in our earlier report.

This study indicates that there may be important correlations between ED management and ICU use in APE patients, but it cannot demonstrate a causal effect. The retrospective nature of the study and the inability to objectively compare the degree of respiratory distress between patients prevents us from proving that MS leads to increased intubation rates and not that patients in need of intubation receive MS. In designing our selection criteria, we attempted to isolate only those patients with severe symptoms and tried to identify a population that was equally ill and at risk for respiratory failure.

We believe even with these limitations that we have identified some trends in the treatment of APE patients that warrant exploration in prospective studies.

CONCLUSION

There exists an association between specific ED treatments and ICU admission rates. Interventions with the greatest positive correlation include CSL and use of NPSV, whereas that with the greatest negative correlation is use of MS.

REFERENCES


