

Emergency Department Length of Stay: a Major Risk Factor for Pneumonia in Intubated Blunt Trauma Patients

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Background: Pneumonia occurs commonly in intubated patients and is morbid and occasionally mortal. Pneumonia prevention strategies have been successful in the intensive care unit and are favorably regarded, cost effective, and efficacious. Trauma patients are often intubated emergently in the prehospital or emergency department (ED) setting. Nationwide, hospital crowding has resulted in prolonged ED length of stay (LOS). We sought to study the association between prolonged ED LOS and rates of pneumonia.

Methods: This was a 2-year retrospective case-control study of pneumonia risk among blunt trauma patients presenting to an urban Level I trauma center who were emergently intubated. The trauma

registry was queried for demographic and clinical information. All patients who were intubated prehospital or in the ED and developed pneumonia were identified as cases. A group of matched controls with equivalent age, injury severity score, abbreviated injury score (AIS) chest, and AIS head who did not develop pneumonia were identified. A comparison of ED LOS between the two groups was assessed using conditional logistic regression.

Results: We identified 509 emergently intubated blunt trauma patients. Of these, 33 developed pneumonia and could be matched with comparable controls. The case subjects had a mean age of 44.6 (± 24.3), a mean injury severity score of 32.7 (± 9.4), a mean chest AIS of 1.5 (± 1.6), and a mean head AIS of 4.4

(± 1.2). The ED LOS for the cases was significantly longer than that for the controls (281.3 minutes vs. 214.0 minutes, $p < 0.05$). Each hour increased the risk of developing pneumonia by approximately 20%.

Conclusions: In blunt trauma patients who are emergently intubated, increased ED LOS is an independent risk factor for pneumonia. Ventilator associated pneumonia interventions, successful in the intensive care unit, should be implemented early in the hospital course, and efforts should be made to minimize hospital crowding and ED LOS.

Key Words: Pneumonia, Emergency department boarding, Ventilator associated pneumonia, Intubation.

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Ventilator associated pneumonia (VAP) is the most common hospital acquired infection among patients requiring mechanical ventilation.^{1,2} The incidence of pneumonia in the intensive care unit (ICU) has been estimated to be as high as 40%. The mortality rate for patients with VAP is approximately 50%.³ In addition to high rates of mortality, VAP has been demonstrated to lead to longer durations of mechanical ventilation, longer ICU stays, longer

hospital stays, and has been estimated to add an average of \$40,000 to the cost of hospital admission.^{4,5}

A population particularly at risk for VAP is that of trauma patients.^{5,6} Specific risk factors for pneumonia include trauma admission,^{5,7} prehospital intubation,⁸ and emergent intubation.^{9,10} Intubated blunt trauma patients are 3.5 times more likely to develop VAP than intubated penetrating trauma patients.¹¹ Emergency department (ED) length of stay (LOS) has been associated with an increased 30-day mortality¹² in patients without trauma. To our knowledge, this is the first analysis to investigate time in the emergency department as a risk factor for pneumonia in intubated blunt trauma patients. There are implications for the delivery of critical care in the ED as well as for hospital-wide bed management.

METHODS

The Hospital of the University of Pennsylvania is a 650-bed tertiary care facility in Philadelphia, PA serving a population of 10 million. The Trauma Center at Penn is a state-designated Level I regional resource center located in Southwest Philadelphia and serves both a local urban population as well as neighboring counties by a combination of ground emergency medical service (EMS) programs and a hospital-based aeromedical program with advanced airway management skills, including rapid sequence intubation.

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We performed a retrospective case-control study to evaluate whether duration of time spent in the ED was a risk factor for pneumonia. We searched the trauma registry for all blunt trauma patients admitted to our trauma center during a 1-year period (2003) who were intubated emergently (pre-hospital or in the ED). Patients taken directly to the operating room were excluded. Demographic data collected included age and sex. Clinical data collected included injury severity score (ISS), head abbreviated injury score (AIS), and chest AIS. Outcome data included ED LOS, ICU LOS, hospital LOS, and pneumonia. Case subjects were defined as those who developed pneumonia as inpatients. Pneumonia was defined as (1) fever (>38°C), leukocytosis, and Gram's stain of sputum with predominant organism and white blood cells, or (2) chest roentgenogram with pneumonic infiltrate and culture of sputum demonstrating a pathogen.

Matched controls for case subjects who developed pneumonia were identified from emergently intubated blunt trauma patients who did not develop pneumonia. Controls were matched to cases on four variables thought to be important risk factors for the diagnosis of pneumonia. Specifically, controls were matched to cases according to age group (<25, 25-34, 35-44, 45-54, 55-64, ≥65), AIS head (0, 1-3, 4-5), AIS chest (0, 1-3, 4-5), and ISS (<10, 10-19, 20-29, ≥30). To improve the precision of the parameter estimates, all available control subjects were used.¹³ Cases for whom controls could not be identified were excluded.

A comparison of ED LOS between groups was performed using conditional logistic regression. Odds ratios were calculated to provide an estimate of the effect of ED LOS on developing pneumonia.¹⁴ Age, ISS, chest AIS, and head AIS, all as continuous variables, were entered into the analysis to control for potential confounding within categories of the matching variables. Nonlinearity of the relation between ED LOS and pneumonia risk was tested using a quadratic term. The implications of pneumonia on ICU LOS and hospital LOS were examined using *t* tests. The statistical analyses were conducted with Stata software (Stata Corporation, College Station, TX).

Results are presented odds ratios (ORs), confidence intervals (CIs), and means (±SD). A *p* value of <0.05 represents a statistically significant finding.

RESULTS

A total of 509 blunt trauma patients were emergently intubated during the course of the study. Of these, 129 were taken directly to the operating room and were excluded from analysis. Thirty-nine case subjects were identified. This group had a mean age of 41.93 (±19.72), a mean ISS of 33.95 (±13.37), a mean AIS chest of 2.93 (±0.96), and a mean AIS head of 4.53 (±0.86).

For six case subjects, no matched controls were available. For the remaining 33 case subjects, 107 matched controls were identified, yielding a total sample size of 140 subjects. The two patient populations were similar (Table 1).

Table 1 Study Patient Characteristics and Characteristics of Matched Blunt Trauma Patients

	Pneumonia (N = 33)	No pneumonia (N = 107)
AIS head (mean)	4.3	4.5
AIS chest (mean)	1.8	1.4
ISS (mean)	35.4	31.8
Age, years (mean)	43.9	44.9
% male	76	64
% intubated	42	55
prehospital ED LOS (mean)	*281.3 min	*214.0 min

All subjects sustained blunt trauma and were intubated by pre-hospital personnel or in the emergency department. Items contained within the box are the items that were used to match cases to controls.

* *p* < 0.05.

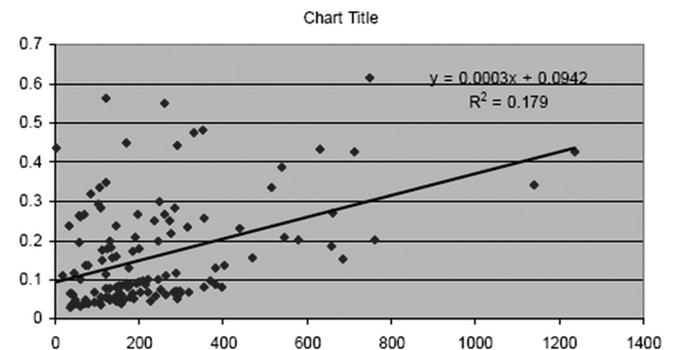


Fig. 1. ED LOS (minutes) (x axis) versus probability of pneumonia (y axis).

ED LOS was a significant risk factor for pneumonia. This effect was linear, with the risk of developing pneumonia increasing approximately 20% for each additional hour that patients spent in the ED (OR 1.21, *p* < 0.05, 95% CI = 1.04-1.39). This is evident graphically when the probability of pneumonia is plotted against the time spent in the ED (Fig. 1). As expected, pneumonia was significantly associated with longer ICU stays (16.3 vs. 5.1, *p* < 0.001) and longer hospital stays (25.2 vs. 11.2, *p* < 0.001).

We found no evidence of effect modification by severity of injury (ISS ≥25 vs. <25). The effect of ED LOS on pneumonia risk did, however, appear to be modified as a function of age and the severity of head and chest injuries. Specifically, older patients (age >50) had increased rates of pneumonia associated with ED LOS (OR = 1.3, CI = 1.00-1.60) compared with that of younger patients (OR = 1.1, CI = 0.92-1.25). Patients with more severe head injuries (AIS >3) had increased rates of pneumonia associated with ED LOS (OR = 1.2, CI = 1.03-1.38) compared with that of other patients (OR = 0.8, CI = 0.50-1.37). And patients with low severity chest injuries (AIS <3) appeared to be more likely to get pneumonia as a function of ED LOS (OR = 1.3, CI = 1.08-1.65) than were other patients (OR = 0.9, CI = 0.72-1.20). This latter effect, however, seems to be primarily

related to the fact that patients with severe injury were on average younger as compared with patients with less severe chest injuries (39 years vs. 49 years, $p < 0.05$).

DISCUSSION

Pneumonia is a morbid and occasionally mortal disease that disproportionately impacts trauma patients. VAP is defined as pneumonia occurring after 48 to 72 hours after tracheal intubation in a ventilated patient.¹⁵ VAP is divided into early onset (48–72 hours until diagnosis) and late onset (>72 hours until diagnosis). The average time between intubation and diagnosis of VAP is 3.3 days.⁵ The pathogenesis of VAP has been described in detail as a two-step process including bacterial colonization and subsequent aspiration. A number of risk factors have been associated with VAP, including prior antibiotic therapy, invasive devices, medications altering gastric emptying and pH, and colonization of respiratory equipment.¹⁵

A number of strategies have been used to decrease the incidence of VAP in the ICU including selective decontamination of the gastrointestinal tract, limiting the use of medications altering gastric emptying and gastric pH, semi recumbent positioning of patients, careful attention to the sterility of respiratory-therapy equipment, and careful attention to the type of suction catheter used and the method of suctioning.¹⁵ The 100K Lives campaign has introduced innovations that have reduced the morbidity and mortality of the intensive care patient. The VAP bundle, consisting of deep venous thrombosis prophylaxis, gastric ulcer prophylaxis, elevation of the head of the bed, and sedation holds have been shown to decrease the incidence of VAP by an average of 44.5%.¹⁶ This bundle, in one study with only a 79.1% total compliance, resulted in a 5.4-day average decrease of LOS in the ICU as well as a 4.7-day decrease of ventilator days.¹⁷

ICU bundles are important adjuncts to care in the ICU, but they typically are not implemented in the ED. There has been recent attention drawn to the phenomenon of ED crowding and improved mechanisms of throughput for critical patients is warranted. We hypothesized that longer ED LOS would be associated with an increased rate of pneumonia in intubated trauma patients. The ED setting is typically busy and often does not allow for the implementation of ICU protocols such as the VAP bundle. Specifically, intubated blunt trauma patients are often initially paralyzed for urgent evaluation, but left paralyzed out of habit, as a matter of practice, or because nursing ratios do not ensure the safety of awake intubated patients. Trauma patients are often left with their beds flat as they are typically on spinal precautions. The shift in mindset from evaluation to maintenance in the ED also explains the absence of deep venous thrombosis and ulcer prophylaxis.

The idea of delivering critical care in the emergency department is not new,¹⁸ and has recently regained new attention as early interventions have been demonstrated to

provide mortality benefits.¹⁹ The optimal delivery of care to the emergent patient is of paramount importance, but there may be unintended consequences. The delivery of critical care is resource intensive, and previous data has suggested that prolonged ED LOS may be associated with negative health outcomes.¹² In addition, a recent national call for an immediate end to the practice of boarding admitted patients²⁰ suggests that hospital administrators should look for innovative solutions to bed management dilemmas.

Although powerful in the novel findings that ED LOS is an independent risk factor for pneumonia in intubated blunt trauma patients, this study has limitations. This study is a retrospective analysis using a trauma registry. Although the cases were matched with controls according to four variables, the categories were imperfect and the cases had a higher ISS than the controls had. This occurred because ISS was matched by group. The imbalance between groups would be expected to bias the results positively away from the null, but the differences between groups was controlled for by entering ISS into the logistic regression model. In addition, we were limited by the diagnosis of pneumonia in that our sample was obtained from the trauma registry, so no distinction could be made between pneumonia and VAP. All faculty caring for ICU patients are board-certified intensivists and are familiar with the ICU diagnosis of pneumonia. It was impossible to confirm that all diagnoses of pneumonia met Centers for Disease Control and Prevention criteria for VAP.

This analysis draws a direct link between the amount of time that intubated blunt trauma patients spend in the emergency department and an increased incidence of pneumonia. Future prospective studies using strict criteria for the diagnosis of VAP would be helpful in supporting the causal pathway proposed here. This analysis suggests not only that we do harm to our patients by permitting ED boarding, but that the perceived gains are short term. That is, VAP is known to be associated with longer ICU stays, longer hospital stays, and increased hospital costs. There are important policy consequences associated with these findings.

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**EARL G. YOUNG, M.D.
RESIDENT PAPER COMPETITION**

A \$500 cash prize and certificate will be presented for the best resident paper presented at the 38th Annual Meeting of the Western Trauma Association to be held February 24-March 1, 2008 in Squaw Creek, Olympic Valley, California. This award is presented in honor of Earl G. Young, M.D., a former President and Founding Member of the Western Trauma Association. Completed manuscripts will be submitted to the *Journal of Trauma: Injury, Infection, and Critical Care* for publication. Original resident or fellow clinical or basic science research abstracts must be submitted by October 1, 2007 using the Western Trauma Association website online submission process at: www.westerntrauma.org. Questions regarding the submission process may be directed to Christine Cocanour, MD, WTA Program Chairman, via e-mail at Christine.Cocanour@ucdmc.ucdavis.edu or at (916) 734-7330.