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# Trauma-associated pneumonia: time to redefine ventilator-associated pneumonia in trauma patients



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## KEYWORDS:

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Trauma-associated pneumonia;  
Rib fracture;  
Pulmonary contusion;  
Failed prehospital intubation

## Abstract

**BACKGROUND:** The high prevalence of ventilator-associated pneumonia (VAP) in trauma patients has been reported in the literature, but the reasons for this observation remain unclear. We hypothesize that trauma factors play critical roles in VAP etiology.

**METHODS:** In this retrospective study, 1,044 ventilated trauma patients were identified from December 2010 to December 2013. Patient-level trauma factors were used to predict pneumonia as study endpoint.

**RESULTS:** Ninety-five of the 1,044 ventilated trauma patients developed pneumonia. Rib fractures, pulmonary contusion, and failed prehospital intubation were significant predictors of pneumonia in a multivariate model.

**CONCLUSIONS:** It is time to redefine VAP in trauma patients based on the effect of rib fractures, pulmonary contusions, and failed prehospital intubations. The Centers for Disease Control and Prevention definition of VAP needs to be modified to reflect the effect of trauma factors in the etiology of trauma-associated pneumonia.

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In the United States, the importance of improving healthcare quality has been more emphasized in recent years. In accordance with these efforts, a significant weight has been prompted to physicians and hospitals on measuring and reporting patient complications and outcomes. The National Healthcare Safety Network, which

was formed in 2005 by the Centers for Disease Control and Prevention, annually publishes various nosocomial infection rates including a separate report module for device-associated infections.<sup>1</sup> Ventilator-associated pneumonia (VAP) is one of the most frequently occurring hospital-acquired infections that is currently being reported under this module.<sup>2</sup> According to the most recent Centers for Disease Control and Prevention (CDC) guideline, VAP is defined as a pneumonia in a patient who is on mechanical ventilation for more than 48 hours with radiological evidence of new or progressive infiltrate, symptomatic

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evidence of systemic infection, and laboratory detection of causative agent.<sup>3</sup> However, the criteria for diagnosis of VAP has been criticized, and are still in debate for its poor accuracy and reliability.<sup>2,4-6</sup> Even in medical intensive care unit (ICU) settings, for which the CDC VAP criteria were developed, it has been argued that VAP is possibly overdiagnosed because of the poor accuracy of the diagnosis criteria.<sup>6</sup> However, because of its association with increase in patient morbidity and healthcare costs, it has been proposed as one of the measurements for quality of care.<sup>4,7,8</sup> In the most recent 2012 National Healthcare Safety Network report, VAP rate was 3.6 per 1,000 ventilation days in the trauma critical care unit of 75 participating hospitals. On the other hand, VAP rate in the medical critical care unit of 112 participating major teaching hospitals was only .97 per 1,000 ventilation days. This shows that the reported prevalence of VAP in trauma patients is about 4-folds higher than in ventilated nontrauma patients.<sup>1,9</sup>

According to the study by Cook et al, trauma patients are at higher risk for developing pneumonia in comparison with the medical ICU patients. In trauma patients, additional variables such as injury severity score (ISS), which measures the severity of the trauma, and the critical need for prehospital intubation in the field increase the risk of developing a pneumonia.<sup>10</sup> In addition, the risk of developing pneumonia also increases with patients who obtain severe head and neck trauma.<sup>11</sup> Multiple studies also show that trauma factors such as pulmonary contusion, rib fracture, sternal fracture, spinal cord injury (SCI), and traumatic brain injury (TBI) increase the risk of developing a pneumonia.<sup>12-18</sup> Therefore, the role of trauma factors in the development of pneumonia in ventilated trauma patients, and the distinction between VAP and trauma-associated pneumonia (TAP) remain in question. It is also dubitable whether it is appropriate to report VAP in ventilated trauma patients under the same criteria as ventilated nontrauma or medical patients. In this study, we hypothesize that trauma factors play a critical role in aggravating the development of pneumonia in ventilated trauma patients, and consequently TAP should be differentiated from VAP.

## Patients and Methods

In this retrospective study, 1,077 ventilated trauma patients were identified from December 2010 to December 2013 using our trauma registry. Excluded from the study were patients who were diagnosed with pneumonia on admission to the emergency department (ED) ( $n = 2$ ), patients who died less than 24 hours after admission to the ED ( $n = 28$ ), and patients who had insufficient data ( $n = 3$ ). Therefore, after the exclusion of those 33 patients, 1,044 ventilated trauma patients were identified for this study. Study outcome was dichotomous: patients who developed pneumonia and those who did not. For each patient, data collection included demographics, mechanism of injury (MOI), ISS, ventilation days, days to develop pneumonia,

hospital and ICU length of stay (LOS), and discharge status. Furthermore, data on trauma factors including rib fracture, aspiration, blood in or around mouth, blood in or around nose, failed prehospital intubation, facial fractures, TBI, spinal injury, sternal fracture, and pulmonary contusions were collected. Variables were analyzed and compared between 2 groups: patients who developed pneumonia and those who did not. The relationship between the development of pneumonia and the trauma factors were also analyzed using univariate and multivariate logistic regression analyses. The group of patients who developed pneumonia was further studied by dividing them into groups depending on the number of trauma factors. The variables were compared using appropriate tests including chi-square test, Fisher's exact test, and Student *t* test. A *P* value less than .05 was considered significant. Statistical analysis was performed using IBM SPSS Statistics version 22 (IBM Corp., Armonk, NY).

## Results

Over the 3-year study period, we identified 1,044 trauma patients who were intubated on the ventilator. The average age of the patients was  $44.3 \pm 19.9$  years old, and the majority of them were male (74.9%). Motor vehicle collision (MVC) was the main MOI (56.5%), and other MOIs included falls (18.2%), gunshot wounds (10.4%), blunt injury (4.2%), penetrating injury (3.5%), and other unclassified MOIs (7.2%). In 202 patients (19.3%), prehospital intubation was attempted regardless of its success, and of the 202 patients, 77.7% had a failed prehospital intubation attempt.

Among the 1,044 ventilated trauma patients, 95 patients (9.1%) developed pneumonia and 949 patients (90.9%) did not. There was no difference in age between the pneumonia patients and nonpneumonia patients (Table 1). However, the rate of pneumonia was higher in men than in women. When various MOIs were compared between the 2 groups, there was a significant association between MVC and the development of pneumonia. The patients who had MVC were 1.2 times more likely to develop pneumonia than the patients who had other MOIs. When the disposition of the patients was studied, patients who developed pneumonia were discharged to either acute care facility, intermediate care facility, rehabilitation centers, or skilled nursing home facility more often than home ( $P < .001$ ). Interestingly, the mortality rate of those who developed pneumonia was lower than those who did not ( $P = .01$ ). The relationship between these variables and the development of pneumonia was studied by separating patients into 2 groups for each variable: below median and above median (Table 1). The median values of ISS, hospital LOS, and ICU LOS were 18, 8, and 4, respectively. Patients who had ISS greater than 18 were 1.5 times more likely to develop pneumonia, and patients with hospital LOS greater than 8 and ICU LOS greater than 4 were 2.3 and 2.6 times

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