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Ventilator-associated pneumonia in severe traumatic brain injury: the clinical significance of admission chest computed tomography findings

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) in severe traumatic brain injury (STBI) is a significant morbidity. Bilateral dependent consolidation (BDC) can be seen on admission chest computed tomography (CCT) in STBI. We hypothesize that this finding may be associated with VAP.

Materials and methods: We retrospectively studied patients who sustained STBI after blunt injury and survived >48 h, who were admitted over a 40-mo period. We defined STBI as an admission Glasgow Coma Scale Score ≤8. We identified VAP by an elevated white blood cell count, a new infiltrate on chest x-ray, and a positive respiratory culture in a ventilated patient. Variables included demographics, injury, admission CCT, and culture data. We compared BDC-positive and BDC-negative patients.

Results: There were 33 cases of VAP in 94 study patients (35.1%), in whom the incidence of intracranial pressure (ICP) monitoring (66.7% *versus* 39.3%; $P = 0.011$) was significantly increased. Ventilator-associated pneumonia was significantly increased in the 28 patients (29.8%) in the BDC-positive group (16 [57.1%] *versus* 17 (25.6%); $P = 0.004$). Bilateral dependent consolidation independently predicted VAP. In the 33 VAP cases, gram-negative organisms were present in 27 patients (81.8%), with a predominance of Enterobacteriaceae (16 patients [48.5%]). Culture results did not significantly differ between the early (<4 d) *versus* late or BDC-positive *versus* BDC-negative VAP groups.

Conclusions: Ventilator-associated pneumonia is common after STBI, and BDC is independently associated; however, there is no predilection for specific organisms. Admission CCT findings may prove useful in identifying a group of STBI patients at higher risk for VAP.

1. Introduction

Ventilator-associated pneumonia (VAP) is a significant morbidity [1,2], particularly as it relates to severe traumatic brain injury (STBI) [3–5]. The incidence of VAP with STBI approaches 40% in some series [3,5]. Early determination of high-risk patients is important [4,6–8], and because diagnosis of VAP can be elusive, identification of these factors is even

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more critical [1,6,9]. Also, distinction between early and late VAP is considered important because it pertains to types of pathogenic organisms [4].

Admission chest computed tomography (CCT) in trauma is controversial because it may add little additional information over plain chest x-ray (CXR) [10]. However, CCT can direct important management decisions [11–13] or predict clinical course [14]. This is particularly true in STBI patients, as CCT is shown to be superior to CXR for clinically significant lesions in this population [15]. Bilateral dependent consolidation (BDC) of the lung fields can incidentally be seen on CCT of patients with severe neurologic injury, but there are few data analyzing the significance of this finding [15]. A presumed association with aspiration based on culture results has yet to be defined [16]. We performed this study to determine whether BDC on admission CCT in STBI patients is associated with VAP having a unique microbial signature.

2. Materials and methods

After we obtained institutional review board approval, we retrospectively analyzed records from all patients diagnosed with STBI after blunt mechanisms, who were admitted from July 1, 2008 to December 31, 2011 at our level I center. We defined STBI as an admission Glasgow Coma Scale Score (GCS) ≤8 on admission with an intracranial injury (International Classification of Diseases–9 code of 851.xx to 854.xx). Trauma patients with diminished mental status are admitted as high-level activations, and patients with a GCS ≤8 undergo early endotracheal intubation, as per protocol. Adjunct diagnostic imaging is obtained at the discretion of the trauma staff. The study group was composed of STBI patients surviving >48 h after blunt mechanisms, who underwent at least one admission CXR and CCT. We reviewed patient records to include all CXR and CCT studies using our digital imaging and storage system or hard copies, when applicable. We also reviewed final staff radiology reports. For the purposes of this study, BDC was identified as a consolidative process seen on admission CCT involving the posterior lung fields, with concurrence of this finding on final radiology reporting (Fig.).

Study variables included demographics, mechanism of injury, injury severity, procedures performed, exposure to prophylactic antibiotics, culture results, and results of admission CXR and CCT. We defined VAP by an elevated white blood cell (WBC) count, a new finding on CXR consistent with a pneumonic process, and a positive respiratory culture in a patient ventilated for >48 h. Diagnostic lower respiratory tract cultures were obtained by non-bronchoscopic bronchoalveolar lavage. We defined early VAP as having an onset in <4 d of admission.

We compared BDC-positive and BDC-negative patients. We used logistic regression to determine whether the presence of BDC on admission CCT was independently associated with the development of VAP. Pulmonary culture results from patients developing early *versus* late and BDC-positive *versus* BDC-negative VAP were compared. Results are expressed as means with standard deviations (±SD), percentages, odds ratios with 95% confidence intervals (CIs), and *P* values or raw data, where appropriate. We performed statistical analysis using chi-square, Fisher's exact test, or *t*-test, when applicable. $P < 0.05$ was considered statistically significant. We performed analysis using SPSS for Windows, version 20 (Chicago, IL).

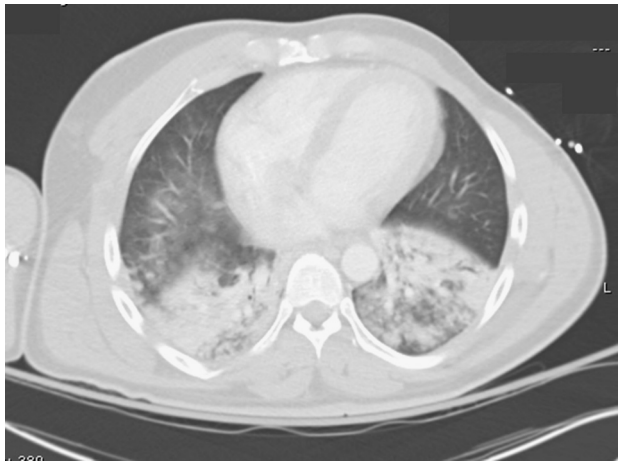

Fig. – Chest computed tomography of a 41-year-old man after an assault, who had facial fractures and a subdural hematoma. Radiology reporting interpreted this CCT as 'possible aspiration.'

3. Results

A total of 94 patients met inclusion criteria. Most were male (69 patients [73.4%]) and mean age was 34.4 y (± 21.1 y) . Mean injury severity score (ISS) was 34.8 (± 17.5). A total of 28 patients (29.8%) had BDC on admission CCT; 33 (35.1%) developed VAP; 41 (43.6%) had a normal admission CXR, whereas 14 (14.9%) had no abnormalities discovered on CCT. A total of 13 patients (13.8%) underwent laparotomy, 27 (28.7%) underwent craniotomy, and 46 (48.9%) had an intracranial pressure (ICP) monitor placed. There were 20 patients (21.3%) with an isolated head injury. A total of 59 patients (62.8%) received prophylactic antibiotics within 24 h of admission for invasive procedures. Overall mortality was 30 patients (31.9%) (Table 1).

Comparison of the 28 BDC-positive *versus* the 66 BDC-negative patients revealed no significant difference in male gender (24 patients [85.7%] *versus* 45 patients [68.2%]; $P = 0.124$), mean age (34.2 y [± 20.3 y] *versus* 34.5 y [± 21.6 y]; $P = 0.942$), incidence of motor vehicle collision/motor cycle collision (MVC/MCC) mechanisms (12 [42.9%] *versus* 20 [30.3%]; $P = 0.240$), incidence of pedestrian *versus* MVC mechanisms (8 [28.6%] *versus* 21 [31.8%]; $P = 0.755$), incidence of severe injury (ISS ≥ 25) (19 [67.9%] *versus* 37 [56.1%]; $P = 0.387$) or admission GCS = 3 (18 [64.3%] *versus* 30 [45.5%]; $P = 0.095$). The incidence of ICP monitoring (12 [42.9%] *versus* 34 [51.5%]; $P = 0.443$), craniotomy (6 [24.4%] *versus* 21 [31.8%]; $P = 0.309$), and laparotomy (3 [10.7%] *versus* 10 [15.2%]; $P = 0.569$] also did not differ between groups. Despite these many similarities, the incidence of VAP in BDC-positive patients was