Synergistic impact of acute kidney injury and high level of cervical spinal cord injury on the weaning outcome of patients with acute traumatic cervical spinal cord injury

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ABSTRACT

Introduction: Respiratory neuromuscular impairment severity is known to predict weaning outcome among patients with cervical spinal cord injury; however, the impact of non-neuromuscular complications remains unexplored. This study was to evaluate possible neuromuscular and non-neuromuscular factors that may negatively impact weaning outcome.
Methods: From September 2002 to October 2012, acute traumatic cervical spinal cord injury patients who had received mechanical ventilation for >48 h were enrolled and divided into successful ($n = 54$) and unsuccessful weaning groups ($n = 19$). Various neuromuscular, non-neuromuscular factors and events during the intensive care unit stay were extracted from medical charts and electronic medical records. Variables presenting with a significant difference ($p < 0.2$) between these two groups were included in the univariate analysis. Following univariate analysis, those significantly different variables ($p < 0.05$) were subjected to multivariate logistic regression to identify independent predictors of unsuccessful weaning.
Results: Compared to successful weaning patients, unsuccessful weaning patients were older; more often had high level of cervical spinal cord injury (C1–3), lower pulse rates, and lower Glasgow Coma Scale score on admission, higher peak blood urea nitrogen, lower trough albumin, and lower trough blood leukocyte counts. Furthermore, unsuccessful weaning patients had a higher incidence of pneumonia, acute respiratory distress syndrome, shock and acute kidney injury during the intensive care unit stay. Multivariate logistic regression analysis revealed acute kidney injury and high level of cervical spinal cord injury were independent risk factors for failure of weaning. Importantly, patients with both risk factors showed a large increase in odds ratio for unsuccessful weaning from mechanical ventilation ($p < 0.001$).
Conclusions: The presence of acute kidney injury during the intensive care unit stay and high level of cervical spinal injury are two independent risk factors that synergistically work together producing a negative impact on weaning outcome.

Introduction

Cervical spinal cord injury is a devastating disease and may cause serious complications that require support from mechanical ventilation in an intensive care unit (ICU) [1,2]. The complications mainly result from impairment of the neural control of respiratory muscles, the severity of which is correlated with the cervical level of the injury [3,4]. This respiratory neuromuscular impairment is particularly disadvantageous to such patients when

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they need to be discontinued from ventilator [5]. Although the clinical management of cervical spinal cord injury patients has been greatly improved [2,4,6], these patients still have a high risk of weaning failure and some of them eventually become ventilator-dependent [7,8]. Thus, weaning patients with cervical spinal cord injury from the ventilator remains a challenge for clinicians [1,9].

Only a few studies have evaluated the predictors for cervical spinal cord injury patients who merit weaning from ventilation. A higher level of cervical spinal cord injury, an older age, and a lower Glasgow Coma Scale (GCS) score on admission have been reported to be associated with weaning failure in this patient population [8,10,11]. Additionally, negative inspiration force and forced vital capacity have been suggested to be weaning predictors in patients with high level of cervical spinal cord injury [11]. However, most of these weaning predictors, if not all, appear to be directly related to the respiratory neuromuscular impairment found in cervical spinal cord injury patients and thus it is not surprising that these risk factors exert a negative impact on weaning outcome. It is worth noting that, at ICU admission, or during an ICU stay, cervical spinal cord injury patients may develop various complications, such as acute kidney injury (AKI) [12,13], electrolyte imbalance [14,15], shock [13,16,17], and respiratory infection [13,18]. All of these are secondary to or are not even related to cervical spinal cord injury-induced respiratory neuromuscular impairment. Importantly, many of these non-neuromuscular complications have been reported to be associated with a higher risk of weaning failure in ICU patients without cervical spinal cord injury [19–21]. However, whether these non-neuromuscular complications may work together with respiratory neuromuscular impairment to synergistically produce a negative impact on the weaning outcome of cervical spinal cord injury patients remains unknown.

The objectives of this study were, firstly, to identify respiratory neuromuscular and non-neuromuscular risk factors that may have a negative impact on weaning outcome among patients with acute traumatic cervical spinal cord injury, and, secondly, to evaluate any possible synergistic impacts of these two categories of risk factors on weaning outcome among these patients.

Methods

Design, setting and patients

This retrospective study was conducted at Taipei Veteran General Hospital, a 3000-bed tertiary medical centre. The study was approved by the Institutional Ethical Review Board of Taipei Veterans General Hospital (VGHTPE-IRB No. 201008001IC). Informed consent was not required for this observational study according to our institutional guidelines. Among patients admitted between September 2002 and October 2012, we identified by chart review patients who had suffered cervical spinal cord injury and had then developed respiratory failure. Patients were eligible for inclusion if acute spinal cord injuries were in the cervical region and had a traumatic aetiology. Patients were excluded if (1) the time of the traumatic cervical spinal cord injury was longer than 2 weeks before admission, (2) they were aged <18 year-old, (3) data could not be collected because medical charts unavailable, (4) the duration of mechanical ventilation (MV) support was shorter than 48 h for surgical requirement, (5) they were transferred to another hospital with the reason not being weaning failure, or (6) they died before successful weaning without completing the weaning protocol. The patients enrolled were divided into successful and unsuccessful weaning groups according to the weaning outcome at hospital discharge.

Data collection

The data used in this study was extracted from medical charts and electronic medical records and included age, gender, body mass index, level of cervical spinal cord injury, co-morbidities, smoking history, laboratory results, radiological records, Glasgow Coma Scale (GCS) score, respiratory failure, vital signs and CNS complications at admission. During the course of their ICU stay, clinical events involving the patient, including AKI, pneumonia, acute respiratory distress syndrome (ARDS), bacteremia, and urinary tract infection were all recorded. Finally, the length of hospitalization, the length of the ICU stay and the duration of invasive MV were also collected.

Definition

The neurological level of spinal cord injury was determined as the most caudal segment of the spinal cord with normal motor and sensory function on both sides of the body [22]. A high level of cervical spinal cord injury included injuries at levels C1–C3, while a low level of cervical spinal cord injury included injuries at levels C4–C7 [10,11]. Respiratory failure denotes respiratory compromise and a requirement for invasive mechanical ventilator support. ARDS criteria was according to the Berlin definition [23]. AKI was defined as a 50% or greater increase in serum creatinine, a 25% or greater decrease in glomerular filtration rate from the patient's baseline level or a urine output less than 0.5 ml/kg/h for at least 6 h [21,24]. Complications of the central nervous system included seizure, stroke, hypoxic encephalopathy, subarachnoid haemorrhage, intracranial haemorrhage, epidural haemorrhage and skull bone fracture. The presence of shock was defined as a systolic blood pressure less than 90 mmHg despite adequate fluid resuscitation; along with the use of vasopressors for more than 48 h [21]. Successful weaning was defined as being free from mechanical ventilator before discharge from hospital; unsuccessful weaning was defined as failure of weaning trial during hospitalization and being ventilator-dependent on discharge from hospital.

Statistical analysis

We analyzed the differences in data between acute traumatic cervical spinal cord injury patients with successful and unsuccessful weaning. We employed the Kolmogorov–Smirnov test to check the distribution of the continuous variables, The Mann–Whitney U test was used to compare continuous variables with a non-normal distribution, while Fisher's exact test was used to compare categorical variables. Variables presenting with a significant difference ($p < 0.2$) between the two groups were included in the univariate analysis. Following univariate analysis, those variables that were found to be significant ($p < 0.05$) were subjected to multivariate logistic regression to identify independent predictors of unsuccessful weaning. We considered a two tail p value of <0.05 to be significant and, furthermore, we calculated odds ratios (ORs) with 95% confidence intervals (CIs). The continuous and categorical variables are presented as mean ± SD SD and n (%), respectively. These analyses were performed using SPSS version 19.0 (SPSS Inc., Chicago, IL).

Results

Characteristics of the study patients

Over the 10-year study period, 523 patients were admitted with a diagnosis of traumatic cervical spinal cord injury and 139 patients were excluded according to the exclusion criteria.