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Risk factors for prolonged duration of mechanical ventilation in acute traumatic tetraplegic patients—a retrospective cohort study☆,☆☆

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ABSTRACT

Purpose: Respiratory complications constitute an important determinant of length of stay in tetraplegic patients. In a population of tetraplegic patients, we investigated the factors involved in the duration of mechanical ventilation (MV) and whether the duration of MV was associated with the long-term neurologic status.
Material and Methods: In a retrospective study in 3 intensive care units (ICUs) (January 2001 to December 2009), consecutive patients (≥18 years) hospitalized for acute (≤24 hours) traumatic tetraplegia were included in the study. Patients with severe brain injury or who died in the first 48 hours were excluded. The primary outcome was the duration of MV. The secondary outcomes were the American Spinal Injury Association (ASIA) motor score on ICU discharge and at 1 year.
Results: A total of 164 consecutive adult patients with tetraplegia were analyzed. Median (interquartile range) ASIA motor scores were 15 (6-26) on admission, 22 (9-40) on ICU discharge (n = 145 survivors), and 37 (10-80) at 1 year (n = 52 complete follow-up). The median duration of MV was 11 (2-26) days. In multivariate analysis, MV duration increased with pneumonia ($P < .0001$), atelectasis ($P = .0042$), and tracheotomy ($P < .0001$). In exploratory analysis, an increased duration of MV was the only factor associated in multivariate analysis with a low ASIA motor score on ICU discharge ($P = .0201$) and at 1 year ($P = .0003$).
Conclusions: Prevention of pneumonia and atelectasis is critical for the reduction of MV in tetraplegic patients. Prolonged MV was independently associated with poor neurologic status.

1. Introduction

Spinal cord injury (SCI) affects 12 000 people per year in the United States [1]. One third of the patients with SCI are tetraplegic, and 50% present with a complete lesion [1]. The average age at injury is 32 years, and life expectancy exceeds 12 years after trauma. Spinal cord injury is one of the main causes of prolonged disability in young individuals and is one of the most expensive medical conditions (mean cost: $53 000 a year in the United States) [2]. To date, no treatment resulting in a major functional or neurologic recovery is available [3]. Data regarding independent risk factors for poor neurologic status are sparse, and recognition of modifiable factors that dampen neurologic status is, therefore, a major issue.

Spinal cord injury is a major cause of prolonged mechanical ventilation (MV) for critically ill patients [4]. Restrictive respiratory failure is partially responsible for prolonged MV, and little preventive care can be proposed in this setting. However, acute respiratory complications are a major factor in determining the duration of MV and hospital costs in tetraplegic patients [5]. Hospital-acquired pneumonia (HAP) affects up to 30% patients with SCI and increases the rates of tracheotomy and death [5]. In a large cohort of patients with SCI, respiratory complications in an intensive care unit (ICU) were a more important determinant of the duration of hospitalization than the level of injury [6]. Prevention of respiratory complications could limit the disabilities of tetraplegic patients.

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To date, the impact of the complications associated with the MV in the long-term neurologic status in tetraplegic patients has not been documented. Three decades ago, "vigorous pulmonary therapy" was proposed to decrease the need for a ventilatory support and to increase survival in patients with traumatic quadriplegia [7]. Therapeutics aiming to prevent respiratory complications and to reduce the duration of MV remains poorly efficient, and no specific respiratory care can be recommended [8]. We therefore aimed to investigate: first, the modifiable risk factors associated with the duration of MV and second, the independent factors involved in the long-term neurologic status of tetraplegic patients.

2. Methods

2.1. Ethics statement

The Institutional Review Board of the Rennes University Hospital approved the study (France; no.: 11-10; date of acceptance July 25, 2010). The study was epidemiological and noninterventional, and informed consent was waived.

2.2. Funding source and potential conflict of interest

No author has any related conflict of interest to disclose. This study was performed with institutional funds.

2.3. Subjects

This is a retrospective multicentric study using data collected from January 2001 to December 2009 in 3 French surgical ICUs. Consecutive patients (≥18 years) hospitalized for acute (≤24 hours) traumatic tetraplegia were included in the study. Exclusion criteria were injury occurring more than 24 hours before ICU admission, nontraumatic SCI, associated severe traumatic brain injury (Glasgow Coma Score ≤8), or death within 48 hours of ICU admission.

2.4. General care for tetraplegic patients

Surgical stabilization of an unstable rachis lesion was always discussed with the neurosurgical team before ICU admission and was performed early as required. According to French guidelines, secondary ischemic cord injuries were prevented by keeping body temperature below 38°C, ensuring normoglycemia and normocapnia, avoiding hypoxemia, and maintaining mean arterial pressure above 70 mm Hg. Except when contraindicated, sedated patients were kept in a semirecumbent position [9]. Chest physiotherapy was started in the first 72 hours after the trauma.

2.5. Definitions

Traumatic tetraplegia was defined as a severe or complete loss of motor function in all 4 limbs resulting from an acute traumatic lesion of neural elements in the spinal canal. The spinal cord lesion was confirmed by computed tomography or magnetic resonance imaging.

The American Spinal Injury Association (ASIA) impairment scale is as follows [10]: grade A (no motor or sensory function is preserved in the sacral segments S4-S5), grade B (sensory but not motor function is preserved below the neurologic level and includes the sacral segments S4-S5), grade C (motor function is preserved below the neurologic level, and more than half of key muscles below the neurologic level have a muscle grade of <3), grade D (motor function is preserved below the neurologic level, and at least half of the key muscles below the neurologic level have a muscle grade of ≥3), grade E (motor and sensory functions are normal). The reported level of functional deficit was the lowest level of normal motor function.

The ASIA motor scale is as follows: 20 prespecified muscles (5 in the upper limb, 5 in the lower limb, 5 in the upper extremity, and 5 in the lower extremity) are tested. Each muscle is scored in a 5-point muscle grading scale: 0 (total paralysis), 1 (palpable contraction), 2 (active movement, full range of motion without gravity), 3 (full range of active motion against gravity), 4 (full range of active motion against some resistance), 5 (normal strength if identifiable inhibiting factors were not present). The ASIA motor scale ranges from 0 (complete motor deficit) to 100 (no motor deficit).

Hospital-acquired pneumonia was considered when at least 2 signs (body temperature >38°C or <36°C; leukocytosis >12 000/mL, or leukopenia <4000/mL; purulent pulmonary secretions) associated with the appearance of a new infiltrate were present or when changes occurred in an existing infiltrate on chest x-ray [11]. The diagnosis needed to be confirmed by a respiratory tract sample using a quantitative culture with a predefined positive threshold of 10^4 colony-forming units (CFU)/mL for a bronchoalveolar lavage and 10^3 CFU/mL for a protected specimen. *Early-onset HAP* was defined as a pneumonia that occurred between days 2 and 7 after the trauma. Late-onset HAP occurred on day 8 or after.

Pulmonary atelectasis was considered when absence of air in part or all of a lung, such as a collapsed lung, was noticed either on chest x-ray or thoracic computed tomography [12]. However, atelectasis is particularly difficult to record in a retrospective study. We therefore considered atelectasis according to a compatible chest x-ray modification with bronchoscopic confirmation during the ICU stay.

2.6. Data collection

Age (years), sex, weight (kilograms), medical history, Simplified Acute Physiology Score (SAPS) II, Injury Severity Score (ISS), clinical and anatomical level of spinal lesion (cervical vertebra number), ASIA scores (impairment scale, motor and sensory scores, sacral sensory dysfunction), associated injuries (yes/no), transfusion (yes/no), vasoactive drugs on admission (yes/no), and surgery before admission (yes/no) were recorded. Stress-ulcer prophylaxis (yes/no), corticosteroids (dexamethasone, hydrocortisone, or none), ventilatory support (lower positive end-expiratory pressure [PEEP; cm H_2O] and higher tidal volume [milliliters per kilogram] in the first 24 hours), pulmonary atelectasis (yes/no), HAP (yes/no), and duration of MV (days) were recorded during the ICU stay. Neurologic status (ASIA scores, functional level) and mortality were assessed on ICU discharge and 1 year after the injury. The ASIA scores were assessed by intensivists on admission and on ICU discharge and by physical therapists at 1 year.

2.7. Statistical analysis

Continuous variables were expressed as median (interquartile range [IQR]) or mean ± SD, and qualitative variables, as number (%). Pearson correlation coefficient was used to measure association between quantitative variables and duration of MV. The Student *t* test or Wilcoxon nonparametric test was used to assess association between binary variables and duration of MV. A multivariate linear regression model was constructed to assess the duration of MV in the entire population. A logarithm transformation of the length of MV was performed to ensure model validation. Lesions of the phrenic nerve, observed in SCI C03-C05, are a major determinant of the duration of MV; thus, the multivariate linear regression model of MV was adjusted on a functional level (C01-C05 and C06-C08) [8]. Variables identified as potential risk factors by the univariate analysis with a cut-off point at 0.20 were included in a multivariate linear regression adjusted on a functional level and on the study center (included as a categorical variable in the model). Then a backward selection was applied. Postregression diagnoses were performed to ensure that all linear regression assumptions were valid (normality and homoscedasticity of residuals). The models were presented with β regression