An Evaluation Of The Usefulness Of Weaning Parameters In Patients With Lower Cervical Spine Injury

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Abstract

Pulmonary impairment is a well-known complication in patients with lower cervical spine injury (C4-T1) with neurologic deficit. We evaluated prospectively collected data with regard to the ability of weaning parameters (spirometric data) to predict pulmonary collapse in these patients. We found that only low FVC (forced vital capacity) was able to predict pulmonary collapse. All other parameters including negative inspiratory force, respiratory rate, tidal volume and vital capacity were statistically similar between patients that developed pulmonary collapse and those that did not develop pulmonary collapse.

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INTRODUCTION

Pulmonary impairment is a well-known complication in patients with lower cervical spine injury [C4-T1] with neurologic deficit. The flaccidity of intercostal and abdominal muscles results in a significant reduction of respiratory volumes. In spite of phrenic nerve sparing, vital capacity data in the acute setting have been shown to be as low as 30 % of predicted values [1]. The ability to predict pulmonary collapse would assist significantly in the management of lower cervical spine injury patients with neurologic deficit. Therapeutic interventions such as early tracheostomy or more aggressive pulmonary toilet may reduce mortality and morbidity. Several indices such as vital capacity, tidal volume, respiratory rate, negative inspiratory force and even tidal volume to respiratory rate ratio have been shown in various populations to accurately predict the outcome of weaning from mechanical ventilation [2,3,4]. We have previously published the lack of utility of these standard weaning parameters in patients with lower C-spine injury with neurologic deficit5. We hypothesized that patients that go on to develop pulmonary collapse will manifest alterations (obstructive flow pattern) due to retention of pulmonary secretions. Forced vital capacity (FVC) is a weaning parameter that may provide a window into this evaluation of retained secretions. We prospectively evaluated the usefulness of conventional weaning parameters (vital capacity, tidal volume, respiratory rate, and negative inspiratory force) and a new marker, forced vital capacity, in predicting impending pulmonary collapse in patients with lower cervical spine injury [C4-T1] with neurologic deficit.

MATERIALS AND METHODS

Data were collected prospectively on 20 patients with lower cervical spine injury with neurologic deficit seen over a two year period in a rural university based level 1 trauma center. As this was a non-interventional data collection study, Institutional Review Board exemption was obtained. The patients were followed if they had a lower cervical spine injury (C4-T1) with neurologic deficit. All patients had respiratory weaning parameters obtained with 24 hours after surgical repair of their spine injury and prior to extubation. All weaning parameters were obtained through the endotracheal tube with the cuff inflated. The respiratory therapists performing the weaning parameters were questioned regarding the technique to verify uniform gathering of data. All weaning parameters were obtained from the ventilators, which the patients were on (Puritan Bennett 7200A, Puritan Bennett Corp, Waltham, MA) prior to extubation. The parameters were obtained at one setting only. Each parameter was obtained either 3 times if the values were within 5% of each other or 5 times if greater variability was noted. When the parameter was obtained 3 times a simple average was used. When the parameter was obtained 5 times the largest and smallest values were discarded and the 3 others were averaged to obtain the parameter. Tidal volume, respiratory rate and negative inspiratory force were obtained in a standard fashion. The vital capacity (VC) was obtained by a slow inspiratory maneuver with a short end inspiratory pause followed by a slow expiration. The forced vital capacity (FVC) was obtained by a slow inspiratory maneuver with a short inspiratory pause followed by a rapid expiration. All respiratory weaning parameter data and demographic data were verified at the end of the study by a detailed chart review. Demographic data collected includes age, gender, mechanism of injury, level of injury in the spinal cord, and injury severity score (ISS). Outcome data included pulmonary collapse, hospital length of stay, and survival. Pulmonary collapse was defined as collapse of any portion of either lung requiring reinstitution of mechanical ventilation during the hospitalization. All patients were followed until discharge. Statistical analysis was performed using one way analysis of variance in comparing data between patients with and without pulmonary collapse. Statistical significance threshold was $p < 0.05$.

RESULTS

There were a total of 14 men and 6 women with ages ranging from 18 to 42 with an average age of 25.4. All the patients that went on to develop pulmonary collapse did so within the first 5 days after being extubated. There was no significant difference in history of smoking or age between patients that developed pulmonary collapse and patients without pulmonary collapse (24.9 ± 7.1 vs. 26.1 ± 5.6, respectively). There was no significant difference in ISS between patients that developed pulmonary collapse and patients without pulmonary collapse (21.5 ± 2.1 vs. 23.6 ± 1.8, respectively). The age, mechanism of injury, gender, and ISS data is listed on table 1. Average weaning parameter data is listed on table 2. There was no difference in negative inspiratory force, respiratory rate, tidal volume, and vital capacity in patients with and without pulmonary collapse. However forced vital capacity was significantly lower in patients that went on to develop pulmonary collapse as compared to patients who did not develop pulmonary collapse.

Figure 1

Patient #	Sex	Age	ISS	Mechanism of Injury	Pulmonary Collapse ?	Smoking History ?
1.	M	18	24	MVC	No	Yes (1ppd)
2.	F	18	20	MVC	Yes	No
3.	F	22	22	DIV	Yes	Yes (0.5 ppd)
4.	M	24	22	MVC	Yes	No
5.	F	22	25	MVC	No	No
6.	F	24	24	DIV	Yes	No
7.	M	26	22	MVC	Yes	No
8.	F	27	24	MVC	Yes	Yes(1 ppd)
9.	M	42	24	LOG	Yes	No
10.	M	25	24	LOG	No	No
11.	M	35	22	MVC	Yes	No
12.	M	22	18	DIV	Yes	Yes (occ)
13.	M	32	20	DIV	No	No
14.	M	21	22	DIV	Yes	No
15.	M	28	24	DIV	No	No
16.	M	27	26	DIV	No	No
17.	F	19	18	MVC	Yes	No
18.	M	19	20	MVC	Yes	No
19.	M	35	24	MVC	No	No
20.	M	22	22	MVC	No	No

MVC=motor vehicle crash,

LOG = logging accident,

DIV = diving accident,

ISS = injury severity score.

Figure 2

Pulmonary Collapse	NIF (mmHg)	RR	TV (ml/kg)	VC (ml/kg)	FVC (ml/kg)
yes	33.75 ± 3.77 27.45 (to) 39.50	21.5 ± 2.1 14 (to) 28	5.06 ± 0.71 3.90 (to) 6.30	19.14 ± 2.57 15.50 (to) 23.25	5.79 ± 1.30 4.10 (to) 7.45
no	32.88 ± 5.51^{+} 26.90 (to) 39.75	23.6 ± 1.8^{+} 13 (to) 30	5.09 ± 0.45^{+} 4.15 (to) 6.25	17.71 ± 3.29^{+} 13.25 (to) 23.50	11.93 ± 1.63* 8.75 (to) 14.50

Mean + SEM, (range) $^{*}p < 0.0001$, ^{+}p = ns

NIF = Negative Inspiratory Force,

RR = Respiratory Rate,

TV = Tidal Volume,

VC = Vital Capacity,

FVC = Forced Vital Capacity.

DISCUSSION

Pulmonary complications are commonly reported in patients with lower cervical spine injury despite the phrenic nerve sparing. Comprehensive respiratory management with chest physiotherapy including postural drainage, positive pressure insufflation, humidification, deep breathing and assisted coughing has considerably reduced the mortality from respiratory failure [6,7,8]. However respiratory complications account for up to fifty percent of deaths in patients with traumatic tetraplegia [9]. The lowering of respiratory volumes is a common finding, possibly due to the flaccidity of the intercostal and abdominal muscles leading to a less effective diaphragmatic contraction. In fact, vital capacity data in the acute setting have been shown to be as low as 30 % of predicted values 1. The exact relationship between the lowering of lung volumes and requirement of reintubation due to the development of pulmonary complications is unknown.

There is a great need to be able to predict the development of pulmonary collapse and the need for reintubation, so that interventional therapeutics may be started at an earlier stage. Conventional weaning parameters (vital capacity, tidal volume, respiratory rate and negative inspiratory force) as well as tidal volume to respiratory rate ratio have been effective in predicting the outcome of weaning trials in various populations without cervical spinal cord injuries 2-4 , These same parameters were ineffective in predicting pulmonary complications in our previous study of patients with lower cervical spine injuries [5] . We felt that theoretically there should be a relationship between pulmonary collapse and early alterations in lung volumes in these patients as all the patients that went on to pulmonary collapse did so within the first 5 days after extubation. Perhaps we were not looking at the appropriate lung volumes. We also felt that the pulmonary collapse was related to the inability to clear pulmonary secretions. This inability to clear secretions may manifest early on as a partial obstructive problem. We needed to assess a lung volume that would be affected by a partial obstruction. None of the previously tested directly assessed this aspect of the problem. We felt that the addition of forced vital capacity as a weaning parameter would detect a partial obstructive problem which may be present in the patients that go on to develop pulmonary collapse. As we were only theorizing this ability to predict pulmonary collapse, we could not justify the performance of a full spirometry with its added expense for each patient.

Our approach took advantage of the fact that as the severity of obstruction increased (due to the build up of secretions) the FVC was significantly reduced while the VC (which may not be reduced) provides a better estimate of total lung size [10]. A recent study by Braggion et al. has shown that there can be a discrepancy in FVC values based upon the inspiratory maneuver prior to the expiratory maneuver11. They found that slow inspiratory maneuver allows for better detection of an expiratory gradient resulting in lower FVC [11]. Our approach took advantage of this, and provided a better window into evaluating expiratory flow obstruction. As we did not perform a full spirometric evaluation we were unable to obtain FEV1 values. Clearly, this parameter may confirm a definite problem in these patients. As a part of further evaluation we will be performing full spirometric evaluation on our next set of C-spine injured patients. Further studies are needed to determine the utility of these indices as well as other causes of pulmonary collapse that is often seen in patients with lower cervical spine injury despite sparing of the phrenic nerve.

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