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Risk factors associated with post-extubation stridor in the trauma intensive care unit

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Abstract

BACKGROUND: Post-extubation stridor is an uncommon complication in medical intensive care units (ICUs) but has not been well studied in trauma patients. We sought to determine the incidence of reintubation due to stridor in trauma patients and describe associated risk factors.

METHODS: A retrospective review of all intubated trauma patients was performed. Data collected included presence of stridor, demographic data, and details of intubation and extubation.

RESULTS: Of all trauma patients reintubated, 31% were for stridor. Although female gender, age less than 18, blunt mechanism, and duration of intubation 5 days or more were associated with reintubation for stridor, endotracheal tube diameter was not. Mortality was not increased with reintubation.

CONCLUSIONS: Trauma ICU patients are reintubated for stridor at a higher rate than medical ICU patients. Age, gender, blunt mechanism, and duration of intubation are risk factors for this complication.

Stridor is an accepted clinical manifestation of laryngeal edema[1] and can herald loss of airway. When stridor is noted after extubation, it is often an acute, precipitous, and stressful event. The complication can develop quickly and may require immediate intervention to prevent reintubation. If supportive measures fail, it may be difficult to re-establish an airway because of the underlying edema. In addition to these immediate concerns, extubation failure typically leads to longer intensive care unit (ICU) stays and more days on the ventilator and has been associated with increased morbidity and mortality in medical populations.[2,3] Although relatively well studied in the medical ICU literature, there is limited research examining reintubation, particularly reintubation due to stridor, in the trauma population.

Most stridor studies have been conducted in medical or mixed medical–surgical ICUs,[1,4–10] where post-extubation stridor (PES) has been identified as an infrequent cause of reintubation, making up approximately 1% to 15% of all reintubations.[1,4,11] Among the risk factors cited for reintubation due to stridor are female gender, longer duration of intubation, and absence of a cuff leak.[1] Another possible risk factor is a larger endotracheal tube (ETT) relative to a patient's laryngeal diameter,[6,9] although this finding has not been universally supported.[12,13]

The pathophysiology of medical ICU patients can differ greatly from trauma patients, making it difficult to extrapolate data from one population to another. A review of the limited trauma literature shows that many risk factors for reintubation are unique and distinct from medical patients.[14,15] Furthermore, in a mixed medical and trauma

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ICU, it was found that admission for trauma was associated with an increased rate of reintubation due to stridor.[9] In the only study to our knowledge examining PES and extubation failure specifically in a trauma population, there was a 33% incidence of stridor leading to reintubation[12]—a rate much higher than in medical ICU studies.

Because of previous medical ICU literature describing trauma as a risk factor for stridor,[9] a higher reported rate of stridor in trauma patients,[12] and from anecdotal observations by the trauma intensive care staff, we hypothesized that in a trauma population, PES is a more frequent cause of extubation failure than previously described in the medical literature. The purpose of this study was to evaluate the incidence of PES as the cause of extubation failure in a trauma population and identify associated risk factors.

Methods

A retrospective study of all intubated patients admitted to the trauma service was conducted at the Community Regional Medical Center, a 650-bed American College of Surgeons–verified level 1 trauma center in Fresno, CA, from May 2007 to May 2014. Patients were excluded from the study if they underwent tracheostomy, were transferred or died before their first extubation attempt, or were successfully extubated but remained intubated after a subsequent surgical procedure.

A patient was considered to have failed extubation due to laryngeal edema if they were reintubated within 48 hours of extubation, and if clinical charting by the nurse, respiratory therapist or physician reported laryngeal edema, upper airway obstruction or, most commonly, stridor, as the direct cause of, or being temporally related to, the patient's reintubation.

Patients in the study were divided into 2 groups: failed extubation with stridor (FES) and successful extubation (SE). A patient was placed in the SE group if they remained off the ventilator for greater than 48 hours. Patients with documented stridor who did not require intubation were also included in the SE group. These 2 groups were compared by the following variables obtained from the trauma database: age, gender, injury type, ISS, Glasgow Coma Scale on arrival to the emergency department, Abbreviated Injury Score of the head and neck, and chest, presence of chest tube, total ventilator days, ICU length of stay, hospital length of stay, placement of tracheostomy, and mortality.

A matched cohort analysis was done to evaluate the importance of the relationship of tracheal and ETT size. In this additional analysis, each FES patient was then matched for age, gender, and ISS, with 2 patients from the SE group. Matching was limited to these demographics to avoid overmatching. FES patients were excluded from further analysis if they could not be matched with patients in the SE group in an attempt to limit potential bias. Comparisons between these 2 groups included weight, laryngeal diameter, and ETT size. Patient weight was measured at admission and within 2 days of extubation in lieu of recorded fluid balance, which often had wide variation.

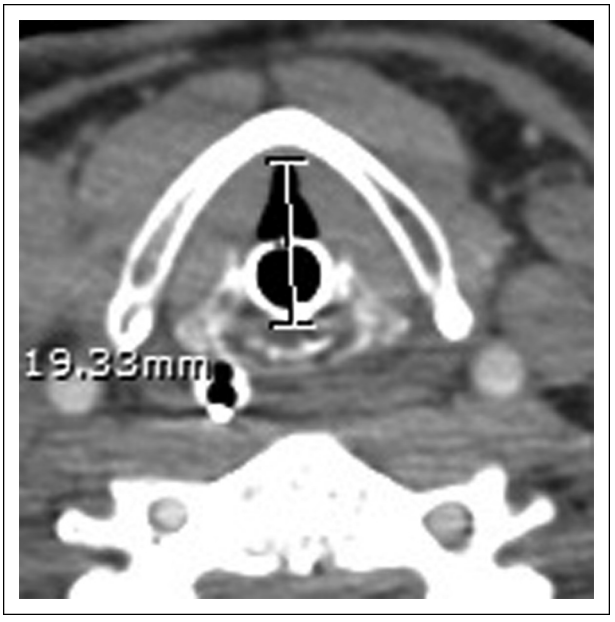

Figure 1 Example of measurement of laryngeal diameter.

The anterior–posterior axial laryngeal diameter was measured at the mid-point between the notch and inferior edge of the thyroid cartilage in the FES group and matched groups (Fig. 1). This location was chosen as it most consistently approximated the location of the patient's vocal cords, the narrowest and most dependent part of the larynx, and where Colice et al[16] most commonly found laryngeal injuries in intubated patients. These data were combined with the external diameter of the patient's ETT to calculate an ETT to laryngeal diameter ratio for each patient. Patients in the matched cohorts without computed tomographic scans were excluded from laryngeal diameter and ETT to laryngeal diameter ratio analysis but were included in comparison with weight and weight change.

Additional comparisons between mortality and tracheostomy rates between FES, SE, and patients failing extubation for reasons other than PES were also performed.

Statistical analysis was performed using paired *t* tests for matched data, 2-tailed independent *t* tests for unmatched data, and chi-square analysis. Statistics were performed using the Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, Version 23.0. IBM Corp, Armonk, NY), and significance was attributed to a *P* value less than .05. This study was approved by the institutional review board of the University of California San Francisco, Fresno, and Community (Regional) Medical Centers.

Results

In the 7-year time period, there were 2,880 intubated trauma patients admitted to Community Regional Medical

Center. A total of 1,255 patients were excluded due to death (715), transfer (280), or tracheostomy before attempted extubation (660), with some patients meeting multiple exclusion criteria. The cohort was 1,625 patients. Of these, 1,477 were successfully extubated on the first attempt and 148 (9%) failed extubation and were reintubated. Of the 148 patients who failed extubation, 46 (31%) failed due to stridor (Fig. 2). Of note, 316 patients were extubated within 24 hours of admission and 2 required reintubation, but neither were reintubated for stridor.

Comparisons between all FES and SE patients are listed in Table 1. There were a greater percentage of women, patients intubated 5 days or more, patients younger than 18 years, and patients with a blunt mechanism of injury in the FES group. Additionally, FES patients had more days on the ventilator, longer ICU length of stay, and overall length of stay. Mortality between these groups was not different, but the tracheostomy rate was higher in the FES group. There were no differences between Glasgow Coma Scale at arrival to the ER, Abbreviated Injury Score head and neck or chest, or presence of a chest tube.

The results of the cohorts matched by gender (female gender 40 vs 40%, $P = 1.00$), age (41.6 vs 41.5 years, $P = .98$), and ISS (23 vs 21, $P = .62$) are listed in Table 2. One FES patient could not be case matched and was not included in further analysis of weight, laryngeal diameter, or ETT size. The absolute laryngeal diameter and the ratio of the ETT diameter to laryngeal diameter were not different between the case-matched FES and SE groups. Further analysis of the patients where the ETT completely occluded the lumen of the larynx was not different between the FES and SE groups. Weight and weight change were not different between the groups. Of note, there was no difference in the number of patients without computed tomographic scans between the groups (10 of 45 FES and 33 of 90 SE; $P = .09$).

Mortality and tracheostomy rates were similar among FES patients and patients who failed extubation due to other causes. Comparing all patients who failed extubation (FES + failed for other causes) with the SE group, mortality was not different (Table 3) but tracheostomy rates were higher in those failing extubation.

Comments

To our knowledge, this is the largest study evaluating reintubation and stridor in the trauma ICU. Of the 148 patients who required reintubation, 46, or nearly a third, required reintubation because of stridor. This is more than twice the rate reported in the medical ICU literature (1% to 15%)[4,11] but consistent with the only other study evaluating a trauma population.[12] Age, gender, mechanism of injury, and duration of intubation were identified as risk factors associated with this complication. This study also found that trauma patients failing extubation because of stridor (or for any cause) had mortality rates similar to successfully extubated patients. This contrasts with the medical ICU literature that reports an increase in mortality among reintubated patients.[2,3,17]

The lower associated mortality may be because of the demographic differences between the trauma and medical ICU populations. When medical ICU patients fail extubation, it tends to be due to respiratory failure, failure to

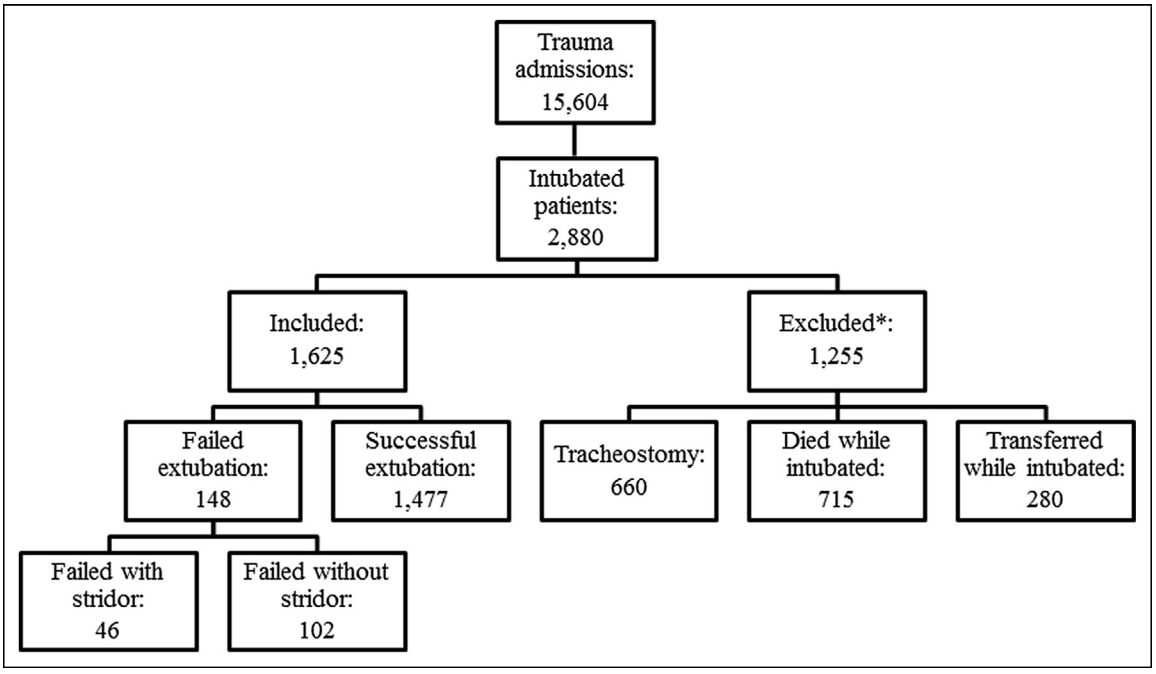

Figure 2 Patient selection. "*," Total number of excluded patients is greater than the sum of the exclusion categories because many patients met multiple exclusion criteria.

Table 1 Comparison of patients failing extubation with stridor and all successfully extubated patients

Variable	Stridor	Successful extubation	*P* value
N	46	1,477	—
Age < 18 y	11 (24%)	156 (11%)	.004
Female gender	19 (41%)	308 (21%)	.001
Blunt injury	44 (96%)	1,199 (81%)	.013
AIS head and neck ≥ 3	26 (57%)	694 (47%)	.20
AIS chest ≥ 3	20 (43%)	580 (39%)	.57
Chest tube	14 (30%)	394 (27%)	.57
Vent days ≥ 5*	30 (65%)	548 (37%)	<.001
Died	2 (4%)	21 (1%)	.11
Tracheostomy	21 (46%)	89 (6%)	<.001
Age	41 ± 23	36 ± 18	.20
ISS	23 ± 10	20 ± 10	.15
GCS	9 ± 5	10 ± 5	.19
Vent days†	16 ± 14	6 ± 7	<.001
ICU length of stay	16 ± 14	7 ± 8	<.001
Hospital length of stay	23 ± 14	14 ± 13	<.001

AIS = Abbreviated Injury Score; GCS = Glasgow Coma Scale; ICU = intensive care unit.
*Number of vent days before initial extubation attempt.
†Total number of vent days during hospitalization.

manage secretions, and cardiac issues[11,17] which are often related to serious underlying conditions with an expected increase in associated mortality. Conversely, trauma patients tend to be younger, healthier, and have fewer comorbidities. The different mortality rate with reintubation between these populations would suggest that trauma and medical ICU patients should be treated as separate entities in future study.

Although mortality was not increased in reintubated trauma patients, ventilator days, ICU length of stay, and total hospital stays were significantly greater. This demonstrates the importance of preventing this complication despite its nominal effect on mortality as it increases resource utilization and exposes the patient to all the potential morbidities associated with prolonged intubation and ICU stays.

The finding that longer intubation is associated with increased risk for reintubation due to stridor would suggest that the duration of the irritation is more significant than the size of the ETT relative to the patient's larynx. Previous findings show that the area of injury is most commonly the posterior cords and larynx,[16,18] where the ETT would rest regardless of its size or the size of the larynx. In children, the larynx is located more anteriorly which may exacerbate this injury, possibly explaining the increased incidence in patients younger than 18 years.

In addition to these findings, when comparing the FES and the case-matched SE group, the ratio of ETT diameter to larynx diameter was not associated with reintubation due to PES. Previous studies suggesting an association between stridor and ETT size used calculations correlating height to laryngeal diameter[6] or the direct ratio of height to ETT

Table 2 Comparison of patients failing extubation with stridor and successfully extubated matched on age, gender, and ISS

Variable	Stridor	Successful extubation	*P* value
N	45	90	—
Female gender	18 (40%)	36 (40%)	1.00
Age	41.6 ± 22.9	41.5 ± 22.7	.98
ISS	23 ± 10	21 ± 10	.62
ETT size	7 ± 1	7 ± 1	.56
Larynx size	18.5 ± 3.8	19.5 ± 4.9	.27
ETT:larynx	.64 ± .19	.60 ± .20	.39
Initial weight	81.5 ± 17.1	86.4 ± 20.2	.26
Extubation weight	89.1 ± 18.6	90.2 ± 21.4	.92
Weight change	7.7 ± 12.4	3.8 ± 6.2	.20
Percent weight change	10.6 ± 16.2	4.7 ± 7.8	.15

Larynx size is measured in millimeters, and weight in kilograms.
ETT = endotracheal tube.

Table 3 Mortality and tracheostomy rates of patients failing extubation with stridor compared with those failing for other causes and patients successfully extubated compared with all patients failing extubation

Outcome	Stridor	Failed without stridor	*P* value
N	46	102	—
Died	2 (4%)	3 (3%)	.66
Tracheostomy	21 (46%)	52 (51%)	.55
	Successful extubation	Failed extubation*	*P* value
N	1,477	148	—
Died	21 (1%)	5 (3%)	.071
Tracheostomy	89 (6%)	73 (49%)	<.001

*Includes patients who failed with stridor and failed for any other causes.

diameter[9] without direct measurements of the airway. In the present study, direct measurement of the airway was performed. Furthermore, analysis of the patients with the maximum ETT to larynx ratio (ie, where the ETT was circumferentially filling the larynx) showed no significant association with developing PES and reintubation.

Our study is susceptible to the weaknesses of all retrospective studies, including the necessity of relying on chart review to discern the cause of extubation failure. However, the trauma registry specifically addresses reintubations, and a diligent chart review was conducted on each patient.

Not all potential risk factors were available through our database and chart review, such as location of intubation, smoking status, and presence of a cuff leak before extubation. It is practice of many of the attending surgeons to check for a cuff leak before extubation; however, these data were not recorded consistently in the medical record and, thus, was not available for study. Additionally, although there are articles describing absence of cuff leak as a reliable indicator of PES,[5] there is some evidence that cuff leaks do not predict PES.[6,13,19] Furthermore, our extubation failure rate is comparable with previously reported rates in the trauma literature ranging from 4% to 9%,[12,14,20] and thus, lack of such a test does not seem to have an effect on extubation failure in our patients.

Further prospective trials are needed to better describe risk factors for PES as the cause of extubation failure in a trauma population. This research should focus on factors that can be mitigated to reduce this complication.

Conclusions

In trauma ICU patients, PES requiring intubation occurs at more than twice the highest reported rate in the medical ICU literature. Female gender, age younger than 18 years, blunt mechanism of injury, and intubation for 5 days or more, are associated with increased risk of reintubation due to PES, whereas ETT relative to larynx size is not. Reintubation due to stridor, or for any other cause, was not associated with increased mortality. Because of these differences between populations, future reintubation studies should analyze trauma ICU patients separately from medical ICU patients.

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