Occurrence and Complications of Tracheal Reintubation in Critically Ill Adults

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BACKGROUND: Timing and preparation for tracheal extubation are as critical as the initial intubation. There are limited data on specific strategies for a planned extubation. The extent to which the difficult airway at reintubation contributes to patient morbidity is unknown. The aim of the present study was to describe the occurrence and complications of failed extubation and associated risk factors, and to estimate the mortality and morbidity associated with reintubation attempts. METHODS: Cohort study of 2,007 critically ill adult patients admitted to the ICU with an ETT. Patients were classified in 2 groups, based on the requirement for reintubation: "never reintubated" versus "≥ 1 reintubations." Baseline characteristics, ICU and hospital stay, hospital mortality, and in-patient costs were compared between patients successfully extubated and those with reintubation outside the operating room, using regression techniques. Reasons, airway management techniques, and complications of intubation and reintubation were summarized descriptively. RESULTS: 376 patients (19%) required reintubation, and 230 (11%) were reintubated within 48 hours, primarily due to respiratory failure. Patients requiring reintubation were older, more likely to be male, and had higher admission severity score. Difficult intubation and complications were similar for initial and subsequent intubation. Reintubation was associated with a 5-fold increase in the relative odds of death (adjusted odds ratio 5.86, 95% CI 3.87–8.89, *P* < .01), and a 2-fold increase in median ICU and hospital stay, and institutional costs. Difficult airway at reintubation was associated with higher mortality (adjusted odds ratio 2.23, 95% CI 1.01–4.93, *P* = .05). CONCLUSIONS: Nearly 20% of critically ill patients required out of operating room reintubation. Reintubation was associated with higher mortality, stay, and cost. Moreover, a difficult airway at reintubation was associated with higher mortality. *Key words: extubation; mechanical ventilation; ICU; cohort study; airway management.* [Respir Care 2012;57(10):1555–1563.

Introduction

As many as 10–30% of mechanically ventilated patients will fail extubation and require reintubation during their hospital stay.[1–3] While the causes of extubation failure are diverse, patients have generally been classified in the lit-

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erature as early (hours) or late (days) failures, where the major etiologies of early and late failure are upper-airway obstruction and underlying medical condition, respectively.[4,5] Regardless of the cause, reintubation itself is independently associated with greater odds of developing ventilator-associated pneumonia[2,6] and with an excess hospital mortality, reported to be up to 42%.[2,7–12] The ability to accurately identify patients at higher risk of extubation failure and what the likely causes of failure may be has the potential to positively impact morbidity and mortality by reducing extubation failures and improving patient safety at the time of reintubation. Further, a thorough understanding of the frequency and burden of complications associated with reintubation is needed. Thus, the aims of our current study were: to investigate the occurrence and timing of extubation failure in a population of intubated patients requiring ICU admission; to estimate the adjusted mortality and incremental costs associated with failed extubation; and to describe techniques and frequency of complications at reintubation.

QUICK LOOK

Current knowledge

Timing and preparation for tracheal extubation are as critical as the initial intubation, but there are limited data on specific strategies for planned extubation. The extent to which the difficult airway at reintubation contributes to morbidity is unknown.

What this paper contributes to our knowledge

Nearly 20% of critically ill patients required out-of-operating-room reintubation. Reintubation was associated with higher mortality, longer stay, and higher cost. Identification of a difficult airway at reintubation was associated with higher mortality.

Methods

Patient Population

The study site was Harborview Medical Center, a 413-bed municipal medical center in Seattle, Washington, affiliated with the University of Washington, and the only Level 1 trauma center in a 5 state area (Washington, Wyoming, Alaska, Montana, and Idaho). Exclusive of pediatrics, it has 88 ICU beds, with separate ICUs for medical, cardiac, trauma/surgical, burn, and neurology/neurosurgery patients. All ICUs have 24-hour coverage and are staffed by intensivist-lead teams consisting of an attending physician, critical care fellow, upper level resident, and junior level resident. The departments of surgery, anesthesiology, and internal medicine provide physician coverage, attendings, and trainees.

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The medical records of critically ill adult patients admitted to one of the medical, trauma/surgical, neuroscience, or burn ICUs between July 1, 2008, and August 31, 2009, and who were endotracheally intubated, either inside or outside the hospital, were evaluated. All data were available from the hospital database, originating from computerized medical and billing records and from a prospectively collected registry of trauma-related admissions. The University of Washington institutional review board approved this study with a waiver of informed consent.

Eligibility Criteria

All patients who were endotracheally intubated, either in the pre-hospital setting or at any time during their hospital stay, including the ward, operating room, or ICU, and who required ICU admission during the study period were included. All extubations took place in the ICU. Patients < 18 years of age and those not eligible for endotracheal reintubation were excluded. Ineligibility for reintubation was defined as endotracheal tube (ETT) removal in the context of initiation of comfort care measures (do not intubate order), indwelling tracheostomy or tracheostomy placement without attempting extubation, or death while the patient's trachea was still intubated. Events of reintubation in the operating room for elective or emergency surgical procedures and reintubation for exchanging the ETT were not considered. Data on all reintubations occurring outside the operating room were collected. Detailed data were collected on the first reintubation only, because only a small number of patients had subsequent events ($n = 24$).

Pre-hospital intubations are performed by paramedics as part of the responding emergency medical services. The out of operating room airway management model at our institution is chiefly anesthesiology based, with a paging system notifying the anesthesia providers carrying the airway pager. The responding airway team consists of an anesthesia trainee or nurse anesthetist and an anesthesiology attending.

All patients underwent a daily protocolized ventilator weaning assessment. Patients were considered for a spontaneous breathing trial (SBT) if they had evidence of resolution or improvement of the underlying cause of respiratory failure, a minute ventilation < 15 L/min, PEEP ≤ 8 cm H_2O, intracranial pressure < 20 cm H_2O, hemodynamically stable without vasopressors, pH ≥ 7.25 with intact respiratory drive, $F_{IO_2} < 0.5$, and $P_{aO_2}/F_{IO_2} \geq 150$ mm Hg. Sedation for mechanical ventilation was provided per standardized ICU protocol, targeting a goal of 0 to −2 on the Richmond Agitation and Sedation Scale. Unless contraindicated, a spontaneous awakening trial was performed daily, followed by an SBT.[13] Failure of the SBT was defined as: respiratory rate > 35 breaths/min; oxygen saturation < 92% for > 30 seconds; reduction in minute ventilation to < 75% of baseline during mechanical ventilation; a heart rate > 140 beats/min or a change of > 20% from baseline; a systolic blood pressure > 180 or < 90 mm Hg; sustained increase in anxiety, diaphoresis, or other clinical sign of respiratory distress; an increase in intracranial pressure > 20 cm H_2O for > 2 min; arrhythmia; pH ≤ 7.25; or a P_{aCO_2} increase of ≥ 10 mm Hg.[14] Additional factors considered prior to extubation included the requirement for tracheal suctioning more than every 4 hours, presence of an effective spontaneous cough, presence of a leak around the deflated ETT cuff with a sustained manual inspiratory pressure of < 30 cm H_2O, and any recent history of upper-airway obstruction or stridor. These criteria are followed for all intubated patients unless extubation is unplanned. Noninvasive ventilation by oronasal mask is available for use in recently extubated patients at the discretion of the primary team caring for the patient, but there are no protocol-based criteria for its use in this setting at our institution.

Data Collection

Data were abstracted from the electronic medical record using a database repository containing physiologic and laboratory variables. Data abstraction via manual medical record review was performed to collect detailed information on intubation techniques and complications of airway management that were not retrievable electronically. Data abstraction was conducted by the primary author (NM), with independent verification on a random sample by the senior author (MMT). Additionally, for complex situations, adjudication of events was carried out via case-by-case discussion among 3 investigators (NM, AMJ, and MMT).

Demographic variables included age, sex, ethnicity, weight, height, and severity of illness, measured by the Simplified Acute Physiology Score II (SAPS II). Admission services included medical, general surgery, neurological surgery, orthopedic surgery, vascular surgery, and otolaryngology. Reasons for intubation were classified as respiratory failure, upper-airway obstruction, altered mental status, and cardiopulmonary arrest. Providers performing the intubation procedures were paramedics, anesthesiology staff or residents, nurse anesthetists, and non-anesthesiology physicians. Details of intubation and reintubation included type of airway (oral/nasal), technique (direct laryngoscopy, intubating laryngeal mask airway, videolaryngoscopy, and fiberoptic bronchoscopy), number of attempts to place the ETT, and need for surgical airway.

For patients requiring reintubation, time to reintubation and type and dose of medications used for the procedure were recorded, along with the same variables collected for initial intubation. Decisions to reintubate were made by the primary clinical ICU service providing patient care at the time of the event. Pharmacologic agents were collected only at reintubation, as induction agents could be tracked via the hospital pharmacy administration system.

Study End Points and Study Definitions

Patients were classified in 2 groups, based on the requirement for reintubation (ie, "never reintubated" versus "one or more reintubations"). The primary end point was hospital mortality. Secondary end points were hospital and ICU stay; hospital costs and charges; and characteristics (indications and techniques), reasons for, and complications of intubation and reintubation.

Difficult intubation (DI) was defined as one requiring 3 attempts at airway instrumentation to place the ETT, or ≥ 2 attempts at direct laryngoscopy with a Cormack-Lehane grade 3 or 4 view of the vocal cord aperture, or DI documented by the provider managing the airway. An airway complication was defined as any of the following events, documented up to one hour following the intubation: hypoxemia ($S_{pO_2} < 92\%$), hemodynamic instability (hypotension [systolic blood pressure < 90 mm Hg], hypertension [systolic blood pressure > 180 mm Hg], bradycardia [heart rate < 50 beats/min], tachycardia [heart rate > 120 beats/min]), documentation of aspiration, performance of surgical airway, cardiac arrest, hypoxic brain injury, and death. We used variables documented within one hour because vital signs are entered hourly in the electronic medical record, thus allowing vital signs to be collected up to the next nearest hour. Extubation failure was defined as the requirement for reinstitution of mechanical ventilation any time after initial extubation requiring out of operating room tracheal intubation during the hospital stay. Reintubation events in the operating room for elective or emergency procedures did not count toward the study-defined out of operating room reintubation.

Cost was estimated from the institutional perspective. Hospital charges for each patient were obtained from hospital administrative records. Charges were converted to cost by applying the institution specific cost-to-charge ratio (0.668). Dollar values for cost have been adjusted for inflation and are reported in 2007 United States dollars. As the data are current, we did not correct for the inflation factor during the last 6 months of 2009.

Statistical Analysis

Data are expressed as mean ± SD for measured characteristics, or in frequency distributions for categorical characteristics. Baseline characteristics were compared between the 2 groups of patients, never reintubated versus those reintubated at least once, using an independent 2-sample Student *t* test for measured characteristics. The *t* tests used do not assume equal variances between the 2 groups. Chi-square tests were used to compare the 2 groups and categorical characteristics. For the primary analysis, multivariable logistic regression was used to estimate the adjusted odds ratio (OR) of mortality and to account for potential confounders, comparing patients never reintubated versus those reintubated at least once. For analytical purposes, only the first out of operating room reintubation was considered. Potential confounders selected a priori included age, sex, body mass index, SAPS II, and medical/surgical admission. Hospital stay and cost data were modeled with multivariable linear regression on the log transformed response variable. The 2 response variables were log transformed to make them more symmetric. Robust (sandwich) variance estimates were used in all regression models.

In order to compare characteristics and complications of first intubation and reintubation, we performed a subgroup analysis among patients who required at least one reintubation. To account for intra-class correlation, variables were compared using the McNemar test for paired binary data (dichotomous variables) or paired *t* test (continuous variables), as appropriate.

We planned a priori 2 secondary analyses. The first analysis was restricted to reintubation events that occurred within 48 hours of extubation. The other secondary analysis included only patients whose cause of reintubation was due to respiratory failure or airway obstruction, to estimate the attributable morbidity of these events on patient outcome. An observed significance level of .05 was considered statistically significant. All *P* values are 2-sided. Statistical software (Stata 11.0, StataCorp, College Station, Texas) was used for the analyses.

Results

Study Population

We evaluated 2,571 critically ill patients, and 2,007 patients met study inclusion criteria. The Figure shows the flow diagram of the cohort selection and reasons for exclusion. Overall, 376 patients (19%) required at least one reintubation during the hospital stay, with an additional 14% requiring airway manipulation for elective or emergency procedures in the operating room. Multiple reintubations occurred in 24 (6%) patients, and overall 53 (14%) patients who required reintubation underwent tracheotomy procedure. Of the entire population, the out of operating room intubations occurred within 24 hours in 187 (9%) and within 48 hours in 230 (11%) of the patients. The median time to first reintubation was 22 hours (IQR 6–63).

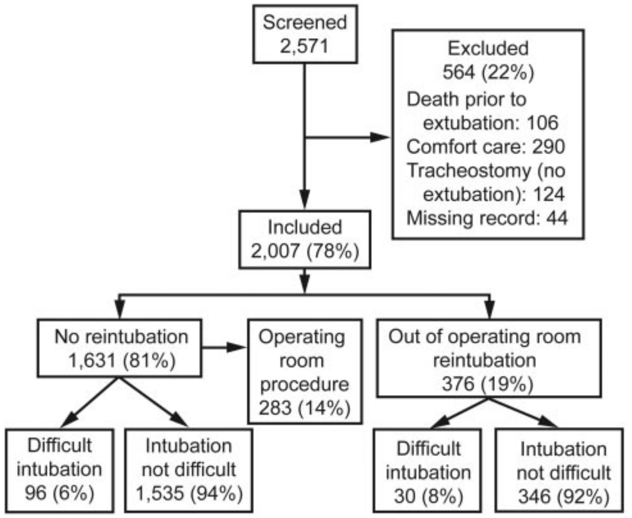

Figure. Flow diagram of the cohort selection, with stratification on reintubation status, location of reintubation, and intubation difficulty.

Patients who were reintubated were more likely to be older, male, and to have worse disease severity scores (Table 1).

Characteristics of Intubation and Reintubation

In the entire cohort, the most common reasons for intubation were respiratory failure (36%), intubation for procedures (26%), altered level of consciousness (19%), and airway obstruction (17%, Table 2). Excluding reintubations for operating room procedures, the distribution of reasons for reintubation was significantly different from the ones at initial intubation ($P < .01$, McNemar test), with the most common reasons for reintubation being respiratory failure (77%) and airway obstruction (17%).

There were no substantial differences in type of airway (oral or nasal) inserted, laryngoscopy techniques used, or Cormack-Lehane grade (see Table 2). Direct laryngoscopy was the most commonly used intubation technique. However, at reintubation the inner diameter of the ETT was significantly smaller and more likely to have been placed by a staff or resident anesthesia provider.

DI was encountered in 8% of patients at both initial and subsequent reintubation. No association was found between encountering a DI either initially or at reintubation, with only 4% increase in likelihood of difficulty at reintubation given the initial intubation was also difficult (OR 1.04, 95% CI 0.57–1.90).

Table 1. Baseline Subject Characteristics at ICU Admission, Stratified by Requirement for Reintubation

	All Subjects (N = 2,007)	No Reintubation* (n = 1,631)	Reintubation (n = 376)	P†
Age, mean ± SD y	49.5 ± 17.9	49.6 ± 17.8	53.4 ± 17.7	< .01
Male, no. (%)	1,326 (66)	1,060 (65)	266 (71)	.03
Weight, mean ± SD kg	85.6 ± 24.1 (n = 1,989)	86.5 ± 26.1 (n = 1,615)	85.4 ± 23.6 (n = 374)	.34
BMI, mean ± SD kg/m^2	29.7 ± 16.6 (n = 1,987)	30.4 ± 18.6 (n = 1,613)	29.6 ± 16.2 (n = 374)	.42
Race/Ethnicity, no. (%)				.44
White	1,497 (74)	1,194 (73)	285 (76)	
African American	182 (9)	152 (9)	30 (8)	
Asian	138 (7)	108 (7)	30 (8)	
Hispanic	126 (6)	110 (7)	16 (4)	
Other	82 (4)	67 (4)	15 (4)	
SAPS II, mean ± SD	39.4 ± 15.2	38.4 ± 14.9	43.7 ± 15.9	< .01
Type of Admission, no. (%)				.13
Medical	1,289 (64)	1,060 (65)	229 (61)	
Surgical	718 (36)	571 (35)	147 (39)	
Emergency surgery	401 (56)	317 (56)	84 (57)	.73
Admitting Service, no. (%)				.75
General surgery	531 (26.5)	431 (26.5)	100 (26.6)	
Orthopedics	336 (16.8)	52 (3.2)	15 (4.0)	
Vascular surgery	67 (3.3)	48 (2.9)	7 (1.9)	
Neurosurgery	517 (25.8)	419 (25.7)	98 (26.1)	
Head and neck	55 (2.7)	48 (3.0)	7 (1.9)	
Medicine	479 (23.9)	395 (24.3)	84 (22.3)	
Other	20 (1.0)	16 (1.0)	4 (1.1)	
Trauma, no. (%)	980 (49)	794 (49)	186 (50)	.87
Post-extubation steroids, no. (%)	7 (0.35)	5 (0.31)	2 (0.53)	.50
Post-extubation noninvasive ventilation, no. (%)	58 (2.9)	38 (2.33)	20 (5.32)	< .01

* This group also includes subjects who were reintubated for procedures in the operating room.
† Two-sample t-test with assumption of unequal variance, or chi-square statistic.
BMI = body mass index
SAPS II = Simplified Acute Physiology Score II

The occurrence of reintubation-related complications was equally and highly prevalent at intubation and reintubation (see Table 2). However, their distribution differed between the initial and subsequent event. Specifically, bradycardia and hypertension were recorded more commonly at initial intubation than at reintubation. There were no emergency surgical airways performed at reintubation. Of the 53 elective tracheotomies, 9 (17%) were performed in patients who had an initial DI. Clear documentation of the induction agents and their dose was unavailable in 8% of medical records. Propofol (51%) and etomidate (29%) were the most commonly used sedative agents. Use of succinylcholine was found in 33% of reintubations.

Patient Outcomes

The overall hospital mortality for the entire cohort was 6% (Table 3). There was a significantly higher mortality in the group requiring reintubation (18%), compared to the "no reintubation" group (3%). After adjusting for potential confounders, reintubation was independently associated with a greater than 5-fold higher mortality (adjusted OR of death 5.86, 95% CI 3.87–8.89, $P < .01$, adjusted for age, sex, SAPS II, and medical admission). While a first DI was not associated with increased mortality ($P = .40$), difficulty at reintubation was associated with higher mortality ($P < .01$). In adjusted analyses, difficulty at reintubation remained associated with higher mortality (adjusted OR of death 2.23, 95% CI 1.01–4.93, $P = .05$).

There was substantial morbidity associated with reintubation, as indicated by about a 2-fold increase in median ICU and hospital stay, compared with patients never reintubated (4 vs 16 d, and 10 vs 23 d, respectively, $P < .01$, see Table 3). Likewise there was a 2-fold increase in hospital cost and charges associated with reintubation ($24,700 vs $64,000, and $97,200 vs $223,600, respectively, $P < .01$,

Table 2. Indication, Techniques, and Complications of First Intubation and Reintubation

	No. (%)			
	All Subjects (N = 2,007)	First Intubation (n = 376)	Reintubation (n = 376)	P*
Indication for Intubation				
Respiratory failure	721 (36)	159 (42)	289 (77)	< .01†
Airway obstruction	338 (17)	54 (14)	65 (17)	
Altered mental status	385 (19)	66 (18)	11 (3)	
Procedure (elective or emergency)	517 (26)	84 (23)	NA	
Cardiac arrest	46 (2)	13 (3)	11 (3)	
Type of Airway				
Oral	1,986 (99)	368 (98)	367 (98)	> .99‡
Nasal	21 (1)	8 (2)	7 (2)	
Endotracheal Tube Inner Diameter	(n = 1,934)	(n = 365)	(n = 349)	
7.0 mm	494 (26)	79 (22)	104 (30)	< .01§
7.5 mm	923 (48)	180 (49)	192 (55)	
8.0 mm	423 (22)	88 (24)	36 (10)	
Other	94 (5)	18 (2)	5 (1)	
Technique				
Direct laryngoscopy	1,878 (94)	346 (93)	345 (92)	> .99‖
Laryngeal mask airway	8 (0.4)	2 (0.5)	1 (0.3)	
Video laryngoscope	114 (6)	26 (7)	31 (8)	
Fiberoptic scope	55 (3)	12 (3)	6 (2)	
Cormack-Lehane View Grade	n = 745	n = 159	n = 297	
I	536 (72)	117 (74)	212 (71)	.49¶
II	154 (21)	30 (19)	64 (21)	
III or IV	55 (7)	12 (8)	21 (7)	
Unknown	1,262 (63)	217 (58)	79 (36)	
Provider Training				
Attending	104 (5)	23 (6)	38 (12)	< .01**
Resident	558 (29)	120 (33)	252 (78)	
Certified Registered Nurse Anesthetist	209 (11)	41 (11)	30 (9)	
Non-anesthesia provider	1,037 (54)	179 (49)	1 (0.3)	
Complications				
Difficult intubation	125 (6)	29 (8)	30 (8)	> .99††
Any complications	964 (48)	188 (50)	195 (52)	.67‡‡
Hypoxemia (S_{pO_2} < 92%)	160 (8)	43 (11)	43 (11)	> .99
Bradycardia (HR < 50 beats/min)	52 (3)	12 (3)	0 (0)	< .01
Tachycardia (HR > 120 beats/min)	451 (23)	79 (22)	93 (26)	.23
Hypotension (SBP < 90 mm Hg)	318 (16)	70 (19)	86 (23)	.16
Hypertension (SBP > 180 mm Hg)	274 (14)	52 (14)	18 (5)	< .01
Aspiration	52 (3)	9 (3)	3 (0.8)	.18
Cardiac arrest	4 (0.3)	0 (0)	0 (0)	NA
Death	1 (0.06)	0 (0)	0 (0)	NA

* P values were computed using the exact McNemar test for paired binary data and compare characteristics of first intubation and reintubation among 376 subjects who required out of operating room reintubation.
† Comparing respiratory failure versus all other indications (odds ratio 4.3, 95% CI 2.6–7.3).
‡ Odds ratio 1.25, 95% CI 0.27–6.30.
§ Comparing inner diameter size 7.5 or less versus larger inner diameter (odds ratio 2.17, 95% CI 1.44–3.31).
‖ Odds ratio of direct laryngoscopy 0.94, 95% CI 0.44–1.98.
¶ Comparing grade I view versus all other grades (odds ratio 0.74, 95% CI 0.34–1.55).
** Comparing residents versus all other providers (odds ratio 4.6, 95% CI 3.18–6.83).
†† Odds ratio 1.04, 95% CI 0.57–1.90.
‡‡ Odds ratio 1.08, 95% CI 0.80–1.44.
NA = not applicable
HR = heart rate
SBP = systolic blood pressure

Table 3. Subject Outcomes Stratified by Requirement for Reintubation

	All Subjects (N = 2,007)	No Reintubation (n = 1,631)	Reintubation (n = 376)	P*
Hospital mortality, no. (%)	111 (6)	45 (3)	66 (18)	< .01
Time to extubation failure, median (IQR) h	NA	NA	22 (6–63)	NA
ICU Stay†				< .01
Median (IQR) d	6 (2–14)	4 (2–10)	16 (9–25)	
Mean ± SD d	10.5 ± 13.3	8.2 ± 10.8	20.7 ± 17.7	
Days from first extubation to ICU discharge, median (IQR) d	3.2 (1.3–9.6)	2.5 (1.1–6.4)	11.9 (5.6–21)	< .01
Hospital Stay‡				< .01
Median (IQR) d	12 (5–22)	10 (5–19)	23 (13–36)	
Mean ± SD d	17.1 ± 18.6	14.5 ± 16.2	28.1 ± 23.7	
Hospital Charges (× $1,000)§				< .01
Median (IQR)	116.3 (53.1–214.6)	97.2 (44.6–178.8)	223.6 (125.0–333.3)	
Mean ± SD	156.6 ± 145.7	133.4 ± 125.7	256.1 ± 180.0	
Hospital Direct Costs (× $1,000)‖				< .01
Median (IQR)	28.8 (13.8–54.7)	24.7 (11.3–24.7)	62.3 (33.0–127.2)	
Mean ± SD	40.6 ± 39.6	33.7 ± 32.2	70.6 ± 52.6	

* P values comparing "no reintubation" versus "reintubation" group, using 2-sample t test with assumption of unequal variance. Stay, cost, and charges have been log transformed prior to fit the regression models; ratios of medians are adjusted for age, sex, Simplified Acute Physiology Score II, and medical versus surgical status.
† Ratio of median ICU stay 2.04 (95% CI 1.85–2.26).
‡ Ratio of median hospital stay 2.20 (95% CI 1.98–2.43).
§ Ratio of median charges 2.04 (95% CI 1.85–2.26).
‖ Ratio of median direct costs 2.20 (95% CI 1.98–2.43).
NA = not applicable

see Table 3). Prolonged stay largely explained the incremental cost.

In sensitivities analyses, when we restricted the analysis to the subset of patients who required reintubation for respiratory failure (n_1 = 1,015, n_2 = 228) or upper-airway obstruction (n_1 = 1,341, n_2 = 65), our findings were substantially unchanged: adjusted OR of hospital mortality 5.05 (95% CI 2.82–9.02) in the subgroup with respiratory failure; adjusted OR of hospital mortality 5.19 (95% CI 2.11–12.77) in the subgroup with airway obstruction. The findings were also comparable when we restricted the analysis to patients who failed extubation within 48 hours (n_1 = 1,341, n_2 = 230), adjusted OR of hospital mortality 5.69 (95% CI 3.40–9.50).

Discussion

In this large cohort of critically ill patients, our main findings are that older age, male sex, and initial severity of illness were associated with greater likelihood of extubation failure, which was most often caused by respiratory failure or upper-airway obstruction. Half of the reintubations occurred by 22 hours. In addition, the need for reintubation was associated with increased stay and cost of care. Patients who required reintubation had significantly higher hospital mortality, relative to those never reintubated. It is interesting to note that experiencing difficulty during the initial intubation did not predict similar difficulty upon subsequent reintubation attempts. Insofar as half (49%) of the initial intubations were performed in the pre-hospital setting by non-anesthesia providers, it is likely that the combination of the environment in which the airway management was occurring and the level of expertise of the airway managers both contributed to the reported difficulty. Greater than two thirds (78%) of subsequent reintubations were performed by an anesthesia trainee, under more controlled conditions and with an attending anesthesiologist in attendance. Additionally, 9 patients with initial DI underwent elective tracheotomy. On the other hand, it is possible that patients with easier initial intubation became subsequently more difficult due to worsening edema, airway trauma, or cervical halo placement. We also found that encountering a DI at reintubation was associated with incremental mortality.

The overall proportion of reintubation in our cohort was nearly one in five (19%) and is consistent with the range reported in the literature, but slightly in excess of the 5–15% range proposed by the collective task force guidelines for weaning and discontinuing ventilatory support, published a decade ago.[15,16] The optimal reintubation rate—one that balances the complications of ongoing mechanical ventilation and those encountered at the time of reintubation—is not currently known. Large data sets, such as the one developed for this report, may be helpful in defining this balance.

We acknowledge the retrospective data collection in this study. Despite thorough chart review, the ability to robustly categorize the reasons for extubation failure was limited. In addition, data regarding airway management difficulties and associated complications were abstracted from electronic notes that were entered by the airway managers, nurses, and respiratory therapists. Single episodes of hypoxemia, hypotension, hypertension, bradycardia, or tachycardia were recorded as entered in the electronic medical record. However, our nursing staff is trained not to enter invalid values resulting from artifacts. Because the electronic record contains information input by bedside providers rather than being electronically captured, it is possible that the true extent of these occurrences may have been underreported. Additionally, reasons for reintubation could have been misclassified. Only the presence of a non-biased passive observer to collect such data systematically in a prospective manner could have obviated these limitations. There was a substantial mortality difference between patients never reintubated and those who required reintubation. However, despite the careful attempt to control for confounding, it is possible that residual confounding is present in these data. For example, noninvasive ventilation post-extubation was used more often in the reintubation group. Some authors have suggested that, when employed without adequate selection, it delays more appropriate and timely treatment, namely reinstitution of mechanical ventilation via an ETT, and results in worse outcomes.[17] Additionally, etomidate was used as an induction agent in nearly 30% of reintubations. Although contentious, its use is reportedly associated with worse outcomes in the critically ill.[18] More likely is that the need for reintubation identifies 2 groups of patients with inherently different prognosis, due to the substantial morbidity arising from the recurrence of respiratory failure. In other words, reintubation may simply be a marker of greater severity of illness/injury, without any directly attributable morbidity or mortality. Thus, the reader is cautioned not to draw conclusions of causality based on our analysis.

Conclusions

Our findings of an association between extubation failure and morbidity, mortality, and resource consumption corroborate prior reports. Among populations of medical and burn ICU patients, reintubation within 48–72 hours of extubation resulted in significantly more days of mechanical ventilation, longer ICU and hospital stay, and greater likelihood of in-hospital mortality or transfer to a long-term care or rehabilitation facility.[2,5,6] Reintubation has also been reported as an independent predictor of ventilator-associated pneumonia.[6] In contrast, a retrospective review of extubation failures in a trauma ICU reported similar mortality between those who failed extubation and the overall trauma center mortality.[10] Nonetheless, our translation of traditional resource utilization metrics to actual dollar cost outcomes adds to the current knowledge base and highlights the financial impact of each additional day of ventilator dependence and stay in the hospital. The mean hospital direct cost was $70,600 in patients who failed extubation versus $33,700 in those who did not.

Seventeen percent of the patients who failed extubation in our series did so due to upper-airway obstruction, consistent with the 15% reported by Epstein and Ciubotaru in a group of 74 medical ICU patients.[11] Our study did not find appreciable differences in the OR of hospital death when the reason for reintubation was airway-related, with the exception of a possible incremental mortality in patients with DI.

One of the primary reasons for doing retrospective studies such as ours is to generate hypotheses, which can then be studied prospectively. After meeting criteria to undergo an SBT and subsequently meeting extubation criteria, 11% of patients in our series required reintubation within 48 hours. Thus, a key unanswered question of clinical importance is how to accurately identify patients at high risk of early extubation failure so that strategies aimed at minimizing difficulty during reintubation and potential complications can be adequately studied. Insofar as the odds of complications and death have been shown to correlate with increasing numbers of airway instrumentations,[19] further study of protocolized extubation strategies, which might include pre-extubation stratification of reintubation risk, would be desirable.

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