

# Can We Identify Patients at High Risk for Unplanned Extubation? A Large-Scale Multidisciplinary Survey

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**BACKGROUND:** Unplanned extubation represents a threat to patient safety, and risk factors and prevention strategies for unplanned extubation have not been fully explored. **OBJECTIVES:** To define high-risk patients for unplanned extubation and determine clinicians' beliefs on perceived risks for unplanned extubation. **METHODS:** With a Web-based survey instrument we surveyed critical care clinician members of the American Association for Respiratory Care, the American Association of Critical Care Nurses, and the Society of Critical Care Medicine. **RESULTS:** Surveys were completed by 1,976 clinicians, including 419 respiratory therapists, 870 critical care nurses, and 605 critical care physicians. The majority of respondents considered an outward migration of the endotracheal tube (by 3 cm, 2 cm if an air leak is present) to represent a risk for unplanned extubation. Respondents considered the following as high risk for unplanned extubation: absence of physical restraints (72% of respondents), a nurse/patient ratio of 1/3 (60%), trips out of the intensive care unit (59%), light sedation (43%), and bedside portable radiograph (29%). In addition, most respondents considered accidental removal of the nasogastric tube (71%) or tugging on the endotracheal tube (87%) by the patient to be risk factors for unplanned extubation. The rank order of the perceived risks was related to the respondents' primary discipline. **CONCLUSIONS:** We identified perceived risk factors and defined "near misses" for unplanned extubation. Our findings should inform strategies for prevention of unplanned extubation. *Key words:* extubation, unplanned; intensive care unit; patient safety. [Respir Care 2010;55(5):561–568. © 2010 Daedalus Enterprises]

## Introduction

The quality of health-care delivery and patient safety are national policy issues.<sup>1,2</sup> Despite efforts to highlight the importance of patient safety,<sup>3</sup> the rate of medical errors<sup>4</sup> and the resulting increase in health-care costs are still underestimated by many health-care professionals.<sup>5</sup> In in-

tensive care units (ICUs), numerous factors pose risk to patient safety and increase the potential for medical errors.<sup>6,7</sup> It is estimated that 17% of ICU patients suffer one or more serious adverse events; 1.7 errors occur per patient day, of which 30% are potentially serious.<sup>8</sup>

A large proportion of patients admitted to ICUs require intubation and mechanical ventilation,<sup>9</sup> one important complication of which is unintentional removal of the endotracheal tube (ETT), which disconnects the patient from the ventilator and loses airway access. Unplanned extubation, which may be deliberate (self-extubation) or accidental, poses substantial risks to patients, and consumes health-care resources; therefore, efforts to prevent unplanned extubation are warranted.<sup>10,11</sup> While unplanned extubation is a familiar occurrence in the ICU, there is no agreed-upon strategy for prevention.

Medical errors, unintended acts of commission or omission, originate from inadequate monitoring, failure to act on results, or failure to respond to or to communicate available information.<sup>3</sup> A prevention system triggered by

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identifying at-risk situations may be safer and more efficient.<sup>12</sup> The concept of early-stage error-prevention is widely accepted and is used in various industries.<sup>13</sup> A “near miss” is defined as any process deviation that did not affect outcome but a recurrence carries a substantial risk of a serious adverse outcome. A near miss is contrasted to an “adverse event,” in which injury results from medical error, and its extreme form, a “sentinel event,” where the result is unanticipated death or permanent major loss of function. Targeting near misses is essential for improving patient safety, as near misses are expected to occur at a higher rate than unplanned extubations, thus allowing for systematic evaluation for risk factors. Such information provides the basis for developing prevention strategies.

Therefore, we constructed a survey instrument to assess opinions on perceived causes of unplanned extubation and to develop a multidisciplinary definition of near misses for unplanned extubation.

## Methods

### Survey Instrument

A team of researchers designed, pre-tested, and analyzed the survey instrument. The survey was designed to identify perceived risk factors for unplanned extubation in adult patients (> 18 y old) and to develop a working definition of a near miss of unplanned extubation.

We used the Focus Groups method<sup>14</sup> in the early stages of constructing the survey. Survey items were selected by a panel of experts in critical care medicine, representing critical care nursing, critical care medicine, and respiratory care. Items were selected based on existing literature, clinical training, and experience.

The survey instrument (which is available on request) had 3 sections. The first section was structured to collect demographic information. The second section sought to define factors that predispose to unplanned extubation, with questions focused on perceived risks, and allowed open-ended responses. The third section included 2 case vignettes designed to understand how critical care clinicians apply the concepts of medical error, near miss, and adverse event to unplanned extubation.

**Vignette 1.** A 56-year-old patient recovering from respiratory failure due to an exacerbation of COPD has been on mechanical ventilation for the past 3 days. He successfully completed a weaning trial at 8:00 AM, but extubation was postponed because he may go for a computed tomogram in the afternoon. He is minimally sedated, calm, and easily arousable. During airway suctioning, the ETT falls out when the patient has a strong cough and violent head shaking.

**Vignette 2.** A 30-year-old patient has multiple trauma, including pulmonary contusions and acute respiratory distress syndrome. He has been on mechanical ventilation for 3 days, with a fraction of inspired oxygen of 0.60 and positive end-expiratory pressure of 15 cm H<sub>2</sub>O. He has been heavily sedated but is now on a “drug holiday.” While moving him into the prone position, the ETT gets caught on the intravenous tubing and falls out. He is promptly re-intubated.

### Validity Testing

We used the following methods to test the survey instrument’s validity.

**Content Validity.** We conducted 3 focus group meetings of critical care experts, including 9 critical care nurses, 4 critical care respiratory therapists (RTs), and 11 critical care physicians. We distributed 55 pilot surveys to faculty and fellows of our Pulmonary and Critical Care Division, RTs, and critical care nurses at Tufts Medical Center, to gather opinions about conditions associated with airway near-misses and airway accidents, to include in the final survey. The pilot survey results supported the survey’s construct validity, as there was general agreement between the ratings and theory. With the input from the focus groups and the pilot survey we selected the items in the final survey instrument. The final decision was based on extensive literature review and the authors’ experience.

**Face Validity.** The survey was reviewed for face validity and further reviewed for content validity by members from the Division of Pulmonary, Critical Care, and Sleep Medicine, Critical Care Nursing, and Respiratory Care at Tufts Medical Center, and by experts in the study of medical errors.

### Preliminary Survey Testing

We pre-tested the survey for length and comprehensibility by physicians, RTs, and nurses at Tufts Medical Center and an affiliated center.

The survey was further refined based on recommendations from the research committee of the Society of Critical Care Medicine and feedback from leadership of the American Association for Respiratory Care (AARC) and the American Association of Critical Care Nurses (AACN).

### Survey Participants, Distribution, and Administration

The survey was conducted with cooperation from the AARC, AACN, and the Society of Critical Care Medicine. We posted the final version on <http://www.surveymonkey->

.com, and invited participants via e-mail. The AARC posted the survey web-link on its home page, the Society of Critical Care Medicine invited 5,871 of its members, and the AACN invited 2,000 of its members to participate. Our local institutional review board approved the study.

### Statistical Methods

Responses were compared with chi-square tests, Fisher's exact test, and Kruskal-Wallis 1-way analysis of variance, as indicated. We performed multivariate analysis with a logistic regression model to control for years of experience, practice setting, site for securing the ETT, and the presence of expert airway backup. All reported *P* values are based on 2-sided tests. We considered a 2-sided *P* of  $< .05$  significant. We present the survey responses as total responses and percent of valid answered questions. We calculated a weighted average to account for asymmetrical response rate among different specialties. All statistical analysis was performed with statistics software (SPSS 16, SPSS, Chicago, Illinois).

## Results

### Respondent Demographics

A total of 1,976 surveys were completed, by 419 RTs, 870 critical care nurses, and 605 critical care physicians. Eighty-two respondents did not declare their clinical credentials. Eighty-eight percent of the respondents practiced in the United States, and all the geographic regions and hospital settings that we invited to participate were represented (Table 1). Emergency backup for airway management was available by an anesthesiologist to 67% of the respondents and by an intensivist to 42%.

### Patients Perceived to Be at Risk for Unplanned Extubation

In general, in looking at the responses to all questions on risk, the responses of RTs fell between those of the nurses and physicians. Indeed, the responses of RTs (who constituted 21% of all respondents) were nearly identical to those of the weighted average of all respondents (Table 2). In the absence of an air leak, univariate analysis showed that 73% of all respondents considered an outward migration of the ETT by either 2 cm (34%) or 3 cm (38%) to represent a risk for unplanned extubation. Similarly, RTs' opinions were evenly distributed between 2-cm and 3-cm of outward migration as a risk factor for unplanned extubation. In contrast, there was a statistically significant difference between the nurses who favored 2 cm (46%), whereas physicians favored 3 cm (45%). Adding an air leak resulted in 4-fold increase in selecting the smallest

possible distance of ETT migration as a near miss; the 1-cm threshold that was selected by only 10% in the absence of air leak rose to 44%. The threshold was still significantly different between the nurses, who favored the lowest threshold of 1 cm, and the physicians' 1 cm or 2 cm. The statistical differences persisted after controlling for years of experience, critical care capacity of the hospital or ICU, the availability of expert airway backup, and which anatomical landmark to use for measuring the ETT position.

More than three quarters of the RTs and nurses indicated they used the lips as the landmark for measuring ETT position; the remainder used the incisors. In contrast, half of the physicians used the incisors and half used the lips. The ETT measuring landmark affected the threshold selection for near misses. Clinicians who measure the ETT at the lips selected a lower threshold (1 cm) (odds ratio 1.70, 95% confidence interval 1.31–2.07,  $P < .001$ ), compared to selecting a higher threshold (2 cm) by those who measure the ETT position at the incisors (odds ratio 0.77, 95% confidence interval 0.61–0.98,  $P = .03$ ).

Eighty-seven percent of the respondents considered the patient tugging on the ETT a risk for unplanned extubation, and 71% considered removing a nasogastric tube a risk for unplanned extubation. Two thirds of respondents considered the daily routine chest radiograph useful in identifying near-miss events, because the radiograph allows visualization of the tip of the ETT in relation to the carina. Half of all respondents believed that the definition of a near-miss depends on the patient's medical condition. Ninety-five percent viewed frequent near-misses as a threat to patient safety, but only 44% considered "unplanned extubation" a medical error. More RTs (52%) and physicians (51%) considered an unplanned extubation an error than nurses (35%) ( $P \leq .001$ ).

### Situations Perceived Conducive to Unplanned Extubation

The majority of respondents considered the absence of physical restraints (72% of respondents); a nurse/patient ratio of 1/3 (60%); and trips out of the ICU (eg, for computed tomogram) (59%) to be conditions associated with airway near misses (Table 3). Forty-three percent considered light sedation, and 29% considered bedside portable radiograph to pose a high risk for unplanned extubation. Compared to the physicians, the vast majority of the RTs and nurses thought absence of restraints constitutes a risk factor. In contrast, only one third of the RTs thought the nurse/patient ratio was important. In contrast, a higher percentage of RTs (compared to physician and nurses) thought portable chest radiograph was a risk factor.

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Table 1. Respondent Demographics and Clinical Settings and Specialties

	Total n (%)	Nurses n (%)	RTs n (%)	Physicians n (%)
Total*	1,976 (100)	870 (44)	419 (21)	605 (31)
Practice Location				
United States	1,733 (88)	842 (96)	398 (95)	430 (71)
Outside United States	188 (10)	28 (3)	21(5)	75 (12)
ICU Setting				
Medical	446 (24)	144 (17)	145 (35)	150 (25)
Cardiac	107 (6)	96 (11)	9 (2)	0
Surgical	262 (14)	117 (13)	34 (8)	102 (17)
Trauma	84 (4)	27 (3)	24 (6)	32 (5)
Cardiothoracic surgery	132 (7)	92 (11)	18 (4)	22 (4)
Neuroscience	38 (2)	23 (3)	1 (0.2)	14 (2)
Multidisciplinary	792 (42)	346 (40)	166 (40)	267 (44)
Burn	8 (0.4)	4 (0.5)	2 (0.5)	1 (0.2)
Intermediate†	10 (0.5)	8 (1)	0	2 (0.3)
Long-term acute-care unit	15 (0.8)	2 (0.2)	11 (3)	1 (0.2)
Critical Care Experience				
1–3 y	246 (13)	95 (11)	17 (4)	125 (21)
3–10 y	407 (21)	168 (19)	57 (13)	175 (29)
10–20 y	589 (30)	265 (31)	132 (32)	186 (31)
> 20 y	654 (35)	338 (39)	209 (50)	97 (16)
Hospital Setting				
University hospital	593 (31)	202 (23)	88 (21)	292 (48)
Non-university teaching hospital	505 (26)	209 (24)	129 (31)	157 (26)
Community hospital	773 (40)	423 (49)	198 (48)	138 (23)
Veterans Affairs hospital	45 (2)	31 (4)	2 (0.5)	11 (2)
Beds in Primary ICU‡				
> 21 beds	404 (21)	165 (19)	91 (22)	141 (23)
16–20 beds	548 (29)	252 (29)	116 (28)	170 (28)
11–15 beds	529 (28)	241 (28)	109 (26)	169 (28)
6–10 beds	381 (3)	186 (3)	78 (19)	109 (18)
< 5 beds	52 (3)	23 (3)	20 (5)	9 (2)
Total Critical Care Beds§				
> 100 beds	243 (13)	93 (11)	75 (18)	74 (12)
70–100 beds	212 (11)	90 (10)	43 (10)	74 (12)
50–69 beds	305 (16)	122 (14)	45 (11)	131 (22)
30–49 beds	406 (21)	196 (23)	72 (17)	132 (22)
10–29 beds	619 (32)	304 (35)	138 (33)	164 (27)
< 10 beds	126 (7)	60 (7)	41 (10)	21 (4)
Availability of Expert Airway Backup				
Anesthesiologist	1,200 (67)	542 (65)	253 (65)	405 (71)
Intensivist	732 (42)	288 (35)	163 (44)	281 (48)

\* Percentages may not total 100% because some respondents did not disclose their specialty. The percentages are calculated based on valid answers for each question, and decimals were rounded up to the next round number.

† Intermediate category included step-down, intermediate care, and telemetry units.

‡ Total number of beds in the primary intensive care unit (ICU).

§ Total number of licensed critical care beds in the (primary) hospital.

RT = respiratory therapist

Responses to the Vignettes

The majority considered vignette 1 (deliberate self-extubation by a low-risk patient; outcome omitted) to represent an airway accident, whereas only one in 4 considered

it an error in medical management (Table 4). One in 5 respondents did not consider this event to represent a medical error. In contrast, in vignette 2 (accidental extubation in a high-risk patient, with prompt re-intubation and without immediate untoward injury) more than one third con-

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Table 2. Definitions of and Beliefs About Airway Near-Miss Events\*

Definitions of Airway Near-Miss†	Respondents (%)			
	Weighted Average	Nurses	RTs	Physicians
Outward Migration of the ETT				
In the Absence of Air Leak				
1 cm	10	17	11	3‡
2 cm	34	46	35	22‡
3 cm	38	30	39	45
4 cm	11	4	8	20‡
In the Presence of Air Leak				
1 cm	44	53	44	34‡
2 cm	29	28	29	31
3 cm	21	16	21	26
4 cm	3	1	3	5
Patient observed tugging on ETT§	87	93	87	82‡
Removal of the nasogastric tube	71	75	73	65‡
Daily chest radiograph is valuable in identifying near misses	65	68	61	65
Patient's condition influences the definition of a near miss	50	55	45	49
Frequent near misses compromise patient safety	94	95	94	93
Unplanned extubation should be considered a medical error	46	35‡	52	51
Appropriate landmark for measuring ETT position				
Lips	71	84	78	48¶‡
Incisors	29	14	21	50
Do not measure	2	2	1	2

\* All values are percentages from valid responses only; invalid or skipped responses were excluded. The weighted average is based on the percent of responses per specialty, to adjust for unequal response rates in the categories. Percentages do not total 100% because some respondents disagreed with all the options. For questions with graded responses, the affirmative answers were limited to "agree" and "strongly agree"; neutral responses were excluded. Responses were compared with chi-square test to test differences between proportions.

† Respondents were allowed one selection for each definition; the values represent percent of total respondents who agreed with one selection; the percentages are not cumulative.

‡  $P < .001$ . All reported  $P$  values are from 2-sided tests.

§ Respondents were asked whether they consider the patient's tugging on the endotracheal tube (ETT) a near miss.

|| Respondents were asked whether they consider an intubated patient's removal of the nasogastric tube a near miss.

¶ Among the 132 physicians who indicated anesthesia as their primary specialty, 57 (43%) selected the lip, and 73 (55%) selected the incisors as the landmark for measuring ETT position.

RT = respiratory therapist

sidered the case to represent an error in medical management, and only one in 10 thought it did not represent a medical error. For both vignettes, the RTs were less likely than the nurses and physicians to conclude that these scenarios should not be considered an error.

### Discussion

This large survey is the first to suggest a definition of an airway near-miss event and to explore how critical care RTs, nurses, and physicians define the risk factors for airway near-misses. With weighted averages we define an airway near-miss event as outward ETT migration of 2 cm if measured at the lips, or 3 cm if measured at the incisors. In the presence of air leak, ETT movement of just 1 cm if measured at the lips, or 2 cm if measured at the incisors, can be considered a near miss. This working definition may be used for systematic evaluation of airway events, with a goal of improving safety for mechanically ventilated patients in the ICU. Furthermore, the survey indi-

cates risk factors to be targeted in analyzing factors associated with airway near-miss events.

The survey showed that critical care RTs, nurses, and physicians are willing to use safety language such as management error and airway accident. The culture of safety and the adoption of safety language such as the term "error" was better accepted than previously reported.<sup>5,15</sup> Ninety-four percent thought that frequent airway near misses compromise patient safety, and 46% percent viewed unplanned extubation as management error. Respondents were more likely to accept *accidental* but not *deliberate* extubation as an error. The responses to the vignettes suggested that a term that lacks accountability ("accident") is favored over the term "error," similar to previous studies, which also suggested that clinicians choose words carefully in error disclosure. This tendency may reflect legal concerns, and also influences the way errors would be perceived and prevention strategies would be approached. Another sign of the tendency to accept patient safety concepts was the very low percentage that considered both

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Table 3. Respondents' Perceived Conditions Associated With Airway Near Misses\*

Preventable Causes	Respondents (%)			
	Weighted Average	Nurses	RTs	Physicians
Absence of physical restraints	72	72	85	59†
Nurse/patient ratio of 1:3	60	81	35†	65
Trips out of the ICU	59	60	55	62
Light sedation	43	37	43	49
Portable radiograph	29	20	43†	23
Night shifts	10	5	6	20
Other‡				
Nursing activities	7	2	11†	4
Inadequate ETT taping	4	2	8†	2
Oral suctioning	5	4	5	5
Presence of physical restraints	3	4	1	4
Nurse/patient ratio of 1:2	3	3	2	4
Heavy sedation	2	2	1	1
Day shifts	1	1	1	1

\* Responses were compared with the Kruskal-Wallis 1-way analysis of variance, and we performed multivariate analysis to control for years of experience, practice setting, endotracheal tube (ETT) securement site, and the presence of expert airway backup, with a logistic regression model.

† A 2-sided *P* value of < .05 was considered significant. All reported *P* values are based on multivariate analysis.

‡ Other: responses re-categorized respondents' input to inadequate taping and nursing activities (described as bathing or turning patient in bed). Respondents were asked to select the 3 most important conditions that may lead to a near-miss airway event.

RT = respiratory therapist

Table 4. Responses to the Vignettes\*

	Respondents (%)		
	Error in Medical Management	Airway Accident	Not Considered an Error
Vignette 1: Low-risk patient; self-extubation; outcome omitted			
Total	25	56	19
Nurses	20	62†	18
Respiratory therapists	29	57	14†
Physicians	29	48	23
Anesthesia physicians ( <i>n</i> = 123)	28	43	29†
Non-anesthesia physicians ( <i>n</i> = 378)	31	48	21
Vignette 2: High-risk patient; unintended extubation; prompt re-intubation			
Total	36	54	10
Nurses	36	54	10
Respiratory therapists	39	55	6†
Physicians	33	54	12
Anesthesia physicians ( <i>n</i> = 123)	32	56	12
Non-anesthesia physicians ( <i>n</i> = 377)	34	54	12

\* Responses were compared with the chi-square test to test differences between proportions; we performed multivariate analysis to control for years of experience, practice settings, endotracheal tube securement site, and the presence of expert airway backup, with a logistic regression model.

† A 2-sided *P* value of < .05 was considered significant. All reported *P* values are based on multivariate analyses.

vignettes “not to be an error.” However, clinicians assuming care of problem-prone, high-risk ICU-patients may consider it unfair to categorize unplanned extubation as a medical error.<sup>16</sup> The term “accident” may imply an unplanned, unforeseen, unintentional event that is difficult to

prevent and might be considered more acceptable to patients by physicians. For the same reason we prefer the terms “unplanned”<sup>10</sup> or “unintended”<sup>17</sup> extubation. Nevertheless, unplanned extubation interferes with therapy,<sup>18</sup> is associated with significant morbidity and mortality,<sup>10,19</sup>

and should be the target of well designed preventive initiatives.

In assessing perceived risk for factors for airway near-miss events, the respondents ranked the absence of physical restraints, a 1/3 nurse/patient ratio, trips out of the ICU, light sedation, and obtaining a portable chest radiograph as most important. For unclear reasons, RTs thought the nurse/patient ratio was less important and obtaining a portable chest radiograph more important than did the nurses and physicians.

The relationship between unplanned extubation and the risk factors identified in our survey (see Table 3) requires further study; we postulate that targeting some of those risk factors may result in preventing near-miss events and, consequently, unplanned extubation. That said, one inherent limitation of surveys is that they assess respondent perceptions of reality, in this case, the perceived risk of unplanned extubation. Clearly, perceived risk may not accurately reflect actual risk, which is best assessed with an observational study of airway care practices in ICUs. Our survey does provide key factors that should be included in such an observational study. Practices such as using an experienced transport team,<sup>20</sup> avoiding unnecessary trips out of the ICU, reducing the number of unnecessary portable chest radiographs,<sup>21</sup> and ensuring vigilance during bedside radiographs are necessary and may help reduce near misses and unplanned extubations. Our findings do not necessarily suggest using physical restraints or sedation to minimize airway accidents, since they may cause physical or emotional trauma<sup>22</sup> and prolong mechanical ventilation.<sup>23</sup>

We anticipate that our survey findings will provide clinicians with opportunities to identify conditions that place patients at high risk for unplanned extubation and allow implementing of early prevention.<sup>12</sup> Patients at high risk for unplanned extubation should be flagged and additional preventive measure should be considered. Direct observational studies to examine the association of those conditions and the actual occurrence of unplanned extubation will help compare perceptions to reality and serve as a starting point for preventive strategies.

Our analyses suggest that the differences in perceived risk might be related to the measurement site of the ETT. The majority of the RTs and nurses measured the ETT at the lips during daily care, whereas physicians favored using the incisors as the reference point. That measurement difference highlights an important communication gap that may increase the risk of adverse events.

### Limitations

Survey research methods have some inherent limitations, and the results are not definitive. As with any survey, our survey has its limitations and may have inadver-

tently introduced biases. The survey respondents represent a cluster (members of societies) convenience sample that may not have included the entire spectrum of critical care clinicians (sampling bias). It is likely that our survey was completed by the critical care clinicians who were most interested in airway safety and thus more likely to complete the survey (respondents' bias). Therefore, it is possible that respondents who are not interested in airway safety or not comfortable with completing a Web-based survey did not respond, and their opinions would not be reflected in the results (non-respondents bias). We avoided leading questions or opinionated inferences, but the responses might have been influenced by the survey's obvious intention of improving airway safety. There is also a possibility that limiting the number of responses to the vignettes might have introduced bias.

### Conclusions

Our survey represents the first step toward systematically studying airway near misses, by providing a working definition. We acknowledge that strategies addressed to reduce perceived risk may or may not be effective in reducing adverse events. Further studies are needed to address patient airway safety and to determine associated risks and outcomes with direct observational studies.

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