Plan to Have No Unplanned: A Collaborative, Hospital-Based Quality-Improvement Project to Reduce the Rate of Unplanned Extubations in the Pediatric ICU

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BACKGROUND: Although under-reported and understudied, unplanned extubations carry a significant risk of patient harm and even death. They are an important yardstick of quality control of care of intubated patients in the ICU. A unit-based risk assessment and multidisciplinary approach is required to decrease the incidence of unplanned extubations. METHODS: As part of a quality-improvement initiative of Children's Hospital at Montefiore, all planned and unplanned extubations in a multidisciplinary 20-bed pediatric ICU were evaluated over a 12-month period (January to December 2010). At the end of 6 months, an interim analysis was performed, and high-risk patient groups and patient care factors were identified. These factors were targeted in the second phase of the project. RESULTS: Over this period, there were a total of 267 extubations, of which 231 (87%) were planned extubations and 36 (13%) were unplanned. A patient care policy targeting the risk factors was instituted, along with extensive nursing and other personnel education in the second phase. As a result of this intervention, the unplanned extubation rate in the pediatric ICU decreased from 3.55 to 2.59/100 intubation days. All subjects who had an unplanned extubation during nursing procedures or transport required re-intubation, whereas none of the unplanned extubations during ventilator weaning required re-intubation. CONCLUSIONS: A targeted approach based on unit-specific risk factors is most effective in quality-improvement projects. A specific policy for sedation and weaning can be very helpful in managing intubated patients and preventing unintended harm. *Key words: endotracheal extubation; quality improvement; medical errors; mechanical ventilation; intensive care unit; pediatric; patient safety.* [Respir Care 2015;60(8):1105–1112. © 2015 Daedalus Enterprises]

Introduction

The care of intubated patients in the ICU is a highly skilled and complex medical intervention. Multiple, seemingly counterintuitive objectives need to be attained simultaneously, including early mobilization with light sedation and ensuring that the endotracheal tube does not get dislodged. Unplanned extubations have been noted as the most serious and common airway accident in critically ill subjects with artificial airways.[1] The sudden and unexpected dislodgement of an endotracheal tube can lead to potential adverse events and even death. Unplanned extubations often lead to emergent and less controlled re-intubation. Repeated intubations, especially when performed emergently, can increase the risk of laryngeal or tracheal injury and scarring and pulmonary injury from excessive ventilation, and can potentially increase the incidence of ventilator-associated pneumonia.[2] Although the risk of unplanned extubations can be almost eliminated by keeping

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the patient heavily sedated and paralyzed, this approach can lead to a longer duration of intubation and its inherent risks. Improvements in routine practice have primarily targeted inadequate sedation, ineffective restraint, and insecure tube fixation.[3] The current debate focuses on risk assessment and appropriate methods to prevent unplanned extubations in acute and critical care adult settings.

In the pediatric ICU (PICU) at Children's Hospital at Montefiore, the care of intubated children before this project was not standardized, the sedation scoring system was inconsistently used, and the tube securement practice was variable. The unplanned extubation rate of the unit was noted to be very high at 3.5/100 intubation days compared with the suggested benchmark of one unplanned extubation/100 intubation days.[2] Although the risk factors for an unplanned extubation have been previously described, due to variations associated with sedation and assessment of planned extubations in our unit, we believed that the local risk factors may differ fundamentally from those in other PICUs. This project was devised with an initial assessment of the local risk factors, followed by targeted interventions to reduce risk. The primary aims of this project were to improve the care process of managing the sedation and care of intubated patients and to improve patient outcome by decreasing the serious safety events of unplanned extubations. In this report, we describe the context in which the quality-improvement project was implemented and the specific local problems, risk factors, and system dysfunction that were addressed.

QUICK LOOK

Current knowledge

Complications resulting from mechanical ventilatory support of the pediatric patient vary in severity and frequency. Unplanned extubations may be increased in pediatric patients due to the use of uncuffed tubes and patient characteristics. In recent years, the rate of unplanned extubations has been used to benchmark the quality of patient care in intensive care with respect to sedation, weaning, and use of restraints.

What this paper contributes to our knowledge

The rate of unplanned extubations was 13%, over half of which required re-intubation. The unplanned extubation rate as a percent of total extubations dropped, along with the rate of unplanned extubations/100 intubation days and total intubation duration.

Methods

As a non-research-based quality-improvement activity, this project did not require formal institutional review board approval. We adhered to all quality-improvement ethical guidelines in planning and implementing this project as published previously.[4] Children's Hospital at Montefiore is a free-standing academic children's hospital affiliated with the Albert Einstein College of Medicine in Bronx, New York. The PICU is a 20-bed mixed medical/surgical/cardiovascular unit with > 1,200 admissions/y. There is a 24-h PICU attending and a PICU fellow in the unit. For this project, all planned and unplanned extubations in the PICU were evaluated over a 1-y period (January to December 2010). We recorded demographic data and a set of variables (potential risk factors) based on prior published literature[5] and clinical judgment of local factors. The monthly rate of unplanned extubations was recorded and presented to the PICU operations committee. A core multidisciplinary group (including representatives from medical, nursing, and respiratory leadership) was established and met regularly to identify, understand, and make changes to the process and structure of care. At the end of 6 months, an interim analysis of risk factors associated with unplanned extubations was performed, and a care policy was established to improve the consistency and reliability of the care of intubated patients. The intended improvement strategy continued to evolve over time in response to the feedback from stakeholders and in response to changes in the environment. Data collection as part of a quality-improvement initiative was continued for an additional 6 months. There was no intrinsic financial support dedicated to this project.

In our institution, all extubations are expected to be planned and include feeding discontinuation for specified times based on the type of formula, discontinuing sedation, and spontaneous breathing trials as deemed appropriate clinically. All planned extubations require the presence of a nurse (RN), respiratory therapist (RT), and PICU fellow or attending in the room with equipment available to assist breathing if required. Unplanned extubations for the purpose of the project were defined as any extubation that occurred in the absence of a predetermined plan and time. Two forms of unplanned extubation as described by Kapadia et al[1] were identified. Self-extubation was defined as an unplanned extubation when patient activity resulted in extubation. Accidental extubation occurred when patient activity did not contribute to the extubation, as when a tube was inadvertently dislodged during turning or transportation.

The State Behavioral Scale[6] was used to determine the level of sedation in the intubated subjects. Sedation scores of −3, −2, and −1 were categorized as sedated, and sedation scores of 0, +1, and +2 were categorized as awake and calm, awake and agitated, and very agitated, respectively. The number of subjects who were very agitated versus those who were not (all other sedation categories)

were compared in the planned and unplanned extubation groups. The amount of secretions was noted either by direct interview with the nurse, RT, or doctor directly involved in the care of the subject at the time of extubation or retrospectively from the chart. Secretions were categorized as mild, moderate, or copious. In our unit, we have a standard way of securing endotracheal tubes with 3M Medipore soft cloth white tape (3M, St Paul, Minnesota); however, some patients transferred from the operating room come with different kind of adhesive tapes, like Megazinc Pink tape (Omega Medical, Phoenix, Arizona), which is changed to white tape per unit policy. However, sometimes, the pink tape is inadvertently left in place. Some subjects transferred from other hospitals had different endotracheal-tube-securement devices in place. The rate of unplanned extubations was compared between those with the standard PICU mode of tube securement versus Megazinc Pink adhesive tape or a securement device.

The rate of unplanned extubations, number of accidental extubations (occurring during medical or nursing procedures), sedation level, and other factors identified as potentially modifiable were compared before and after policy institution. The number of unplanned extubations requiring re-intubations was also compared. Re-intubation was defined as intubation required within 1 h of an unplanned extubation. To evaluate the process, we primarily used the objective outcome data of the rate of unplanned extubations. A standardized rate of measuring unplanned extubations using the method described by Little et al[7] was calculated. This method relates the number of unplanned extubations to duration of risk exposure by reporting unplanned extubations/100 intubation days. Data were collected in Excel (Microsoft, Redmond, Washington) and analyzed using the JMP statistical software package (JMP, Cary, North Carolina). A chi-square test was used to compare categorical data, whereas the Student *t* test was used to compare continuous data when normally distributed and the Mann-Whitney *U* test when non-normally distributed. The odds ratio was also calculated for categorical data. Statistical significance was defined as $P < .05$. Although we conducted an interim data analysis at the end of 6 months to create the best-practice policy for the quality-improvement project, the data presented in this study represent the total duration (12 months) of the project.

Results

Demographics

During the project period (12 months), there were a total of 267 extubations in the PICU. Among them, 231 (87%) were planned, and 36 (13%) were classified as unplanned. The unplanned extubation rate over the 12-month period was 3.19 unplanned extubations/100 intubation days. Of the 36 unplanned extubations, 14 (38%) were accidental (5 during transport, 9 during nursing or medical procedures or care), 8 (22%) occurred while subjects were being weaned from sedation for planned extubations, 8 (22%) occurred while care was being transitioned from the operating room team to the PICU team, and 6 (16.6%) occurred at other instances. Twenty unplanned extubations (55%) required re-intubation within 1 h. The majority (81%) of the extubations occurred from 8 AM to 4 PM, and the age distribution of the subjects mirrored a typical PICU population. Due to the nature of our practice, a majority of subjects were post-surgical and had a short intubation duration (42% with < 24 h). For $> 50\%$ of the extubated subjects, the primary nurse had more than one assigned subject (54.6% with 1:2 nurse/subject ratio). Only 9% of our subjects were nasally intubated (Table 1). There were 8 significant adverse events related to unplanned extubations: death, 0; cardiac arrest, 3; significant desaturations ($< 70\%$ for > 5 min), 3; and difficult re-intubation (requiring advanced airway techniques with anesthesia or otolaryngology), 2 (data not shown).

Comparison of Planned Versus Unplanned Extubations

To identify the local risk factors for unplanned extubations, we compared the predetermined subject and environmental factors collected at the time of extubation between the planned and unplanned extubations. The mean duration of intubation was 103 ± 143.5 h for planned and 90 ± 105.4 h for unplanned extubations ($P = .62$ by Mann-Whitney test). We observed a significantly higher incidence of unplanned extubations at night in subjects < 1 y of age, surgical subjects, and subjects who were agitated and had copious secretions. Of the 23 nasally intubated subjects, none had an unplanned extubation. No significant difference was noted between the planned and unplanned extubation groups with respect to the presence or absence of restraints, nurse/subject ratio, or intubation duration (Table 2). As determined by multiple regression analysis, time of extubation, diagnosis (medical/surgical), and sedation level were independently associated with unplanned extubation. Copious secretions were noted to have the highest odds ratio for unplanned extubation; however, they were not independently associated with unplanned extubation (Table 3).

Comparison of Subjects Who Required Re-Intubation After an Unplanned Extubation and Those Who Did Not

The most common consequence of an unplanned extubation is the need for emergent re-intubation. We compared the group of subjects who required re-intubation with the group of subjects who did not following an un-

Table 1. Demographics

Parameter	Values
Total No. of extubations during the study period	267
No. of unplanned extubations (%)	36 (13)
Total No. of intubation days	1,127.9
No. of unplanned extubations requiring re-intubation (%)	20 (55)
No. of unplanned extubations/100 intubation days	3.1
No. of accidental extubations (%)	
During transport	5 (16)
During procedures	9 (25)
No. of unplanned extubations during weaning period (%)	8 (22)
No. of unplanned extubations during operating room-to-PICU transition (%)	8 (22)
No. of extubations according to time distribution (%)	
8 AM to 4 PM	217 (81)
4 PM to 12 AM	35 (13)
12 AM to 8 AM	15 (5)
Age distribution of subjects, *n* (%)	
< 1 mo	65 (24)
1 mo to 1 y	81 (30)
1 y to 5 y	55 (20)
5–15 y	38 (14)
> 15 y	28 (10)
Subject type, *n* (%)	
Medical	76 (28)
Surgical	191 (71)
Intubation duration, h	
Mean ± SD	100.6 ± 139.4
Median (IQR)	48 (24–120)
Intubation duration distribution, *n* (%)	
< 24 h	113 (42)
24–96 h	63 (23)
96–168 h	51 (19)
>168 h	40 (14)
Nurse/subject ratio, *n* (%)	
2:1	17 (6)
1:1	104 (38.9)
1:2	146 (54.6)
Oral vs nasal intubation, *n* (%)	
Oral	244 (91)
Nasal	23 (9)

IQR = interquartile range
PICU = pediatric ICU

Table 2. Planned Versus Unplanned Extubations

Factor	No. of Extubations (%)		*P*
	Planned (231)	Unplanned (36)	
Mean intubation duration, h	103 ± 143.5	90 ± 105.4	.62
Extubation time			
8 AM to 4 PM	198 (85.7)	19 (52.8)	< .001
4 PM to 8 AM	33 (14.2)	17 (47.2)	
Intubation duration			
< 1 d	96 (41.6)	17 (47.2)	.44
1–6 d	102 (44.2)	12 (33.3)	
> 6 d	33 (14.3)	7 (19.4)	
Age group			
< 1 y	119 (51.5)	27 (75)	.008
> 1 y	112 (48.5)	9 (25)	
Subject type			
Medical	59 (25.5)	17 (47.2)	< .01
Surgical	172 (74.5)	19 (52.8)	
Agitation			
Not agitated	184 (79.7)	15 (41.7)	< .01
Agitated	47 (20.3)	21 (58.3)	
Secretions			
Copious	16 (6.93)	15 (41.6)	< .01
Mild to moderate	215 (91%)	21 (58.3)	
Extubated to			
Discontinued*	13 (5.6)	0 (0)	< .001
Room air	66 (28.6)	0 (0)	
Nasal cannula	85 (36.8)	5 (13.9)	
Face mask	30 (13)	2 (5.6)	
CPAP/BPAP	37 (16)	9 (25)	
Re-intubated†	0 (0)	20 (55.6)	
Oral vs nasal intubation			
Oral	208 (90)	36 (100	.048
Nasal	23 (10)	0 (0)	
Restraints			
Yes	189 (81)	27 (75)	.33
No	42 (18)	9 (25)	
Tube securement			
White tape	210 (90.9)	27 (75)	< .01
Pink tape	14 (6.1)	8 (22.2)	
Holder	7 (3.0)	1 (2.8)	
Nurse/subject ratio			
2:1	13 (5.6)	4 (11.1)	.37
1:1	89 (38.5)	15 (41.7)	
1:2	129 (55.8)	17 (47.2)	

* The subject had a tracheostomy, died, or was transferred to another institution.
† Although 23 subjects failed planned extubation (9.9%), none were emergently intubated without trial of other modes of respiratory support.
BPAP = bi-level positive airway pressure

planned extubation. Although we did not have a large enough sample size (not adequately powered) to detect a significant difference, we found a few subject and environmental factors that had positive associations. All the accidental extubations in the 1-y period (total of 14) required re-intubation, whereas no subject who had an unplanned extubation while waiting to have a planned extubation ($n = 8$) required re-intubation. Among subjects who had unplanned extubations during transition from operating room care to PICU care, 75% (6 of 8) required re-intubation (data not shown). Younger subjects were noted to be at a higher risk for re-intubation, with 62.9%

Table 3. OR of an Unplanned Extubation

Factor	OR	95% CI	Description
Night/day	5.3	2.5–11.3	Extubations at night have a 5.3 OR of an unplanned extubation compared with extubations in the day at 95% CI 2.5–11.3.
Infants/older	2.8	1.3–6.2	Children < 1 y old have a 2.8 OR of an unplanned extubation compared with children > 1 y old at 95% CI 1.3–6.2.
Agitation	5.48	2.6–11.4	Subjects with severe agitation have a 5.48 OR of an unplanned extubation compared with subjects who are not severely agitated.
Secretions	9.59	4.1–22.1	Subjects with too many secretions have a 9.59 OR of an unplanned extubation compared with those who do not.
Medical/surgical	2.6	1.27–5.3	Medical subjects have a 2.6 OR of an unplanned extubation compared with surgical subjects.

OR = odds ratio

Table 4. Unplanned Extubations That Required Re-Intubation Versus Those That Did Not

Factor	No. of Unplanned Extubations: Without Re-Intubation (16) (%)	With Re-Intubation (20) (%)	P*
Extubation time			
8 AM to 4 PM	10 (52.6)	9 (47.3)	.29
4 PM to 8 AM	6 (35.2)	11 (64.7)	
Intubation duration			
< 1 d	6 (35.2)	11 (64.7)	.55
1–6 d	6 (50)	6 (50)	
> 6 d	4 (57.1)	3 (42.8)	
Age group			
< 1 y	10 (37)	17 (62.9)	.12
> 1 y	6 (66.6)	3 (33.3)	
Subject type			
Medical	10 (58.8)	7 (41.1)	.10
Surgical	6 (31.5)	13 (68.4)	
Agitation			
Not agitated	6 (40)	9 (60)	.65
Agitated	10 (47.6)	11 (52.3)	
Secretions			
Mild or moderate	12 (57.1)	9 (42.8)	.06
Copious	4 (26.6)	11 (73.3)	
Restraints			
Yes	14 (51.8)	13 (48.1)	.12
No	2 (22.2)	7 (77.7)	
Tube securement			
White tape	13 (48.1)	14 (51.8)	.57
Pink tape	3 (37.5)	5 (62.5)	
Holder	0 (0)	1 (100)	
Nurse/subject ratio			
2:1	3 (75)	1 (25)	.31
1:1	5 (33.3)	10 (66.6)	
1:2	8 (47)	9 (52)	

* Pearson chi-square test

of the < 1-y-old subjects who had an unplanned extubation requiring re-intubation compared with only 33.3% of the > 1-y-old subjects ($P = .12$). Subjects who had unplanned extubations from 4 PM to 8 AM were at greater risk, with 64.7% requiring re-intubation compared with 47.3% who had an event between 8 AM and 4 PM. Secretions also contributed to a higher risk of re-intubation, with 73.3% of the subjects with copious secretions requiring re-intubation compared with 42.8% of those with mild-to-minimal secretions ($P = .06$) (Table 4).

Quality-Improvement Efforts and Their Impact

On the basis of the interim analysis at the end of 6 months of the project, we created a best-practice policy for care of intubated patients. Nursing and medical staff were educated regarding the elements of the care bundles by formal and informal training sessions. The high-risk environmental factors (weaning period, operating room-to-PICU transition) and patient-specific risk factors (infants, nursing procedures) were emphasized and targeted. In view of the high incidence of subjects who did not require re-intubation after an unplanned extubation in our unit, daily assessment of extubation readiness was encouraged. RTs were authorized to assess the risk of an unplanned extubation and extubation readiness. Steps for more active involvement of RTs in care discussion were instituted (Table 5).

In the implementation phase of this quality-improvement process, there were 108 extubations in the ICU, 11 of which were unplanned. The unplanned extubation rate as a percent of total extubations dropped from 15.7% to 10.1% ($P = .19$). The rate of unplanned extubations/100 intubation days dropped from 3.55 to 2.59 (27% decrease). The average intubation duration decreased slightly in the implementation phase (94.3 ± 112.2 h vs 106.1 ± 154.4 h); however, the median remained the same (48 h). Because of the safety guidelines implemented in the unit, the largest decline was seen in the accidental extubations, which decreased from 48% of all unplanned extubations to 18.1%. With early extubation readiness assessment and weaning,

Table 5. Intubated Subject Care Policy

(1) All intubated subjects should have sedation scores recorded and documented every 1 h.
(2) All subjects returning from the operating room need to have sedation accessed. The operating room pink tape should be changed as soon as possible (without waiting for x-ray). X-rays should be obtained as soon as possible.
(3) All subjects, including infants, should be on appropriate sedation. There should be a PRN sedation equivalent to the hourly worth of sedation also written. Requirement of PRN sedation should be part of resident morning presentation.
(4) All subjects waiting to wake up for extubation need closer monitoring of sedation and agitation.
(5) Sedation should be assessed during any nursing intervention (including suctioning). Subjects may receive PRN sedation prior to suctioning.
(6) Attempts should be made to evaluate extubation readiness daily and extubate early.

PRN = pro re nata

we expected that the extubation failure rate after a planned extubation would be higher; however, the failure rate remained largely unchanged (10.3% in implementation phase vs 9.7%, $P = .88$) (Table 6).

Discussion

Unplanned extubations have been an area of concern for many hospitals. By carrying out this quality-improvement project, we were successful in decreasing the rate of unplanned extubations from 3.55 to 2.59/100 intubation days, indicating that education, attention to detail and quality, and mitigating local risk factors can improve care of intubated patients. Understanding the factors associated with unplanned extubations is crucial for identifying patients at risk, and thus for developing interventions to reduce this risk.

Over the course of the year, 13.4% of our extubations were unplanned, with a rate of 3.19/100 intubation days. This number varies widely in the literature depending on the source. The value cited most often is 10%,[8] although in terms of unplanned extubations/100 intubation days, this ranges from 0.11[8] to 2.7[9]/100 intubation days. These rates are higher in PICUs compared with adult ICUs (0.68–2.8/100 intubation days), and neonatal ICU rates (1.9-3.0/100 intubation days) are higher than PICU rates.[2] Our re-intubation rate after unplanned extubations was 55%. The reported rate varies between 52% and 61%,[2,10,11] neonatal ICU rates are 65–83%, and adult rates are 23–78%.[2] The optimal rate of unplanned extubations remains to be determined. Most quality-improvement programs target an arbitrary rate of one unplanned extubation/100 intubation days,[5] which may represent an appropriate benchmark for a quality-improvement program but may not be sustainable without an increase in ventilator duration.

As shown in a previous study,[2] we found that young children had a significantly higher rate of unplanned extubations. Shorter airway length, lack of cognitive and emotional maturity to accept and tolerate artificial airways, and use of uncuffed tubes, among other factors, are likely to contribute to a higher rate of unplanned extubations in younger patients.[6] Concerns of neurodevelopment effects of benzodiazepines on the developing brain[12] may be another factor to consider while balancing the risk/benefit of over-sedation versus high rates of unplanned extubations in this population. A clearer documentation of not only unplanned extubations but also the actual long-term harm caused by them may help to justify higher sedation in infants and neonates.

In our project and in previous studies,[8] agitation or inadequate sedation was shown to be associated with increased risk of unplanned extubations. Although increasing sedation will decrease the risk of unplanned extubations, caution should be exercised in seeking low rates of unplanned extubations by excessive use of sedatives and neuromuscular blockers, which in turn can result in worse patient outcomes. Sedation algorithms (such as the Penn State Children's Hospital sedation algorithm)[13] or targeted sedation regimens (such as the RESTORE trial)[14] have the potential to balance the risk and benefits; however, whether their utilization will decrease the risk of unplanned extubations but not increase ventilator duration remains to be validated in independent studies. Use of restraints did not lead to any decrease in unplanned extubations in our project. Adult studies have shown an increase in unplanned extubations in restrained subjects, with the hypothesis that hand restraints could promote unplanned extubations by increasing a patient's anxiety due to the inability to communicate by gesturing.[15] However, Tominaga et al[16] reported an increase in unplanned extubations when a hospital policy following a joint commission on accreditation of health-care organizations restricted the use of physical restraints in patients.

The presence of copious secretions not only increases the risk of unplanned extubations but also increases the risk of re-intubation after an unplanned extubation. Although this is subjective and difficult to qualify, similar results were noted in a previous study.[17] However, in our project, copious secretions were not independently associated with risk of unplanned extubations. Moreover, compared with agitation, secretions are harder to control, as medications may result in dried secretions and tube blockage. Careful monitoring of patients with copious secretions can help control the risk.

Nurse staffing and patient burden have been a focus in view of recent emphasis on identifying system failures to minimize patient risk. Although most of the previous work

Table 6. Comparison of Observation and Implementation Phases

Factor	Observation Phase	Implementation Phase	Total	*P*
Duration	01/01/10 to 06/30/10	07/01/10 to 12/31/10		
No. of extubations	159	108	267	
No. of unplanned extubations (%)	25 (15.7)	11 (10.1)	36 (13.4)	.19
No. of intubation days	703.2	424.7	1,127.9	
No. of unplanned extubations/100 intubation days	3.55	2.59	3.19	
Subjects re-intubated, *n* (%)	16 (64.0) (16 of 25)	4 (36.3) (4 of 11)	20 (55.5) (20 of 36)	.12
Extubation failure (planned extubation), %	9.7 (13 of 134)	10.3 (10 of 97)		.88
Intubation duration, h				
Mean ± SD	106 ± 154.4	94.3 ± 112.1		
Median (IQR)	48 (24–124)	48 (24–120)		
No. of accidental extubations (%)	12 (48)	2 (18.1)	14 (38.8)	
No. during weaning (%)	5 (20)	3 (27)	8 (22)	
No. during transport from operating room (%)	6 (24)	2 (18)	8 (22)	

IQR = interquartile range

has shown that decreased staffing leads to increased risk of unplanned extubations,[2] we did not find similar results in our project. Two pediatric studies[5,18] and an adult study[8] did not report any difference with staff work load. This may be due to differences in the way staffing is distributed and the availability of help from other nursing staff and RTs between pediatric and adult units. In our project, unplanned extubations were equally distributed between day and night. Christie et al[19] found self-extubations to be equally distributed among all nursing shifts, but accidental extubations occurred more frequently during day shifts, when nursing and physician activity is maximal. The high risk of unplanned extubations in patients being weaned or waiting to wake up to extubate calls for an expedited weaning protocol. Similar results have been reported in both adult and pediatric literature.[2] Sadowski et al[5] reported that 46% of unplanned extubations (of 141 over a period of 5 y) occurred in subjects who were being weaned from mechanical ventilation, 22% of whom required re-intubation. None of our subjects who had unplanned extubations during weaning required re-intubation. A standard weaning strategy has been shown to decrease unplanned extubations[5]; however, due to the heterogeneity of the PICU patient population, this remains hard to implement and requires more research.

In our study, 55% of the subjects who had unplanned extubations required re-intubation. Averages are between 40% and 52% in the literature (References 20 and 5, respectively). In our study, the factors (although not statistically significant) linked to higher incidences of re-intubation after unplanned extubations were accidental extubation, younger age, excessive secretions, and nighttime. Very similar findings were observed by Sadowski et al.[5] Association of large amounts of secretions with risk of re-intubation has also been reported in the adult planned extubation population.[17] A larger number of patients may lead to significant results, which can offer more insight into extubation readiness in pediatric patients.

Despite identifying risk factors and using an evidence-based policy implementation to successfully decrease the risk of unplanned extubations, our project had several limitations. The variables associated with extubation events were recorded retrospectively, so there is a chance of bias in recording. Due to nature of our project, it was not possible to blind the observer. Ideally, these observations needed to be made in real time; however, there was no valid or feasible way to do this, as this would require placing an independent observer in the ICU for substantial periods of time, as unplanned extubations have, by definition, an unpredictable time of occurrence. The 30% reduction in the rate of unplanned extubations obtained in our project is less than that reported in the literature in similar quality-improvement projects in the PICU: 50% and 80% (References 5 and 18, respectively). This may be related to the shorter duration of the project. We also began with a much higher rate, and although a benchmark of one unplanned extubation/100 intubation days may be an appropriate aim, there are limitations with regard to the type of unit, complexity and volume of subjects, and availability of resources. However, quality improvement is a continuous process, and we have been able to identify areas for further improvement in risk assessment and staff education.

Conclusions

We documented a rapid improvement in the care process and safety outcomes in a busy pediatric critical care

unit by focusing on local risk factors by prospective identification, followed by careful attempts to target them by education and monitoring. Despite its local focus, we believe that this project has generated new knowledge about the risk factors for unplanned extubations in the PICU and also about systems of care in a multidisciplinary PICU and how best to change these systems for improvement.

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