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Risk Factors of Unplanned Extubation in Pediatric Intensive Care Unit

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Background: Unplanned extubation (UE) is an unprecedented happening in pediatric intensive care unit (PICU); which may lead to severe complications in patients. The risk factors of UE have been discussed but much details are still required in this regard. This study aimed to evaluate predisposing and risk factors of unplanned extubation in PICU.

Materials and Methods: Patients intubated in PICU who had UE were compared to a control group without UE in a retrospective study. Fifty-nine patients with UE matched with 180 controls were enrolled. Factors including age, gender, use of cuffed endotracheal tube (ETT), duration of intubation, patient agitation, and ETT fixation method were analyzed.

Results: A total of 59 UEs occurred in 239 intubated patients in a total of 1631 intubated patient-day. This represents UE incidence rate of 1.95% per patient-day and 3.6% per intubated patient-day. In multivariate analysis, risk factors for UE included age younger than 2 years (OR: 1.34, 95% CI: 1.13-3.61, P=0.001), male gender (OR: 2.53, 95% CI: 1.35-4.23, P=0.005), agitation (OR: 1.83, 95% CI: 1.54-5.36, P=0.001), high saliva secretion (OR: 4.42, 95% CI: 2.35-5.45, P=0.007), and duration of intubation (OR 1.39, 95% CI: 1.22-2.58, P=0.01).

Conclusion: Unplanned extubation can be a catastrophic incident if enough attention is not paid to the patients at risk in PICU. These risk factors are age younger than 2, male gender, agitation, high salivary secretion and duration of intubation.

Key words: Unplanned extubation, Pediatric ICU, Risk factors, Incidence, Mortality

INTRODUCTION

Unplanned extubation (UE) is an unprecedented happening in pediatric intensive care unit (PICU); which may lead to severe complications in patients. The incidence of UE is estimated to be 3 to 16% in mechanically ventilated patients in the intensive care unit (ICU) settings (1). The PICU is naturally a vulnerable environment for high-risk patients for UE (2). Many pediatric intensive care units monitor unplanned extubation rates as a quality of care (3). Unsuccessfully managed UE has the potential of worsening outcome by exposing patients to complications of premature removal of ventilator support and has impact on mortality, respiratory failure, duration of mechanical ventilation, and length of ICU and hospital stay (4). Notwithstanding, reintubation can rescue patients from catastrophe but it increases the risk of laryngeal or tracheal injury and scarring, pulmonary injury from excessive ventilation, and ventilator-associated pneumonia (5). Studies have shown higher mortality in patients with unsuccessfully managed UE as compared to those with successfully Managed UE (6). Previous studies have indicated that UE occurs in 0.6% to 13.3% of intubated pediatric patients and at a rate of 0.11–1.26 events per 100 ventilator days (7,8). Factors such as patient's agitation, nurse-patient ratio, and excessive secretions have been shown to be associated with UE (9). Recognition of high-risk populations and the implementation of UE care may be a necessary tool to decrease mortality of UE in PICUs

(10). Major implications of UE on patient's management indicate the need to enhance the knowledge of clinicians about UE in pediatric population with special emphasis on the following topics: 1) incidence; 2) risk factors; and 3) strategies to prevent unplanned extubations. This retrospective study was performed on UE cases in a tertiary-care referral PICU. The aim of this study was to evaluate predisposing and risk factors of unplanned extubation in PICU.

MATERIALS AND METHODS

Study Design:

This study was reviewed and approved by the University Review Board and hospital ethics committee and was performed in accordance with the ethical standards laid down in an appropriate version of the 2000 Declaration of Helsinki. Information about the trial was given comprehensively both orally and in written form. All patients' accompanying adults gave their informed written consents prior to inclusion in the study.

All patients admitted to the PICU of Mofid Pediatric Hospital during the past year for a minimum of 12 h who had UE were compared to a control group without UE. Patients were enrolled and their data were retrospectively extracted from hospital archives. Fifty-nine patients with UE matched with 180 controls were enrolled in the study. All patients' information was extracted from patient files and recorded in a datasheet. Data collection and analysis were performed blindly.

Unplanned extubation determination:

Pediatric patients (children under 18 years of age) who experienced UE and their matched controls in PICU from January 2010 to January 2011 were identified and all data were extracted from patient records and files. Demographic and baseline clinical data were collected including age, gender, diagnosis and use of sedatives (name of drug, dose, and interval of administration).

Unplanned extubation (UE) was determined as unintentional removal of an ETT by patient or accidental removal of an ETT during nursing care, procedures or transport. It was detected and reported by the nurse or physician in charge. None of our cases were of multiple UE.

The primary outcome variable for the analysis was the occurrence of UE. For each UE, a control was matched in blinded fashion from the remaining mechanically ventilated patients who did not experience UE. Controls were matched for five variables in the following order: age ±5 (month), indication for mechanical ventilation (MV), duration of MV, and sex.

Secretions were collected in a small specific tank for 24 hours and measured. Sedation/analgesia was provided using standard protocol with fentanyl (1 µg/kg infusion) plus midazolam (0.02 mg/kg).

Statistical Analysis:

Results are expressed as mean± SD (standard deviation) according to the distribution of the continuous variables. Statistical calculations were performed using the SPSS version 18 software. *Kolmogorov–Smirnov* (*K–S test*) and *Shapiro-Wilk* tests were used to analyze the normality and equality of continuous variables. *Student's t* test was used to compare continuous normally distributed variables. *Mann–Whitney* U or Chi-square test was used for non-parametric variables. Multivariate regression analysis was applied for the assessment of risk factors for UE compared to control group. P-Value less than 0.05 ($P < 0.05$) was considered significant.

RESULTS

In 1-year period, a total of 239 patients admitted to the PICU and intubated were enrolled in this study. These 239 patients were intubated for a total of 1,631 days with an average of 6.85 intubated days/patient. Fifty-nine cases (24.8%) had UE and 180 cases were matched as controls without UE. This represents UE rate of 3.6% per total number of intubated patient-days (59/1631). All patients with unplanned extubations had been orally intubated. No patient in the unit intubated nasally. Patient-to-nursing staff ratios varied from 1:1 to 2:1. The age and sex

distribution in the control group were not significantly different from the case group (Table 1).

Table 1. Baseline characteristics of test patients (unplanned extubation) and matched control patients (no unplanned extubation)

	Cases (n=59)	Controls (n=180)	p-value
Mean age, months (SD)	28.5±38.7	34±48.5	0.43
Age less than 2 years (No)%	32(54%)	62(35%)	0.01
Mean weight, kg (SD)	14.3±6.9	18.2±9.5	0.22
Continuous sedation infusion (%)	69.6%	72.7%	0.17
Use of restraints (%)	30.5%	35.7%	0.12
Nurse-to-patient ratio	1:1.7	1:1.5	0.35
Mechanical ventilation days	13±9	11±8	0.45
PICU days	18±6	17±8	0.19
ETT fixation (Band/Paste)	3/56	127/111	0.001

ETT: endotracheal tube, PICU: pediatric intensive care unit

The amount of secretion in our UE cases was as follow: 1 case (2%) with mild secretion (less than 5 ml/hour), 43 cases (72%) with moderate (between 5-10 ml/hour), and 15 cases (27%) with excessive secretion (more than 10 ml/hour). Distribution of various risk factors for UE among patients with unplanned extubation is shown in Table 2. Besides, the percentage of these variables per total days (1631) of intubated patient-day (IPD) in UE patients is demonstrated in Table 2.

Patient self-movement was the most frequent finding in UE (40% of cases). UE occurred in 1 case ventilated through T-piece ventilation, and 55 cases (88%) under mechanical ventilation. Three patients were attached to ambo bag ventilation during transfer while UE happened. From 59 UEs, 50 patients (85%) had one, 7 (12%) had two and 2 patients (3%) had three unplanned extubations. Thirty-six patients (61%) with UE required re-intubation. There was no case of mortality in UE patients or the control group. As a matter of fact, in our study all UEs were uneventful and none of our cases died of UE in 24 h after UE and were all reintubated.

In multivariate analysis, risk factors for UE included age less than 2 years (OR: 1.34, 95% CI: 1.13-3.61, P=0.001), male gender (odds ratio (OR): 2.53, 95% CI: 1.35-4.23, P=0.005), agitation (OR: 1.83, 95% CI: 1.54-5.36, P=0.001), high salivary secretion (OR: 4.42, 95% CI: 2.35-5.45, P=0.007), and duration of intubation (OR 1.39, 95% CI: 1.22-2.58, P=0.01) (Table 3). Other factors such as length of ICU stay, weight, method of fixation, using sedatives, and time of day were not significant risk factors for UE (Table 3).

Table 2. Distribution of various risk factors for UE among patients with unplanned extubation and percentage of these variables per total days (1631) of intubated patient-day (IPD) in UE patients

	Number of UE	UE/ IPD (%)
Detection device		
Pulse oximetry	26(44.05%)	1.59%
Ventilator alarm	8(13.55%)	0.49%
Physical exam	14(23.8%)	0.85%
Patient cry	11(18.7%)	0.67%
ETT (Cuffed/uncuffed)	9/50	0.55% / 3.01%
Use of restraints	18	1.12%
ETT fixation (Band/paste)	3/56	0.18% / 3.46%
Sex (Male/Female)	41/18	2.51% / 1.1%
Extubation (Transfer/in bed)	3/56	0.18% / 3.46%
Mental status		
Agitated	28(47.5%)	1.71%
Unconscious	7(11.9%)	0.41%
Lethargic	9(15.25%)	0.55%
Calm	10(16.9%)	0.61%

UE: unplanned extubation, IPD: Intubated patient-day, UE/100 IPD: UE rates per 100 days of intubated patient days, ETT: endotracheal tube

Table 3. Results of the multivariable, conditional logistic regression analysis

Variables	Odds ratio	95% confidence interval	p-value
Age<2 years	1.64	1.13-3.61	0.001
Weight	1.44	0.65-1.84	0.55
Male	2.53	1.35-4.23	0.005
Female	0.67	0.55-1.48	0.71
Cuffed ETT	0.45	0.32-0.95	0.014
Paste fixation of ETT	1.91	1.24-3.73	0.01
Continuous sedation infusion	0.83	0.64-1.36	0.29
Agitation	1.83	1.54-5.36	0.001
PICU days	1.19	0.82-1.38	0.09
Duration of intubation	1.39	1.22-2.58	0.01
Night shifts (8pm-8AM)	0.75	0.13-1.21	0.35
Secretion more than 5 ml/hour	4.42	2.35-5.45	0.007

ETT: endotracheal tube

DISCUSSION

Unplanned extubation (UE) could be a common event in busy pediatric intensive care units (PICU). UE outcome and mortality are variable in different settings; alas, it can delay patient extubation or increase mortality. Evaluation of UE risk factors could help PICU minimize them and prevent such event.

Although age itself was not a significant predictive of UE, age of younger than 2 years was a significant risk factor for it. This was confirmed by other studies emphasizing the necessity of greater vigilance of nursing for children under 2 years of age (11). Sex (male gender) was also a detrimental risk factor for UE even when adjusted for UE rate per 100 days of intubation in order to be normalized to the overall incidence of gender. Some studies suggest a regulatory role for estrogen in secretion of tracheal goblet cells (12), therefore females may have less secretion which could contribute to less UE. In addition, greater than normal secretions could enhance the risk of UE (13); which is consistent with our study. Our findings emphasized the importance of regular ETT suctioning to prevent subsequent accumulation of fluids and secretions leading to UE particularly in patients with more than 5 ml/hour secretions. Higher incidence of UE in uncuffed tubes and protective effects of cuffed tubes were also noted. Yet, controversy about cuffed tubes in different studies and lack of general consensus of experts in applying cuffed tubes in various pediatric age groups are undeniable (14,15).

Patients' agitation is of paramount importance in anticipation of UE consistent with other studies (16). Although sedation protocols were in place in our PICU to minimize agitations, 47.5% of our patients were under influence of sedative hypnotics while got agitated and UE happened. Measures to estimate the balance between agitation and over sedation is challenging considering that over-sedation may cause cardiovascular compromise, prolonged paralysis, and atelectasis (17,18). Therefore, it is the duty of nursing staff and physicians to have a clinical impression on patient's sedation state (19,20). Besides, unexpected movements of patients are the most frequent cause of UE in our study consistent with other studies (21). Therefore, unexpected movement of patient either inadvertently or intentionally proves that moving patient with extreme care could significantly decrease the risk of UE. Furthermore, our results showed that UE occurs in bedridden ICU patients more often than expected. Also, there was a marked difference in the type of ETT fixation (paste 3.46% vs. band 0.18%). Since the literature has highlighted this as an important risk factor, type of ET fixation device and the differences in UEs must be taken seriously (22).

Many risk factors are implied to be a major determinant of UE in pediatric patients but in our study many of these variables were non-significant. Lack of a significant difference in timing of UE incident (night or day) in our study is consistent with other studies (23). UE in adult ICU (AICU) is significantly higher in night shifts than daytime due to a reduction in staff vigilance at night (24). The variation of timing of UE incidence in night and day shifts between PICU and AICU may also reflect the difference in staff vigilance or their number per patient in PICU and AICU.

At this point, preventive strategies are the only options to reduce the incidence of UE and its complications. Therefore, close monitoring of patients in PICU by both alarming devices and nursing staff is the mainstay of preventing UE, particularly for those at increased risk of UE. Likewise, the likelihood of an UE increased with higher patient/nurse and patient acuity/nurse ratios (25). Our findings were used to improve the quality of care of infants in PICU by revising the protocols in place without changing the nurse-to-patient ratio. The amended protocol included extra vigilant monitoring in patients younger than 2 years of age, using suctioning in more tight schedules if moderate to high secretions persist, and implementation of sedation protocol in agitated children according to anesthesiology consults. One of the limitations of this study was the use of information based on record review. In fact, spontaneous reports of UEs can

be underestimated when using an inappropriate data collection tool or the PICU team is not involved in the process.

In conclusion, extreme care in high-risk patients, assessing the level of sedation and regular suctioning of ETT are the most important preventive strategies for UE in PICU. Understandably, our available knowledge only describes a very limited aspect of poorly understood, impeccably sophisticated elements leading to UE. More information is required to determine whether modified protocols could actually and robustly decrease the incidence of UE.

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