

Factors Affecting Invasive Management after Unplanned Extubation in an Intensive Care Unit

A Lan Lee, M.D.¹, Chi Ryang Chung, M.D.¹, Jeong Hoon Yang, M.D., Ph.D.^{1,2},
Kyeongman Jeon, M.D., Ph.D.^{1,3}, Chi-Min Park, M.D., Ph.D.^{1,4}, and Gee Young Suh, M.D., Ph.D.^{1,3}

¹Department of Critical Care Medicine, ²Division of Cardiology, Department of Medicine, ³Division of Pulmonary, Department of Medicine, ⁴Department of Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea

Background: Unplanned extubation (UE) of patients requiring mechanical ventilation in an intensive care unit (ICU) is associated with poor outcomes for patients and organizations. This study was conducted to assess the clinical features of patients who experienced UE and to determine the risk factors affecting reintubation after UE in an ICU.

Methods: Among all adult patients admitted to the ICU in our institution who required mechanical ventilation between January 2011 and December 2013, those in whom UE was noted were included in the study. Data were categorized according to noninvasive or invasive management after UE.

Results: The rate of UE was 0.78% (the number of UEs per 100 days of mechanical ventilation). The incidence of self-extubation was 97.2%, while extubation was accidental in the remaining patients. Two cases of cardiac arrest combined with respiratory arrest after UE were noted. Of the 214 incidents, 54.7% required invasive management after UE. Long duration of mechanical ventilation (odds ratio [OR] 1.52; 95% confidence interval [CI] 1.32-1.75; $p = 0.000$) and high ICU mortality (OR 4.39; 95% CI 1.33-14.50; $p = 0.015$) showed the most significant association with invasive management after UE. In multivariate analysis, younger age (OR 0.96; 95% CI 0.93-0.99; $p = 0.005$), medical patients (OR 4.36; 95% CI 1.95-9.75; $p = 0.000$), use of sedative medication (OR 4.95; 95% CI 1.97-12.41; $p = 0.001$), large amount of secretion (OR 2.66; 95% CI 1.01-7.02; $p = 0.049$), and low PaO₂/FiO₂ ratio (OR 0.99; 95% CI 0.98-0.99; $p = 0.000$) were independent risk factors of invasive management after UE.

Conclusions: To prevent unfavorable clinical outcomes, close attention and proper ventilatory support are required for patients with risk factors who require invasive management after UE.

Key Words: intensive care units; reintubation; unplanned extubation.

Introduction

Unplanned endotracheal extubation (UE) is defined as deliberate self-extubation by a patient receiving mechanical ventilation support or accidental extubation by staff nursing and medical procedures.[1] Incidence of UE of 0.5-35.8% has been reported.

[2,3] UE can lead to serious hemodynamic or airway complications, including bronchospasm, aspiration pneumonia, hypotension, arrhythmias, and cardiorespiratory arrest. [4] These complications can result in poor clinical outcomes of patients in the intensive care unit (ICU). Some studies reported prolonged mechanical ventilation and longer ICU stay and hospital stay in patients who experienced unplanned

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Correspondence to: Gee Young Suh, Division of Pulmonary and Critical Care Medicine, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, Korea
Tel: +82-2-3410-3429, Fax: +82-2-3410-6956
E-mail: gy.suh@samsung.com

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extubations.[4-7] In particular, reintubation after UE was associated with increased mortality.[6,8-10] However, risk factors affecting reintubation after UE have not yet been established. This study was conducted in order to assess the clinical features of patients who experienced UE and to determine the risk factors affecting invasive management after UE in ICU.

Materials and Methods

1) Study design

This study used a retrospective exploratory design and was conducted in an open room setting in adult medical intensive care units (MICU; 3 MICU, 42 beds) and surgical intensive care units (SICU; 3 SICU, 48 beds), but not the neurosurgical intensive care unit at a single center. The study was approved by the institutional review board.

2) Data collection

The charts of patients who received mechanical ventilation (MV) in MICU and SICU between January 2011 and December 2013 were reviewed. Neurosurgical patients and pediatric patients (≤ 18 years) were excluded. Data were categorized according to management after UE. One was non-invasive management, including simple oxygen supply and noninvasive positive pressure ventilation (NIPPV) and the other was invasive management, including delayed intubation, immediate intubation, and cardiopulmonary resuscitation after UE. Data included patients' demographics, admission diagnosis, ventilation day, and clinical outcomes. The patients' history of sedation, use of restraints, Richmond Agitation-Sedation Scale (RASS) scores, degree of secretion, $\text{PaO}_2/\text{FiO}_2$ ratio (PF ratio), and type of ventilator mode were used for analysis of factors affecting invasive management after UE. The number of patients who experienced UE was used to describe clinical features and outcomes of patients who experienced UE, and the number of incidents was used to determine the risk factors affecting invasive management after UE.

3) Definitions

UE was defined as the premature removal of an endotracheal tube by a patient receiving mechanical ventilation

support (self extubation) or the unintentional removal of an endotracheal tube by staff during nursing and medical procedures (accidental extubation).[1] Incident was UE in MICU and SICU.

Medical or surgical patients admitted to the ICU were categorized by operation. The patients' clinical features were noted by the person who found the incident first. Patients' status without use of vasopressors was expressed as stable vital status. A large amount of secretion was explained by secretion causing a tube fixing problem on patients' face. Recurrent UE was defined as more than two times. The managements after UE were simple oxygen supply, NIPPV, immediate intubation within 1 hr after UE, delayed intubation within 48hrs after UE, and cardiopulmonary resuscitation (CPR).

Weaning trial was performed according to daily assessment for spontaneous breathing trial when patients were considered clinically stable, with adequate mentation, adequate oxygenation (PF ratio >200), and adequate pulmonary function (respiratory rate $<35/\text{min}$, negative inspiratory pressure ≤ -15 cmH_2O , tidal volume >5 mL/kg , expiratory volume $<10-15$ L/min , and no significant respiratory acidosis). Reintubation was performed according to the usual criteria (increased signs of respiratory work, for protection of the airway, persistent low $\text{SaO}_2 <90\%$ with $\text{FiO}_2 \leq 50\%$, or severe arterial blood gas deterioration).

4) Statistical analysis

The Statistical Package for the Social Sciences (SPSS) software, version 20.0 (SPSS Inc, Chicago, IL, USA) was used for data analysis. All categorical values were expressed as a percentage of the group from which they were derived and compared using the chi-square test and Fisher's exact test. Continuous variables were analyzed using independent Student's t test for normally distributed variables, and expressed as the mean \pm standard deviation. Univariate logistic regression analysis for screening and multivariate binary logistic regression analysis were performed for analysis of the independent risk factors affecting invasive management after UE. Two-sided p values of <0.05 were considered statistically significant.

Results

1) Clinical features and outcomes of patients who experienced UE

A total of 8,621 patients received MV in MICU and SICU

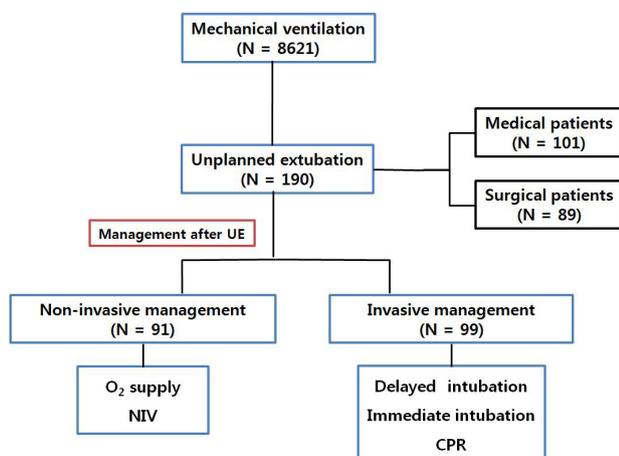


Fig. 1. Flowchart of patient selection. UE: unplanned extubation; NIV: non-invasive ventilation; CPR: cardiopulmonary resuscitation.

Table 1. Clinical features and outcomes of patients experienced unplanned endotracheal extubation

	Patients (n = 190)
Gender, male	138 (72.6)
Age, yrs	59.7 ± 14.4
BMI, kg/m ²	22.3 ± 3.8
Medical patients	101 (53.2)
Categories of diagnosis	
Pulmonary	64 (33.7)
Cardiovascular	32 (16.8)
Gastrointestinal	18 (9.5)
Nephrology	13 (6.8)
Hepatobiliary	12 (6.3)
Others	51 (26.9)
Recurrent UE	23 (12.1)
MV duration, days	6.1 ± 6.0
Hospital length of stay, days	50.4 ± 80.0
ICU length of stay, days	13.8 ± 13.7
In hospital mortality	92 (48.4)
ICU mortality	47 (24.7)

Continuous variables are expressed as the mean ± standard deviation. Categorical variables are expressed as number of patients (%).

BMI: Body mass index; UE: unplanned extubation; MV: mechanical ventilation; ICU: intensive care unit.

(Fig. 1). The incidence rate of UE was 2.2% (the number of UE per 100 ventilated patients) and the incidence density of UE was 0.78% (the number of UE per 100 days of mechanical ventilation). The study included 190 patients who experienced UE. Of these, 23 patients experienced UE more than two times (Table 1). Of total patients, 53.2% were medical patients, the majority of patients had a pulmonary disease when admitted to the ICU. The mean duration of MV was 6 days, and ICU stay was almost 14 days. The ICU mortality rate was 24.9% (Table 1), and patients who received invasive management after UE had longer duration of MV and ICU stay than those who did not (Table 2). In addition, higher ICU and in hospital mortality were observed in the invasive management group than in the non-invasive management group. In binary logistic regression analysis, long duration of MV (odds ratio [OR] 1.52; 95% confidence interval [CI] 1.32-1.75; $p = 0.000$) and high ICU mortality (OR 4.39; 95% CI 1.33-14.50; $p = 0.015$) showed the most significant association with invasive management after UE (Table 3).

Table 2. Clinical outcomes of patients received invasive managements after unplanned endotracheal extubation in univariate analysis

	Non-invasive Patients (n = 91)	Invasive Patients (n = 99)	p-value
Recurrent UE	8 (8.8)	15 (15.2)	0.179
MV duration, days	2.7 ± 3.1	9.2 ± 6.4	0.000
Hospital length of stay, days	39.5 ± 35.7	60.4 ± 104.7	0.071
ICU length of stay, days	10.1 ± 11.3	17.2 ± 14.8	0.000
In hospital mortality	29 (31.9)	63 (63.6)	0.000
ICU mortality	8 (8.8)	39 (39.4)	0.000

Continuous variables are expressed as the mean ± standard deviation. Categorical variables are expressed as number of patients (%).

UE: unplanned extubation; MV: mechanical ventilation; ICU: intensive care unit.

Table 3. Clinical outcomes of patients received invasive managements after unplanned endotracheal extubation in multivariate analysis

	*p-value	OR	95% CI
MV duration, days	0.000	1.52	1.32 - 1.75
ICU mortality	0.015	4.39	1.33 - 14.50

*p values are calculated with the multivariate logistic regression analysis.

OR: odds ratio; CI: confidence interval, MV: mechanical ventilation; ICU: intensive care unit.

Table 4. Factors associated with invasive management after unplanned endotracheal extubation in univariate analysis

	Non-invasive Events (n = 97)	Invasive Events (n = 117)	p-value
Gender, male	73 (75.3)	84 (71.8)	0.568
Age, yrs	62.6 ± 12.6	55.6 ± 14.9	0.000
BMI, kg/m ²	22.4 ± 3.8	22.1 ± 3.9	0.570
Medical patients	40 (41.2)	94 (80.3)	0.000
Pulmonary disease	27 (27.8)	48 (41)	0.044
MV duration before UE, days	2.6 ± 2.6	3.0 ± 3.6	0.285
Cause, accidental	2 (2.1)	4 (3.4)	0.549
Vital status, unstable	29 (29.9)	35 (29.9)	0.998
Use of restraint	43 (44.3)	46 (39.3)	0.459
Use of sedative medication	57 (58.8)	104 (88.9)	0.000
RASS	-0.56 ± 1.87	-0.15 ± 1.72	0.102
Large amount of secretion	10 (10.3)	30 (25.6)	0.004
PF ratio	290.0 ± 117.1	197.3 ± 88.1	0.000
Weaning	8 (8.2)	1 (0.9)	0.007
Ventilator mode, pressure control	6 (6.2)	24 (20.5)	0.003

Continuous variables are expressed as the mean ± standard deviation. Categorical variables are expressed as number of patients (%).

BMI: Body mass index; MV: mechanical ventilation; UE: unplanned extubation; RASS: Richmond Agitation–Sedation Scale scores; PF: PaO₂/FIO₂.

2) Factors associated with invasive management after UE

Of the 214 incidents, 54.7% were invasive management after UE. Delayed intubation, immediate intubation, and CPR as invasive management were 8.4%, 45.3%, and 0.9% of total incidents, respectively. Simple oxygen supply and NIPPV as non-invasive management after UE were 36.0% and 9.3% of total incidents. The majority of incidents were self extubations (97.2%). Restraint was used in almost half of the total of 214 incidents, and sedative medication was used in 75.2%. Of total incidents, 81.8% received MV with pressure support mode.

Invasive management after UE was necessary in younger patients, medical patients, patients with pulmonary disease, with low PF ratio, with large amount of secretion, and with pressure-controlled ventilator mode (Table 4). In addition, the invasive management group included more patients using sedative medication and who did not receive a weaning trial than the non-invasive management group (Table 4). In

Table 5. Factors associated with invasive management after unplanned endotracheal extubation in multivariate analysis

	*p value	OR	95% CI
Age, yrs	0.005	0.96	0.93 - 0.99
Medical patients	0.000	4.36	1.95 - 9.75
Use of sedative medication	0.001	4.95	1.97 - 12.41
Large amount of secretion	0.049	2.66	1.01 - 7.02
PF ratio	0.000	0.99	0.98 - 0.99

*p values are calculated with the multivariate logistic regression analysis. OR: odds ratio; CI: confidence interval; PF: PaO₂/FIO₂.

multivariate binary logistic regression analysis, younger age (OR 0.96; 95% CI 0.93-0.99; p = 0.005), medical patients (OR 4.36; 95% CI 1.95-9.75; p = 0.000), use of sedative medication (OR 4.95; 95% CI 1.97-12.41; p = 0.001), large amount of secretion (OR 2.66; 95% CI 1.01-7.02; p = 0.049), and low PF ratio (OR 0.99; 95% CI 0.98-0.99; p = 0.000) were independent risk factors in invasive management after UE (Table 5).

Of total 134 medical patients, 70.1% was received invasive managements after UE. Use of sedative medication, low PF ratio, and pressure-controlled ventilator mode were associated with invasive managements after UE in medical patients. On multivariate analysis, low PF ratio (OR 0.993; 95% CI 0.988-0.997; p = 0.001) was significantly associated with invasive management after UE in medical patients. Of total 80 surgical patients, 28.8% was received invasive management after UE. Male, younger age, pulmonary disease, long duration of MV before UE, use of sedative medication, large amount of secretion, low PF ratio, and pressure-controlled ventilator mode were associated with invasive managements after UE in surgical patients. Of these factors, younger age (OR 0.874; 95% CI 0.782-0.976; p = 0.017) and low PF ratio (OR 0.978; 95% CI 0.961-0.996; p = 0.017) were independent risk factors in surgical patients requiring invasive management after UE.

Discussion

This study reported on clinical features and outcomes of patients who experienced UE, clinical outcomes of patients who received invasive management after UE, and factors associated with invasive management after UE.

Incidence of events of 0.78% in this study was consistent with rates reported in the previous studies, ranging from 0.1% to 3.6% UE per 100 ventilation days.[2-3,11] Previous studies on UE have reported association of UE with longer stays and duration of mechanical ventilation.[4-7,12] Moreover, in recent studies UE in surgical or medical ICU was associated with high ICU and in-hospital mortality rates.[10,13] Many previous studies have reported risk factors for UE. In previous studies, presence of agitation, higher level of consciousness, inadequate sedation, use of benzodiazepines, Acute Physiology and Chronic Health Evaluation II score ≥ 17 , nursing care, use of physical restraints, and insufficient endotracheal tube fixation were risk factors for UE.[1,4,7,12,14-18]

Reintubation after UE was associated with higher hospital costs, demanded more chronic care, and had a greater incidence of ventilator-associated pneumonia (relative risk 1.8).[5,6,19] In the majority of previous studies on reintubation after UE, prolonged MV and longer ICU stay were attributed to patients who required reintubation after UE, and reintubation was associated with increased mortality in UE patients.[6,8,9,20] In our study, comparing non-invasive management after UE, we found that patients who required invasive management had a significantly prolonged MV duration and high ICU mortality.

Reintubation rates after UE, which varied according to the population studied, type of UE, and level of ventilatory support, of 1.8% to 88% have been reported.[9,21] In our study, the rate of invasive management after UE was 54.7%, similar to previous studies ranging from 13.3% to 78.3% in mixed-patient populations.[21] Various factors, including age older than 65 years, accidental extubation, full ventilatory support, PF ratio < 200 to 250 mmHg before unplanned extubation, Glasgow coma scale score < 11 , nonsurgical patients, diagnosis of pneumonia, and presence of ≥ 3 comorbidities have been reported as risk factors of reintubation after UE.[8,21-24] In our study, risk factors of invasive management after UE were slightly different from those of previous studies. Unlike previous results, patients requiring invasive management after UE were younger than those in the non-invasive management group after UE. In addition, we found that a large amount of secretion was one of the risk factors for invasive management after UE. Patients with a large amount of secretion may have problems with secur-

ing the endotracheal tube, and require full ventilator support.

Some studies reported that a negative RASS score and deep sedation under full MV were risk factors associated with reintubation after UE.[4,10] Although the RASS score was not a risk factor of invasive management after UE in our study, our data showed an association of sedation with invasive management after UE. We found a significant association of a medical and surgical patient with low PF ratio before UE with invasive management after UE. This result was consistent with those of several previous studies, which reported low PF ratio before UE as a risk factor for reintubation after UE.[8,10,20,25]

After UE, inappropriate management can lead to poor clinical outcome. A previous study reported on outcome of extubation failure.[13] In contrast with successful extubation, failed planned or unplanned extubation was followed by marked clinical deterioration, suggesting a direct and specific effect of extubation failure and reintubation on patient outcomes. Accordingly, more rapid intubation should be considered in patients with risk factors of invasive management after UE. Interestingly, in our study almost half of the incidents were noninvasive management after UE. This result reflects inadequate ventilatory support in many patients who received MV. Failure to identify patients who are ready for removal of MV is an important factor contributing to increased incidence of unplanned extubation. Proper application of MV and weaning protocols will probably be helpful in reducing the incidence of reintubation after UE. Therefore, risk factors of invasive management after UE should be considered, because hasty decisions regarding intubation after UE can lead to unnecessary MV and poor clinical outcome in patients without risk factors of invasive management after UE.

In conclusion, we demonstrated an association of patients requiring invasive management after UE with unfavorable clinical outcomes. Therefore, attention should be paid in order to prevent inappropriate management and unfavorable clinical outcomes in patients with risk factors of invasive management after UE.

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