



Unplanned Extubation in Patients with Mechanical Ventilation: Experience in the Medical Intensive Care Unit of a Single Tertiary Hospital

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Background: Potentially harmful unplanned extubation (UE) may occur in patients on mechanical ventilation (MV) in an intensive care unit (ICU) setting. This study aimed to evaluate the clinical characteristics of UE and its impact on clinical outcomes in patients with MV in a medical ICU (MICU).

Methods: We retrospectively evaluated MICU data prospectively collected between December 2011 and May 2014.

Results: A total of 468 patients were admitted to the MICU, of whom 450 were on MV. Of the patients on MV, 30 (6.7%) experienced UE; 13 (43.3%) required reintubation after UE, whereas 17 (56.7%) did not require reintubation. Patients who required reintubation had a significantly longer MV duration and ICU stay than did those not requiring reintubation (19.4±15.1 days vs. 5.9±5.9 days and 18.1±14.2 days vs. 7.1±6.5 days, respectively; $p<0.05$). In addition, mortality rate was significantly higher among patients requiring reintubation than among those not requiring reintubation (54.5% vs. 5.9%; $p=0.007$). These two groups of patients exhibited no significant differences, within 2 hours after UE, in the fraction of inspired oxygen, blood pressure, heart rate, respiratory rate, and pH.

Conclusion: Although reintubation may not always be required in patients with UE, it is associated with a poor outcome after UE.

Keywords: Airway Extubation; Respiration, Artificial; Intensive Care Units

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Introduction

Endotracheal intubation is needed in patients on mechanical ventilation (MV) to support ventilation and maintain lung volume and provide a suctioning route for the prevention of tracheal obstruction and hypoxia due to airway secretions¹. Endotracheal tube (ETT) removal, or extubation, is performed by a physician or nurse after successful weaning from MV and represents the final step in liberation from MV².

Planned extubation (PE) refers to ETT removal by a physician or nurse according to a schedule or protocol. In contrast, unplanned extubation (UE) is defined as accidental or patient-induced ETT removal and occurs in 3%–16% of patients on MV³⁻⁸. UE can provoke injuries of the upper respi-

ratory tract, aspiration of gastric or tracheal substances, and severe hypoxia consequent to respiratory failure. In addition, complications such as a failure to reintubate, acute respiratory failure, healthcare-associated pneumonia, and infection occur frequently in patients requiring reintubation^{7,9,10}.

Several previous reports regarding UE in Korea can be found in the literature¹¹⁻¹⁵. However, reports limited to medical intensive care units (MICU) settings are lacking. This study aimed to investigate the clinical characteristics and outcomes after UE in the MICU of a single regional tertiary hospital.

Materials and Methods

1. Patients

Patient demographic and clinical characteristic data were prospectively collected in the MICU of Gyeongsang University Hospital (hospital total, 890 beds; MICU, 13 beds; patients:nurses ratio=3:1) between December 2011 and May 2014. Patients who experienced an UE during their intensive care unit (ICU) stay were selected for this study, and their data were subjected to a retrospective assessment of the following variables: (1) demographic and clinical variables, including age, gender, cause of ICU admission, body mass index, underlying disease, time interval between UE and reintubation, duration of MV, and status at the time of UE; (2) physiologic and laboratory data before and within 2 hours after UE, such as vital signs, arterial blood gas analysis, mode of MV, and use of physical restraints; and (3) clinical outcomes, including the mortality and the length of ICU and hospital. Patients with surgical, pediatric, or neurologic issues and events were excluded from our study.

Weaning from MV was performed by the attending physician, staff member, or internal medicine resident when MV was no longer needed to support a respiratory condition, as determined by meeting the general criteria such as requirements of a reduction in the fraction of inspired oxygen (FiO₂) of <0.4, sufficient spontaneous tidal volume per breath (≥5 mL/kg), and a stable hemodynamic state¹⁶. The decision to remove an ETT was made by the attending physician according to the patient's status. The general criteria of removal of ETT were usually based on intact cough strength, alert mental status, and no copious amount of sputum². In cases of extubation, the ICU medical attendant determined the time and situation when the patient could self-respire without requiring respiratory support equipment; following an evaluation, the ETT was removed by a physician or assisting nurse in the ICU. There were no intensivists during study period in the hospital.

UE was defined as unplanned oropharyngeal tube removal that was not intended by the health care provider and was further classified as accidental extubation or self-extubation¹⁷. Accidental extubation was defined as ETT removal during

nursing practice or positioning changes without the physician's approval. Self-extubation was defined as ETT removal directed by the patient's intention or effort. Tolerated UE was defined as no longer requiring intubation after UE; failed UE was defined as a necessary reintubation after UE. We compared the clinical characteristics and outcomes of both groups. Reintubation is considered in criteria showing like altered mentality, diaphoresis, tachycardia, tachypnea, agitation, and inability to protect airway or manage secretion¹⁸.

All data were analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). The statistical analysis included Student's t test for parametric data and the Mann-Whitney U test for non-parametric data. The chi-square test was used to evaluate statistical differences between compared groups. A p-value of <0.05 was considered statistically significant.

Results

1. Comparison of clinical characteristics between patients with UE and control subjects

A total of 468 patients were admitted to the MICU during our study period. Of these, 18 who were not subjected to invasive MV were excluded, and 450 patients remained eligible for our study. Among these patients, 30 had an UE; the latter represented 6.7% of all patients on MV.

Table 1 presents a comparison of the clinical characteristics and variables in patients with a control subjects and UE. No significant differences were observed between UE and control subjects in terms of age, sex, cause of ICU admission, underlying disease, Acute Physiology and Chronic Health Evaluation (APACHE) II score, Sequential Organ Failure Assessment (SOFA) score, and presence of septic shock and acute respiratory distress syndrome (ARDS). The duration of MV, lengths of stay (LOS) in the ICU and hospital did not differ significantly between the groups.

At the time of UE, 29 patients had been physically restrained; 18 patients had not received sedative agents and remained in an alert state. Delirium occurred in four patients. High flow nasal cannula or bilevel positive end-expiratory pressure was applied to three patients after UE. However, these patients required reintubation. Two patients developed ventilator-associated pneumonia during ICU stay. The causes of death were progressive respiratory failure due to pneumonia in five patients, cardiac tamponade in one patient, progression of underlying interstitial lung disease in one patient, and unidentifiable causes in two patients.

2. Comparison between tolerated UE and failed UE

The rate of reintubation after UE was 43.3% (13/30 patients); 17 patients (56.7%) tolerated UE. Of the 13 reintubated

Table 1. Comparison of clinical characteristics between patients with control subjects and UE

Clinical characteristic	Control subjects (n=420)	UE (n=30)	p-value
Age, yr	68.30±14.15	71.00±12.67	0.309
Male	270 (64.3)	24 (80)	0.111
Cause of ICU admission			0.46
Pneumonia	176 (41.9)	16 (53.3)	
Septic shock	55 (13.1)	2 (6.7)	
AECOPD	46 (11.0)	7 (23.3)	
Others	143 (34)	5 (16.7)	
Underlying			
DM	139 (33.1)	10 (33.3)	>0.999
HTN	170 (40.5)	15 (50.0)	0.340
TB	59 (14.0)	6 (20.0)	0.416
CKD	62 (14.8)	5 (16.7)	0.790
HF	79 (18.8)	7 (23.3)	0.630
APACHE II	18.95±8.82	16.50±7.88	0.140
SOFA score	8.07±4.47	6.77±3.23	0.117
Septic shock	150 (36.2)	8 (26.7)	0.329
ARDS	70 (16.7)	1 (3.3)	0.066
Duration of MV, day	9.59±17.32	10.87±11.86	0.692
LOS in ICU, day	10.29±18.77	11.1±11.05	0.816
LOS in hospital, day	25.39±36.45	30.70±28.50	0.435

Values are presented as mean±SD or number (%).

UE: unplanned extubation; ICU: intensive care unit; AECOPD: chronic obstructive pulmonary disease acute exacerbation; DM: diabetes mellitus; HTN: hypertension; TB: tuberculosis; CKD: chronic kidney disease; HF: heart failure; APACHE: Acute Physiology and Chronic Health Evaluation; SOFA: Sequential Organ Failure Assessment; ARDS: acute respiratory distress syndrome; MV: mechanical ventilation; LOS: length of stay; ICU: intensive care unit.

patients, nine (64.2%) were reintubated within 48 hours. Table 2 shows the clinical characteristics, variables, and outcomes in the tolerated and failed UE groups. The tolerated UE and failed UE groups did not differ significantly in terms of age, sex, cause of ICU admission, underlying disease, APACHE II score, SOFA score, and presence of ARDS. An analysis of vital signs and blood gas levels immediately (within 2 hours) after UE did not reveal differences between the tolerated UE and failed UE groups. Furthermore, neither the ventilator mode at the time of UE nor the use of inotropics and sedative agents differed between the tolerated UE and failed UE groups. The inotropics was used in three tolerated UE patients (1 in dopamine only and 2 in dopamine and norepinephrine). In terms

Table 2. Comparison of clinical characteristics between patients with tolerated and failed UE

Clinical characteristic	Tolerated (n=17)	Failed (n=13)	p-value
Age, yr	69.4±15.9	73.1±6.6	0.399
Male	15 (88.2)	9 (69.2)	0.360
Cause of ICU admission			0.553
Pneumonia	9 (52.9)	7 (53.8)	
Septic shock	2 (11.8)	0	
AECOPD	3 (17.6)	4 (30.8)	
Others	3 (17.6)	2 (15.4)	
Underlying disease			
DM	6 (35.3)	4 (30.8)	>0.999
HTN	9 (52.9)	6 (46.2)	>0.999
TB	3 (17.6)	3 (23.1)	>0.999
CKD	3 (17.6)	2 (15.4)	>0.999
HF	2 (11.8)	5 (38.5)	0.190
APACHE II	16.9±9.1	16.0±5.9	0.778
SOFA score	7.5±3.2	5.1±2.9	0.051
Septic shock	7 (41.2)	0	0.023
ARDS	4 (23.5)	4 (36.4)	0.671
Physiologic and laboratory parameter			
Systolic BP	132.4±13.1	135.3±22.6	0.685
Diastolic BP	80.3±9.1	76.0±16.1	0.400
HR, 1/min	99.5±18.9	103.7±19.1	0.557
RR, 1/min	22.2±3.5	24.7±5.9	0.195
pH	7.41±0.10	7.42±0.07	0.664
PaCO ₂ , mm Hg	37.5±10.3	46.3±18.2	0.136
PaO ₂ , mm Hg	87.5±21.3	81.5±27.3	0.509
HCO ₃ , mmol/L	23.2±5.1	28.5±8.4	0.064
SpO ₂ , %	95.8±2.2	95.7±2.3	0.853
FiO ₂	35.4±8.8	38.1±5.6	0.339
Ventilatory support			
ACMV	1 (5.9)	2 (15.4)	0.565
SIMV	5 (29.4)	2 (15.4)	0.427
CPAP	8 (47.1)	7 (53.8)	>0.999
T-piece	3 (17.6)	2 (15.4)	>0.999
Use of sedative agents	2 (11.8)	2 (15.4)	>0.999
Use of inotropic agents	2 (11.8)	1 (7.7)	>0.999
Duration of MV, day	5.9±5.9	19.4±15.1	0.015
LOS in ICU, day	7.1±6.5	18.1±14.2	0.009
LOS in hospital, day	25.8±23.8	41.6±34.8	0.167
Mortality	1 (5.9)	6 (54.5)*	0.007

Values are presented as mean±SD or number (%).

*Two patients were not reintubated at the request of the families. Accordingly, we have excluded these patients from comparisons of mortality. Nine unplanned extubation patients died in this study.

UE: unplanned extubation; ICU: intensive care unit; AECOPD: chronic obstructive pulmonary disease acute exacerbation; DM: diabetes mellitus; HTN: hypertension; TB: tuberculosis; CKD: chronic kidney disease; HF: heart failure; APACHE: Acute Physiology and Chronic Health Evaluation; SOFA: Sequential Organ Failure Assessment; ARDS: acute respiratory distress syndrome; BP: blood pressure; HR: heart rate; RR: respiratory rate; PaCO₂: partial alveolar pressure of CO₂; PaO₂: partial pressure of alveolar O₂; SpO₂: O₂ saturation; FiO₂: fraction of inspired O₂; ACMV: assist control mechanical ventilation; SIMV: synchronized intermittent mandatory ventilation; CPAP: continuous positive airway pressure; MV: mechanical ventilation; LOS: length of stay.

of time interval between UE and reintubation, four patients were within 6 hours after UE, two patients were from 18 to 24 hours. Two patients were from 24 to 48 hours of UE and two patients were do-not intubation due to family request. Patients who required reintubation had a significantly longer MV duration and ICU stay compared with those who did not require reintubation (16.9 ± 14.1 days vs. 5.6 ± 5.9 days and 6.6 ± 6.4 days vs. 16.2 ± 13.1 days, respectively; $p<0.05$). In addition, overall mortality rate was significantly higher among patients who required reintubation than among those who did not (54.5% vs. 5.9% , $p=0.007$). Two patients were not reintubated because of family requests. Accordingly, we have excluded these patients from comparisons of mortality.

Discussion

In this retrospective study of ICU patients during invasive MV, although only a small number of patients experienced UE, the overall mortality rate among these patients was significantly higher for those who required reintubation than for those who did not. In addition, the MV duration and ICU stay were significantly longer among patients who required reintubation than among those who did not.

The incidence rate of UE in our study was 6.7%, which was similar to or slightly higher than that in previous reports. The rate of UE may vary widely according to several ICU-related factors, including the location, sedation strategy, nurse-to-patient ratio, and restraint policy. Reports published during the past 20 years have claimed relatively high rates of UE relative to that observed in our study, and these rates of UE, which range from 2%–16%, vary among studies³⁻⁸. Coppolo and May⁶ and Stauffer et al.¹⁹ reported an 11% self-extubation rate among 112 patients and UE rate of 13%, respectively, which concurred with another more recent report¹⁷. In Korea, several studies have reported rates similar to that observed in our study. Koo et al.¹² reported that in two multidisciplinary ICU, 62 episodes of UE in 56 patients were reported during a 35-month study period, for an incidence rate of 2.8%; Lee et al.¹¹ reported a 4.85% rate of UE over a study period of 1 year. Another recent report from Korea reported a UE rate of 7.1%, similar to our study¹⁵.

UE may have detrimental effects on patient outcomes because of the higher risk of extubation failure, which is known to be associated with a poor clinical prognosis^{2,18}, when compared with PE. Many studies have reported higher complication rates and poorer clinical outcomes in patients after UE relative to those without UE. For example, Vassal et al.⁸ experienced difficulty with airway maintenance as a post-UE complication. Studies have also been conducted to investigate prognosis after UE. Epstein et al.⁹ also reported the effects of UE on patient outcomes and prognosis; these included longer ICU and hospital LOS and a longer MV duration for patients

who failed UE relative to those who tolerated UE. A higher rate of nosocomial pneumonia was also documented both after UE and after reintubation²⁰.

Regarding mortality, several studies have found no difference in the mortality rates associated with UE and PE. Epstein et al.¹⁸ reported that the mortality rates of patients after UE and PE did not differ, and a prospective study in an adult ICU also observed a similar mortality rate (7/46 UE and 98/380 PE patients)⁴. However, patients who were reintubated after UE were found to have a higher mortality rate either than patients with PE or those not reintubated after UE^{9,18}.

Reintubation after UE should not be required in all cases; we reported a reintubation rate after UE of approximately 40%, and the reported reintubation rates after UE vary widely (31%–70%) among researchers^{3,6,12,21}. Because reintubation after UE is not mandatory, it is important to recognize the factors associated with extubation failure in these patients. For example, age is an important factor that determines the rate of reintubation after UE^{21,22}. However, pneumonia, a cause of respiratory failure, was the most important predicting factor for reintubation after UE²³. A previous study reported that a pre-extubation $\text{FiO}_2 < 0.4$ and ventilator-delivered tidal volume < 7.0 L/min were important factors associated a lack of requirement for reintubation²⁴. In our study, we observed no differences in clinical and physiologic parameters between patients with tolerated and failed UE within 2 hours of UE. That is because the reintubation was required in most patients in 6 hours after UE.

The relatively high success rate of UE indicates that physicians do not always remove ETTs at the correct time, even if successful PE is possible. Occasionally, physicians hesitate to perform extubation after successful weaning in the absence of subjective criteria such as decreased mentation, excessive secretion, and decreased respiratory muscle strength. Therefore, it is important to recognize the precise criteria supportive of extubation after weaning in the ICU.

As UE may be harmful to intubated critically ill patients, it is important to prevent this unexpected event. Several methods to achieve this have been proposed. An appropriate sedation strategy may reduce the risk of UE in critically ill patients²⁵; from the viewpoint of preventing UE, continuous sedation with daily interruptions might be a better strategy²⁵. However, prolonged and continuous sedation for UE prevention might prolong the durations of MV and ICU stay. Adequate application of physical restraints might also reduce the incidence of UE, although the efficacy of this technique has been not demonstrated²⁶. In cases of frequent UE, careful ICU restraint policies may need to be reset. In our study, most patients were applied physical restrain at the time of UE, representing inadequate restrain policy in the hospital. Previous retrospective studies have also reported that ETT fixation methods such as adhesive tape²⁷ and tube holding devices²⁸ might reduce the risk of UE. More importantly, a standardized weaning protocol

may reduce the risk of UE and the requirement for reintubation²⁹.

In conclusion, UE can occur in patients on MV in an ICU setting and can negatively influence a patient's prognosis. Accordingly, appropriate steps must be taken to prevent UE. Further investigation is needed to identify the risk factors associated with UE as well as the prevention methods.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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