

# FACTORS PREDICTING REINTUBATION AFTER UNPLANNED EXTUBATION

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**Background and Purpose:** Factors predicting reintubation after unplanned extubation (UE) are not well established. We prospectively studied the incidence and clinical features of UE and predictive factors for reintubation in medical intensive care unit (ICU) patients. We also validated the scoring system of Listello and Sessler to predict the outcome after UE.

**Methods:** Over a 14-month period, patients who had a first UE while being treated in our medical ICU were identified. Data including clinical features, laboratory data and ventilator parameters were collected and compared between the reintubation and non-reintubation groups.

**Results:** Fifty episodes of UE occurred during the study period, 8.5% of all endotracheal intubations. More than half of the episodes of UE (26/50, 52%) occurred within 48 hours after intubation; reintubation was required in 33 episodes (33/50, 66%). In univariate analysis the only significant difference between the reintubation and non-reintubation groups in pre-extubation parameters was pneumonia as the cause of respiratory failure, which was significantly associated with the need for reintubation (52% vs 18%, respectively; odds ratio 4.96; confidence interval 1.24–19.91;  $p = 0.02$ ). All patients with pneumonia who had UE within 5 days after intubation required reintubation. In contrast, there was a low rate of reintubation in patients with heart disease (3/9, 33%). Validation of the scoring system of Listello and Sessler revealed that outcome of UE was correctly predicted in only 62% (31/50) of episodes.

**Conclusions:** Pneumonia as the cause of respiratory failure was the most important predicting factor for reintubation after UE. Reintubation after UE may not be necessary, especially in patients with heart disease as the cause of respiratory failure. The scoring system of Listello and Sessler did not accurately predict reintubation after UE in this study.

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## Key words:

endotracheal intubation  
unplanned extubation  
reintubation  
mechanical ventilation  
pneumonia  
congestive heart failure

Unplanned extubation (UE) is a frequent event that can cause morbidity and mortality. It occurs in about 3% to 14% of mechanically ventilated patients in intensive care units (ICUs) [1–6]. Since UE is abrupt and unpredictable, traditional weaning parameters including maximal inspiratory pressure, spontaneous breathing tidal volume, and rapid shallow breathing index are usually unavailable. Several studies have investigated the predictive criteria for reintubation after UE [2, 6–9]. However, the findings were diverse and inconclusive. In this prospective study, we evaluated the incidence and clinical features of UE, and factors

predicting the need for reintubation after UE in medical ICU patients. We also validated the scoring system for reintubation proposed by Listello and Sessler [6].

## Materials and Methods

### Data collection

From September 1998 to November 1999, patients who had a first UE (accidental or deliberate self-extubation)

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while being treated in the medical ICU of National Cheng Kung University Medical Center were identified and enrolled in this study. Data including age, sex, cause of respiratory failure, ventilator settings, duration of intubation in ICU, use of sedative agents or restraints in the 24 hours preceding UE, and latest arterial blood gas data before UE were collected immediately after the UE. The authors collected patient data every day after UE, but all decisions about the use of sedatives, physical restraint and reintubation were made in the ICU by the attending physician in charge. Causes of respiratory failure were categorized according to strict definitions. Pneumonia was defined when the chest roentgenogram showed new pulmonary consolidation, not otherwise explained, in combination with fever ( $> 38^{\circ}\text{C}$ ), purulent tracheobronchial secretions, and peripheral leukocytosis. Chronic obstructive pulmonary disease (COPD) was defined as the cause of respiratory failure when respiratory failure was due to acute exacerbation of COPD without pneumonia. Heart disease was defined as the cause of respiratory failure if patients without pneumonia had congestive heart failure due to cardiomyopathy, myocardial infarction, or ventricular arrhythmia. Intoxication was considered the cause of respiratory failure in one patient with glyphosphate intoxication and one with paraquat intoxication.

### Factors predicting reintubation after UE

Selected clinical factors were assessed as predictors of reintubation after UE. These factors, identified in previous studies as associated with reintubation following UE [5–10], included: control mode (full mechanical ventilatory support) *versus* partial support mode (weaning with pressure support mode or T-piece device); most recent arterial pH prior to UE; most recent fraction of inspired oxygen ( $\text{FiO}_2$ ); ratio of  $\text{PaO}_2$  to  $\text{FiO}_2$  prior to UE; ventilator-delivered minute volume, VVE (ventilator rate multiplied by set tidal volume); duration of intubation in the ICU; highest heart rate  $> 120/\text{minute}$  in the 24 hours prior to UE; mental status other than alert; and the presence of at least three coexisting medical disorders, as proposed by Listello and Sessler [6]. We compared these values between patients who required reintubation and those who did not. The decision to reintubate the patient was made by the attending physician based on the patient's clinical symptoms and arterial blood gas data after UE.

### Validation of the scoring system of Listello and Sessler

We validated the scoring system of Listello and Sessler for reintubation, which assigns one point for each of the following seven parameters [6]: synchronized

intermittent mechanical ventilation or assisted controlled ventilation at a rate of more than six prior to UE; pH greater than 7.45 prior to UE;  $\text{PaO}_2/\text{FiO}_2$  less than 250 prior to UE; highest heart rate of more than 120/minute in the 24 hours prior to UE; not alert; not postoperative; and presence of at least three coexisting medical disorders from history of COPD, history of congestive heart failure, renal dysfunction (serum creatinine  $>$  upper limits of normal [ULN]), liver dysfunction (serum bilirubin  $>$  ULN or aspartate aminotransferase or alanine aminotransferase  $> 2\text{ULN}$ ), history of neurologic disorder such as stroke, seizure or coma, current use of antibiotics, and electrolyte abnormality (serum sodium, potassium, phosphate or calcium outside normal range). In this model, Listello and Sessler found that a total score of at least 4 favored reintubation, and a total score of 3 or less favored non-reintubation. We compared these seven parameters between patients who required reintubation and those who did not.

### Statistical analysis

For comparison of patient groups, reintubation after UE was defined as the placement of an endotracheal tube within 48 hours after UE. Data from reintubation and non-reintubation cases were compared using the JMP software program (SAS Institute Inc, Cary, NC, USA). Chi-square and Fisher's exact tests were used to compare percentages, and Student's *t*-test was used to compare means. A *p* value of less than 0.05 was considered statistically significant.

## Results

A total of 590 intubated adults were treated in our ICU during the 14-month study period. Fifty (8.5%) of these patients had at least one UE during the study period (48 deliberate and two accidental self-extubations). All patients were intubated by the oral route. Five patients had COPD and pneumonia, and two patients had chronic heart failure and pneumonia. The cause of respiratory failure was attributed to pneumonia in these patients because their underlying diseases were stable before admission. Five patients had heart failure and COPD, and the cause of respiratory failure was determined by the ICU physician based on the most recent aggravating factor. The most common reason for respiratory failure and ICU admission was pneumonia (20/50, 40%), followed by COPD (11/50, 22%), heart disease (10/50, 20%), sputum impaction (2/50, 4%), intoxication (2/50, 4%), surgery (2/50, 4%), and others (3/50, 6%). Of the

patients with heart disease, seven had congestive heart failure and three had complications of acute myocardial infarction including ventricular tachycardia, ventricular fibrillation and cardiogenic shock. UE occurred more frequently during the early period after intubation, and occurred within 2 days after intubation in about half of the patients (26 episodes; 26/50, 52%) (Fig. 1). Reintubation was required in 33 patients (33/50, 66%).

There was no significant difference in pre-extubation parameters between the two groups, except for the cause of respiratory failure. Pneumonia was significantly associated with the need for reintubation (17/33, 52%; odds ratio 4.96; confidence interval 1.24–19.91;  $p = 0.02$ ) (Table).

Analysis of the outcome of UE according to the underlying cause of respiratory failure revealed that all 13 patients with pneumonia who had UE within 5 days after intubation needed reintubation. The reintubation rate remained high in patients with pneumonia who had UE more than 5 days after intubation (4/7, 57%) (Fig. 2A). In contrast, the reintubation rate was low in patients with heart disease who had UE within 5 days after intubation (3/9, 33%) (Fig. 2B). COPD was also an important cause of respiratory failure, but the reintubation rate (6/11, 55%) was not related to the timing of UE in COPD patients (Fig. 2C).

Testing the validity of the scoring system of Listello and Sessler, 20 of 26 (77%) patients with a score of 4 or more were reintubated and 11 of 24 (40%) with a score of 3 or less were not reintubated. A correct prediction was made in 31 of 50 (62%) episodes. There was no significant difference in the seven parameters of this model between reintubated and non-reintubated patients (Table).

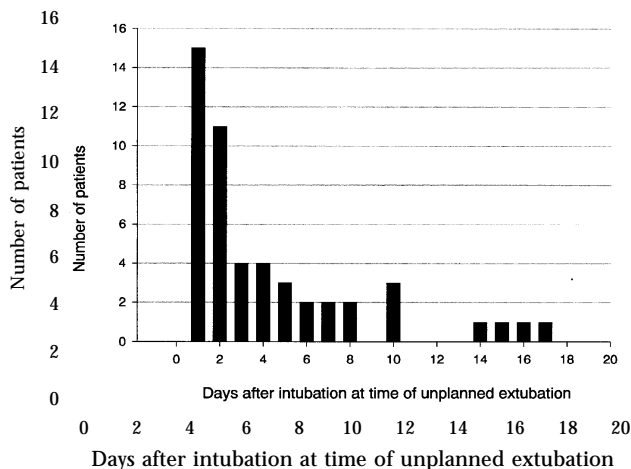


Fig. 1. Timing of unplanned extubation after intubation.

## Discussion

Several large prospective studies have demonstrated that UE is common in medical and surgical ICUs [2, 8–11]. In our study, 50 episodes of UE occurred in 590 patients who required intubation and mechanical ventilation, representing an incidence of 8.5% during a 14-month period in our ICU. One death associated with UE due to rapid development of cardiac arrest after extubation also occurred during this period.

UE occurred more frequently within 48 hours of intubation in our ICU, and about half of all UE episodes occurred within this early period. This result is similar to that of a study by Coppolo and May, in which 70% of self-extubations occurred within 48 hours of intubation [1]. Physical restraint was almost routinely applied during the first 2 days in our ICU (85%), but sedative agents were not routinely given (6%). Vassal et al found that the duration of ventilation before self-extubation was far longer than in Coppolo and May's study [7]. The patients in Vassal et al's study all received effective sedation during their first 24 to 48 hours of intubation, and this was thought to be the cause of the difference [7]. Several studies have recommended that all patients who are intubated should have standard orders for adequate sedation to prevent UE [3, 12, 13], but this should not be accomplished at the expense of unnecessarily prolonged weaning and delay of planned extubation. To prevent UE, suitable sedation should be considered during the first 2 days of intubation, because more than half of UE episodes occurred during this period, and a short period of sedation has a decreased complication rate compared to prolonged sedation.

Reintubation was not needed in 34% of patients with UE in our study. Reintubation after UE should not be considered mandatory [5]. Because weaning parameters are often unavailable at the time of UE, it would be useful to define routinely available pre-extubation respiratory and ventilatory parameters that predict which patients are likely to require reintubation. In this study, we assessed the validity of predictors of reintubation among patients with UE. Clinical factors selected for study were those identified as associated with reintubation in previous studies [2, 5, 6, 8, 9]. However, no significant difference was found in the pre-extubation parameters between the reintubation and non-reintubation groups except for the cause of respiratory failure. Pneumonia was present in 17 of the 33 cases (52%) in the reintubation group and was significantly associated with the need for reintubation. Our results are different from those of Jiang et al [14], who demonstrated that pre-extubation  $FiO_2$ ,  $PaO_2$ /

**Table.** Comparison of clinical parameters in reintubated and non-reintubated patients after unplanned extubation (UE)

Clinical parameter	Reintubated	Non-reintubated	<i>p</i>
n (%)	33/50 (66%)	17/50 (34%)	
Age	72 ± 2	69 ± 3	0.46
Sex			
Male (%)	69	64	0.72
Female (%)	31	36	
Duration of intubation (days)	4.6 ± 4.5	2.8 ± 2.4	0.30
Mental status other than alert (%)	12	0	0.28
Coexisting disease ≥ 3 of 7 (%)	64	59	0.74
Heart rate > 120 in 24 hours prior to UE (%)	42	29	0.37
FiO <sub>2</sub>	0.44 ± 0.14	0.40 ± 0.05	0.42
PaO <sub>2</sub> /FiO <sub>2</sub> ratio	248 ± 16	278 ± 23	0.27
Latest pH prior to UE	7.41 ± 0.05	7.44 ± 0.05	0.12
VVE (L)	7.9 ± 0.5	6.6 ± 0.8	0.19
Ventilator mode (%)			
Control mode	76	59	
Support mode	24	41	0.22
Cause of respiratory failure (%)			
Pulmonary disease	69	47	0.12
Pneumonia*	52	18	0.02
Chronic obstructive pulmonary disease	18	29	0.48
Heart disease	12	35	0.05

VVE = ventilator-delivered minute volume; FiO<sub>2</sub> = fraction of inspired oxygen; Control mode = full mechanical ventilatory support with pressure or volume control mode; Support mode = pressure support mode or spontaneous breathing by T-piece device. \**p* < 0.05.

FiO<sub>2</sub>, ventilator mode, and gender were associated with reintubation. Patients with acute respiratory failure due to pneumonia had a higher reintubation rate, but this difference was not statistically significant. However, Jiang et al's study was retrospective, which may have led to more bias in data collection, and they had fewer pneumonia patients.

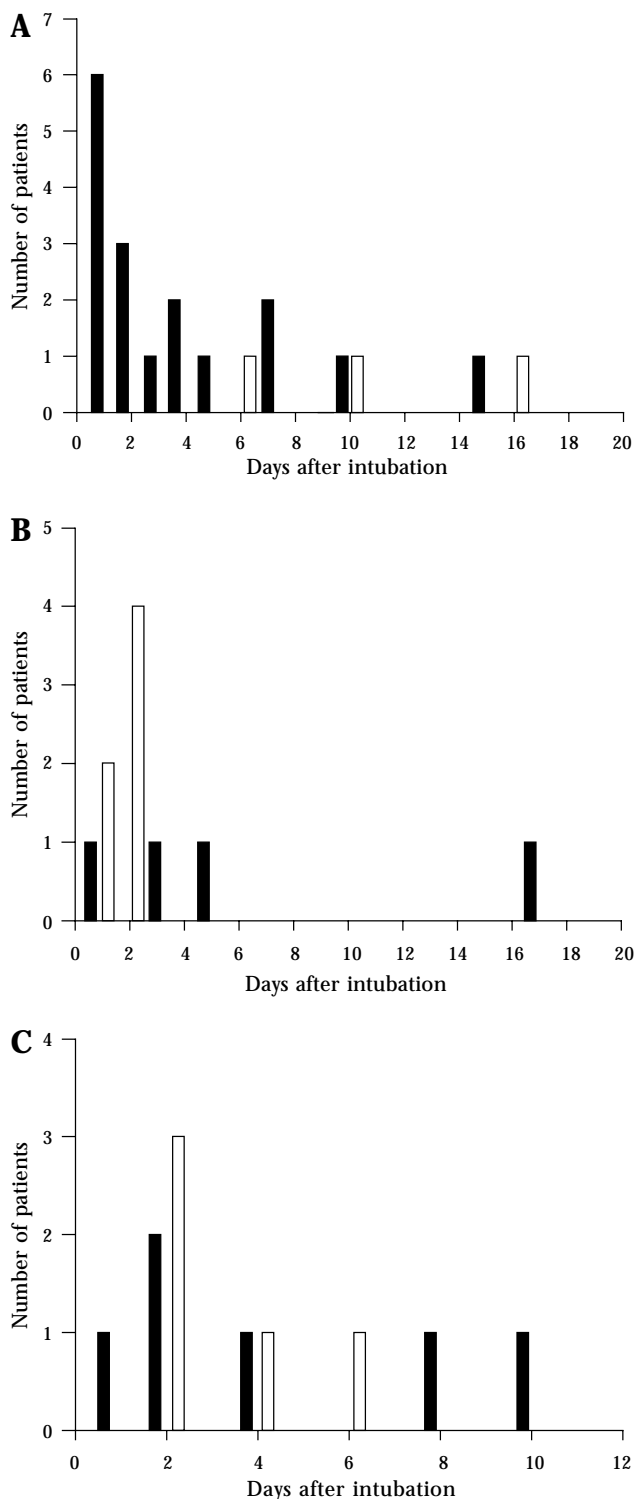
In this study, patients with heart disease who had UE within 5 days of intubation had a low reintubation rate (3/9, 33%). In contrast, all 13 patients with pneumonia who had UE within 5 days after intubation needed reintubation. When UE occurred more than 5 days after intubation, the reintubation rate was still high (4/7, 57%) in patients with pneumonia. Respiratory failure due to heart disease is associated with a rapidly improving course after effective treatment, while pneumonia patients need more time to recover even with aggressive therapy. The results of our single-illness analysis support the findings of Listello and Sessler that the single strongest univariate predictor for successful avoidance of reintubation is whether the underlying indication for intubation has resolved or improved [6].

We also tested the validity of the model of Listello and Sessler for prediction of reintubation and non-reintubation after UE. This model contains seven statistically significant factors by multiple variant logistic regression analysis [6]. In our study, no difference was

found between reintubated and non-reintubated patients in these seven parameters. Of our patients with a score of 4 or more, 77% required reintubation, while 40% with a score of 3 or less did not require reintubation. Outcome of UE was correctly predicted by this scoring system in 62% of patients in our study. However, our results were not as promising as those of Listello and Sessler, who found that the outcome was correctly predicted in 67 of 80 patients (84%) [6].

Differences between our prospective study and the retrospective study of Listello and Sessler may explain these discrepant results. First, their patients were from medical and surgical ICUs, while our patients were all from the medical ICU. Second, our study included a higher percentage of elderly patients than Listello and Sessler's study (average age, 71 ± 13 vs 53 ± 19 yr). Third, we probably had a higher percentage of pneumonia patients (20/50, 40%). Although cleansing of airway secretions is critical to avoid reintubation, especially in patients with pneumonia [15], no parameter in the Listello scoring system can represent the ability to maintain airway hygiene. This might also explain the poor results of validation of the predictors of reintubation using the scoring system of Listello and Sessler in our study.

In conclusion, UE was a common event in patients with intubation, and approximately half of the cases of UE occurred within 48 hours of intubation in



**Fig. 2.** Timing and outcome of unplanned extubation in A) 20 patients with acute respiratory failure due to pneumonia, B) 10 patients with acute respiratory failure due to heart disease, and C) 11 patients with acute respiratory failure due to COPD. Black bars indicate the number of patients with reintubation episodes, while white bars indicate the number who did not require reintubation on the indicated day.

the medical ICU. Pneumonia was the most important prognostic factor for reintubation after UE and a low reintubation rate was observed in patients with heart disease. The scoring system of Listello and Sessler did not accurately predict reintubation after UE.

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