

Multidisciplinary interventions and continuous quality improvement to reduce unplanned extubation in adult intensive care units

A 15-year experience

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Abstract

We conduct a retrospective study of patients with unplanned extubation (UE) in adult intensive care units (ICU) at a medical center. In 2001, a multidisciplinary team of intensivists, senior residents, nurses, and respiratory therapists was established at Chi Mei Medical Center. The improvement interventions, implemented between 2001 and 2015, were organized around 8 key areas: standardizing procedures, improving communication skills, revising sedation and weaning protocols, changing strategies for restraints, establishing a task force for identifying and managing high-risk patients, using new quality-improvement models as breakthrough series and team resource management, using the strategy of accountability without assigning blame, and changing a new method to secure endotracheal tube. We measured the outcome as the annual event and the rate of UE. During this 15-year period, there were 1404 episodes of UE, with 44,015 episodes of mechanical ventilation (MV) (319,158 ventilator-days). The overall rate of UE was 3.19/100 ventilated patients (4.40/1000 ventilator-days). In 2001, there were 188 episodes of UE and the rate of UE was 6.82/100 ventilated patients or 9.0/1000 ventilator-days. After this continue quality improvement project had been implemented, the annual number of episodes of UE declined to 27, and the rate fell to 0.95/100 ventilated patients or 1.36/1000 ventilator-days in 2015. Overall, the trend analysis showed the change was significant with $P < .0001$. In conclusion, UE in adult ICU can be continuously and effectively reduced using multidisciplinary and sequential quality improvement interventions.

Abbreviations: BTS = breakthrough series, ETT = endotracheal tube, ICU = intensive care unit, MV = mechanical ventilation, TRM = team resource management, UE = unplanned extubation.

Keywords: continuous quality improvement, intensive care unit, unplanned extubation

1. Introduction

In an intensive care unit (ICU), acute respiratory failure that requires endotracheal intubation with mechanical ventilation (MV) is a common clinical condition. Once the acute condition

requiring MV support is resolved, physicians should start to plan extubation after a smooth weaning process and as soon as possible as the patient has passed a weaning test. However, unplanned extubation (UE), which is defined as an endotracheal tube (ETT) being removed by the patient or accidentally, can

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occasionally occur before the scheduled extubation. Deliberate UE occurs when a patient intentionally pulls out an ETT, whereas accidental UE is the unintentional removal of the ETT either by the patient or by the staff, which can occur with repositioning, other procedures, or coughing. Most important, however, is that a UE results in prolonged use of MV, longer ICU and hospital stays, and an increased need for chronic care, especially for a failed UE.^[1,2]

To avoid this potentially life-threatening situation, many preventive interventions have been developed and implemented in various ICUs.^[3–8] Despite these efforts, the reported rates of UE remain between 7% and 18% in most ICUs.^[1,9–12] Other studies have identified several risk factors of UE: patient factors such as irritability, an altered level of consciousness, the lack of a sedation protocol, and structural and environmental factors, such as oral intubation, the method of securing the tube, and physical restraints.^[12–15] All of the above findings should suggest that although a single intervention might temporarily reduce the UE rate, a comprehensive and sustained program is the only way to solve this complication in the ICU. Therefore, as with other quality-improvement programs, reducing the UE rate needs multidisciplinary teamwork and continuous effort. We report a 15-year quality improvement project to solve this problem.

2. Material and methods

2.1. Setting and patients

This study was done at the Chi Mei Medical Center, a 1288-bed tertiary medical center with 96 ICU beds: 48 medical ICU beds, 9 cardiac beds, and 39 surgical beds for adults. Every year, an average of 5514 patients is admitted to the ICU, and, from 2001

to 2015, there were 2934 patients intubated because of respiratory failure. The ICU is covered by intensivists, senior residents, nurses, respiratory therapists, dietitians, physical therapists, and clinical pharmacists. Each shift had the same workload and patient-to-nursing staff ratios of 2:1. There were no differences in nursing experience by shift. Each respiratory therapist was responsible for fewer than 10 patients at the same time on every shift. The ICU team made rounds at least once daily, and respiratory therapists were responsible for all of the weaning processes and spontaneous breathing trials of all MV patients.

2.2. Improvement interventions

In 2001, a multidisciplinary team of intensivists, senior residents, nurses, and respiratory therapists was established. The improvement interventions, organized around 8 key areas, were implemented over a 15-year period: standardizing procedures; improving communication skills; revising sedation and weaning protocols; changing strategies for restraints; establishing a task force for identifying and managing high-risk patients; using new quality-improvement models as breakthrough series (BTS) and team resource management (TRM); using the strategy of accountability without assigning blame; and new method to secure ETT. The year of the initial implementation of each intervention is shown, and some events and several methods were used to implement this quality improvement program (Fig. 1A: arrows with the numbers 1–8). In February 2002, we standardized procedures using education programs for fixating ETT and establishing strategies for restraining patients and improving communication skills (e.g., using simple cartoon cards) (label 1); in January 2003, we revised flow charts for

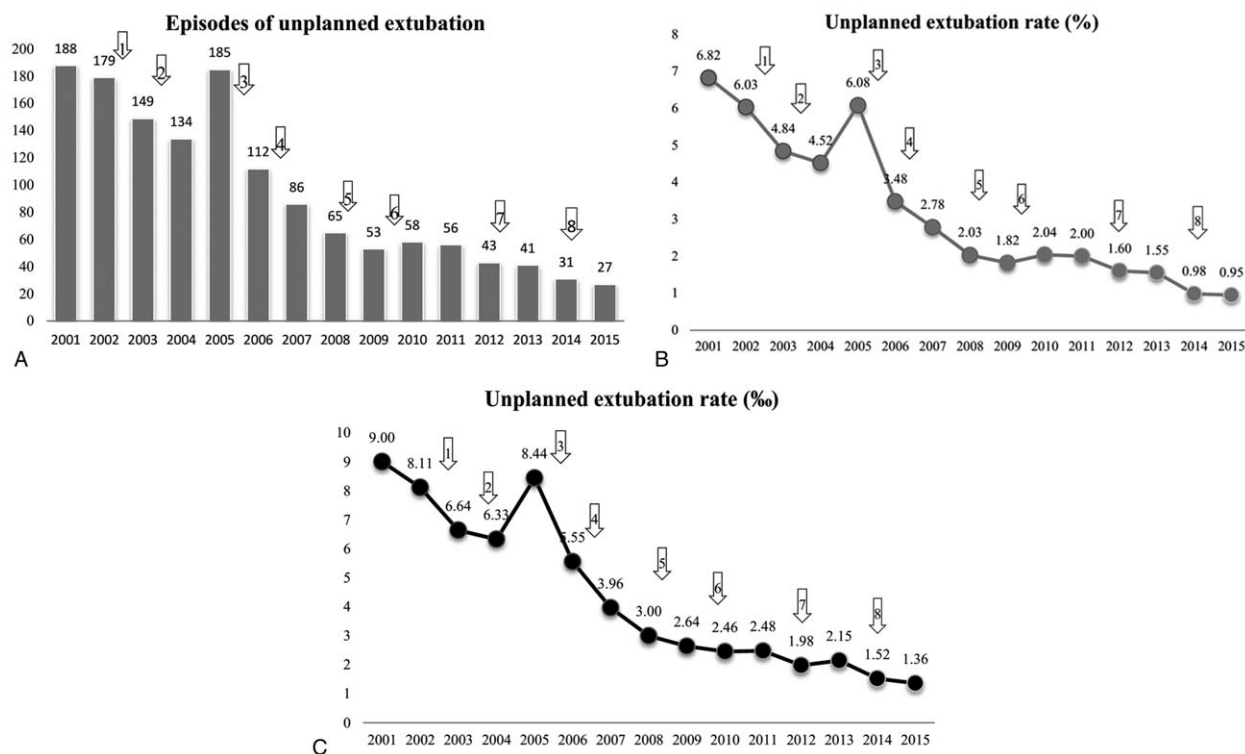


Figure 1. The rate of unplanned extubation is shown in number of episodes (A), episodes per 100 patients (B), and episodes per 1000 ventilator-days (C) (labels 1 to 8 represent different interventions).

sedation and weaning protocols (label 2 and Supplemental Digital Content—Appendix 1 and 2; <http://links.lww.com/MD/B699>); in July 2005, we used Root Cause analysis to determine that the reason for an unexpected rise in the rate of UE was that we had recruited new nurses for ICU expansion and then changed to a new strategy for restraining patients (label 3), and the ratio of restraints raised from 1.58% to 20.30%; in January 2006, we established a task force to identify and manage high-risk patients, used the computerized recording system, and created event review processes (label 4); from 2008 to 2010, we used new quality improvement models, as when we introduced BTS (label 5) and TRM (label 6); since 2012, we have used the strategy of accountability without assigning blame, in discussions between the head nurse and staff members reviewing what happened and how to avoid repeats of the event, and set up a significant board that shows the number of days without a UE episode (label 7); and, finally, in January 2014, we used the AnchorFast Guard tube fastener to secure oral ETT and replaced adhesive tape and cloth tape ties (label 8). We used the cycle of plan-do-check-act (PDCA) to map the current process, assess process variation, identify areas for improvement, and implement process changes. The data were retrospectively collected on a routine basis and the analysis was carried out. Therefore, no informed consent was required and the study was specifically waived by the Institution Review Board, and the study was approved by the Institutional Review Board of Chi Mei Medical Center.

2.3. Data analysis

A UE was defined as the dislodgement or removal of the ETT from the trachea in a patient undergoing invasive MV at a time that was not specifically planned for or ordered by the physicians in charge of the patient. The quantity of the UE was presented by episodes, episodes/100 patients, and episodes/1000 ventilator-days. Ventilator days were calculated using the difference between the times of intubation and extubation. We also calculated the failed rate of UE as the ratio of reintubation within 48 hours/100 UE.

2.4. Statistical analysis

The data are expressed as number, percentage (%), or per mille (‰) for each year. The linear trend test was used to estimate the trend of unplanned extubation rate in each year or based on the Poisson regression to examine the trend in observed single-year prevalence of the unplanned extubation with ventilator-days. SAS 9.4 (SAS Institute, Cary, NC) was used for all statistical analyses. Significance was set at $P < .05$.

3. Results

During this 15-year period, there were 1404 episodes of UE, 44,015 episodes of MV, and 319,158 MV days. The overall rate of UE was 3.19/100 ventilated patients or 4.40/1000 ventilator-days.

In 2001, there were 188 episodes of UE and the rate of UE was 6.82/100 ventilated patients or 9.0/1000 ventilator-days. After this continue quality improvement project had been implemented, the annual number of episodes of UE declined to 27, and the rate fell to 0.95/100 ventilated patients or 1.36/1000 ventilator-days in 2015. There was only 1 exception for which the annual number of episodes and rate of UE increased to 185 episodes and 6.08/100 ventilated patients or 8.44/1000 ventilator-days in 2005 compared

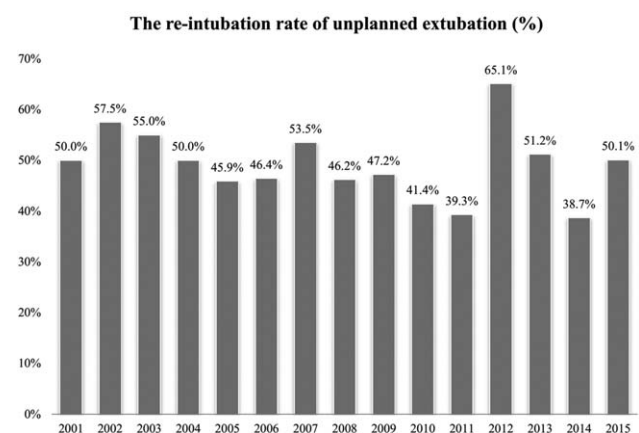


Figure 2. The reintubation rate of unplanned extubation in the recent 15 years.

with 2002 to 2004. This increase can be attributed to the hospital's having moved some experienced critical care nurses to support a newly set-up branch hospital, which decreased the quality of care in the ICU of our hospital's main branch ICU. Overall, the trend analysis showed the change was significant with $P < .0001$ (Fig. 1).

Extubation failed in more than half of the episodes (704/1404 [50.1%]) and required reintubation within 48 hours. The annual rate of failed UE ranged from 38.7% to 65.1% (Fig. 2). Among the cases of failed UE requiring reintubation, oxygenation failure was the most common cause of UE failure (64.7%), followed by unstable hemodynamics (14.3%), secretions (12.7%), upper airway obstruction (12.7%), and encephalopathy (2.4%).

4. Discussion

This is the largest and longest published study on a quality improvement project to reduce UE. We have provided evidence that UE can be effectively reduced using a multidisciplinary and continuous quality improvement program. Fifteen years after a series of interventions were implemented at our hospital, the UE rate in our adult ICU gradually declined from 6.82/100 ventilated patients in 2001 to 0.95/100 ventilated patients in 2015. There was only 1 exception for which the annual number of episodes and rate of UE increased to 185 episodes and 6.08/100 ventilated patients or 8.44/1000 ventilator-days in 2005 compared with 2002 to 2004. This increase can be attributed to the hospital's having moved some experienced critical care nurses to support a newly set-up branch hospital, which decreased the quality of care in the ICU of our hospital's main branch ICU. Other studies^[5,16–18] report similar findings in different populations. Fontanez-Nieves et al^[16] reported a significant reduction of UE from 16.1 to 4.5/100 ventilator-days in neonates using the methods with 3 PDCA cycles over 20 months; Tripathi et al^[5] reported a reduction in a pediatric ICU (PICU) from 3.55 to 2.59/100 intubation days after implementing a patient care policy targeting the risk factors, followed by extensive nursing and other personnel education over 12 months; Merkel et al^[17] found a significant decrease in 3 years in the rate of UE in a neonatal intensive care unit (NICU) after bundles of potentially better practices had been implemented following sequential PDSA cycles; and Rachman and Mink^[18] also reported that the effect of the quality improvement program to reduce UE had been successfully maintained even 9 years after implementation in the

PICU. In summary, our findings and those of other studies^[5,16–18] indicate that a multidisciplinary quality improvement program can effectively reduce UE in the ICU, and the effect can be maintained and even improved 15 years after the sequential introduction of different interventions.

There have been several preventive measures to avoid UE in previous reports,^[1,19–22] including continuous education of nurses, agitation avoidance, 24-hour bedside surveillance, appropriate nurse to patient ratio, the method for securing the endotracheal tube when adjusting patient positioning, and supervision of patients ready for withdrawal from MV. In this study, we used several interventions during this quality improvement program. From the start of this program in Feb 2002, we developed flow charts for standardization of procedures (as fixation of endotracheal tube and restraints of patients) and improvement of communication skills as the usage of simple cartoon cards, and led to the reduction of the rate of UE from 6.03 per 100 ventilated patients in 2002 to 4.84 per 100 ventilated patients in 2004. This finding is consistent with previous report in neonate that UE rate can be reduced with process standardization and frontline staff education, emphasizing vigilant ETT maintenance.^[16] Tanios et al^[23] reported on the different effects of various sedation strategies on UE in a mixed ICU. Their findings that a strategy of continuous sedation with a daily interruption of the sedative was associated with a lower rate of UE than was no sedation or intermittent sedation. In this study, we have the similar findings that after revising sedation and weaning protocols in Jan 2003, and the rate of UE had declined from 4.84 per 100 ventilated patients in 2003 to 4.52 per 100 ventilated patients in 2004. In contrast to previous reports^[12,24] showed that physical restraints were associated higher risk of unplanned extubation, we found that appropriate physician restraint can help reduce the rate of UE. After changing strategy for restraints in 2005, the rate of UE had declined from 6.08 per 100 ventilated patients in 2005 to 3.48 per 100 ventilated patients in 2006. To set-up a task force for identification, use of the computerized recording system, and carefully each event process for a real-time analysis is also an important tool. It can help explore the gap in compliance with process improvement, and increase awareness among all staff. Through this intervention, the rate of UE was effectively reduced from 3.84 per 100 ventilated patients in 2006 to 2.03 per 100 ventilated patients in 2008. Additionally, we introduced 2 quality improvement methods including BTS and TRM in 2008, and 2009, respectively, it helps us maintain the rate of UE around 2 per 100 ventilated patients. To our knowledge, this is the novel finding that we show the usefulness of BTS and TRM in the quality improvement program to reduce UE for the first time. BTS—a short-term (6- to 15-month) learning system that brings together a large number of teams from hospitals or clinics to easily learn from each other and from recognized experts in topic areas where they want to make improvements. TRM was integrated into the training of the team members involved, and provided them with useful skills in teamwork and further apply the learned skill to the daily practice to prevent UE. In 2012, we introduced the strategy of accountability and review each UE cases by all team members shortly after the event. We also set up a tracking board to display days without UE event to remind the team of their success. By these interventions, the UE rate is reduced to less than 2 per 100 ventilated patients. Finally, in Jan 2014, we used the new method to secure endotracheal tubes and decrease the UE rate to less than 1 per 100 ventilated patients, as evidenced by recent published paper that endotracheal tube

holder can reduce ETT movement and prevent UE as compared with adhesive tape.^[22]

This study has some limitations. First, all of our findings were based on the experience of a single institution. Not all interventions can be applied in all ICUs; however, we still provide valuable information about the quality improvement process for preventing UE. Second, we did not record whether we use sedatives or physical restraints more often to avoid UE during this process.

5. Conclusions

UE in an adult ICU can be continuously and effectively reduced using multidisciplinary and sequential quality improvement interventions.

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