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BRIEF REPORT

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Effectiveness of a continuous quality improvement program aiming to reduce unplanned extubation: a prospective study

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Abstract *Objective*: To evaluate the effectiveness of a continuous quality improvement (CQI) program in reducing the incidence of unplanned endotracheal extubation.
Design: Prospective study over a 9-month period.
Setting: Adult intensive care units (ICUs including coronary care unit, medical ICU, surgical ICU, and cardiovascular surgical ICU) in a university-affiliated medical center.
Patients: 831 consecutive mechanically ventilated patients.
Interventions: CQI program focusing on standardization of procedures, improvement of communication, and identification and management of high-risk patients.
Measurements and results: With the implementation of this CQI program, the overall incidence density of unplanned extubation (defined as number of new unplanned extubations per mechanical ventilation patient-days) significantly decreased from 2.6% in the first trimester to 1.5% in the second trimester and 1.2% in the third trimester (p=0.01). This reduction was essentially the result of a decrease in unplanned extubation in orally intubated patients (incidence density 4.6, 1.7 and 1.0% for three trimesters, respectively; p<0.0001). Unplanned extubation in nasally intubated patients remained largely unaffected (1.2, 1.4, and 1.4% for three trimesters, respectively; p=0.92).
Conclusions: The implementation of a concerted CQI program is effective in reducing the overall incidence of unplanned endotracheal extubation.

Key words Mechanical ventilation · Endotracheal intubation · Unplanned extubation · Self-extubation · Intensive care unit · Quality improvement

Introduction

Unplanned extubation (UE) is a common problem in the intensive care unit (ICU) and is associated with various complications and mortality. In recent years, there has been a surge of interest in understanding UE [1–5]. Several studies have described the incidence, contributing factors and outcome in patients of UE, yet none of the previous studies has, to our knowledge, addressed the issue concerning the effectiveness of quality improvement efforts in reducing this untoward phenomenon.

Aiming to reduce the incidence of UE in our ICUs, we instituted a continuous quality improvement (CQI) program based on the approach proposed by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO, Oakbrook Terrace, Ill., USA) and conducted a prospective study to evaluate the effectiveness of this program [6].

Materials and methods

Prior to the start of this study, we prepared our intensivists, ICU fellows, nursing staff, and respiratory therapists with a series of in-service educational courses focusing on the principles and practices of CQI as well as the importance of controlling UE. We coordinated a multidisciplinary CQI task force consisting of the above medical and ancillary services.

From June 1993 to February 1994, our CQI team prospectively monitored all mechanically ventilated patients in our 35-bed adult ICUs (including the coronary care unit, medical ICU, surgical ICU, and cardiovascular surgical ICU). Patient information, diagnosis, route of intubation, and duration of mechanical ventilation were recorded for each patient and subsequently transcribed to our computer database.

During this 9-month study period, the following interventions were implemented: (1) standardizing selected procedures, including endotracheal tube securing (twill tape method) and use of physical restraints [7, 8]; (2) encouraging active communication between staff and patients in order to help manage patients' discomfort and improve patients' understanding of the danger of deliberate extubation; (3) avoiding unnecessary delay of elective extubation by facilitating communication with primary service physicians, particularly in surgical units; (4) identifying high-risk patients with either a high risk of UE (agitation/disorientation, history of previous self-extubation) or a high risk of reintubation and associated complications (fractional inspired oxygen (FIO_2) >50%, history of difficult intubation); (5) edu-

cating housestaff on appropriate use of sedatives, analgesics, and psychotropic agents, with emphasis on high-risk patients.

At each occurrence of UE, a one-page event report with information such as risk factors, uses of chemical and physical restraints, and method of securing the endotracheal tube was filled out by the nurse caring for the patient. All reports were verified by the charge nurses and subjected to frequent double-checks by respiratory therapy CQI staff to ensure accuracy. The report was then submitted to the CQI team and all data were transcribed to a specifically designed computer database. At the end of each month, collected data were analyzed and the results were carefully reviewed by the CQI team. Action plans were discussed and necessary steps were taken to solve the identified problem.

In this study, we measured the incidence of UE by calculating the incidence density which was defined as the number of new UE per mechanical ventilation patient-days. The statistical computer program BMDP (BMDP Statistical Software, Los Angeles, Calif., USA) was utilized for data analysis. A contingency table was used to compare frequency distributions, and a test for linear trend was applied where appropriate. A $p<0.05$ was considered statistically significant.

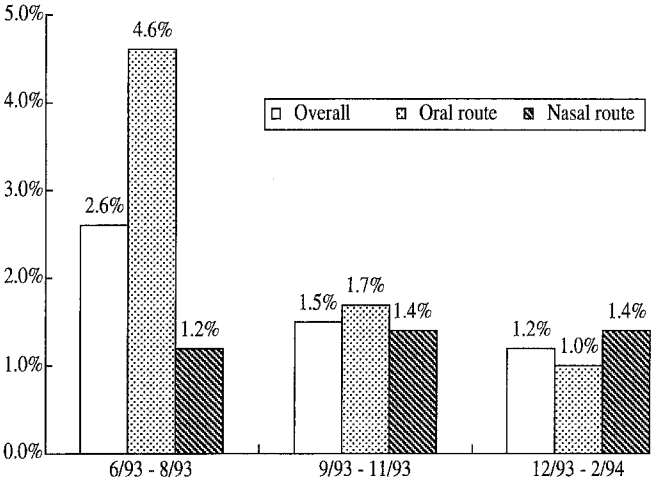

Fig. 1 Change of incidence density of UE over a 9-month period after the implementation of a CQI program

Results

From June 1993 to February 1994, 831 consecutive mechanically ventilated patients including 249 medical ICU patients, 211 surgical ICU patients, 159 coronary care unit patients, and 212 cardiovascular surgical ICU patients (643 males, 188 females; average age, 62.6 years) were enrolled in this study. The total number of ICU mechanical ventilation days were 4381 patient-days. The average durations of intubation were not statistically different among three trimesters (5.0, 5.2, and 5.1 days, respectively; $p=0.97$). During this 9-month period, 76 incidents of UE (71 deliberate extubations and 5 accidental extubations) were observed in 64 patients.

As shown in Fig. 1, the overall incidence density of UE decreased from 2.6% (35/1366) in the first trimester to 1.5% (24/1552) in the second trimester and 1.2% (17/1463) in the third trimester ($p=0.01$; $p<0.005$ for linear trend). Also, despite the absence of statistical significance, there appeared to be a decreasing trend in major complications associated with UE. In the first trimester, major complications included one patient with aspiration pneumonia and two deaths related to hemodynamic and oxygenation deterioration within 12 h of UE despite reintubation. Notably, one of the deaths was not in the arbitrarily defined high-risk category. In the second trimester, there was one event of aspiration pneumonia; and in the third trimester, no major complication was observed.

During this 9-month period, the incidence density of UE was higher among orally intubated patients than among nasally intubated patients [45/2082 (2.2%) vs. 31/2299 (1.3%); $p=0.04$]. When we further analyzed the data according to different trimesters, this difference was remarkable only in the first trimester [25/548 (4.6%) vs. 10/818 (1.2%); $p=0.0001$] but not in the second or the third trimester [12/693 (1.7%) vs. 12/859 (1.4%), $p=0.59$; 8/841 (1.0%) vs. 9/622 (1.4%), $p=0.38$]. Moreover, the incidence density of UE among orally intubated patients was significantly reduced from 4.6% in the first trimester to 1.7% in the second trimester and 1.0% in the third trimester ($p<0.0001$; $p<0.0001$ for linear trend). In contrast, the incidence density of UE among nasally intubated patients remained unchanged (1.2, 1.4, and 1.4% for these three trimesters, respectively; $p=0.92$).

During the study period, 58% (44/76) of the UEs occurred in high-risk patients and 42% (32/76) in patients not at high risk. Eighteen (41%) of the 44 high-risk UE patients and 20 (62%) of the 32 UE patients not at high risk did not require reintubation ($p=0.07$).

Among 44 high-risk UEs, 58% (18/31), 62% (8/13), 73% (8/11), and 67% (2/3) of patients with agitation, history of previous self-extubation, $FIO_2>50\%$, and history of difficult intubation were reintubated, respectively. Seventy-seven percent (10/13) of patients with more than one risk factor required reintubation.

Discussion

UE of the endotracheal tube is not uncommonly seen in the ICU. Its incidence varies widely from 3 to 16% in the literature, and its occurrence has been associated with serious complications, such as various arrhythmias, hemodynamic instability, aspiration pneumonia, hypoxic encephalopathy, and even death [1–3].

Although we did not design this prospective study in such a fashion that the effectiveness of specific interventions might be evaluated, we nevertheless clearly demonstrated the overall effectiveness of a CQI program in reducing the incidence of UE. In addition, a trend of a decrease in major complications appeared to be present. It should be pointed out that better control of UE could be achieved through aggressive sedation and analgesic use, which may adversely prolong the duration of intubation. It is thus important to recognize that the average duration of intubation was not prolonged during this 9-month period.

In our study, the overall incidence density of UE was significantly lower in nasally intubated patients than in orally intubated patients. This result was similar to that of Coppolo and May, who reported self-extubation in 1 (4%) of 24 nasally intubated patients and 11 (12%) of 88 orally intubated patients [1]. Our finding, interestingly, was primarily due to a remarkable difference during the first trimester. This difference may not be surprising, given the potential disadvantages of poor endotracheal tube anchor stability and patient tolerance associated with orotracheal intubation. On the other hand, it is intriguing to observe the disappearance of this difference as the CQI program matured over time. This suggests that with successful implementation of a CQI program, these two routes were no different when UE is the sole concern.

Moreover, it is important to note that our CQI efforts reduced UE only in orally intubated patients, not in the nasally intubated patients. The lack of response in the latter group may be in part related to its low incidence of UE in this study. We speculate that in those ICUs with a high incidence of UE in nasally intubated patients, a similar CQI program may help decrease UE in such patients.

In this study, 41% of the high risk and 62% of the patients not at high risk did not require reintubation, which confirmed the observation of previous studies that immediate reintubation should not be considered as mandatory after UE [4, 5]. This high success rate in the patients not at high risk might be in part attributed to delay of elective extubation. During this study, we have also observed the hesitancy of using physical restraints by our nursing staff in seemingly cooperative patients not at risk. Whether such patients should be restrained or not remains a rather difficult clinical decision which should be made on an individual basis. Nevertheless, it is important to recognize that UE may sometimes contribute to a serious outcome in such patients, as demonstrated by one death in the first trimester.

The appropriate threshold indicating acceptable quality in controlling UE has not been previously investigated. Our data suggest an incidence density of 1.2% may be a reasonable level to aim at in the early phase of a CQI program. Table 1 lists the major components of an ideal CQI program in reducing UE.

Table 1 Major components of CQI program in reducing incidence of unplanned extubation

1. Organize a multidisciplinary CQI task force which should include intensivists, ICU CQI nursing staff, and respiratory therapy CQI staff
2. Formulate in-service educational courses with literature review for ICU fellows, residents, respiratory therapists, and nursing staff, focusing on the principles and practices of CQI as well as on UE
3. Design an incident report for pertinent data collection and develop a computer program for data analysis, if possible
4. Standardize procedures
   Endotracheal tube securing (twill tape method, adhesive tape method, or commercial tube holder) [7, 9, 10] and use of physical restraints [8]
5. Encourage active communication between staff and patients to help manage patients' discomfort and improve patients' understanding of risk of UE
   Preoperative education may be important for patients undergoing major elective surgery
6. Avoid undue delay of elective extubation
7. Select criteria to identify high-risk patients [4, 5]
8. Develop guidelines for the use of sedatives, analgesics, and psychotropic agents
9. Establish threshold for evaluation
10. Collect, organize, and analyze pertinent data
11. Evaluate care
12. Take actions to solve the identified problems and make changes of protocols as necessary
13. Assess actions and document improvement

In this study, the twill tape method was chosen arbitrarily to secure the endotracheal tube. A recent study demonstrated no difference between adhesive tape and twill tape in terms of tube movement in orally intubated patients [7]. Whether commercial tube holder devices help to further decrease UE in orally intubated patients remains to be investigated. Also, future CQI programs and studies may better define high risk UE by incorporating the findings of two recently published studies [4, 5].

Finally, despite the study population being mostly men and mainly elderly, we think the results may be generalized to different ICU patient populations and the implementation of a concerted CQI program can be helpful in reducing UE.

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