Influence of Sedation Strategies on Unplanned Extubation in a Mixed Intensive Care Unit

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Background Identifying risk factors for unplanned extubation in patients receiving mechanical ventilation can help guide prevention strategies.

Objective To assess the risk of unplanned extubation with different sedation strategies.

Methods A 36-month quality improvement study in a 33-bed intensive care unit at a tertiary-care center.

Results A total of 92 unplanned extubations occurred (7.5 events/1000 days of mechanical ventilation): patients who were receiving continuous sedation protocol with daily interruption of sedatives had 1.5 events/1000 ventilator days, patients receiving the intermittent sedation protocol had 5.0 events/1000 days, and patients with no sedation protocol had 16 events/1000 days (P < .05). Median duration of mechanical ventilation before unplanned extubation was 2 days. Most unplanned extubations (94%) were deliberate, and 53% occurred in patients scheduled for weaning. Most unplanned extubations in the continuous sedation protocol group (71%) occurred during weaning, in comparison to the intermittent sedation protocol (54%) and no sedation protocol groups (48%, P < .05). The highest incidences of agitation were in patients receiving the intermittent sedation protocol as compared with the other 2 groups (77% vs 50% vs 49%, P < .05). Overall, 73% of patients who had an unplanned extubation did not require reintubation; those who did were older (mean age: 68 vs 53 years, P = .01) and were male (80% vs 20%, P = .02). Reintubation was unrelated to the time of unplanned extubation.

Conclusion Strategies of no sedation or intermittent sedation are both associated with higher rates of unplanned extubation when compared to a strategy of continuous sedation with daily interruption of sedatives. Sedation strategies that allow agitation may increase the risk of unplanned extubation. (American Journal of Critical Care. 2014;23:306-315)
Although mechanical ventilation is a lifesaving intervention, it can be associated with multiple complications related to either the intervention itself or various therapies used to facilitate it, such as ventilator-associated pneumonia, ventilator-induced lung injury, delirium, and critical illness polyneuropathy. In addition to potential complications due to the presence of the endotracheal tube, other complications may arise if the ventilator circuit is inadvertently disconnected or the patient experiences unplanned extubation.

Unplanned extubation is due to either inadvertent or deliberate removal of the endotracheal tube by a patient. Such extubation is associated with increased hospital and intensive care unit (ICU) lengths of stay and nosocomial pneumonia. Many efforts to reduce the duration of mechanical ventilation specifically target decreasing untoward sequelae of the intervention or ensuring safe implementation of the therapy. Among these efforts are precautions to optimize mechanical ventilation to reduce complications such as ventilator-associated pneumonia and ventilator-induced lung injury. Efforts are also directed to discontinuing mechanical ventilation and promptly extubating patients once endotracheal intubation is no longer required. Although these strategies are well described and usually an integral part of mechanical ventilation, strategies to minimize unplanned extubation are poorly understood or implemented.

Many researchers have studied risk factors and opportunities for interventions to prevent unplanned extubation, but the effects of various sedation strategies on unplanned extubation have not been compared. Therefore, we determined the characteristics associated with unplanned extubation in a mixed ICU with an emphasis on the type of sedation strategy used.

Methods

This project used nonidentifiable, aggregate data from a quality improvement initiative. Therefore, approval by the institutional review board was not required, and requirements for review and informed consent were waived.

Unplanned extubations in a 33-bed multidisciplinary ICU in a tertiary care teaching hospital during a 36-month period were examined retrospectively. Patients treated with mechanical ventilation via an endotracheal tube were sedated according to 1 of 2 standard protocols approved by the ICU committee. Sedation orders were written by each patient’s attending physician in accordance with hospital policy. Only a physician (or surrogate) could prescribe sedatives, and the goal was to provide moderate sedation. Decisions on patient care or choice of sedation protocol were made by the attending physicians.

Data Collection

Data collected during a quality improvement initiative to identify, analyze, and suggest plans to decrease unplanned extubations were used for the study. Unplanned extubation was considered an iatrogenic event, and practitioners (registered nurses and respiratory care practitioners) were required to complete a report for every unusual event and complete a data collection sheet (Appendix A) for each occurrence of unplanned extubation. The sheet included the patient’s name, diagnoses, assignment ratio, and clinical characteristics at the time of the extubation, including the score on the Richmond Agitation-Sedation Scale (RASS), type of sedation protocol, presence of restraints, and the primary indication for intubation. The size of the endotracheal tube, type of securement, duration of intubation before the unplanned extubation, and the date and time of the extubation were also recorded. Providers also recorded data on whether patients had been started on weaning from mechanical ventilation can increase stays in the intensive care unit and rates of nosocomial pneumonia.
Interdisciplinary Extubation Monitor

### Patient Data

- **Diagnosis:**
- **Respiratory Diagnosis:**
- **Patient 1:1:**
- **Patient Agitated:**
- **Sedation Ordered:**
- If yes, sedation type, dose, and time(s) in last 4 hours:
- **Restraints On?**

### Tube Data

- **Size:**
- **Date of Intubation:**
- **Time:**
- **Secured with:**
- **Check if present:**

### Extubation Data

- **Date:**
- **Time:**
- **Planned extubation:**
- **Last ABGs prior to extubation:**
  - **Mode:**
  - **Rate:**
  - **FiO₂:**
  - **pH:**
  - **Paco₂:**
  - **Paco₂:**
  - **O₂ Sat:**
- **Last Spontaneous Ventilatory Parameters:**
  - **Respiratory Rate (RR):**
  - **Tidal Volume (VT):**
  - **Minute Ventilation (V):**
  - **Negative Insp. Force (NIF):**
  - **Vital Capacity (VC):**
- **Staff Caring for Patient:**
- **On Break?:**
- **Covered by:**

### Outcomes

- **If reintubated, enter date/time and check those reasons that apply:**
  - **Left Exubated**
  - **Expired**
  - **Expired**
  - **Inability to Manage Secretions**
  - **Refractory Hypoxemia**
  - **Hypercapnea**
  - **Somnolence**
  - **Dyspnea**
  - **Patient Anxiety**
  - **Staff Anxiety/Concern**

### Appendix A

Registered nurses and respiratory care practitioners were required to complete this form and an unusual-occurrence report each time an unplanned extubation occurred.

Abbreviations: ABG, arterial blood gas; ET, endotracheal tube; FiO₂, fraction of inspired oxygen; O₂ Sat, oxygen saturation; RCP, respiratory care practitioner; RR, respiratory rate.

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mechanical ventilation and whether results of arterial blood gas analysis were available.

The ICU director or a designee reviewed the report of each unplanned extubation to verify the collected data. Patient-unique identifiers were excluded from the data, and nonidentifiable data were entered in a database for review and analysis. Three strategies of sedation were included in the study. The first strategy was no sedation and only opioid analgesics for pain management; morphine or fentanyl was administered as needed. With the second method, intermittent boluses of sedative (midazolam) and opioid analgesic (fentanyl) were given according to protocol (Appendix B). With the third method, continuous sedation with a daily interruption of sedation (DIS) was used according to protocol. Propofol was administered for the initial 72 hours, midazolam was used if sedation was needed beyond 72 hours, and fentanyl was given by continuous intravenous infusion.11,12

During the study period, patients were weaned from mechanical ventilation according to an institutionally approved protocol directed by a respiratory care practitioner. Respiratory care practitioners screened patients every morning to assess readiness to wean, and patients who passed the screening had a 2-hour spontaneous breathing trial with ventilator settings of 6 cm H₂O continuous positive airway pressure and 6 cm H₂O pressure support. Patients who did not pass the screening did not have breathing trials. Any patient who successfully completed the spontaneous breathing trial was evaluated for extubation, and a respiratory care practitioner consulted with the patient’s physician to obtain an extubation order.

**Statistical Methods**

Statistical testing was 2-sided with a type I error rate of α = .05. IBM SPSS Statistics, version 19 (IBM SPSS Inc), was used for all analyses. No sample-size analysis was performed; a convenience sample was used. Patients’ characteristics were compared by using 1-way analysis of variance, χ² tests, and the Kruskal-Wallis H test for independent samples. A χ² test with the Yates continuity correction or the Fisher exact test was used to test for associations between categorical variables. Continuous variables are presented as mean and standard deviation and were compared by using 1-way analysis of variance. Highly skewed data were analyzed by using the nonparametric Mann-Whitney rank-sum test; results are presented as medians and the 25th and 75th percentiles (interquartile range).

**Results**

During the study period, 92 unplanned extubations occurred for which data were collected and analyzed. Patients were stratified on the basis of the sedation strategy used during mechanical ventilation. Briefly, the 3 sedation strategies were no sedation, intermittent sedation, and continuous sedation with DIS. The rate of unplanned extubations per 1000 ventilator days was 16 events for the no-sedation strategy, 5.0 events for intermittent sedation, and 1.5 events for continuous sedation with DIS (P < .05; Figure 1). The mean age for the entire cohort was 57 years (SD, 21), and 53% were men. The overall rate of unplanned extubation was 7.5 events per 1000 ventilator days. Patients in the 3 groups did not differ significantly in age or sex (see Table).

At the time of the unplanned extubation, 62% of patients were agitated as indicated by the score on the RASS (score, ≥2), and only 38% were either calm or lightly sedated (score on the RASS, 0 to -2). Although more patients in the intermittent-sedation group (77%) were agitated than in the continuous-sedation (50%) and no-sedation (49%) groups, the differences were not significant (P = .54; Figure 2). Similarly, more unplanned extubations occurred during weaning in patients receiving continuous sedation (71%) than in patients receiving intermittent sedation (54%) or no sedation (48%), but the differences were not significant (P = .49). The overall median duration of mechanical ventilation before unplanned extubation was 2 days (interquartile range, 0-6 days) and was similar among the 3 groups. The median was 2 days (interquartile range, 1-5 days) for no sedation, 1 day (interquartile range, 0-5 days) for intermittent sedation, and 3 days (interquartile range, 1-7 days) for continuous sedation with DIS (P = .14; see Table). Most of the unplanned extubations (94%) were classified as deliberate (directly due to the patient’s own action), and overall 53% occurred after weaning from mechanical ventilation had already been started. For the majority of patients (95%), the standard ratio of 1 nurse to 2 patients was in effect when the unplanned extubation occurred; for the remaining patients (5%), the ratio was 1 nurse to 1 patient. A total of 77% of the patients had physical restraints, generally wrist

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**The unplanned extubation rate differed by sedation protocol used.**

**About 62% of patients were agitated when the unplanned extubation occurred.**
Appendix B

Critical care order set for the management of pain and agitation (intermittent sedation protocol).

Abbreviations: A.Fib, atrial fibrillation; A.Flut, atrial flutter; ACS, acute coronary syndrome; ATC, around the clock; EF, ejection fraction; IV, intravenous; MCAB, minimally invasive direct coronary artery bypass surgery; mcg, microgram; MD, physician; MIDC or MIDCAB, minimally invasive direct coronary artery bypass surgery; O2 sat, oxygen saturation; prn, as needed; PS, pain score; q, every; RASS, Richmond Agitation-Sedation Scale; RR, respiratory rate; VALVE, patients undergoing surgical valve repair; VF, ventricular flutter; VT, ventricular tachycardia.

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restraints, and a caregiver (nurse or respiratory care practitioner) was present in the patient’s room during 22% of the occurrences. The rate of unplanned extubation did not differ ($P = .62$) according to the presence or absence of a care provider in the patient’s room; rates were 14% for no sedation, 33% for intermittent sedation, and 17% for continuous sedation with DIS (see Table). The majority of occurrences took place during the night shift, with a bimodal pattern, at 10 PM and 4 AM (Figures 2 and 3).

Of the total cohort, only 27% required reintubation within 48 hours. The leading reasons for reintubation were hypoxia (33%) and excessive secretions (33%). Of the patients with accidental unplanned extubation, 60% required reintubation compared with 20% of patients with deliberate unplanned extubation. Differences in age were significant ($P = .01$) between patients who required reintubation (68 years; SD, 20) and patients who did not (53 years; SD, 21), and the percentage of men was significantly higher ($P = .02$) in the reintubated group (80%) than in the other group (20%). Among the patients with deliberate unplanned extubation who required reintubation, 61% were agitated (score ≥2 on the RASS) at the time of unplanned extubation, and 39% were calm ($P = .86$). Reintubation was unrelated to the time of day of the unplanned extubation.

**Discussion**

We compared patients who were sedated according to 2 different protocols with patients who received no sedative agents (only opioid analgesics for pain management). The 2 protocols were continuous sedation with DIS$^{11}$ and intermittent sedation with bolus doses of sedative and opioid analgesic agents. The rate of unplanned extubations was significantly lower for patients who had continuous sedation with DIS than for patients who had intermittent sedation or no sedation. Because our study was observational, systematic assessment of other risk factors was limited. Patients were assigned to sedation strategies according to the preference of the treating physicians, and no other differences in baseline characteristics were noted among groups. The agents used in the 3 groups were similar. The main sedative for both intermittent sedation and continuous sedation with DIS was midazolam given either as a continuous intravenous infusion or as intermittent bolus doses; the main opioid analgesic was fentanyl given as either a continuous infusion or intermittent boluses. The score on the RASS was used to guide the sedation goal. Patients receiving no sedatives were given morphine or fentanyl to control pain measured by using a pain scale. The dissimilarity of agents, albeit minor, still might have been a confounding factor in our findings. However, the wide differences in the rate of unplanned extubations among the 3 groups suggests that sedation strategies played a major role in contributing to the extubations.
Unlike Kress et al,\textsuperscript{11} who compared (1) DIS among patients given a continuous intravenous infusion of sedatives with (2) interruption of sedation only at the discretion of the ICU team, we compared (1) intermittent sedation with (2) continuous sedation with DIS. Kress et al found no difference in unplanned extubations between patients who had continuous sedation with DIS and patients who had continuous sedation that did not include DIS. Girard et al\textsuperscript{13} assessed a different sedation strategy that paired sedation and weaning by introducing a spontaneous awakening trial. We did not use that strategy; therefore our results cannot be directly compared with their findings. In their study,\textsuperscript{13} patients who passed the initial screening underwent a spontaneous awakening trial in which all sedatives and analgesics were interrupted (except for analgesics needed for active pain). Patients were monitored for 4 hours, and those who successfully completed the trial were evaluated for a spontaneous breathing trial for weaning from mechanical ventilation. The rate of unplanned extubation was significantly higher ($P=.03$) in the patients who underwent the spontaneous awakening trial (10%) than in the

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Percentage of unplanned extubations that occurred during the night shift (7 PM-7 AM).}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Unplanned extubation by time of day. Most unplanned extubations (73\%) occurred during the night shift; 2 peaks were noted at 4 AM and 10 PM.}
\end{figure}
patients who did not (4%), but the need for reintubation was similar in both groups. Of note, this finding supports our finding that reintubation is rarely required when unplanned extubation occurs during weaning from mechanical ventilation and supports the notion that the sedation strategy, not the type of sedatives, influences the incidence of unplanned extubation.

Providing sedation by using intermittent boluses is a reactive approach and may allow patients to be agitated until sedation is instituted, thus increasing the chance for unplanned extubation. Even if the sedation goals are similar, a continuous sedation strategy keeps patients at the target goal except during the limited duration of DIS when monitoring can be intensified. Girard et al\(^\text{15}\) allowed spontaneous awakening trials to continue for up to 4 hours, which in addition to the 2 hours of subsequent spontaneous breathing trials prolonged the observation time and chances for unplanned extubation.

Mehta\(^\text{14}\) assessed the effect of continuous infusion with or without DIS. The incidence of self-extubation was comparable; 9% of patients in each group self-extubated. In a study of 31 patients in a surgical ICU, Curry et al\(^\text{13}\) found that most patients had low levels of sedation in the hour preceding extubation, with a mean score of 2.42 (SD, 1.06) on the RASS. Most patients were receiving benzodiazepine and opioid analgesics, and 3 patients had no sedative or analgesic ordered. Similar to our findings, those of Balon\(^\text{16}\) indicated that administration of boluses of sedative on an as-needed basis correlated with an increased risk for unplanned extubation. Tominaga et al\(^\text{17}\) argued for sedation to prevent unplanned extubation. Coppolo and May\(^\text{18}\) noted that unplanned extubation may happen despite the use of sedation and restraints.

Of note, associating sedation with unplanned extubation may reflect the presence of agitation or anxiety as a confounding factor necessitating sedation.\(^\text{19}\) This association may also reflect the delirio-genic effect of benzodiazepines as sedative agents.\(^\text{20,21}\)

In addition, some patients who inappropriately receive benzodiazepines for the management of pain may be predisposed to delirium with paradoxical excitation. Tung et al\(^\text{19}\) compared patients who self-extubated with a matched group of control patients and found that the patients with unplanned extubation were twice as likely to be agitated (54% vs 22%; \(P<.05\)). Strom et al\(^\text{20}\) compared no sedation with continuous sedation with propofol and midazolam with DIS. Both groups of patients were treated with morphine for pain management. Neither sedation strategy was associated with an increase in days without mechanical ventilation, and no differences were found in the rate of unplanned extubation. These results differ from our findings with similar comparison groups; in our study, patients in the no-sedation group (pain management only) had a significantly higher rate of unplanned extubation than did patients in the other 2 groups.

The strength of our findings raises concerns that sedation strategies, rather than choice of sedating agents, may influence the risk for unplanned extubation in a clinical setting. This possibility supports the notion that a sedation strategy that allows agitation or a reactive approach to agitation may increase the risk for unplanned extubations. As in other studies,\(^\text{17,21}\) in our study more events occurred during the night shift, when more scheduled nursing care, such as bathing or routine chest radiographs, takes place. Unlike other investigators, we assessed sedation as a risk factor for unplanned extubation, particularly the effects of various sedation strategies. However, our study has several limitations. As in any retrospective review, we could not assess other confounding factors (eg, delirium) that could affect our observations or other factors that might influence an attending physician’s choice of sedation. Also, the self-reported nature of the events (ie, data were entered by nurses and respiratory care practitioners who were actually providing the patient’s care when the event occurred) may have introduced underreporting or responder bias. We made our best efforts to validate the reports by reviewing the medical records; however, errors were possible.

Our findings suggest that clinicians should recognize that a patient who is receiving sedatives by intermittent dosing is at high risk for unplanned extubation and should consider implementing additional monitoring or prevention plans to limit the occurrence of agitation. In addition, most patients do not require reintubation after a deliberate unplanned extubation, suggesting that implementing aggressive weaning protocols may identify readiness to extubate at an earlier stage and minimize the need for sedation and the duration of mechanical ventilation.

In conclusion, achieving sedation by giving intermittent boluses of sedative or providing only...

The continuous sedation protocol had a lower rate of unplanned extubations than did the intermittent protocol.

Findings suggest sedation strategy plays a major role in unplanned extubation.
opiod analgesics for patients receiving mechanical ventilation may introduce unwanted risks for unplanned extubation that will merit a higher level of airway monitoring. Our findings raise questions about the effect of sedation strategies on unplanned extubation, and larger studies are needed to establish whether our results can be reproduced.

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None reported.

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REFERENCES

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