Unplanned or Accidental Extubation In the Perioperative Environment

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More than 120,000 incidents of unplanned or uncontrolled extubation occur yearly in the perioperative environment and ICU, resulting in significant complications, increased costs and increased hospital lengths of stay.

Introduction

Endotracheal intubation and extubation are procedures routinely performed by anesthesiologists and intensive care physicians. The majority of the time, extubation is a planned event. Even when planned, the rate of complications related to extubation have been reported in the literature to be as high as 12%.[1,2] Incidents of unplanned extubation can occur in the OR setting, the ICU, the emergency department, or any specialty department (medical imaging, endoscopy suite, interventional cardiology) in which an intubated patient may need to be cared for. "Unplanned extubation" is defined as the unintentional and uncontrolled removal of the endotracheal tube (ETT) either due to actions of the patient or during nursing care or movement of the patient.[3-5] Extensive publications exist in the literature devoted to prediction and management of difficult intubation, yet both planned and unplanned extubations have been much less widely studied, especially outside the OR environment where airway complications are higher.[6-7]

Incidence and Risk Factors

In the literature, the reported incidence of unplanned extubation ranges from 0.5% to 35.8% in adults.[4,8-13] The majority of studies have been conducted in the ICU setting because data from outside the ICU are negligible. In the neonatal ICU (NICU), unplanned extubation has been reported as the fourth most common adverse event, and rates have been reported to be as high as 80.8%.[14-17]

On average, in the United States, 1.65 million adult patients are mechanically ventilated each year in the ICU.[18,19] Based on a median unplanned extubation rate of 7.3%, more than 120,000 incidents of unplanned or uncontrolled extubation occur yearly in the ICU.[4] In the NICU, 445,000 patients are mechanically ventilated. Based on the median unplanned extubation rate in the NICU of 18.2%, more than 80,000 neonates experience an unplanned extubation yearly.[16] Outside the ICU, the rate of occurrence is unknown, as published studies are scant.

Why might an unplanned extubation occur in the OR? Occasionally, the patient self-extubates upon emergence. Typically, these patients do not need reintubation, but vocal cord injury may occur if the ETT cuff was not deflated. More concerning are the rare events of unplanned or accidental extubation during the operative procedure. This could occur during lateral or prone positioning, or during operative procedures in or proximate to the airway. Several case reports have described accidental extubation while the patient was in the prone position for spine surgery.[18-20] In one case, extubation occurred during a "wake-up" test to assess neurologic function and was successfully managed with a supraglottic airway device (SAD).[20] In another case, extubation occurred while the patient was prone with the head flexed and secured with surgical pins, requiring fiberoptic intubation (FOI).[21]

Procedures in which the bed is turned 180 degrees away from the anesthesia machine also present a higher risk, since the ETT cannot be directly visualized or monitored during the case. Spond et al reported a case of a patient with Klippel-Feil syndrome undergoing prone cervical fusion with the bed turned 180 degrees away from the anesthesia machine, who was accidentally extubated during the procedure.[22] In this case report, with a known difficult airway, the patient was flipped supine to perform FOI.

Why do unplanned extubations occur in the intensive care setting? The most common cause in adults is self-extubation by the patient (62%-96% of incidents).[23,24] Other common causes include accidental extubation during suctioning, manipulation of the ETT, or moving the patient.[4] Unplanned extubation can occur during turning or repositioning of the patient. When intubated patients need to travel from the ICU for a diagnostic or an interventional procedure, they are moved several times (such as for a CT or MRI scan), providing multiple opportunities for dislodgement or removal of the ETT.

Several risk factors can increase the likelihood of extubation by accident or patient action (Table 1).[4,8,11,25-29] Inadequate securement of the tube can increase the risk for removal or dislodgement. Lack of physical restraints, inadequate patient sedation, or patient agitation or restlessness in the setting of an inadequately secured ETT also increase the risk for tube dislodgement or removal.[4,8,11] Other risk factors that have been linked to unplanned extubation in the intensive care setting include emergency surgery, presence of nosocomial infection, delirium or confusion, congestive heart failure, and lack of a clear plan for extubation.[26-28]

Table 1. Risk Factors for Unplanned Extubation[4,8,11,18-21]

Inadequate securement of the endotracheal tube
Inadequate sedation
Lack of physical restraints
Patient restlessness or agitation
Unclear extubation plan

Absence of clear extubation or weaning policies and procedures also has been associated with an increased risk for unplanned extubations.[4,8,25] Other human factors, such as fatigue, inadequate staffing patterns in the ICU, and level of nursing experience have been linked to unplanned or accidental extubation.[4,25] Nursing workloads and higher nurse-to-patient ratios also have been shown to contribute to unplanned extubation.[24,29] Not surprisingly, the incidence of unplanned extubation is higher during evening and night shifts.[30]

Danielis et al interviewed critical care nurses about precipitating factors for unplanned extubation.[29] They reported lack of communication between health care providers, a chaotic environment, poor nurse-to-patient ratios, and barriers to the ability to directly observe the patient as significant factors.

Complications

In the OR, a significant number of reported airway-related complications occur during extubation. According to the American Society of Anesthesiologists' closed claims database, 12% of all airway claims were associated with extubation.[1,31] The 4th National Audit Project in the United Kingdom, which collected airway-related claims reported by anesthesiologists, found that one-third of claims were due to respiratory complications during emergence and extubation.[32] These were complications related to planned extubation in the OR setting, under presumed controlled conditions. Complication rates related to unplanned extubation are even higher.

Unplanned extubation can lead to a large variety of complications (Table 2).[24,33,34] Unplanned removal of an ETT with the tracheal cuff still inflated can potentially cause injury to the vocal cords. If an intubated patient has a large secretion burden, aspiration of these secretions after an unplanned extubation can lead to aspiration pneumonia. If inadequate ventilation occurs after unplanned extubation, hypoxemia and potentially hemodynamic instability, hypotension, brain damage, cardiac arrest, and even death may result.

Reintubation after unplanned extubation, especially in the presence of airway edema, can be very challenging, and can result in the previously mentioned complications. The reintubation rate after unplanned extubation varies in the literature, but has been reported to be as high as 89%.[4,25,33,35] A study by Mort on unplanned extubations in the ICU found that 89% of patients required reintubation within two hours, and 66% needed to be reintubated within 30 minutes of accidental extubation.[36] Patients with accidental extubation, as opposed to self-extubation, have been reported to have higher reintubation rates as well as poorer prognoses.[73] A study by de Lassence et al

found an overall reintubation rate of 77%, with the majority of patients after accidental extubation requiring reintubation, while 37% of self-extubated patients were not reintubated.[24]

Ventilator-associated pneumonia (VAP) has been clearly linked to prolonged mechanical ventilation and longer ICU and hospital lengths of stay, independent of the cause.[38,39] Unplanned extubation is a risk factor and has been associated with increased rates of ventilator-associated pneumonia.[40] Unplanned extubation, due to the subsequent complications, has been associated with increased ICU and hospital length of stay (LOS), as well as increased mortality.[24,41-43] Other studies, however, found no difference in ICU LOS or mortality rates compared with intubated patients who did not experience unplanned extubation.[8,35] The study by de Lassence et al examined LOS and found that in adult patients with unplanned extubation, both ICU LOS (18 vs. nine days) and hospital LOS (30 vs. 18 days) were prolonged.[24] Similar results have been found in pediatric patients with unplanned extubation.[44,45] Veldman reported an increased NICU LOS of 51 versus nine days.[44]

More severe complications also have been associated with unplanned extubation. A study by Klugman found that 20% of unplanned extubations were followed by cardiovascular collapse, with neonates being at higher risk.[46] Multiple studies have reported increases in mortality rate and poorer prognosis in patients with unplanned extubation.[35,42,47]

Costs

Increases in hospital and ICU LOS as well as in complications all lead to increased hospital costs that can be directly attributed to unplanned extubation.[48-50] Mechanical ventilation in the ICU, independent of any complications associated with it, increases costs. Dasta et al assessed costs in the ICU setting and found that mechanical ventilation increased costs by an average of $1,522 per day.[49] With the average LOS of a patient experiencing an unplanned extubation being 30 days, the total increased cost of an unplanned extubation is $40,992. The complications associated with unplanned extubation in this patient population further increase hospital costs. Roddy et al calculated the costs of unplanned extubation in the pediatric ICU setting, factoring in increased LOS and rate of nosocomial infection, and found that unplanned extubation increased hospital costs by over $36,000 per incident.[50]

Taking into account mortality, increased rates of VAP and increased LOS, the overall cost burden in the United States of unplanned extubation in adult ICUs totals almost $5 billion (Table 3).[24,48,50] In the NICU, the more than 80,000 unplanned extubations yearly costs an additional $2.9 billion.[50]

Prevention

Surprisingly, this important problem remains underrecognized. Many hospitals still do not track rates of unplanned extubation. A major first step in prevention is to increase awareness of the problem. Several strategies can be implemented to reduce the risk for unplanned extubation.

Increased Awareness of Risk Factors

The first step to increase awareness is education of the staff providing care to intubated patients about risk factors for unplanned extubation and how to monitor patients at risk. Vats et al created an airway risk assessment scoring tool to identify and stratify pediatric patients at risk for unplanned extubation in the ICU.[51] Patients were assigned points for several risk factors:

- anatomic risk;
- secretions;
- agitation;
- prone position;
- history of unplanned extubation;
- need for multiple procedures or transports; and
- frequent need for retaping of the ETT.

A score of 5 or greater was considered high risk, and the investigators found that the scoring tool correlated well with the incidence of unplanned extubation.

Several institutions have tackled prevention of unplanned extubation as a quality improvement initiative, incorporating multidisciplinary interventions to affect outcomes.[24,26,52,53] Chao et al reported a significant decrease in unplanned extubation rates, from 3.19 to 0.95 per 100 patients, using a multidisciplinary strategy that focused on these areas: standardization of procedures, improving communication, revising sedation and weaning protocols, changing restraint strategies and securement methods, using team resource management and a no-blame culture, and creation of a task force for identifying high-risk patients.[52] Quality improvement initiatives have also been successful in reducing unplanned extubation rates in pediatric ICUs.[54,55]

Table 2. Complications Associated With Unplanned Extubation[22,29-30]

Clinical Complications	Other Complications
Aspiration pneumonia	Increased hospital costs
Brain damage	Increased hospital LOS
Cardiac arrest	Increased ICU mortality rates
Death	Prolonged ICU LOS
Hemodynamic instability	
Hypoxemia	
Respiratory failure	
Vocal cord injury	

LOS, length of stay

Table 3. Average Yearly Costs Associated With Unplanned Extubation in the ICU[24,48,50]

Day	Non-UE ($)	UE ($)
1	10,794	10,794
2	4,796	4,796
3	3,968	3,968
4	3,968	3,968
5	3,968	3,968
6	3,968	3,968
7	3,968	3,968
8	3,968	3,968
9	3,968	3,968
10	**1,760**	3,968
11	**1,760**	3,968
12	**1,760**	3,968
13	**1,760**	3,968
14	**1,760**	3,968
15	**1,760**	3,968
16	**1,760**	3,968
17	**1,760**	3,968
18	**1,760**	3,968
19		**1,760**
20		**1,760**
21		**1,760**
22		**1,760**
23		**1,760**
24		**1,760**
25		**1,760**
26		**1,760**
27		**1,760**
28		**1,760**
29		**1,760**
30		**1,760**
	59,206	**100,198**
Average cost of UE		**40,992**
Average yearly No. of UEs		**121,000**
Yearly cost of UEs		**4,960,032,000**

ICU Days on MV
ICU Days off MV
Non-ICU Days

MV, mechanical ventilation; **UE,** unplanned extubation

Strategies to Reduce the Incidence of Unplanned Extubation

Individual strategies also can reduce the incidence of unplanned extubation. Standardization of protocols as well as the creation of bundles and checklists in the ICU setting have been shown to reduce VAP and improve outcomes.[56,57] Standardization of restraint and sedation protocols could have a similar benefit for unplanned extubation.[52]

Improving and optimizing securement of the ETT in the ICU can prevent unplanned extubation. Many different methods and securement devices exist to maintain an indwelling ETT. Although no single method or device has been proven superior, there are several attributes that an optimal securement method should have (Table 4).[58-60]

Addressing Human and Environmental Factors

Human factors such as staffing ratios, interprofessional communication and teamwork should be addressed and optimized to reduce risk in both the OR and ICU settings. The simulation environment can be very useful for practicing and teaching teamwork and communication.[61,62] Danielis et al surveyed nurses in the ICU and identified several organizational, environmental and nursing care factors that played a role in unplanned extubations and could be modified.[29] These factors included communication failures, environmental chaos and barriers to direct surveillance of the patient, and poor nurse-to-patient ratios.[29]

Operating Room Strategies

In the OR, a briefing or time-out can be used to discuss extubation risk prevention and strategies for management in high-risk cases, similar to what is recommended for cases at risk for an airway fire.[22] Many

Table 4. Attributes of an Optimal ETT Securement Device[57-59]

Adequate stabilization against external forces that may dislodge tube
Allows tube movement for oral care
Avoids adhesives that could irritate skin
Cost-effective
Ease of placement, use, and maintenance
Enhances patient comfort and minimizes skin pressure
Facilitates suctioning but is not compromised by secretions
Prevents tube movement
Requires infrequent adjustment or change

ETT, endotracheal tube

cases at risk for an airway fire may also be at risk for accidental extubation during the procedure. Careful securement of the ETT for cases in which the airway is inaccessible during the procedure (surgery on the head and neck, prone or lateral procedures, procedures where the bed is turned 90 or 180 degrees away from the anesthesia machine) can potentially prevent extubation. In cases with high risk, immediate availability of alternate airway devices such as video laryngoscopes, flexible bronchoscopes and SADs is recommended for emergent airway management.[20-22]

Prevention of Reintubation After Unplanned Extubation

There are several strategies to maximize oxygenation and ventilation after unplanned extubation that could reduce the need for reintubation, or at least result in a less urgent need for reintubation. Newer methods of high-flow oxygenation via the nasal route that also provide positive pressure ventilation may provide a bridge after unplanned extubation.[63,64] Use of continuous positive airway pressure after extubation, both planned and unplanned, also may be useful, especially in obese patients or individuals with obstructive sleep apnea.[65,66] Lin et al found that the use of noninvasive positive pressure ventilation significantly reduced the reintubation rate after unplanned extubation.[35]

Conclusion and Future Directions

Unplanned extubation is a common and costly problem in the perioperative and intensive care environments, with a large impact on outcomes and hospital costs, yet it remains an underrecognized problem. Increased awareness and prevention are critical. Better tracking and the implementation of quality improvement initiatives can potentially address the problem. Prevention requires commitment not only from clinical care providers but also from leadership, to implement strategies and protocols to standardize care. Rates of unplanned extubation should be identified and tracked, ideally within an electronic health record system.

The Society for Airway Management has collaborated with many medical societies and safety organizations to address the issue of unplanned extubation (Table 5). This collaborative is focused on increasing awareness of the magnitude of the problem as well as improved tracking of events. The collaborative also is developing checklists, core data sets for tracking and Actionable Patient Safety Solutions in conjunction with the Patient Safety Movement Foundation.[67] This information can be downloaded at www.airwaysafetymovement.org or www.patientsafetymovement.org.

Table 5. Society for Airway Management Collaborative

Medical Professional Societies
American Academy of Pediatrics
American Association of Nurse Anesthetists
American Association of Respiratory Care
American College of Emergency Physicians
American Society of Anesthesiologists
Association of Air Medical Systems
National Association of EMS Physicians
National Association of EMTs
National Association of Neonatal Nurses
Society for Airway Management
Society for Pediatric Anesthesia
Society of Critical Care Medicine
Patient Safety Organizations
Airway Safety Movement
Anesthesia Patient Safety Foundation
Children's Hospitals' Solutions for Patient Safety
Do It For Drew Foundation
Emergency Medicine Patient Safety Foundation
Patient Safety Movement Foundation
Quality Improvement Organizations
IMPAQ/CMS Strategic Innovation Engine

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