



# Unplanned Extubation

## A Common and Costly Complication of Airway Management

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Endotracheal intubation and extubation are procedures routinely performed by clinicians who manage the airway of critically ill or injured patients (e.g., emergency physicians, anesthesiologists, and intensive care physicians) and patients undergoing general anesthesia (i.e., anesthesiologists and other anesthesia providers). Most of the time, extubation is a planned, intentional, and controlled event and in these circumstances the rate of complications related to extubation has been reported in the literature to be as high as 12%. The unplanned, unintentional, and uncontrolled removal of the endotracheal tube (ETT) can be either due to actions of the patient removing their own tube, defined as self-extubation, or due to an external force applied to the ETT during nursing care or movement of the patient that causes the dislodgement of the tube, defined as accidental extubation. Unplanned extubation is associated with significant complications, including aspiration pneumonia, hypoxemia, arrhythmias, vocal cord injury, brain damage, and death.

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**D**rew was a teenager who loved skateboarding. He fell one day and sustained a head injury. The local emergency room elected to intubate Drew for transport to a tertiary care center. Enroute, his life-sustaining breathing tube became dislodged. The ambulance team reintubated Drew but did not recognize the tube had been placed in his esophagus. He quickly became hypoxic, his heart rate slowed, and he went into cardiopulmonary arrest. Therefore, the ambulance was diverted to the nearest ER. However, upon arrival the ER physician noted that Drew had sustained irreversible brain ischemia and Drew was pronounced dead. Although Drew's death was tragic it is not an isolated example of complications that can occur from the unintentional and uncontrolled removal of a patient's life-sustaining breathing tube.

Airway management is routinely performed by anesthesiologists, intensivists, emergency physicians, and other trained airway providers such as nurses, anesthesia assistants, respiratory therapists, and paramedics. Airway management includes placing a life-sustaining breathing tube into the trachea (intubation) and eventual removal of the tube when the patient no longer requires the airway support (extubation). Most of the time, removal of the endotracheal tube (ETT) occurs in a planned, intentional, and controlled fashion. Yet even when extubation occurs as part of a planned and controlled situation, it is associated with complications, with rates reported in the literature as high as 12%.<sup>1,2</sup> When removal of the endotracheal tube is unplanned, unintentional, and uncontrolled, it is typically referred to simply as an unplanned extubation (UE). UE can occur when the patient dislodges their tube by pulling on it (self-extubation) or when an external force is applied to the tube during movement of the patient or other nursing care (accidental extubation).<sup>3-5</sup> UE can occur in any setting where intubated patients are cared for, including the operating room, intensive care unit, the emergency department, diagnostic imaging suites,

and procedural areas such as the GI or CV labs. It also can occur during transport between any of these areas.

Many publications in the literature address the challenge of predicting and managing the difficult intubation, but the problems that occur during extubation, including unplanned extubation, are much less widely studied. This is especially true in the intensive care unit (ICU), where airway complications associated with extubation are higher.<sup>4,7</sup>

## **Incidence and Risk Factors**

The incidence of unplanned extubation, as reported in the literature, ranges widely, from 0.5–35.8% in adults and as high as 80.8% in neonates.<sup>4, 8-14</sup> The majority of studies on the incidence of UE were conducted in the intensive care unit. Unplanned extubation in the neonatal ICU (NICU) is the fourth-most commonly reported adverse event.<sup>14-17.</sup>

In the United States, an average of 1.65 million adult patients are intubated and mechanically ventilated in intensive care settings each year.<sup>18-19</sup> The median reported annual unplanned extubation rate in the ICU is 7.3%, which extrapolates to more than 120,000 adult patients who experience an unplanned, unintentional, uncontrolled extubation every year in the ICU.<sup>4</sup> In the NICU, the median reported annual unplanned extubation rate is even higher at 18.2%.<sup>16</sup> On average 80,000 patients are intubated and mechanically ventilated in the NICU, resulting in more than 14,500 neonatal patients in the NICU experiencing an unplanned extubation each year. The rate of occurrence of UE outside the ICU setting is unknown, as very few published studies exist.

While less common in the operating room setting, certain conditions can still lead to accidental or self-extubation in the OR. Most patients receive general anesthesia with muscle relaxation, which reduces the risk of patient movement and accidental extubation. Self-extubation during emergence from anesthesia is rare but does occur. Many patients do not require reintubation, but vocal cord injury is a risk if the ETT cuff was not deflated before tube removal. More serious are the rarer events of accidental extubation that occur during the operative procedure. These events can occur during procedures in or proximal to the airway, or during lateral or prone positioning of the patient. Several case reports exist describing accidental extubation during prone spine surgery.<sup>18-20</sup> One case report describes an extubation that occurred during a wakeup test to perform a neurological exam. This case was successfully rescued with the placement of a supraglottic airway device.<sup>20</sup> Another case report describes an extubation that occurred with the patient in the prone position and

### **Annual Number of Unplanned Extubations and Associated Cost**



the head flexed and secured with surgical pins. This patient's airway was rescued using fiberoptic intubation.<sup>21</sup> Some surgical procedures require the head of the patient to be positioned 180 degrees away from the anesthesia machine, restricting visualization as well as monitoring of the endotracheal tube. Dislodgement of the endotracheal tube, as well as a delay in recognition that extubation occurred, is possible in these cases.

In comparison to the operating room, accidental extubation is much more common in the intensive care environment. Unlike in the operating room environment, general anesthesia and muscle relaxation often are not employed, potentially increasing the risk of patient movement and tube dislodgement.

Self-extubation is the most common cause of UE in adults and has been the cause in 62–90% of reported incidents.<sup>22,23</sup> Other causes include accidental extubation while moving the patient, manipulating the endotracheal tube, or performing suctioning maneuvers. Accidental extubation can also occur while the patient is being turned or repositioned. Intubated patients often need to travel outside the ICU setting for diagnostic scans such as CT or MRI, or for interventional procedures (e.g., endoscopy, cardiac catheterization) and may need to be moved several times during which accidental extubation may occur.

Several risk factors can increase the possibility of extubation due to either patient action or accident (**Table 1**).<sup>4,8,11,24-28</sup>

Inadequate securement of the tube can increase the risk for removal or dislodgement. Additional factors that can increase the risk of dislodgement or removal include lack of physical restraints, inadequate patient sedation, or patient agitation or restlessness in the setting of an inadequately secured ETT.<sup>4,8,11</sup> Use of physical restraints or oversedation can also potentially lead to agitation and increased risk of extubation.<sup>4</sup> Emergency surgery, delirium or confusion, congestive heart failure, or the presence of nosocomial infection have also been linked as risk factors for unplanned extubation in the ICU.<sup>25-27</sup> Lack

of a clear plan for extubation can also increase risk.

The lack of standardized procedures for weaning and extubation has also been associated with increased risk of UE.<sup>4,8,24</sup> Human factors in the ICU can also play a role in increasing risk and have been linked to unplanned or accidental intubation, including fatigue, level of nursing experience, and inadequate staffing patterns.<sup>4,25</sup> Other human factors such as high nursing workload and higher nurse-to-patient staffing ratios have been linked as contributing factors for UE, and it is not surprising that unplanned extubations occur more frequently during evening and night shifts.<sup>23,28,29</sup>

A study by Danielis et al. surveyed nurses in the ICU to identify precipitating factors for unplanned or accidental extubation.<sup>28</sup> The results of the survey identified several key factors: a chaotic working environment, poor nurse-to-patient ratios, lack of communication among providers, and barriers to direct observation of the patient. Many institutions utilize continuous sedation with sedation vacations, and UE has been known to occur when the sedation vacation is instituted but not clearly communicated to the entire care team.<sup>28</sup>

### Complications

In the operating room setting, reported airway-related complications are higher during extubation than during intubation; 12% of all airway claims collected by the American Society of Anesthesiologists' closed claims database occurred during extubation.<sup>1,30</sup> Another report from the 4th National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society found that one-third of reported claims were due to respiratory complications associated with emergence and extubation.<sup>31</sup> In both studies, airway-related complications that occurred outside the operating room setting, under uncontrolled conditions, were even higher.

UE can lead to a large variety of complications (**Table 2**).<sup>22,23,31,32</sup>

**Table 1.**  
**Risk Factors for**  
**Unplanned Extubation**

- Inadequate Securement of the Endotracheal Tube
- Inadequate Sedation
- Lack of Physical Restraints
- Restlessness or Agitation
- Delirium or Confusion
- Unclear or Lack of an Extubation Plan

**Table 2.**  
**Complications**  
**Associated With**  
**Unplanned Extubation**



#### Clinical

- Hypoxemia
- Hemodynamic Instability
- Vocal Cord Injury
- Aspiration Pneumonia
- Respiratory Failure
- Brain Damage
- Cardiac Arrest
- Death



#### Other

- Increased:
  - ICU Length of Stay
  - Hospital Length of Stay
  - Hospital Costs
  - ICU Mortality Rate

**Table 3.**  
Average Yearly Costs  
Associated With Unplanned  
Extubation in the Adult ICU

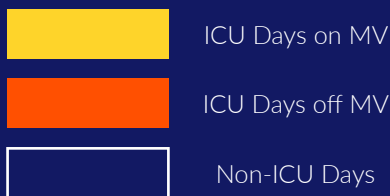
Day	Non-UE	UE
1	\$10,794	\$ 10,794
2	\$ 4,796	\$ 4,796
3	\$ 3,968	\$ 3,968
4	\$ 3,968	\$ 3,968
5	\$ 3,968	\$ 3,968
6	\$ 3,968	\$ 3,968
7	\$ 3,968	\$ 3,968
8	\$ 3,968	\$ 3,968
9	\$ 3,968	\$ 3,968
10	\$ 1,760	\$ 3,968
11	\$ 1,760	\$ 3,968
12	\$ 1,760	\$ 3,968
13	\$ 1,760	\$ 3,968
14	\$ 1,760	\$ 3,968
15	\$ 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
	<b>\$59,206</b>	<b>\$100,198</b>

Average Cost of UE \$40,992  
Avg. Yearly # of UE 121,000



Yearly Cost of  
Unplanned Extubations

**\$4,960,032,000**



When an endotracheal tube is accidentally removed before the tracheal cuff is deflated, injury can occur to the vocal cords or trachea. Intubated patients with large secretion burdens can potentially aspirate these secretions during an unplanned extubation and this can lead to aspiration pneumonia. Unplanned extubation can result in hypoxia if oxygenation or ventilation is inadequate after the tube is removed, and this hypoxia can progress to hemodynamic instability and hypotension, arrhythmias, brain damage, cardiac arrest, and even death if not successfully treated.

Successful reintubation after unplanned extubation can be quite challenging, especially if hypoxia or airway edema is present. The reported reintubation rate after unplanned extubation varies in the literature but may be as high as 89%.<sup>4,34,35</sup> A study by Mort assessing the need for reintubation after unplanned extubation found that 89% of patients needed reintubation within two hours, and 66% required reintubation within 30 minutes after accidental extubation.<sup>35</sup> The need for reintubation after accidental extubation is higher and carries a poorer prognosis compared to reintubation after patient self-extubation.<sup>36</sup> A study by de Lassence et al. reported an overall reintubation rate of 77% after unplanned extubation. The majority of the patients in this study who required reintubation experienced accidental extubation, and 37% of patients who self-extubated did not require re-intubation.<sup>23</sup>

Prolonged mechanical ventilation increases the risk of ventilator-associated pneumonia (VAP), a condition associated with longer ICU and hospital lengths of stay (LOS).<sup>37,38</sup> Unplanned extubation has been associated with increased VAP rates, as well as increased ICU and hospital length of stay and increases in mortality rates.<sup>23,37-42</sup> However, conflicting studies have found no increases in mortality in intubated patients who experienced unplanned extubation.<sup>8,34</sup> De Lassence et al. found that both ICU and hospital length of stay were longer (18 vs.

9 days for ICU LOS and 30 vs. 18 days for hospital LOS) in intubated patients who experienced unplanned extubation.<sup>23</sup> Similar results have been reported in pediatric and neonatal patients with UE.<sup>43-45</sup>

Other, more severe complications have also been reported after unplanned extubation. In a study by Klugman, cardiovascular collapse occurred following 20% of unplanned extubations, and neonatal patients were found to be at higher risk.<sup>46</sup> Increased mortality rate and worse prognosis have been reported in multiple studies examining complications after unplanned extubation.<sup>34,41,46</sup>

### Costs

Complications associated with UE, especially if they increase hospital or ICU length of stay, can significantly increase hospital costs.<sup>47-49</sup> The need for mechanical ventilation in the ICU, even in the absence of complications, adds to hospital costs (Table 3). According to Dasta et al., mechanical ventilation adds an average of \$1,522 to hospital costs per day.<sup>48</sup> The average cost for an ICU stay for a mechanically ventilated patient without an unplanned extubation is \$59,206. Due to an increased ICU length of stay (18 vs. 9 days) for patients who experience an unplanned extubation, the average cost of an ICU stay and complications for a patient who experiences an unplanned extubation is \$100,198. Therefore, due to the increased length of stay and complications that occur due to an unplanned extubation, the additional cost per unplanned extubation is \$40,992.<sup>48,49</sup> A study by Roddy factored in complications such as nosocomial infection and increased LOS in pediatric patients who experienced unplanned extubation in the ICU and found that costs increased by \$36,692 per UE incident.<sup>45</sup> In the United States, the overall cost burden in the ICU from unplanned extubations totals near \$5 billion.<sup>23,47,49</sup> If incidents of unplanned extubation in the NICU are included, this adds an additional \$500 million in hospital costs.<sup>49</sup>

Figure 1. Society for Airway Management Collaborative



## Prevention

The literature clearly shows that UE is both common and costly. Yet, the gravity of this very serious problem remains underrecognized in many hospitals and commonly is not acknowledged as a valid problem. Many hospitals still do not track unplanned extubation rates as a quality metric, and most electronic health record (EHR) systems do not include data sets to track accidental or self-extubation. An informal survey of EHR companies conducted by the Airway Safety Movement found that none surveyed had a data field for UE. A major first step in prevention is to increase awareness of the problem. There are several strategies that can be employed to reduce the risk of UE.

### Increased Awareness of Risk Factors

An important first step to increase awareness of the problem is staff education for providers caring for intubated patients about the risk factors and how to monitor for patients at risk. Vats et al. created an airway risk assessment scoring tool that can stratify pediatric patients and identify patients at risk for unplanned intubation.<sup>50</sup> This tool assigns points for several risk factors, with a score of 5 or higher indicating high risk for UE. The study found a high correlation between the scoring tool and the incidence of unplanned extubation.

Several hospitals have introduced quality improvement initiatives using multidisciplinary interventions to prevent unplanned extubation and improve outcomes. Chao et al. used a multidisciplinary approach of stan-

dardized procedures, revised sedation and weaning protocols, improved restraint and securement methods, and improved communication, and found a significant reduction in UE rates from 3.19 to 0.95 per 100 patients.<sup>51</sup> Chao's strategy also used team resource management and a no-blame culture, and created a task force to identify high-risk patients. Similar quality improvement strategies have demonstrated a reduction in unplanned extubation rates in the pediatric and neonatal ICUs.<sup>53,54</sup> Kandil et al. demonstrated a reduced rate of UE by 75% (1.2 to 0.3 UE per 100 ventilator days) using quality improvement methods.<sup>57</sup> Galote et al. reduced unintended extubations in their Level IV NICU by 61% using quality improvement methods.<sup>56</sup>

### Strategies to Reduce the Incidence of Unplanned Extubation

Individual strategies can also reduce the incidence of UE. Standardization of protocols as well as the creation of bundles and checklists in the ICU setting has been shown to reduce VAP and improve outcomes.<sup>57,58</sup> Standardization of tube restraint methods as well as patient restraint and sedation protocols could have a similar benefit.<sup>51,55,56</sup>

Kandil identified several strategies that should be deployed during high-risk situations to decrease the incidence of unplanned extubation.<sup>55</sup> High-risk situations include repositioning the ETT, moving the patient during nursing procedures, and situations that require transport of the patient from one unit to another. One of the strategies is to require two caregivers to participate in any high-risk situation, with one of the caregivers being solely

**Table 4. Attributes of an Optimal Endotracheal Tube Securement Device**

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

responsible for protection of the tube. The caregiver who is responsible for the protection of the ETT performs a verbal call-out of the ETT depth position prior to movement of the patient (e.g., “ETT 23cm at upper incisors”) and upon completion of movement of the patient (e.g., “ETT at 23 cm... No change”). The same caregiver directs a verbal call-out of when to begin coordinated movement of the patient (e.g., “move on-three... 1... 2... 3”).

Improving and optimizing securement of the ETT can prevent UE. 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 recommended attributes for an optimal securement method (**Table 4**).<sup>59-61</sup>

#### **Human and Environmental Factors**

Human factors that impact the incidence of UE, such as staffing ratios, teamwork, and communication, should be optimized to reduce risk. The use of simulation has been shown to be very effective for teaching and practicing teamwork and communication outside of the clinical setting.<sup>62,63</sup> A survey of nurses in the ICU identified several organizational and environmental factors that could be modified to reduce UE risk, such as communication failures, environmental chaos and barriers to direct surveillance of the patient, and poor nurse-to-patient ratios.<sup>28</sup>

#### **Operating Room Strategies**

Briefings, or time-outs, are often used in the operating room to discuss extubation risks and strategies for prevention and management in high-risk cases, similar to the concerns often discussed for cases at risk for airway fire.<sup>20,21</sup> Cases at risk for airway fire are often also at risk for accidental extubation due to the nature of the procedure. Since the airway is often inaccessible during these

procedures, careful securement of the endotracheal tube is important to reduce extubation risk. In high-risk cases, it is recommended to have alternate airway devices immediately available for reintubation, such as video laryngoscopes, flexible bronchoscopes, and supraglottic airway devices.<sup>20,21</sup>

#### **Strategies to Prevent Reintubation After Unplanned Extubation**

Strategies to maximize oxygenation and ventilation can be employed after unplanned extubation to avoid reintubation, or at least to prevent an urgent need for intervention. Several newer methods of high-flow oxygenation via the nasal route can potentially prevent or delay reintubation.<sup>64,65</sup> Some of these methods also provide continuous positive airway pressure (CPAP), which can be especially useful in obese patients or individuals with obstructive sleep apnea.<sup>66,67</sup> A study by Lin et al. used noninvasive positive pressure ventilation as a strategy after unplanned extubation, and found that it significantly reduced the rate of reintubation.<sup>34</sup> Conversion to tracheostomy or early extubation are other strategies that can potentially reduce risk for unplanned extubation.

#### **Conclusion and Future Directions**

UE 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 under-recognized problem. Increased awareness and prevention are critical. Better tracking and the implementation of quality improvement initiatives can potentially address the problem. Prevention requires commitment from not only clinical care providers but also leadership to implement strategies and protocols to standardize care. The Patient Safety Movement Foundation (PSMF) has identified that a hospitalwide culture of safety is important in reducing UE.<sup>68</sup> Rates of UE should be identified and tracked, ideally within an EHR system.

The Society for Airway Management, a global multidisciplinary society devoted to improving airway safety, created a special projects committee to address unplanned extubation. This committee formed a collaborative with over 20 other medical societies and safety organizations to increase awareness of the magnitude of the problem. The collaborative has published over 20 articles on UE and developed a toolkit consisting of checklists, core data sets, and Actionable Patient Safety Solutions (developed by PSMF) that hospitals can use to track unplanned extubation.<sup>68</sup> These resources can be downloaded from [AirwaySafetyMovement.org](http://AirwaySafetyMovement.org) or [PatientSafetyMovement.org](http://PatientSafetyMovement.org) completely free of charge.

The Children’s Hospitals’ Solutions for Patient Safety Network (SPS Network), consisting of 135+ Children’s Hospitals collaborating to eliminate serious harm in the children being cared for in their facilities, has been very successful in bringing together institutions, sharing

proven best-practice quality improvement methods for UE, instituting those best practices, and publishing their results in peer-reviewed publications. Patterned after this model, a similar network is being formed for adult acute care hospitals. The Adult Hospitals' Solutions for Airway Safety Network will also work together to determine if the quality improvement methods already proven by the SPS Network to reduce UE in the NICU and PICU can be effectively applied to the adult ICU environment. Through research and publication, the Adult Hospitals' network hopes to demonstrate that a proven best-practice quality improvement bundle will decrease the incidence of UE from the literature benchmark of 7.3% and thereby decrease the associated complications and associated costs of nearly \$5 billion. For more information on the Adult Hospitals' Solutions for Airway Safety Network contact [akanowitz@airwaysafetymovement.org](mailto:akanowitz@airwaysafetymovement.org).

## References

- Asai T, Koga K, Vaughan RS. Respiratory Complications Associated With Tracheal Intubation and Extubation. *Br J Anaesth*. 1998;80(6):767-775.
- Domino KB, Posner KL, Caplan RA, et al. Airway Injury During Anesthesia: A Closed Claims Analysis. *Anesthesiology*. 1999;91(6):1703-1711.
- Ismaeil MF, El-Shahat HM, El-Gammal MS, et al. Unplanned Versus Planned Extubation in Respiratory Intensive Care Unit, Predictors of Outcome. *Egyptian J Chest Dis Tuberc*. 2014;63(1):219-231.
- da Silva PS, Reis ME, Aguiar VE, et al. Unplanned Extubation on the Neonatal ICU: A Systematic Review, Critical Appraisal and Evidence-Based Recommendations. *Resp Care*, 2013.58 (7): p. 1237-45.
- Bouza C, Garcia E, Diaz M, et al. Unplanned Extubation in Orally Intubated Medical Patients in the Intensive Care Unit: A Prospective Cohort Study. *Heart Lung*. 2007;36(4):270-276.
- Cook T, Behringer EC, Benger J. Airway Management Outside the Operating Room: Hazardous and Incompletely Studied. *Curr Opin Anaesthesiol*. 2012;25(4):461-469.
- Asai T. Airway Management Inside and Outside Operating Rooms—Circumstances Are Quite Different. *Br J Anaesth*. 2018;120(2):207-209.
- de Groot RI, Dekkers OM, Herold IH, et al. Risk Factors and Outcomes After Unplanned Extubations on the ICU: A Case-Control Study. *Crit Care*. 2011;15(1):R19.
- de Lassence A, Alberti C, Azoulay E, et al. Impact of Unplanned Extubation and Reintubation After Weaning on Nosocomial Pneumonia Risk in the Intensive Care Unit: A Prospective Multicenter Study. *Anesthesiology*. 2002;97(1):148-156.
- Phoa LL, Pek WY, Syap W, et al. Unplanned Extubation: A Local Experience. *Singapore Med J*. 2002;43(10):504-508.
- McNett M, Kerber K. Unplanned Extubations in the ICU: Risk Factors and Strategies for Reducing Adverse Events. *J Clin Outcomes Manag*. 2015;22(7):303-311.
- Kapadia FN, Bajan KB, Raje KV. Airway Accidents in Intubated Intensive Care Unit Patients: An Epidemiological Study. *Crit Care Med*. 2000;28(3):659-664.
- Balon JA. Common Factors of Spontaneous Self-Extubation in a Critical Care Setting. *Int J Trauma Nurs*. 2001;7(3):93-99.
- Meyers JM, Pinheiro J, Nelson MU. Unplanned Extubation in NICU Patients: Are We Speaking the Same Language? *J Perinatol*. 2015;35(9):676-677.
- Barber JA. Unplanned Extubation in the NICU. *J Obstet Gynecol Neonatal Nurs*. 2013;42(2):233-238.
- da Silva PS, Reis ME, Aguiar VE, et al. Unplanned Extubation in the Neonatal ICU: A Systematic Review, Critical Appraisal, and Evidence-Based Recommendations. *Respir Care*. 2013;58(7):1237-1245.
- Franck LS, Vaughan B, Wallace J. Extubation and Reintubation in the NICU: Identifying Opportunities to Improve Care. *Pediatr Nurs*. 1992;18(3):267-270.
- Society of Critical Care Medicine. Critical Care Statistics. [www.sccm.org/Communications/Critical-Care-Statistics](http://www.sccm.org/Communications/Critical-Care-Statistics). Accessed April 10, 2019.
- Wunsch H, Wagner J, Herlim M, et al. ICU Occupancy and Mechanical Ventilator Use in the United States. *Crit Care Med*. 2013;41(12):2712-2719.
- Rapheal J, Rosenthal-Ganon T, Gozal Y. Emergency Airway Management With a Laryngeal Mask Airway in a Patient Placed in the Prone Position. *J Clin Anesth*. 2004;16(7):560-561.
- Hung MH, Fan SZ, Lin CP, et al. Emergency Airway Management With Fiberoptic Intubation in the Prone Position With a Fixed Flexed Neck. *Anesth Analg*. 2008;107(5):1704-1706.
- Kiekkas P, Aretha D, Panteli E, et al. Unplanned Extubation in Critically Ill Adults: Clinical Review. *Nurs Crit Care*. 2013;18(3):123-134.
- de Lassence A, Alberti C, Azoulay É, et al. Impact of Unplanned Extubation and Reintubation After Weaning on Nosocomial Pneumonia Risk in The Intensive Care Unit. A Prospective Multicenter Study. *Anesthesiology*. 2002;97(1):148-156.
- Cosentino C, Fama M, Foà C, et al. Unplanned Extubations in Intensive Care Unit: Evidences for Risk Factors. A Literature Review. *Acta Biomed*. 2017;88(5S):55-65.
- Ai ZP, Gao XL, Zhao XL. Factors Associated With Unplanned Extubation in the Intensive Care Unit For Adult Patients: A Systematic Review and Meta-Analysis. *Intensive Crit Care Nurs*. 2018;47:62-68.
- Aydogan S, Kaya N. The Assessment of the Risk of Unplanned Extubation in an Adult Intensive Care Unit. *Dimens Crit Care Nurs*. 2017;36(1):14-21.
- Piriyapatsom A, Chittawatanarat K, Kongsayreepong S, et al. Incidence and Risk Factors of Unplanned Extubation in Critically Ill Surgical Patients: The Multi-Center Thai University-Based Surgical Intensive Care Units Study (THAI-SICU Study). *J Med Assoc Thai*. 2016;99 suppl 6:S153-S162.
- Danielis M, Chiaruttini S, Palese A. Unplanned Extubations in the Intensive Care Unit: Findings From A Critical Incident Technique. *Intensive Crit Care Nurs*. 2018;47:69-77.
- Kwon E, Choi K. Case-Control Study on Risk Factors of Unplanned Extubation Based on Patient Safety Model in Critically Ill Patients With Mechanical Ventilation. *Asian Nurs Res*. 2017;11(1):74-78.
- Metzner J, Posner KL, Lam MS, et al. Closed Claims' Analysis. *Best Pract Res Clin Anaesthesiol*. 2011;25(2):263-276.
- Cook TM, Woodall N, Frerk C. Major Complications of Airway Management in the UK: Results of the 4th National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth*. 2011;106(5):617-631.
- Chao CM, Sung MI, Cheng KC, et al. Prognostic Factors and Outcomes of Unplanned Extubation. *Sci Rep*. 2017;7(1):8636.
- Kapadia F. Effect of Unplanned Extubation on Outcome of Mechanical Ventilation. *Am J Respir Crit Care Med*. 2001;163(7):1755-1756.
- Lin PH, Chen CF, Chiu HW, et al. Outcomes of Unplanned Extubation in Ordinary Ward Are Similar to Those in the Intensive Care Unit. A STROBE-Compliant Case-Control Study. *Medicine*. 2019;98(11):e14841.
- Mort TC. Unplanned Tracheal Extubation Outside the Operating Room: A Quality Improvement Audit of Hemodynamic and Tracheal Airway Complications Associated With Emergency Tracheal Reintubation. *Anesth Analg*. 1998;86(6):1171-1176.
- Bhattacharya P, Chakraborty A, Agarwal P. Comparison of Outcome of Self-Extubation and Accidental Extubation in ICU. *Indian J Crit Care Med*. 2007;11(3):105-108.
- Rosenthal VD, Udwardia FE, Muñoz HJ, et al. Time-Dependent Analysis of Extra Length of Stay and Mortality Due To Ventilator-Associated Pneumonia in Intensive-Care Units of Ten Limited-Resources Countries: Findings of the International Nosocomial Infection Control Consortium (INICC). *Epidemiol Infect*. 2011;139(11):1757-1763.
- Karvouniaris M, Makris D, Manoulakas E, et al. Ventilator Associated Tracheobronchitis Increases the Length of Intensive Care Unit Stay. *Infect Control Hosp Epidemiol*. 2013;34(8):800-808.
- Gao F, Yang LH, He HR, et al. The Effect of Reintubation on Ventilator-Associated Pneumonia and Mortality Among Mechanically Ventilated Patients With Intubation: A Systematic Review and Meta-Analysis. *Heart Lung*. 2016;45(4):363-371.
- Chuang ML, Lee CY, Chen YF, et al. Revisiting Unplanned Endotracheal Extubation and Disease Severity in Inten-

sive Care Units. *PLoS One*. 2015;10(10):e0139864.

41. Epstein SK, Nevins ML, Chung J. Effect of Unplanned Extubation on Outcome of Mechanical Ventilation. *Am J Respir Crit Care Med*. 2000;161(6):1912-1916.
42. Elmetwally R, Elshafey M, Zeidan A, et al. Predictors and Outcome of Unplanned Extubation in COPD Patients. *Egypt J Anaesth* 2010;26(1):1-11.
43. Veldman A, Trautshold T, Weiss K, et al. Characteristics and Outcome of Unplanned Extubation in Ventilated Preterm and Term Newborns on a Neonatal Intensive Care Unit. *Paediatr Anaesth*. 2006;16(9):968-973.
44. Kanthimathinathan HK, Durward A, Nyman A, et al. Unplanned Extubation in a Paediatric Intensive Care Unit: Prospective Cohort Study. *Intensive Care Med*. 2015;41(7):1299-1306.
45. Roddy DJ, Spaeder MC, Pastor W, et al. Unplanned Extubations in Children: Impact on Hospital Cost and Length of Stay. *Pediatr Crit Care Med*. 2015;16(6):572-575.
46. Klugman D, Berger JT, Spaeder MC, et al. Acute Harm: Unplanned Extubations and Cardiopulmonary Resuscitation in Children and Neonates. *Intensive Care Med*. 2013;39(7):1333-1334.
47. Lee JH, Lee HC, Jeon YT, et al. Clinical Outcomes After Unplanned Extubation in a Surgical Intensive Care Population. *World J Surg*. 2014;38(1):203-210.
48. Dasta JF, McLaughlin TP, Mody et al. Daily Cost of an Intensive Care Unit Day: The Contribution of Mechanical Ventilation. *Crit Care Med*. 2005;33(6):1266-1271.
49. Needham DM, Pronovost PJ. The Importance of Understanding the Costs of Critical Care and Mechanical Ventilation. *Crit Care Med*. 2005;33(6):1434-1435.
50. Vats A, Hopkins C, Hatfield K, et al. An Airway Risk Assessment Score for Unplanned Extubation in Intensive Care Pediatric Patients. *Pediatr Crit Care Med*. 2017;18(7):661-666.
51. Chao CM, Lai CC, Chan KS, et al. Multidisciplinary Interventions and Continuous Quality Improvement to Reduce Unplanned Extubation in Adult Intensive Care Units. A 15-Year Experience. *Medicine*. 2017;96(27):e6877.
52. Chiang AA, Lee KC, Lee JC, et al. Effectiveness of a Continuous Quality Improvement Program Aiming To Reduce Unplanned Extubation: A Prospective Study. *Intensive Care Med*. 1996;22(11):1269-1271.
53. Tripathi S, Nunez DJ, Katyal C, et al. Plan To Have No Unplanned: A Collaborative, Hospital-Based Quality-Improvement Project To Reduce the Rate of Unplanned Extubations in the Pediatric ICU. *Respir Care*. 2015;60(8):1105-1112.
54. Fontanez-Nieves TD, Frost M, Anday E, et al. Prevention of Unplanned Extubations in Neonates Through Process Standardization. *J Perinatol*. 2016;36(6):469-473.
55. Kandil SB, Emerson BL, Hooper M, Ciaburri R et al. Reducing Unplanned Extubations Across a Children's Hospital Using Quality Improvement Methods. *Pediatr Qual Saf* 2018;3: e114.
56. Galote JP, Rodiere M, Carman J et al. Reduction in Unintended Extubations in a Level IV Neonatal Intensive Care Unit. *Pediatrics* 2019;143; e20180897.
57. Scales DC, Dainty K, Hales B, et al. A Multifaceted Intervention for Quality Improvement in a Network of Intensive Care Units: A Cluster Randomized Trial. *JAMA*. 2011;305(4):363-372.
58. Bouadma L, Deslandes E, Lolom I, et al. Long-Term Impact of A Multifaceted Prevention Program on Ventilator-Associated Pneumonia in a Medical Intensive Care Unit. *Clin Infect Dis*. 2010;51(10):1115-1122.
59. Fisher DF, Chenelle CT, Marchese AD, et al. Comparison of Commercial and Noncommercial Endotracheal Tube-Securing Devices. *Respir Care*. 2014;59(9):1315-1323.
60. Gardner A, Hughes D, Cook R, et al. Best Practice in Stabilisation of Oral Endotracheal Tubes: A Systematic Review. *Aust Crit Care*. 2005;18(4):158, 160-165.
61. Mehta NM, Sharma S, Laussen PC. Unplanned Extubation: Securing the Tool of Our Trade. *Intensive Care Med*. 2015;41(11):1983-1985.
62. Umoren RA, Poore JA, Sweigart L, et al. TeamSTEPPS Virtual Teams: Interactive Virtual Team Training and Practice for Health Professional Learners. *Creat Nurs*. 2017;23(3):184-191.

63. Murphy M, Curtis K, McCloughen A. What is the Impact of Multidisciplinary Team Simulation Training on Team Performance and Efficiency of Patient Care? An Integrative Review. *Australas Emerg Nurs J*. 2016;19(1):44-53.

64. Patel A, Nouraei SA. Transnasal Humidified Rapid-Insufflation Ventilator Exchange (THRIVE): A Physiological Method of Increasing Apnoea Time in Patients With Difficult Airways. *Anaesthesia*. 2015;70(3):323-329.

65. Jaber S, Monnin M, Girard M, et al. Apnoeic Oxygenation Via High-Flow Nasal Cannula Oxygen Combined With Non-Invasive Ventilation Preoxygenation for Intubation in Hypoxaemic Patients in the Intensive Care Unit: The Single-Centre, Blinded, Randomised Controlled OPTINIV Trial. *Intensive Care Med*. 2016;42(12):1877-1887.

66. Neligan PJ, Malhotra G, Fraser M, et al. Continuous Positive Airway Pressure Via the Boussignac System Immediately After Extubation Improves Lung Function in Morbidly Obese Patients With Obstructive Sleep Apnea Undergoing Laparoscopic Bariatric Surgery. *Anesthesiology*. 2009;110(4):878-884.

67. Zoremba M, Kalmus G, Begemann D, et al. Short Term Non-Invasive Ventilation Post-Surgery Improves Arterial Blood-Gases in Obese Subjects Compared to Supplemental Oxygen Delivery—A Randomized Controlled Trial. *BMC Anesthesiol*. 2011;11:10.

68. Patient Safety Movement. Actionable Patient Safety Solutions. Challenge 8: Airway Safety. <https://patientsafetymovement.org/actionable-solutions/challenge-solutions/airway-safety/>. Accessed April 10, 2019.

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