COMPLICATIONS OF UNPLANNED EXTUBATION

RECOGNITION & PREVENTION

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INTRODUCTION

Endotracheal intubation is a valuable intervention that is utilized in the out of hospital, military, emergency department, surgery, post-anesthesia, and intensive care settings for patients of all ages to control and protect the airway, and to facilitate mechanical ventilation. However, endotracheal intubation is inherently a temporary procedure designed to support patients until they are able to maintain their own airway and ventilation, or to provide temporary airway control prior to placement of a more permanent airway. As a result, ALL intubated patients ultimately require extubation, a procedure which under the best of circumstances may be associated with significant complications including the need for reintubation.[1]

Extubation is categorized as either planned or unplanned. Planned extubation refers to weaning from mechanical ventilation and removal of the endotracheal tube as planned by the medical team. Unplanned extubation is defined as premature removal of the endotracheal tube by actions of the patient, or during nursing care or manipulation of the patient.[2-10] This paper will focus on unplanned extubation.

INCIDENCE

A comprehensive guided review of the literature reported that unplanned extubation occurs in 7.3% (median) of all adult ICU intubated patients.[7] Other studies have found adult ICU occurrence rates from 2.0% to 10%.[6,11,12] The clear majority (62.8%-96.4%) of unplanned extubations in adult intensive care units are the result of patient self-extubation.[3-5,11,13] Data from outside the anesthesia and ICU settings are scant, but two studies suggest the unplanned extubation rate in the emergency medical services (EMS) setting is approximately 3%, but it is likely higher since these studies relied solely on voluntary self-reporting.[14,15]

Unplanned extubation is the fourth most common adverse event in the Neonatal Intensive Care Unit (NICU).[16] Incidence in the NICU is between 1-4.8 unplanned extubations per 100 ventilated days.[16,17] In a prospective study in a combined pediatric/neonatal ICU da Silva and colleagues found the unplanned extubation rate to be 18.7%.[18] Self-extubation is the most frequent cause of unplanned extubation in neonates (60%); accidental extubation during retaping of the tube, suctioning, weighing, or ventilator circuit changes make up the remainder.[19]

RISK FACTORS

Unplanned extubation can only occur when an endotracheal tube is inadequately secured, allowing either deliberate or accidental forces to pull the tube out of the trachea.[20,21] Current securement practices fall into two broad categories. The first is "manual" and utilizes either twill or a variety of types of adhesive tape to secure the tube. Typically twill tape is cinched around the tube and then wrapped and tied behind the neck to secure the cinch point at the mouth. Adhesive tape is usually wrapped around the tube and then taped to the cheek and neck or pulled together behind the neck, again with the purpose of securing the point where the tape goes around the tube at the mouth. The second category incorporates "commercial devices" specifically designed to secure endotracheal tubes. These devices wrap behind the neck and connect to the endotracheal tube by either a cloth or plastic strip that surrounds the tube, a screw that squeezes the tube, or a channel that the tube goes through. Some commercial devices also utilize adhesive to secure the device to the patient's face. Device effectiveness is typically measured by the amount of force required to displace the device, ability to hold the endotracheal tube in place, ease of application, degree of pressure damage the device causes to oral mucosa, lips, and facial skin, and patient satisfaction or pain.[20,22]

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Reduction of endotracheal tube movement is another goal of tube securement. Movement of the tube caudally (pulling the distal tip toward the head) risks damage to the vocal cords by the endotracheal tube cuff as well as complete removal of the tube. Movement in the opposite direction may cause the distal tip of the endotracheal tube to enter the mainstem bronchus (usually the right). There is no consensus in the literature regarding the maximum safe movement of an endotracheal tube for adults. Santhosh et al proposed a 4-point endotracheal tube slippage scale. <0.5 cm movement was characterized as "no slippage" with no risk for accidental extubation. Mild slippage (0.5-1.0 cm) offered mild risk for extubation, moderate slippage (1-2 cm) created moderate risk for extubation, and severe slippage (>2 cm) signaled a high risk for accidental extubation.[23] Other authors suggest that ET tube position should be assessed radiographically if > 1-2 cm movement occurs, and reintubation performed with > 2-4 cm movement.[24-26] Based on anatomical studies Varshney et al observed that ET tubes inserted using the "black mark" as the depth indicator can only be moved caudally 1.5-2.5 cm before the cuff impacts the vocal cords [27]. Based on these studies it appears that an effective tube securement device should not allow more than 3-3.5 cm of movement, assuming optimal positioning of initial placement.

There is limited literature available regarding the relative effectiveness and complications associated with various tube securement practices, but several themes can be identified. First, any securement device is more secure than having care providers manually hold the tube.[14] In comparisons between twill and tape (manual methods),

twill appears to be superior in providing security and minimizing damage to the oral mucosa, lips, and skin.[22,28] Twill also appears to compress the jugular veins less, and is associated with less patient pain.[28] The performance of tape appears to vary widely depending upon the type of tape used.[29,30] Tape has been found to be an unnecessary source of hospital acquired infection: an integrative review of the literature found that 35-74% of the tape used in the ICU colonized significant bacteria including MRSA and vancomycin-resistant enterococcus.[31]

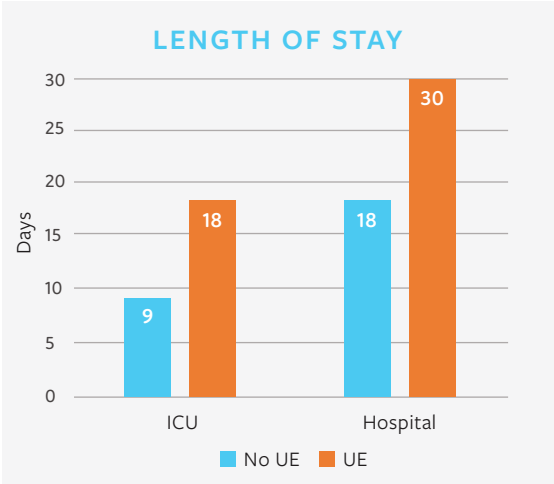
Overall, several authors note that there is currently no ideal device available for tube securement.[20,22]

When comparing commercial devices with manual methods it appears that commercial devices provide superior security and less tissue injury (skin and mucosa) than tape or twill.[22,24,25] Tape has also been associated with skin avulsion injury during extubation.[32] However, in the only study that has directly measured pressure exerted on the skin commercial devices were shown to exert more pressure than tape or twill.[20] Adhesive tape is also less expensive than any other option.[25] Commercial devices vary in their ability to maximize securement and minimize mucosal/skin damage. One institution reported that the incidence of oral pressure injuries increased 243% during the transition from cloth tape to a commercial endotracheal tube fastener. In addition to the increase in the frequency of oral pressure injuries the transition also shifted the location of oral lesions from the corners of the mouth to the lips.[33] Overall commercial devices that simply wrap around the endotracheal tube without utilizing adhesive, a screw device, or a security cylinder are less secure than those that do.[30] The best securement is provided by devices that either have a positive way to attach to the endotracheal tube or are secured to the face using adhesive,[34] although adhesive has potential to increase damage to the face and lips.[20] Overall, several authors note that there is currently no ideal device available for tube securement.[20,22]

In addition to tube securement there are a number of other factors that are associated with the risk of unplanned extubation. Patients that are restless or agitated are more likely to self-extubate.[7,19,35] In fact, one study found that 61% of patients who self-extubated were agitated at the time of the event.[36] Two additional risk factors are associated with self-extubation: inadequate sedation[10,37] and the use of physical restraints, both presumably related to agitation.[37,38] Patients who have a nosocomial infection are also more prone to uncontrolled extubation.[38] Attributes of the intensive care setting have also been associated with increased risk for self- or accidental- extubation. Some evidence suggests that the mode of ventilation in use may increase the risk for self-extubation.[35] Units that do not have clear policies related to weaning, or that are lax in their utilization of policies are also at a higher risk for unplanned extubation.[37] There are inconclusive studies that suggest that nursing shifts, experience of nursing and respiratory care personnel or the absence of clear policies related to weaning contribute to the incidence of unplanned extubation.[37] Neonates are especially likely to experience unplanned extubation related to movement. Neck extension has been reported to create as much as 0.9 cm movement toward the carina or 1.7 cm movement toward the vocal cords.[21] In addition to the risk factors noted above the following are unique to pediatric/neonatal populations:

Neonates: gestational age 30-36 weeks, weight < 1,000 g[39]

Pediatrics: age < 6, planned extubation in next 12 hours, nurse working in unfamiliar unit[40]



COMPLICATIONS

Unplanned extubation creates a variety of complications. De Lassence found that patients who experienced unplanned extubation required substantially longer ICU length of stay (18 vs 9 days) and hospital length of stay (30 vs 18 days). In addition, they had more than double the incidence of ventilator acquired pneumonia (30% vs. 13.8%).[11] These complications and prolonged ICU stay result in a 41% increase in cost, from an average of $56,206 to $100,198 per patient.[41,42] Not surprisingly, an increased APACHE II score and the presence of co-morbidities such as uremia or liver cirrhosis increase the risk of death in patients who experience a UE.[43]

The risk of unplanned extubation also impacts an important treatment guideline in the intensive care setting. Clinical Practice Guidelines for the Management of Pain, Agitation, and Delirium in Adult Patients in the Intensive Care Unit describes the importance of spontaneous awakening trails, spontaneous breathing trails, and early ambu-

lation in reducing complications and improving outcomes for intubated/ventilated patients in ICU.[44,45] One of the most prevalent barriers to execution of these guidelines is staff and patient fear of unplanned extubation during these activities.[46-49]

Similar complications are reported in pediatric and neonatal ICU studies. Veldman et al reported that unplanned extubation increased NICU LOS from 9 to 51 days, and total hours of mechanical ventilation from 52-345 hours.[21] A similar study in a pediatric ICU described increases in ICU LOS (10 vs. 4.5 days) and hospital LOS (16.5 vs. 10 days) associated with unplanned extubation. The study attributed a 36% increase in cost associated with UE, from a median of $64,618 to $101,310.[50]

An increase in complications and mortality is associated with the need for reintubation following UE. Da Silva reported an average of 45.8% of adults who experienced an unplanned extubation required reintubation.[7] Other authors report higher reintubation rates between 47%-79.6%.[6,11,12,35] The need for reintubation has been shown to be most likely in adults with pneumonia.[51] Reintubation is associated with additional complications including increased mortality in patients immediately post-op (from 3% to 11%).[3]

Pediatric and neonatal ICU patients have similar complications related to reintubation. One study reported that 43% of UE patients required reintubation, as compared to only 8% of patients who were weaned without UE. Patients requiring reintubation required 2 additional PICU days (4.6 vs. 2.6 days) when compared to patients without reintubation.[52] One small retrospective study reported that 63% of pediatric UEs required reintubation, and that 20% of the reintubated patients experienced cardiovascular collapse, the majority requiring CPR.[53]

PREVENTION

Prevention of unplanned premature extubation begins with securement. As noted above multiple authors have described the absence of an optimal endotracheal tube stabilizer for patients of any age.[15,20-22,24-26,28,30,34,54-56] Attributes of the optimal securement device include:[20,22,31,33,57]

- Easy to apply and maintain
- Adequate stabilization of the tube against external forces that risk dislodgement
- Prevention of tube movement >3.5 cm
- Security is not compromised when the device is exposed to blood, saliva, or other fluids
- Secures the endotracheal tube without compressing the tube and decreasing the internal diameter
- Enables movement of the tube in the mouth for oral care and ulceration prevention without jeopardizing the position of the distal tip
- Facilitates suctioning of the tube and oropharynx without risk of tube movement
- Allows good visualization of the oral cavity
- Requires infrequent adjustment or change
- Minimizes or eliminates skin pressure
- Avoids the use of adhesives that may cause skin tears
- Cost and time effective
- Enhances patient comfort

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In addition to providing optimal securement, unplanned extubation can be reduced through:[8]

- Process standardization and compliance related to sedation and restraint
- Staff education on airway care, monitoring, and recognition of UE
- Identification of every UE incidence with careful root cause analysis and improvement. Ongoing tracking of rates.
- Continuous sedation of intubated/ventilated patients with daily sedation break for assessment
- Careful and appropriate restraint

SUMMARY AND CONCLUSION

Unplanned extubation is a common, costly, and preventable complication that can result in brain damage, death and most commonly, ventilator-acquired pneumonia leading to prolonged ICU and hospital length of stay with a near-doubling of ICU costs. Inadequate tube securement is a universal factor in ALL unplanned extubations. Ineffective use of unit protocols related to patient restraint, sedation, and weaning by appropriately trained nursing and respiratory therapy staff also contribute the occurrence of unplanned extubation.

Prevention requires a comprehensive and intentional approach that effectively addresses these primary causes using the following principles:

The endotracheal tube should be secured using a commercial device that is easy to apply and maintain, prevents the tube from moving > 3.5 cm when force is applied by the patient or during care procedures without compromising the internal tube diameter, enables oral care and suctioning, and minimizes or eliminates skin pressure and the use of adhesives that may cause skin tears.

Guidelines for care of intubated/ventilated patients should be evidence-based and provide clear parameters for use of sedation, patient restraint, and patient monitoring.

Patient care team members, including physicians, nurses, and respiratory therapy staff, should be well trained on use of the guidelines. Staffing should be adequate 24/7/365 to enable safe monitoring and patient care consistent with the guidelines.

When unplanned extubation (intentional as well as unplanned) occurs, it should be documented, and the rate of incidence monitored as is done with other care complications. Individual cases should be reviewed to identify causative factors, with necessary changes in care guidelines and provider training as necessary.

Adherence to these guidelines combined with the development of improved securement devices, evolving guidelines for safe reduction of sedation in the ICU during ventilator weaning, and more reliable standards for documentation and tracking of unplanned extubation offer promise for reducing the incidence of this serious and preventable complication.

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