Improve endotracheal tube management **in neonatal patients**

The presence of an endotracheal tube (ETT) places patients at risk for several complications. Among neonatal patients, invasive mechanical ventilation tends to be required in the most premature, vulnerable patients who can suffer significant harm from endotracheal tube-related issues, such as unplanned extubations, tube misplacement, or ETT suctioning-related stress.[1-6]

Utilize this guide for background on the types of endotracheal tube-related issues and stressful interventions that may be mitigated with additional monitoring via the SonarMed™ airway monitoring system.

TABLE OF **CONTENTS**

MANAGING ENDOTRACHEAL TUBES IN NEONATAL PATIENTS

OVERVIEW

Keeping an endotracheal tube (ETT) in place can be challenging in neonates as they are not typically paralyzed.[7] Movement can lead to migration of the ETT, which can lead to dislodgement or an unplanned extubation (UE).[8, 9]

UEs are a significant safety concern for neonates. UEs are the most common adverse event during mechanical ventilation in the neonatal intensive care unit (NICU). The risk of UEs in neonates is higher when compared to other populations. UEs often result in an emergent reintubation and may cause cardiovascular collapse, leading to an increase in hospital length of stay and costs.[4, 10]

Learn more:

Unplanned extubations | Endotracheal tube malposition | Tube movement in neonates

The frequency and timing of ETT suctioning, one of the most common procedures in the NICU, is controversial.[11, 12] Though it is essential to prevent life threatening obstruction of the endotracheal tube, the procedure is not without complications and adverse effects.[11] Therefore, it should be used as infrequently as possible while still preventing ETT obstruction. While clinical assessment is recommended to inform whether suctioning is indicated, there is limited evidence evaluating which clinical signs are most predictive of suctioning need.[11, 13]

Learn more:

Suctioning-related harm

Evidence has demonstrated that over-stimulation and caregiving interventions associated with NICU care may be detrimental to neurobehavioral outcomes.[14] A review of the frequency of stressful or painful procedures average that neonates undergo 16 such procedures on average per day.[15]

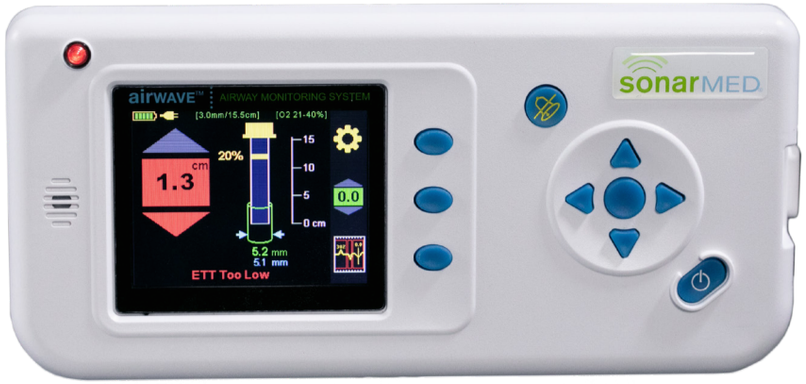
Learn more:

Chest radiographs | Safe kangaroo care

SONARMED™ AIRWAY MONITORING SYSTEM OVERVIEW

SONARMED™ AIRWAY MONITORING SYSTEM OVERVIEW

A minimally disruptive solution that provides actionable airway management information



The SonarMed™ airway monitoring system may help improve a clinician's ability to manage a patient's airway — offering peace of mind to caregivers — by providing precise, continuous, real-time monitoring of the ETT position and patency.

- Helps reduce unplanned extubations
- Optimizes suctioning
- Monitors ETT movement

Throughout the duration of an intubation, the SonarMed™ airway monitoring system:

- Measures the location of the ETT tip within the trachea, and may assist in detection of any movement, to help reduce unplanned extubations
- Assists in identifying the location of any obstructions within the ETT, and the percentage obstructed, for optimized suctioning and removal
- Measures the circumference of the patient's trachea at the tip of the ETT to observe any movement toward a smaller or larger passageway

ENDOTRACHEAL TUBE RELATED **ADVERSE EVENTS**

UNPLANNED EXTUBATIONS

UEs are a frequent and harmful adverse event in mechanically ventilated neonates. UE and subsequent re-intubation is associated with several adverse effects, including cardiopulmonary deterioration, ventilator-associated pneumonia, hypoxemia, hypercarbia, laryngeal trauma, and subglottic stenosis.[18] There are multiple patient-specific and treatment-specific factors that contribute to the risk of UEs.

Frequent:

- 14-41% of infants experience a UE during their NICU hospitalization[4]
- UE rates vary by institution and from 0.54 to 16.1 UE per 100 ventilator days[4]

Harmful and costly:

- Compared to matched patients, patients who suffer UEs have:[4]
  - Excess MV LOS of 6.5 days
  - Excess inflation-adjusted total hospital costs of $49 587

Multifactorial underlying causes:

- Risk factors for UEs include:[19]
  - Age (younger patients)
  - Inadequate tube fixation
  - Agitation
  - Copious secretions
  - Performance of patient procedures
  - Nursing workload
  - Manipulation at the time of UE

ENDOTRACHEAL TUBE RELATED **ADVERSE EVENTS**

UNPLANNED EXTUBATIONS (CONT'D)

Klugman, D. et al.[20]

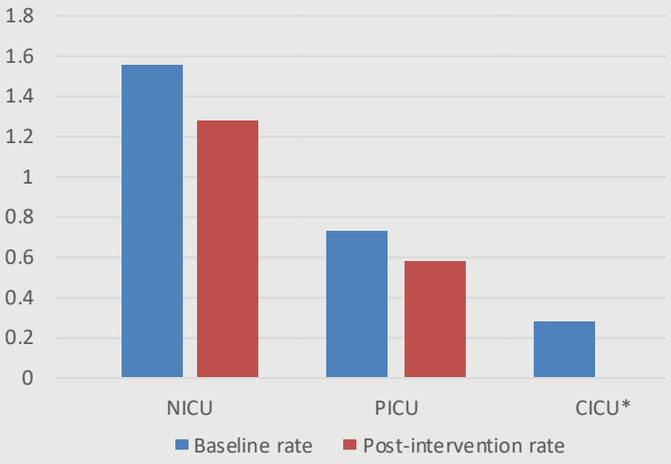
Assessment of an Unplanned Extubation Bundle to Reduce Unplanned Extubations in Critically Ill Neonates, Infants, and Children

JAMA Pediatr 2020 Vol. 174 Issue 6 Pages e200268

Key takeaways:

- UEs rate are higher in the NICU
- Interventions were less effective in the NICU (17.6% absolute reduction) compared to the PICU (20.6% absolute reduction)
- Even after implementation of a quality improvement bundle, the rate of UEs in the NICU was still higher than the goal of less than 0.95 UEs rate for 100 vent days set by Children's Hospitals' Solutions for Patient Safety initiative[21]

UE rate by unit before and after implementation of quality improvement bundle



*No change during study period

STUDY INFORMATION	
STUDY DESIGN	Quality improvement historical controlled study
METHODS	Forty-three children's hospital implemented an unplanned intubation bundle consisting of standardized procedures for: ▪ Securing, assessing, repositioning, and manipulating ETTs ▪ Managing tubes during high-risk situations
RESULTS	▪ Overall UE rate declined from 1.135 to 0.862 per 100 ventilator days ▪ UE rates varied significantly by unit type (figure 1) ▪ Nearly 60 of UEs required reintubation ▪ UE-related cardiovascular collapse declined from 0.041 to 0.025 per 100 ventilators days

ENDOTRACHEAL TUBE RELATED **ADVERSE EVENTS**

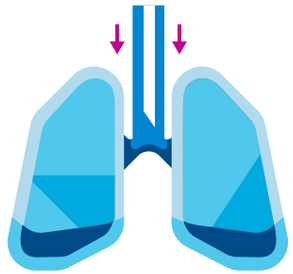
35%
OF NICU PATIENTS
experience ETT misplacement[26]

ENDOTRACHAEL TUBE MALPOSITION

In preterm neonates, the difference between bronchial intubation and risk for unplanned extubation is only a few centimeters.[22]

Inappropriate positioning of the endotracheal tube is associated with a number of adverse events, including atelectasis, hyperinflation, pneumothorax, cardiac arrythmias, or UE.[23,24]

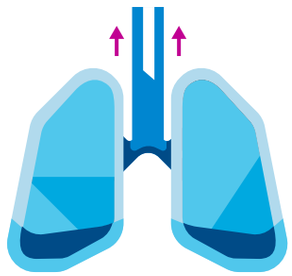
- In a prospective review of neonatal patients whose endotracheal tube depth was set according to the AHA/AAP Pediatric Advanced Life Support guidelines, Volsko et al. found that 69% of endotracheal tubes were malpositioned, with 11.8% positioned above the thoracic inlet and 88.2% positioned < 1 cm above the carina.[22]



ETT
RIDING LOW
Increases the risk of the tube entering a bronchial stem.[4]

Consequences of placing the tube too low:

- In patients where bronchial intubation occur, ventilation is impaired, and the patient is at-risk for ventilator induced lung injury by excessively ventilating one lung and inadequately ventilating the other.[24,27,28]
- Premature patients with immature lungs are particularly vulnerable in this circumstance due to low compliance associated with surfactant deficiency and fluid-filled alveoli, which increases risk of pneumothorax in one lung and atelectasis in the other[23,29]

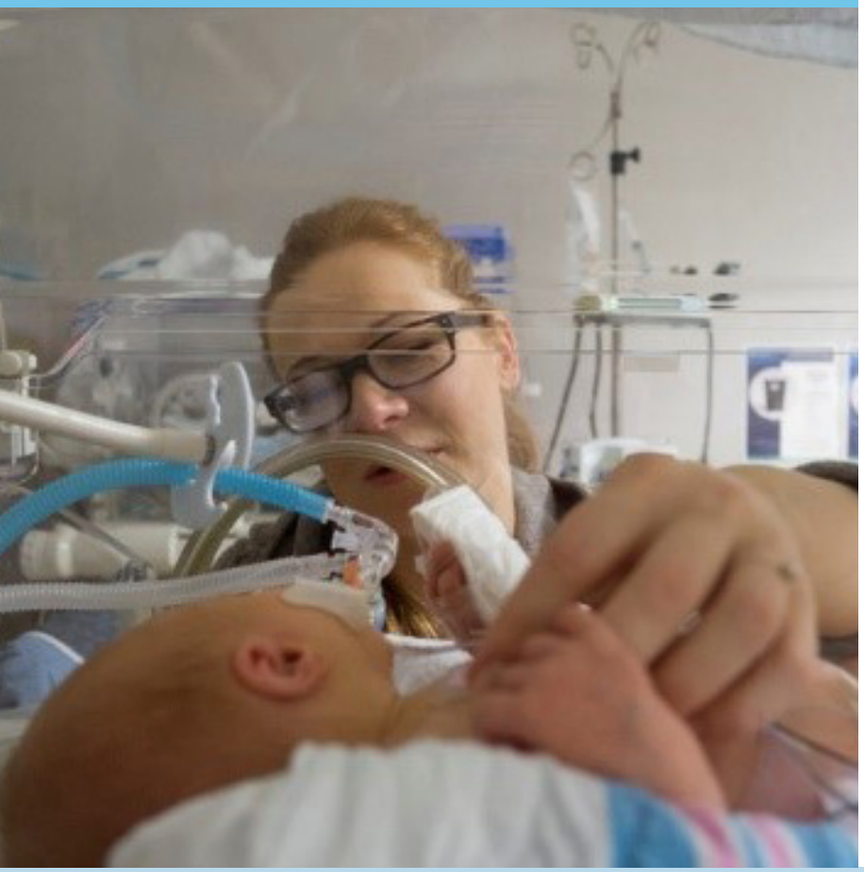


ETT
RIDING HIGH
Increases the risk of tube dislodgement from the trachea.[4]

Consequences of placing the tube too high:

- In a pre/post intervention study investigating the influence of an unplanned intubation prevention bundle that emphasized placing the tube tip below T1, Morris et al. found that high endotracheal tubes are associated with a greater risk of UE.[8]

ENDOTRACHEAL TUBE RELATED **ADVERSE EVENTS**



TUBE MOVEMENT IN NEONATES

Patient movement is associated with migration of the endotracheal tube, which even after initial proper placement may lead to bronchial intubation or unplanned extubation.[9] Extension of the cervical spine will cause the tube to move towards the head. When the head is in a flexed position, the tube will move away from the head.[9]

Movement from patient care and repositioning may contribute to UEs.[18] In neonates, movement is typically not restricted in order to limit sedative exposure.[17]

In a trial of an unplanned extubation quality improvement bundle, Klugman et al.[20] identified the following high-risk procedures as requiring two clinicians for monitoring tube position and preventing movement:

- Bedside imaging procedures
- Bedside invasive procedures
- Kangaroo care/parent holding
- Routing repositioning
- Switching beds
- Early mobility

Consequently, many unplanned extubation prevention programs include assessment of tube positioning at regular periods as well as before and after high-risk procedures.[18, 20, 30, 31]

ENDOTRACHEAL TUBE RELATED **ADVERSE EVENTS**

ETT SUCTIONING-RELATED HARM

The frequency and timing of suctioning ETTs in neonatal patients is controversial. Though it is essential to prevent life threatening complete obstruction of the endotracheal tube, the procedure is not without complications and adverse effects.[11] Therefore, it should be used as infrequently as possible while still preventing obstruction. While clinical assessment is recommended to inform whether suctioning is indicated,[11] there is limited evidence evaluating which clinical signs are most predictive of suctioning need.[13]

Consequences of under-suctioning:

- **Partial occlusion:** Increased airway resistance, which may lead to increased work of breathing and potentially delayed weaning.[33]
- **Complete occlusion:** Medical emergency requiring immediate intervention[33]

Adverse consequences of suctioning:

- Greater risk of ventilator associated pneumonia[34]
- Pain and distress[35]
- Negative end-expiratory pressure,[36] leading to:
  - Reduction in end expiratory lung volume regardless of suctioning method[37-39]
  - Alveolar derecruitment[38, 39]
  - Hypoxemia[39]
- Excessively high expiratory tidal volume and airway pressures following suctioning in patients receiving volume guaranteed ventilation[40]
- Hemodynamic instability
  - Decreases in respiratory rate[41]
  - Lower heart rate[41]
  - Prolonged increases of mean cerebral blood flow velocity[42]

MINIMIZING
STRESS

CHEST RADIOGRAPHS

The American Academy of Pediatrics lists daily chest x-rays as one of top five tests or treatments that lack evidence of efficacy and therefore contribute to "unnecessary utilization of staffing or material resources."[43] Though chest x-rays are considered the "gold standard" for confirming tube placement or misplacement, they contribute to radiation exposure, can be delayed, and require manipulation of the patients, which may move the tube.[44]

- A quality initiative published by Ridore et al. to restrict the frequency of chest x-rays found that they could reduce the number of x-rays by nearly half, saving almost $1.6m annually, without an increase in the number unplanned extubations.[45]
- As mentioned above, Klugmen et al. considers chest x-rays to one of the procedures that is associated with a high risk of unplanned extubations.[20]
- Finally, a prospective study documenting the frequency that neonatal patients undergo painful or stressful procedures found that x-rays account for 6% of all stressful procedures.[15]

MINIMIZING **STRESS**

SAFE KANGAROO CARE

Kangaroo mother care, which is defined as skin-to-skin contact and frequent breastfeeding, has been demonstrated to be associated with multiple positive outcomes in low birthweight infants, including reduced mortality and nosocomial infections as well as increased weight gain and growth.[46] Unfortunately, kangaroo care, due to significant patient repositioning, is also considered a risk factor for UEs.[19, 20]

In fact, a survey of 1,122 nurse managers in hospitals in the United States found that 77% of respondents consider fear of UE to be a significant barrier to kangaroo care implementation.[47]

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