Office of Evidence Based Practice – Specific Care Question: Prevention of Unplanned Extubations in the ICN

Specific Care Question :
For the patient in the ICN (neonate, infant) who is mechanically ventilated, does the method of securing an endotracheal tube (ETT) or other ETT cares (identification of tube depth, documentation of tube position, methods of turning the patient) influence unplanned extubations?

Question Originator:
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Plain Language Summary:

Background

Babies who are in the Neonatal Intensive Care Unit (NICU) may need an endotracheal tube (ETT) inserted to help them breathe. A primary goal of caregivers is to ensure the ETT stays in place. Making sure an ETT does not change position is a challenge. There are many reasons why an ETT may become dislocated: patient movement such as turning the baby or changing a diaper may change the head position and therefore the ETT position. Donn, Khuns & Lawrence (1980) reported that when the skull and upper cervical spine are flexed, extended, or rotated the ETT position is altered. Drool and other fluids can weaken the stickiness of tape used to secure the ETT.

If an ETT is not in the right place, the tube may fall out which is called an unplanned extubation (UPE). NICU caregivers have tried many things to make sure the ETT stays in place. The aim of this synopsis was to analyze published papers, and report on the successful methods used to keep ETTs in place.

Study characteristics

The search for suitable studies was completed in CINAHL November 2017 and PubMed December 2017. Nancy Allen, MS, MLS, RD, LD reviewed the 69 titles and abstracts found in the search and identified 17 articles believed to answer the question. After an in-depth review seven articles answered the question. See Table 1 for excluded studies.

Key results

The purpose of this review is to summarize countermeasures, or interventions, that have been used to reduce unplanned extubation rates in NICUs. No RCTs were identified, so meta-analysis could not be performed. The quality of the evidence is very low. The aim of this synopsis is to collect the countermeasures reported in the literature to prevent UPEs. Seven papers identified from the search strategy below described countermeasures to decrease UPE. Countermeasures and the number of papers that reported the actions are in Table 2.

Summary by Outcome:

Literature Summary:

UPE is a patient safety and quality assurance concern. Hatch et al. (2016) listed non-severe and severe adverse events of UPEs (see Table 1). The remainder of the articles from which the countermeasures were gleaned were either reports of quality improvement, evidence based practice, or LEAN projects.

Table *1*

Adverse Events Associated with Unplanned Extubations

Non-severe Events	Severe Events
Esophageal intubation with immediate recognition	Esophageal intubation with delayed recognition
Oral/airway bleeding	Hypotension that requires any treatment
Difficult bag-mask ventilation	Transition to emergent care
Main stem bronchial intubation (confirmed by chest radiograph)	Chest compressions
Emesis	Pneumothorax
Chest wall rigidity	Direct airway trauma
	Death

Countermeasures were usually bundles of actions; the effect of a single countermeasure cannot be assessed. However, the studies described countermeasures incorporated in the projects, and description and effect can be found in Table 4

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Nancy Allen, MS, MLS, RD, LD

Search Strategy and Results:

- PubMed:
  - Search performed on 12/2017 Search: ("Unplanned extubation" OR "Unplanned extubations" OR (("Respiration, Artificial/adverse effects"[Mesh] OR "Airway Extubation"[Mesh] OR "Intubation, Intratracheal"[Mesh] OR "Endotracheal Tube"[tw]) AND (unplanned[tw] OR accident[tw] OR accidental[tw] OR tape*[tw] OR "Retreatment"[Mesh]))) AND (newborn* OR "neonatal intensive care"[tw] OR neonate* OR infant OR "Intensive Care Units, Neonatal"[Mesh] OR NICU[tw] OR "Intensive Care Units, Pediatric"[Mesh]) Filters: From 2012/01/01 to 2018/12/31 57 results
  - Search performed on 11/9/2017 ("Airway Extubation"[Mesh] AND "Intubation, Intratracheal"[Mesh]) AND "Infant, Newborn"[Mesh] 2 results
  - Search performed on 04/28/2017 ("Airway Extubation"[Mesh] AND "Intubation, Intratracheal"[Mesh]) AND "Infant, Newborn"[Mesh] 25 results

  - Search performed on 10/12/2016 ("Airway Extubation"[Mesh] AND "Intubation, Intratracheal"[Mesh]) AND "Infant, Newborn"[Mesh] 0 results
  - Search performed on 12/31/2015 ("Airway Extubation"[Mesh] AND "Intubation, Intratracheal"[Mesh]) AND "Infant, Newborn"[Mesh] 15 results
- CINAHL:
  - Search performed on 11/9/2017 : [MH "Endotracheal Tubes" AND "Tapes", (Limiters - Published Date: 20151031-20161012); Age Groups: Infant, Newborn: birth-1 month, Infant: 1-23 months 1 result
  - Search performed on 04/28/2017 : [MH "Endotracheal Tubes" AND "Tapes", (Limiters - Published Date: 20151031-20161012); Age Groups: Infant, Newborn: birth-1 month, Infant: 1-23 months 0 results
  - Search performed on 10/12/2016 : [MH "Endotracheal Tubes" AND "Tapes", (Limiters - Published Date: 20151031-20161012); Age Groups: Infant, Newborn: birth-1 month, Infant: 1-23 months 0 results
  - Search performed on 12/31/2015 : [MH "Endotracheal Tubes" AND "Tapes", (Limiters - Published Date: 20050101-20151031); Age Groups: Infant, Newborn: birth-1 month, Infant: 1-23 months 62 results
- Google Scholar:
  - Search preformed on 11/9/2017: " Neobar®endotracheal tube" (Published date 20161012- 20170428) -3 results
  - Search performed on 04/28/2017: " Neobar®endotracheal tube" (Published date 20161012- 20170428) -2 results
  - Search performed on 10/12/2016 " Neobar® endotracheal tube" (Published date 20151231-20161012) -2 results
- Ancestry search on references from Donn (1980) Results 58

Studies included in this review:

Crezee, DiGeronimo, Rigby, Carter, and Patel (2017)
Donn and Kuhns (1980)
Fontanez-Nieves et al. 2016)
Hatch et al. (2016)
Hu et al. (2017)
Longnathan et al. (2017)
Merkel et al. (2014)
Powell, Gilbert, and Volsko (2016)

Studies <u>not</u> included in this review with rationale for exclusion:

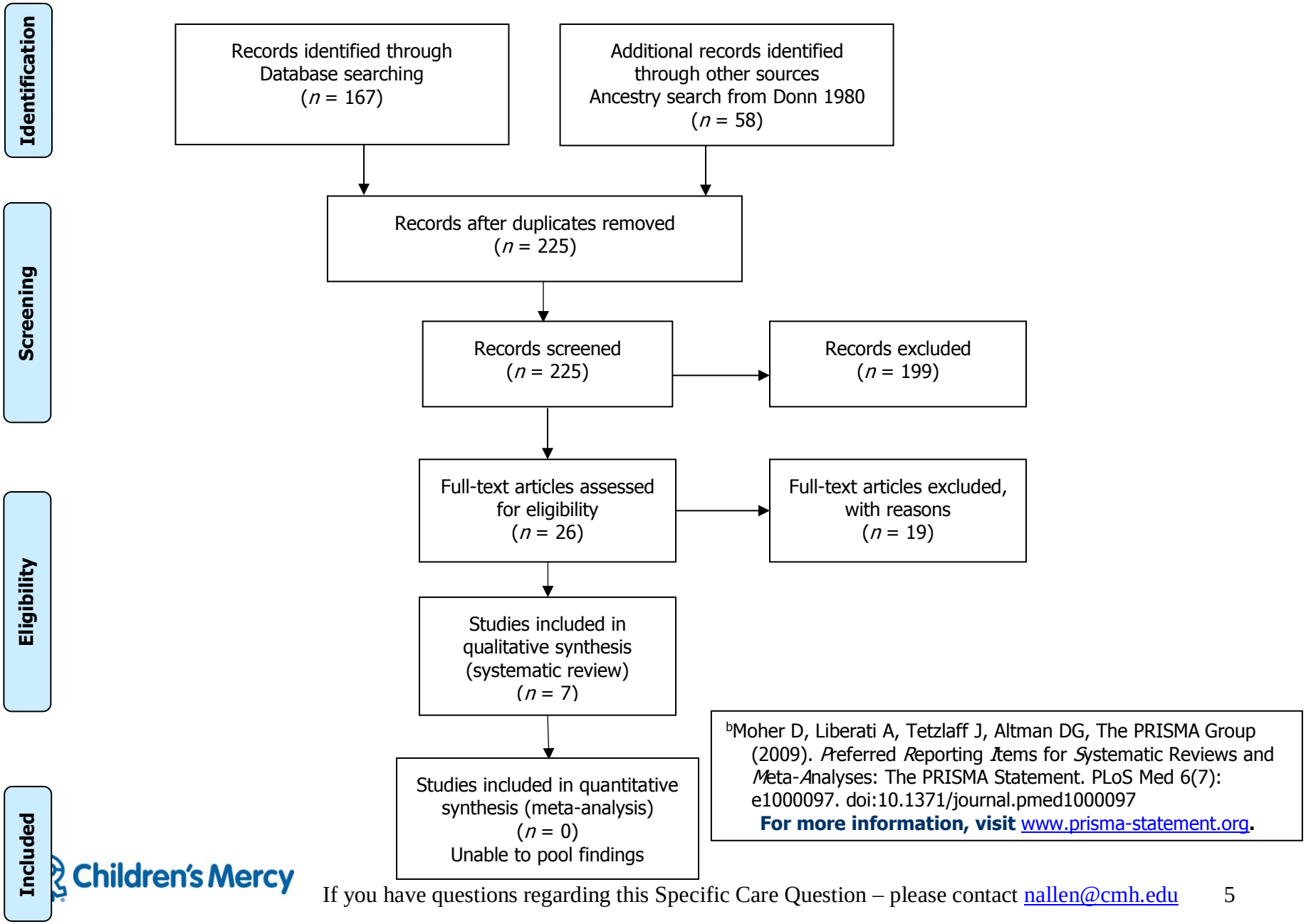
Study ID	Reason for Exclusion
Barber (2013)	Narrative review
Brinsmead, Inglis, & Ware (2013)	Does not answer the question, considers air leaks
Fasano (2012)	Abstract only
Grove, Zerweck, Ekholm, Smith, & Koski (2014)	Compares silicone and paper tapes
Hartrey & Kestin (1995)	Cuffed tubes

Hatch et al. (2017)	Does not answer the question, makes association of chronological age, birthweight, and post menstrual age with risk of UPE
Hunyady, Otto, Christensen, & Jonmarker (2015)	Use of a formula to calculate ETT depth for placement, not ETT maintenance
Jarreau et al. (2000)	It does not talk about taping ETTs.
Kemper, Dullenkopf, Schmidt, Gerber, & Weiss 2014	Does not answer the question, compares formulas for deciding ET tube depth
Kleinman et al. (2010)	2010 PALS Guideline Does not discuss securing ET tubes
Lange, Jonat, & Nikischin (2002)	Naso- tracheal intubations; CMH uses orotracheal intubation in the NICU
Meyers, Pinheiro, & Nelson (2015)	Commentary
Millan et al. (1986)	Compares risk of aspiration orotracheal vs. naso-tracheal intubation
Murphy et al. (2014)	Compares the number of ETT manipulations and VAP rates
Schmolzer & Roehr, (2014)	Goal was to identify ways other than chest radiograph to assess ETT placement. Did not identify any studies
Silva, Reis, Aguiar, & Fonseca, (2013)	Did not identify any studies that addressed strategies to prevent UPEs
Wang, Kuo, & Lee (2011)	Report is on a formula for estimating tube depth
Weiss, Dullenkopf, Gysin, Dillier, & Gerber (2004)	Report on cuffed ET tubes
Weiss, Gerber, & Dullenkopf (2005)	Authors were evaluating a product they developed
Weiss et al. (2006)	Not the correct age

Method Used for Appraisal and Synthesis:
The Cochrane Collaborative computer program, Review Manager (RevMan 5.3) was used to synthesize the included studies.

Updated April 2015, June 2015, Jan 2018

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA)[b]



[b]Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Table *2.*
Countermeasures and Number of Papers

Countermeasures	Number of Papers	References
Standardization of method of tube securement (taping method or use of a device like Neobar®)	7	Crezee et al. (2017); Fontanez-Nieves et al. (2016); Hu et al.; (2017); Longnathan et al. (2017); Merkel et al. (2014); Powell et al. (2016)
Standardization of process for repositioning patients (two staff members)	5	Barber, (2013); Crezee et al. (2017); Fontanez-Nieves et al. (2016); Merkel et al. (2014); Powell et al. (2016)
Real time analysis of each UPE event	3	Powell et al. (2016); Fontanez-Nieves et al. (2016); Merkel et al. (2014)
Bedside cards with ETT information	2	Fontanez-Nieves et al. (2016); Merkel et al. (2014)
Documentation of ETT at designated times	2	Fontanez-Nieves et al. (2016); Hu et al. (2017)
Physical restraints- e.g. mittens	2	Merkel et al. (2014); Silva et al. (2013)
Direct caregiver communication - handoffs	2	Crezee et al. (2017); Powell et al., (2016)
Standardizing head position at chest x-ray	2	Crezee et al. (2017); Powell et al. (2016)
Simulation lab demonstrated proficiency of ETT taping	1	Fontanez-Nieves et al. (2016)
"Days since last UPE" display on unit	1	Merkel et al. (2014)
Weekly assessment of ETT placement	1	Powell et al. (2016)
Standardized process for addressing tube migration whenever noted	1	Powell et al. (2016)

Table *3 Characteristics of Studies*

Donn 1980

Methods	Case study
Participants	**Setting:** US **Number participants not randomized):** 1 **Number who completed the study:** 1 **Gender:** Male **Age:** term newborn with standard ET tube placement, 24 hours after he expired on second day of life **Inclusion criteria:** n/a **Exclusion criteria:** n/a
Interventions	Radiographs of an intubated neonatal cadaver in various positions.

Outcomes	Results in agreement with adult studies: the tube tip moves caudad (towards the carina) with flexion, and cephalad towards the glottal opening) with extension. Lateral rotation causes the tube tip to move cephalad as well. There was no movement of the reference marker in relation to the maxilla, indicating that the tube remained stationary at is site of fixation to the mouth.
Notes	The mandible should be included in chest radiographs when evaluating ETT placement. A flexed neck, in an anteroposterior radiograph as the tech slides a cassette beneath the neonate, the tube tip will be too low in the trachea. The subsequent movement of the ETT to a higher position in the trachea may result in inadvertent extubation. Conversely, an extended neck, may show the tube too high in the trachea. Subsequent advancement of the tube with the neck in neutral position may result in inadvertent intubation of the right main bronchus.

Lai 2014

<table>
<tr><td>Methods</td><td>Cochrane Collaborative Review. Literature search from 1966 to June 2013 complete</td></tr>
<tr><td>Participants</td><td>Included randomized and quasi- randomized control trials of infants who were intubated for mechanical ventilation in the NICU and the topic was methods to secure ETT tubes.
Brown 1988
McCann 1988
McLean 1992
Volsko 1998
Conley 1989

Only the Volsko 1998 (abstract only) used the scaffold device (Neobar®). The Neobar® group had fourteen infants randomized and the tape group had eighteen infants.</td></tr>
<tr><td>Interventions</td><td>None reported</td></tr>
<tr><td>Outcomes</td><td>Could not be perform a meta-analysis - the quality of the five studies was low, overall.
The most common outcome was unplanned extubations.
No study reported on the need for re-intubation, proportion of mal-positioned ETT or tube slippage.
Adverse effects reported include
• Mortality
• Peri-oral or skin trauma
• Tube re-taping

Results from Volsko (1998) on Neobar®
<table>
<tr><td></td><td>Extubations rate per 100 ventilation days</td><td>Extubations rate per 100 intubated days</td></tr>
<tr><td>Neobar® Group</td><td>4.8</td><td rowspan="2">No difference</td></tr>
<tr><td>Tape group</td><td>15.6</td></tr>
</table>
</td></tr>
<tr><td>Notes</td><td>Summary of the included studies</td></tr>
</table>

Table *4*

Interventions and Reported Results from the Included Studies

<table>
<tr><th>Study</th><th>Intervention</th><th>Results</th></tr>
<tr><td>Crezee et al. (2017)</td><td>

Double opposing “Y” cloth tape method for securing the ETT
Two care providers for turning, repositioning, or moving patients
Care providers defined as: (a) respiratory therapist, (b) nurse, (c) physician, or (d) neonatal nurse practitioner (NNP)
Maintain midline head position with neutral chin position during chest radiograph unless contraindicated
Standard time for ETT security assessment: (a) admission, and (b) post-operative
“Difficult Airway” designation made by physician or NNP included in handoff reporting tools
UPE Huddle tool to review any UPE by the end of the 12-hour shift in which it occurred

</td><td>
<table>
<tr><th>Activity</th><th>2013
Before
n (%)</th><th>2014
After
n (%)</th></tr>
<tr><td>Airway/Tracheostomy care</td><td>11 (24)</td><td>10 (48)</td></tr>
<tr><td>Unsecure/loose airway</td><td>0</td><td>5 (24)</td></tr>
<tr><td>Spontaneous</td><td>11 (24)</td><td>3 (14)</td></tr>
<tr><td>Procedures/care</td><td>9 (19.5)</td><td>3 (14)</td></tr>
<tr><td>Other</td><td>15 (32.5)</td><td>0</td></tr>
</table>

UPE rate decreased from 1.15/100 intubated days (2013) to .54/100 intubated days (2014), a 53% decrease.

</td></tr>
<tr><td>Fontanez-Nieves et al. (2016)</td><td>

Double opposing “Y” cloth tape method for securing the ETT using 1’ standard porous tape
Bedside cards with ETT size and appropriate depth insertion
Increases ETT taping education
Documenting ETT at each care time
Two care providers for handling, turning, repositioning, or moving patients
Real-time analysis of each UPE within 48 hours of the event

</td><td>

UPE rate decreased form 16.1/100 intubated days (2012) to 4.5 UPE per 100 intubated days (2013), a 72% decrease from baseline.

</td></tr>
<tr><td>Hu et al. (2017)</td><td>

Developed ETT assessment checklist
Create and post alert signs for high risk of UPE
RRT to assess and document security of ETT each shift

</td><td>

UPE rate decreased from 2.3 UPE/ 100 intubated days pre-interventions (May 2016) to .36 UPE/ 100 intubated days post interventions (Oct 2016), 85% decrease from baseline.

</td></tr>
</table>

	○ Create standard practices of care and/or protocols ○ Implement Standard practices of care and/or protocols (assessed by videotape) ○ Standard practices of care and/or protocols are documented	
Lai, Inglis, Hose, Jardine, & Davies (2014)	○ Could not perform a meta-analysis because the methods of securing ETT were to dissimilar	
Longnathan et al. (2017)	○ ETT using Neobar®	UPE decreased from 1.47/100 intubation days (2011) to 1.17/100 intubation days (2013), a 20% decrease from baseline.
Merkel et al. (2014)	○ At least two licensed professional staff members participate in re-taping and securing ETTs, weighing patients, or transferring the patient ○ Placement of alert cards for high risk of UPE, the security of the ETT at last assessment, depth of the ETT at the gum line, assessed by nursing and respiratory care during routine care ○ Real-time analysis of UPE at the time of the event ○ Display of days since last UPE ○ Placement of mittens or socks on the hands of infants > 34 weeks post menstrual age	UPE decreases from 2.4/100 intubation days (2009) to 0.6/100 intubation days in (2013), a 75% decrease from baseline.
Powell et al. (2016)	○ Two caregivers for any movement that requires turning the head ○ Weekly ETT position related to the patient's growth ○ Simultaneous RN/RT assessments first assessment of the shift ○ Process for addressing ETT migration ○ ETT re-securement after assessment of tape integrity ○ Standardize head position during chest radiographs ○ All UPEs triggered a chart review	UPEs decreased from 3.8/100 intubation days (2012) to 2.7/100 intubated days (2014), a 29% decrease from baseline.

References

Barber, J. A. (2013). Unplanned extubation in the NICU. *J Obstet Gynecol Neonatal Nurs, 42*(2), 233-238. doi:10.1111/1552-6909.12009

Brinsmead, T. L., Inglis, G. D. T., & Ware, R. S. (2013). Leak around endotracheal tubes in ventilated newborns: An observational study. *Journal of paediatrics and child health, 49* (1), E52-E56.

Crezee, K. L., DiGeronimo, R. J., Rigby, M. J., Carter, R. C., & Patel, S. (2017). Reducing Unplanned Extubations in the NICU Following Implementation of a Standardized Approach. *Respir Care, 62*(8), 1030-1035. doi:10.4187/respcare.04598

Donn, S., & Kuhns, L. R. (1980). Mechanism of endotracheal tube movement with change of head position in the neonate. *Pediatric radiology, 9*(1), 37-40.

Fasano, K. (2012). *Implementing a Standard of Care for Endotracheal Tube Taping to Prevent Unintentional Extubation.* Paper presented at the CRITICAL CARE NURSE.

Fontanez-Nieves, T. D., Frost, M., Anday, E., Davis, D., Cooperberg, D., & Carey, A. J. (2016). Prevention of unplanned extubations in neonates through process standardization. *J Perinatol, 36*(6), 469-473. doi:10.1038/jp.2015.219

Grove, G. L., Zerweck, C. R., Ekholm, B. P., Smith, G. E., & Koski, N. I. (2014). Randomized Comparison of a Silicone Tape and a Paper Tape for Gentleness in Healthy Children. *Journal of Wound Ostomy & Continence Nursing, 41* (1), 40-48.

Hartrey, R., & Kestin, I. (1995). Movement of oral and nasal tracheal tubes as a result of changes in head and neck position. *Anaesthesia, 50* (8), 682-687.

Hatch, L. D., Grubb, P. H., Markham, M. H., Scott, T. A., Walsh, W. F., Slaughter, J. C., . . . Ely, E. W. (2017). Effect of Anatomical and Developmental Factors on the Risk of Unplanned Extubation in Critically Ill Newborns. *Amer J Perinatol, 34*(12), 1234-1240. doi:10.1055/s-0037-1603341

Hatch, L. D., Grubb, P. H., Lea, A. S., Walsh, W. F., Markham, M. H., Whitney, G. M., . . . Ely, E. W. (2016). Endotracheal Intubation in Neonates: A Prospective Study of Adverse Safety Events in 162 Infants. *J Pediatr, 168*, 62-66 e66. doi:10.1016/j.jpeds.2015.09.077

Hu, X., Zhang, Y., Cao, Y., Huang, G., Hu, Y., & McArthur, A. (2017). Prevention of neonatal unplanned extubations in the neonatal intensive care unit: a best practice implementation project. *JBI Database System Rev Implement Rep, 15*(11), 2789-2798. doi:10.11124/JBISRIR-2016-003249

Hunyady, A. I., Otto, R. K., Christensen, A., & Jonmarker, C. (2015). Nares-to-carina distance in children: does a 'modified Morgan formula' give useful guidance during nasal intubation? *Paediatr Anaesth, 25*(9), 936-942. doi:10.1111/pan.12693

Jarreau, P.-H., Louis, B., Desfrere, L., Blanchard, P. W., Isabey, D., Harf, A., & Moriette, G. (2000). Detection of positional airway obstruction in neonates by acoustic reflection. *American journal of respiratory and critical care medicine, 161* (5), 1754-1756.

Kemper, M., Dullenkopf, A., Schmidt, A., Gerber, A., & Weiss, M. (2014). Nasotracheal intubation depth in paediatric patients. *British journal of anaesthesia*, aeu229.

Kleinman, M. E., Chameides, L., Schexnayder, S. M., Samson, R. A., Hazinski, M. F., Atkins, D. L., . . . Freid, E. B. (2010). Special report—Pediatric advanced life support: (2010) American heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Pediatrics*, peds. 2010-2972D.

Lai, M., Inglis, G. D., Hose, K., Jardine, L. A., & Davies, M. W. (2014). Methods for securing endotracheal tubes in newborn infants. *Cochrane Database Syst Rev, 7*, CD007805. doi:10.1002/14651858.CD007805.pub2

Lange, M., Jonat, S., & Nikischin, W. (2002). Detection and correction of endotracheal-tube position in premature neonates. *Pediatric pulmonology, 34* (6), 455-461.

Longnathan. P., Nair, V., Vine, M., Kostecky, L., Kowal, D., & Soraisham, A. (2017). Quality Improvement Study on New Endotracheal Tube Securing Device (Neobar) in Neonates. *Indian J Pediatr, 84*(1), 20-24. doi:10.1007/s12098-016-2231-y

McMillan, D. D., Rademaker, A. W., Buchan, K. A., Reid, A., Machin, G., & Sauve, R. S. (1986). Benefits of orotracheal and nasotracheal intubation in neonates requiring ventilatory assistance. *Pediatrics, 77* (1), 39-44.

Merkel, L., Beers, K., Lewis, M. M., Stauffer, J., Mujsce, D. J., & Kresch, M. J. (2014). Reducing unplanned extubations in the NICU. *Pediatrics, 133*(5), e1367-1372. doi:10.1542/peds.2013-3334

Meyers, J. M., Pinheiro, J., & Nelson, M. U. (2015). Unplanned extubation in NICU patients: are we speaking the same language? *J Perinatol, 35*(9), 676-677. doi:10.1038/jp.2015.55

Murphy, F. M., Raymond, M., Menard, P.-A., Bejar-Ardiles, K.-R., Carignan, A., & Lesur, O. (2014). Ventilator associated pneumonia and endotracheal tube repositioning: An underrated risk factor. *American journal of infection control, 42* (12), 1328-1330.

Powell, B., Gilbert, E., & Volsko, T. (2016). Reducing unplanned extubation in the NICU using lean methodology. *Respir Care, 61*(12), 1567.

Schmolzer, G. M., & Roehr, C. C. (2014). Techniques to ascertain correct endotracheal tube placement in neonates. *Cochrane Database Syst Rev*(9), CD010221. doi:10.1002/14651858.CD010221.pub2

Silva, P., Reis, M. E., Aguiar, V. E., & Fonseca, M. (2013). Unplanned extubation in the neonatal ICU: a systematic review, critical appraisal, and evidence-based recommendations. *Respiratory care, 58*(7), 1237-1245.

Wang, T.-C., Kuo, L.-L., & Lee, C.-Y. (2011). Utilizing Nasal-Tragus Length to Estimate Optimal Endotracheal Tube Depth for Neonates in Taiwan. *The Indian Journal of Pediatrics, 78* (3), 296-300.

Weiss, M., Dullenkopf, A., Gysin, C., Dillier, C., & Gerber, A. (2004). Shortcomings of cuffed paediatric tracheal tubes†. *British journal of anaesthesia, 92* (1), 78-88.

Weiss, M., Gerber, A., & Dullenkopf, A. 2005). Appropriate placement of intubation depth marks in a new cuffed paediatric tracheal tube. *British journal of anaesthesia, 94* (1), 80-87.

Weiss, M., Knirsch, W., Kretschmar, O., Dullenkopf, A., Tomaske, M., Balmer, C., . . . Berger, F. (2006). Tracheal tube-tip displacement in children during head-neck movement—a radiological assessment. *British journal of anaesthesia, 96* (4), 486-491.