Evaluating Endotracheal Tube Depth in Infants Weighing Less Than 1 Kilogram

Airway management is essential to the care of critically ill term and pre-term infants. To protect the airway during invasive mechanical ventilatory support, an endotracheal tube (ETT) must be properly placed and maintained in the correct position. However, there are challenges to placing and maintaining an ETT in correct position in this vulnerable population. The tracheal length is relatively short, ranging from 4–6 cm,[1] providing a relatively small target area between the thoracic inlet and the carina to correctly place the ETT tip during intubation. Changes in head position can cause the ETT to migrate cauda with neck flexion and cephalad with neck extension, even when the ETT is secured in place.[2]

Malpositioned ETTs are associated with significant morbidity and mortality. Shallow ETT placement can contribute to unplanned extubation,[3] which is among the most common causes of safety events occurring in the neonatal ICU.[4] Malpositioned ETTs leading to unplanned extubations often result in emergent endotracheal re-intubation, which can be life-threatening if the airway is not secured promptly. Repeated intubations, especially those performed emergently, increase the risk of laryngeal or tracheal injury and scarring.[5] Irritation of the carina, insufficient ventilation, pneumothorax, and atelectasis can result when an ETT is placed too deeply.[6]

To minimize the risk of placing an ETT in a suboptimal position during intubation, the American Academy of Pediatrics, through the Neonatal Resuscitation Program (NRP),[7] provides ETT insertion depth guidelines for infants up to 28 d old. However, the literature reports that the use of this easily remembered guideline can result in ETT malposition. Peterson et al[8] reported inaccuracies with the use of the NRP depth guidelines for very low birthweight infants. ETTs were placed too deeply by 0.3–0.93 cm in infants weighing < 750 g when the NRP guidelines were used. Amarilyo and colleagues[9] studied 31 infants weighing 470–980 g and found that ETTs were malpositioned in 47% of the infants when the NRP guidelines were used during intubation to determine ETT placement.

In this issue of RESPIRATORY CARE, Bartle and colleagues[10] evaluated the predictive value of a simple weight-based calculation for determining the initial depth for ETT insertion for infants weighing < 1 kg. The authors' definitions of ETTs positioned appropriately (ie, in the mid-tracheal positon), too low, and too high were very specific

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and aligned with definitions previously reported in the literature.[11] Specifically, an appropriate position for the ETT tip was defined as below the thoracic inlet and above the carina; an ETT tip located above the thoracic inlet was defined as high, and an ETT tip located below the carina was defined as low. Predicted ETT depth was calculated differently for subjects weighing < 500 g (5.0 cm + 1 cm/kg birthweight) and those weighing 500–999 g (5.5 cm + 1 cm/kg birthweight).

The primary outcome of this study was the proportion of ETTs appropriately positioned on chest radiograph, for each of the aforementioned formulas, with a tolerance level of ± 2 mm of the documented depth. The authors conducted a post hoc analysis using the NRP depth guidelines on ETTs which were malpositioned using the proposed calculations to determine if use of the NRP depth guideline would have predicted the documented ± 2 mm tolerance level more accurately than their proposed formulas.

Of the 131 subjects evaluated, the proposed formulas accurately predicted ETT tip position in 47% of those studied, yielding a sensitivity of 46.6%, a specificity of 53.6%, and a positive predictive value of 68.8%. Post hoc analysis revealed that the proposed formulas provided a closer approximation of actual ETT depth (47%) compared to NRP guidelines (23%). This use of NRP guidelines overestimated the depth of ETT placement by 0.4 ± 1 cm.[10] The authors' findings align with studies that also report inaccuracies associated with the use of the NRP depth guidelines, first described by Tochen[12] in the late 1970s; Chung et al[13] recently reported that the use of the NRP depth guidelines resulted in ETTs

placed too deeply in 21.6% of the 139 neonates enrolled in their study.

It is important to consider the limitations outlined in this study.[10] Limitations in this single-institution retrospective analysis include potential poor adherence to depth-insertion guidelines, inability to control for head position at the time the chest radiograph was taken, variability in the measurement of the ETT marking at the lip documented by the respiratory therapist, and the possibility for mathematical errors (eg, calculation errors, use of the wrong formula). These limitations have the potential to introduce bias and may also affect the position an ETT within the trachea.

Despite its limitations, this study adds to the body of literature reporting the incidence of ETT malposition when the NRP depth guidelines are used. These internally validated equations may have clinical utility in minimizing the propensity for suboptimal placement of an ETT following intubation. However, a prospective evaluation is needed to determine the value of these equations in minimizing ETT malposition following endotracheal intubation in low and very low birthweight infants.

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