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Recommendations for endotracheal tube insertion depths in children

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ABSTRACT

Background: Endotracheal tube (ETT) malposition is frequent in paediatric intubation. The current recommendations for ETT insertion depths are based on formulae that hold various limitations. This study aimed to develop age-based, weight-based and height-based curve charts and tables for ETT insertion depth recommendations in children.

Methods: In this retrospective single-centre study, we determined the individual optimal ETT insertion depths in paediatric patients by evaluating postintubation radiographic images. Age-based, weight-based and height-based ETT insertion depth recommendations were developed using regression analysis. We compared the insertion depths predicted by the models with previously published formulae.

Results: Intubations of 167 children (0–17.9 years) were analysed. Best-fit curves generated with logistic regression analysis revealed R^2 values between 0.784 and 0.880. The insertion depths predicted by the models corresponded well with published age-based and height-based formulae. However, they demonstrated the unsuitability of weight-related linear formulae to predict ETT depth in children.

Conclusion: The recommendations developed in this study facilitate a fast and accurate determination of recommended ETT insertion depths in children. Our recommendations provide greater accuracy than previously published formulae and demonstrate that weight-related linear formulae are unsuitable for predicting ETT depth in children.

INTRODUCTION

Endotracheal intubation in children is a crucial procedure in the prehospital setting, emergency department, intensive care unit and before surgery. Precise positioning of the endotracheal tube (ETT) is essential to reduce the incidence of complications, including atelectasis, pneumothorax, tracheal damage, unplanned extubation and postextubation stridor.¹ The gold standard for confirming the correct ETT position is chest radiography.^{2,3} Nevertheless, as prompt postintubation ventilation is mandatory and instant bedside radiography is not consistently available, methods to reliably estimate the optimal ETT insertion depth are required. Numerous formulae, most of which refer to the patient's age or weight, have been proposed to estimate the correct depth of tube placement within the trachea in children.^{4–11} Unfortunately, commonly used formulae for ETT insertion depth lack optimum accuracy, resulting in a significant

WHAT IS ALREADY KNOWN ON THIS TOPIC

- The incidence of endotracheal tube (ETT) malposition in children is significant.
- Published linear formulae to predict the correct ETT insertion depth do not account for the non-linear growth of children.

WHAT THIS STUDY ADDS

- We calculated accurate insertion ETT depth recommendations using non-linear regression analysis.
- Our recommendations demonstrate that weight-related linear formulae are unsuitable for predicting ETT insertion depth in children.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- Developed curves and tables have the potential to facilitate a fast and accurate determination of ETT insertion depths in children.
- Clinicians should use age-based and height-based formulae rather than weight-related linear formulae to predict ETT insertion depth in children.

incidence of ETT malposition.^{4–11} A formula-based approach may be unreliable because it relies on linear equations. Paediatric growth, however, does not follow a linear relationship, so the ETT insertion depth is unlikely to be optimally predicted by a linear formula.^{12–15}

This study's aim was to develop and compare age-based, weight-based and height-based recommendations for correct ETT insertion depths in children.

METHODS

Study design and subjects

We retrospectively evaluated the CXRs of intubated paediatric patients older than 28 days admitted to our University Medical Centre's paediatric intensive care unit from January 2017 to August 2020. All clinical patient data were obtained from the hospital's healthcare information systems (Soarian, Siemens Healthcare, Erlangen, Germany; ICM, Dräger, Lübeck, Germany). Extracted information included sex, age, weight, height, intubation route and ETT insertion depth. ETT depth was documented from the front teeth. Our institutional policy is to intubate neonates via the nasotracheal route. Therefore, we included only children older



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