BJA

British Journal of Anaesthesia, 116 (3): 393–7 (2016)

doi: 10.1093/bja/aev545
Paediatrics

PAEDIATRICS

A new method for determining the insertion depth of tracheal tubes in children: a pilot study

F. Neunhoeffer*, T. Wahl, M. Hofbeck, H. Renk, M. Esslinger, M. Hanelt and M. Kumpf

Department of Paediatric Cardiology, Pulmology and Paediatric Intensive Care Medicine, University Children's Hospital, Hoppe-Seyler-Str. 1, Tübingen 72076, Germany

*Corresponding author. E-mail: felix.neunhoeffer@med.uni-tuebingen.de

Abstract

Background: Choosing the correct insertion depth of tracheal tubes is crucial for successful airway management in paediatrics. Currently used formulas are based on patient characteristics such as age, body weight and height. The aim of the study is to devise and evaluate more suitable body surface area based diagrams for predicting the correct tracheal insertion depth.
Methods: Calculated insertion depth according to currently used formulas, primary insertion depth and insertion depth corrected by chest radiography ('gold standard') were collected from 237 children. Age, body weight, height and body surface area were noted. Body surface area based diagrams were devised and prospectively evaluated in another set of 123 paediatric patients.
Results: Tracheal tube position according to currently used formulas had to be corrected in 37% of all intubations. New body surface area based diagrams were created. In 20.3%, depth of the tracheal tube had to be corrected according to the new body surface area based diagrams.
Conclusions: The body surface area based diagrams may be a reliable tool for predicting the correct tracheal insertion depth in children.

Key words: airway management; body height; body surface area; body weight; child; intubation, intratracheal

Editor's key points

- Several formulas have been reported for optimal positioning of a tracheal tube in children, but adjustment of position is frequently required.
- From 237 children, new diagrams based on the body surface area were produced for the optimal positioning of a tracheal tube, and their efficacy were assessed in another 123 children.
- The position of a tracheal tube would be more likely to be optimal with the formula based on the body surface area than with the conventional formulas.

Paediatric airway management is often stressful and airway problems are common in paediatric anaesthesia and critical care medicine. Malpositioning of tracheal tubes may lead to serious complications. Once the tracheal tube is not placed deep enough, accidental extubation and laryngeal injury may cause inadequate ventilation, hypoxia, brain damage and death. In contrast, if placed too deep, the tracheal tube may injure the carina or even pass the carina leading to endobronchial intubation. Atelectasis of the unventilated lung and hyperinflation of the ventilated lung will occur.

Particularly in younger children it is difficult to predict the correct tracheal tube length. Malpositioning of the tracheal tube was reported in 30–50% of all tracheal intubations.[1–3] Several

Accepted: December 14, 2015

formulas that determine the correct depth of tracheal tubes exist. These are based on patient parameters such as age, the internal diameter of the tracheal tube, corrected gestational age or anthropometric data such as weight, nasal-tragus-length, sternal-tragus length or foot-length.[4–9] The most commonly used formulas are the age based formula for children older than one yr of age recommended by the Advanced Paediatric Life Support Group (APLS)[10] and the weight based formula of Lau and colleagues[4] for children younger than one yr of age. To the best of our knowledge the body surface area has not been investigated for predicting correct depth of the tracheal tube in children so far. The aim of this study was to evaluate the value of the recommended age based formula by the APLS[10] and the weight based formula of Lau and colleagues[4] in predicting the correct insertion depth of tracheal tubes. Additionally, a further aim of this study was to create and evaluate a body surface area based diagram for predicting the correct position of tracheal tubes.

Methods

Data from 237 children who required oro- or nasotracheal intubation were collected retrospectively between August 2011 and January 2012, from the Paediatric Intensive Care Unit of the University Children's Hospital Tübingen. The study was approved by the appropriate ethics authority. Patients with a tracheostomy or airway anomalies were excluded from this study (see Fig. 1). Before the intubation, procedure insertion depth of the tracheal tube was estimated by one of the two given formulas according to the patient's age (Lau and colleagues [4] <1 yr, APLS >1 yr). The intubation procedure was followed by adapting the insertion depth to the calculated depth of the tracheal tube. Mostly Vygon paediatric plain tracheal tubes (code 520.xx) were used. The tubes have distance markings every 0.5 cm for tubes of size 2.0–3.5 mm ID; distance markings every 1 cm of size 4.0–6.5 mm ID. The tube tip is marked in black to assist the user during intubation to choose the correct insertion depth.

A chest X-ray was done with the patient in supine and the head in neutral position. All X-rays were checked whether the head is in neutral position and whether the jaw position is present on the x-ray. In infants the correct depth of a tracheal tube was defined by a midtracheal area, which means at least 0.5 cm above the carina, but not less than 0.5 cm below the level of the larynx in the chest x-ray. In toddlers the correct depth of a tracheal tube was defined by midtracheal area, between 1 cm above the carina and 1 cm below the level of the larynx. Orotracheal intubation was chosen when intubation and mechanically ventilation was planned for less than 24 h and in urgent cases. Nasotracheal intubation was chosen when intubation and mechanically ventilation was planned for more than 24 h.

Patients were divided into four groups based on the given formulas by Lau and colleagues.[4] and *Advanced Life Support Group*[10]: group 1: orotracheal intubated infants <1 yr of age; group 2: nasotracheal intubated infants <1 yr of age; group 3: orotracheal intubated children ≥1 yr of age; group 4: nasotracheal intubated children ≥1 yr of age (Graph 1; Table 1). Tracheal tube length was defined as distance from lip or nostril to the distal end of the tracheal tube.

The given formula byLau and colleagues.[4] *and Advanced Life Support Group*[10] are age or body weight based.

The following data were collected: age, body height, body weight, route of intubation, insertion depth calculated by the

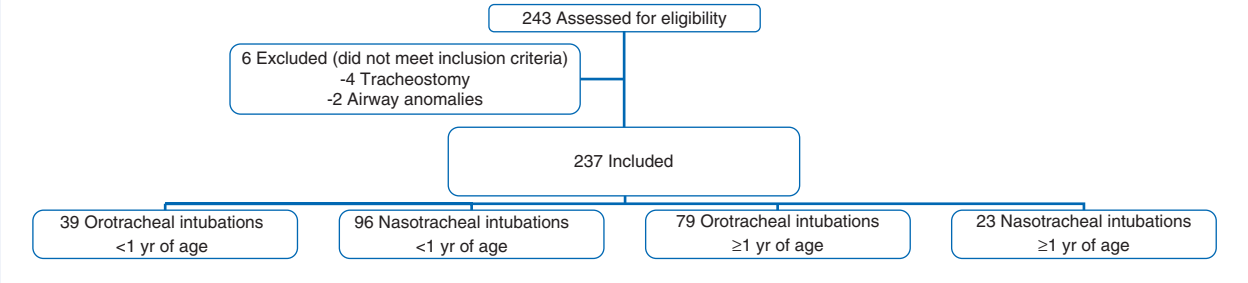

Fig 1 CONSORT flow diagram.

Table 1 Given formulas predicting tracheal tube insertion depth and patient data. The patient characteristics data are listed as median, standard deviation and range

	Group 1	Group 2	Group 3	Group 4
n=	39	96	79	23
Criteria of groups	Orotracheal intubated infants <1 yr of age	Nasotracheal intubated infants <1 yr of age	Orotracheal intubated children ≥1 yr of age	Nasotracheal intubated children ≥1 yr of age
Given formula predicting tracheal tube insertion depth	Body weight (kg)/2 + 8	Body weight (kg)/2 + 9	Age (yr)/2 + 12	Age (yr)/2 + 15
Age	2.1 (0.0–11.0) months		7.5 (1.0–17.0) yr	
Weight	3.7 (1.4–11.0) kg		22.6 (3.2–103.0) kg	
Length	53.0 (38.0–90.0) cm		123.0 (54.0–185.0) cm	
Body surface area	0.24 (0,12–0.52) m^2		0.90 (0.22–2.24) m^2	