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Nasotracheal intubation depth in paediatric patients

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Editor's key points

- The depth of nasotracheal tube placement has traditionally been guided by formulae based on patient age, body weight, or both.
- These formulae are made for uncuffed tracheal tubes, but cuffed tracheal tubes are increasingly used in neonates and children.
- In this study, using different formulae to guide Microcuff paediatric endotracheal tube (PET) placement would have caused misplacement in most cases.
- The depth mark of the Microcuff PET should be used to determine proper tube placement.

Background. The aim of this study was to compare intubation depth using the Microcuff paediatric endotracheal tube (PET) placed with the intubation depth mark between the vocal cords with that of different published formulae/recommendations for nasotracheal intubation depth in children.

Methods. Children aged from birth to 10 yr undergoing elective surgery with nasotracheal intubation were included. Tracheal tubes were adjusted according to the intubation depth mark between the vocal cords using direct laryngoscopy. Nasal intubation depth was recorded and the distance 'tube tip to carina' was measured endoscopically. Based on the recorded nasal intubation depth and measured distance 'tube tip to carina', the position of tube tip and cuff was calculated according to six published formulae/recommendations.

Results. Seventy-six children were studied. For the Microcuff PET, the median tube tip advancement within the trachea was 52.9% (41.1–73.8%) of tracheal length. The shortest distance from the 'tube tip to carina' was 15 mm for a 3.5 mm internal diameter tube. If the six published formulae/recommendations had been used, this would have resulted in endobronchial tube placement in up to 9.1% of cases, and the tube tip would have been placed above the glottis in up to 2.6% of cases. The upper border of the cuff would have been placed in the subglottic area in up to 42.1% of cases and in a supraglottic position in up to 63.2% of cases.

Conclusions. This study indicates that nasal intubation with the intubation depth mark placed between the vocal cords was superior to formula-based nasotracheal tube positioning. The latter would result in a high rate of endobronchial intubations, excessively high cuff positions and even tracheal extubations.

Keywords: airway; children; complications, intubation nasotracheal; tracheal tube; intubation

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Tracheal intubation depth in children is critical because of their short trachea.[1] Correct insertion depth of tracheal tubes is essential to avoid accidental endobronchial intubation, irritation of the carina, misplacement of the cuff between the vocal cords, and accidental tracheal extubation. Moreover, there is an increased risk of tube malpositioning, mainly for neonates, infants, and small children, during head–neck movement.[2–5] Nasotracheal intubation is considered to allow more stable tube placement within the trachea.[6]

In the past, several formulae and recommendations for adjusting nasotracheal intubation depth at the nose have been published (Tables 1 and 2). In recent years, cuffed tracheal tubes have become standard in paediatric anaesthesia.[7] However, there are no data so far with regard to proper positioning of tracheal tube tip and cuff, when using common formulae for nasotracheal intubation depth in cuffed paediatric tracheal tubes.

The aim of this study was to compare intubation depth using the Microcuff paediatric endotracheal tube (PET) placed with the intubation depth mark between the vocal cords with different published formulae/recommendations for nasotracheal intubation depth in children.

Methods

After obtaining Hospital Ethics Committee approval in 2003 (StV 23-03) and informed parental consent, a prospective study including paediatric patients aged between birth and 10 yr was conducted from 2003 until 2009. Patients included were undergoing elective surgery or dental procedures requiring general anaesthesia and nasotracheal intubation. Exclusion criteria were known or suspected airway anomalies and difficult tracheal intubation. Premedication and induction of anaesthesia (inhalation or i.v.) depended on the patient's

† Contribution similar to that of first author.

Table 1 Formulae/recommendations for nasotracheal intubation depth

No.	Formula/recommendation age (yr), weight (kg)	Source, author, year
1	14+(age/2)	*Paediatric Anaesthesia*, Davenport, 3rd Edn, 1980[8]
2	<4 yr 10.5+(weight/2)	Antona and colleagues, 2002[9]
3	>3 kg $L=(3\times S)+2$ S= internal diameter (ID) in mm	Yates and colleagues, 1987[10]
4	(a) <1 yr: 9+(weight/2) (b) >1 yr: 15+(age/2)	Lau and colleagues, 2006[11]
5	Recommendation (see Table 2)	*Manual of Pediatric Anesthesia*, Steward, 5th Edn, 2001[12]
6	Recommendation Tube tip to carina distance of 2 cm in paediatric patients aged from 0 to 7 (yr)	Kim and colleagues, 2003[13]

Table 2 Nasal intubation depth according to recommendation 5[12]

Approximate age of patient (yr)	Nasal intubation length (cm)
Newborn	14
1	15
2	16
4	17
6	19
8	21
10	22

medical condition and preference. A non-depolarizing neuromuscular blocking agent was administered and anaesthesia was maintained with sevoflurane in oxygen/nitrous oxide.

The patient's trachea was intubated using the Microcuff PET (Microcuff GmbH, Weinheim, Germany) and tracheal tube size was selected according to the manufacturer's instructions (Table 3). Nasotracheal intubation was performed in all patients and the glottic intubation mark was placed between the vocal cords using direct laryngoscopy (depth mark-based tracheal tube placement). Subsequently, intubation depth at the base of the nose was recorded and the tube was secured by tapes. With the patient supine and the head in a neutral position, the distance from the tube tip to the carina was measured endoscopically using the drawback technique.[14]

Data analysis

Tracheal length (vocal cords to carina distance) was calculated by adding the 'intubation depth mark to tube tip distance' to the measured distance from the 'tube tip to carina'. The percentage of tube tip advancement within the trachea was then calculated.

Table 3 Age-based tube size selection of the Microcuff PET (2004)[14]

ID (mm)	Age (yr)	Distance depth mark to tube tip (mm)	Distance depth mark to upper cuff border (mm)
3.0	Newborn (≥3 kg) to <1	24	9
3.5	1 to <2	27	10
4.0	2 to <4	30	12
4.5	4 to <6	34	12
5.0	6 to <8	39	16
5.5	8 to <10	45	16

The position of the tracheal tube tip related to the carina was calculated when the tracheal tube would have been inserted according to one of the formulae (1–4) and recommendation (5) for nasotracheal intubation depth. Tube tip position with formula 3 [formula including internal diameter (ID)] was also calculated for age-related uncuffed tubes (ID+0.5 mm ID), resulting in formula 3b.

The number of tracheal tubes placed endobronchially (below the carina) and the number of tracheal tubes at risk of endobronchial intubation after 30° head–neck flexion {maximal downward tube movement (mm) = [(0.83 × age (yr)]+9.3} were calculated.[15] Similarly, the number of tracheal tube tips placed in the supraglottic area and the number of tracheal tubes at risk for tracheal extubation after 30° head–neck extension [maximal upward tube movement (mm)=0.71 × age (yr)+9.9] were calculated.[15]

Under the assumption that the upper cuff border of the Microcuff PET is placed just below the level of the cricoid cartilage if inserted according to the intubation depth mark, the resulting position of the upper cuff border of the Microcuff PET related to the cricoid ring was calculated with each of the four formulae and two recommendations.[16] The number of tubes with cuff position in the subglottic and supraglottic area were calculated. The subglottic area was derived from previous anatomical data of the vocal cord to cricoid ring, the distance being 9 mm in a newborn and 14 mm in an 11-yr-old child.[17 18]

Data are presented as mean (SD) or median (range) as appropriate.

Results

In total, 76 paediatric patients (40 females, 36 males) aged from 3 weeks to 10 yr (mean 5.0 yr) were included in the study. Depth mark-based nasotracheal intubation resulted in a minimum tube tip to carina distance of 15 mm in a 1.9-yr-old infant to a maximum of 56 mm in a 7.4-yr-old girl. The mean tube tip advancement into the trachea was 52.8% (6.4) of the tracheal length, with a minimum of 41.1% and a maximum of 73.8%. Using depth mark-based intubation, none of the tube tips was at risk for endobronchial intubation after potential 30° head–neck flexion (Fig. 1).