BJA

British Journal of Anaesthesia, ■ (■): 1–6 (2018)

doi: 10.1016/j.bja.2018.05.002
Advance Access Publication Date: xxx
Laboratory Investigation

LABORATORY INVESTIGATION

Tracheal tube tip and cuff position using different strategies for placement of currently available tubes

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Abstract

Background: The aim of this study was to compare tracheal tube tip and cuff positions of different cuffed paediatric tracheal tube brands in the tracheas.
Methods: Data from three clinical studies with measured tracheal lengths were pooled in a database including 422 children aged from birth to 16 yr. Dimensional data of seven cuffed paediatric tracheal tube brands (ID 3.0–7.0 mm) were recorded. Positions of tracheal tube tip and upper cuff border were calculated for each of the 422 tracheas using depth mark based tracheal tube placement, placement of the tracheal tube tip at a calculated safety distance above the carina, and mid-tracheal tube placement. Percentage of accidental bronchial intubations and tracheal tube cuff positions in the subglottic or supraglottic region were calculated.
Results: Depth mark based tracheal tube placement resulted in accidental bronchial intubation of up to 18% of cases and tracheal tube cuffs being placed in the subglottic region in up to 91%. Tracheal tube tip placement at a calculated safety distance resulted in up to 54% of tube cuffs placed too high. Mid-tracheal tube placement led to 100% subglottic or supraglottic tracheal tube cuff positions.
Conclusions: All studied cuffed paediatric tracheal tubes have major design flaws potentially leading to airway complications. Tracheal tube manufacturers are urgently asked to improve the design of cuffed paediatric tracheal tubes. Alternative strategies for tracheal tube placement can allow safe tracheal tube placement of uncuffed but not of cuffed tracheal tubes.

Keywords: airway management; complications; paediatric; tracheal intubation; tracheal tube

Editorial decision: January 3, 2018; **Accepted:** January 3, 2018

Editor's key points

- Use of cuffed tracheal tubes has become standard practice in paediatric anaesthesia, but it is not clear whether or not depth marks printed on currently available cuffed tubes are good indicators of appropriate depth.
- Depth marks printed on currently available cuffed tubes are not good indicators of adequate depth for placement of these tubes in children.

Use of cuffed tracheal tubes in children has become standard practice in paediatric anaesthesia.[1] Because of the relatively short tracheas of children, tracheal tube cuff position, tracheal tube cuff length, and accordingly the position of an intubation depth mark are critical in cuffed paediatric tracheal tubes.[2] Inadequately placed or absent intubation depth marks could lead to critical tracheal tube tip positions, with an increased risk of either accidental bronchial intubation or extubation.[3] Inadequate position, length of the tracheal tube cuff mounted on the tracheal tubes, or both could result in placement of the tracheal tube cuff in the subglottic or even in the supraglottic region.[4] Evidence exists that many cuffed paediatric tracheal tubes do not fit the paediatric anatomy, and manufacturers were urgently asked to improve their cuffed tracheal tubes for paediatrics.[4–6]

The aim of this study was to compare tracheal tube tip and cuff positions in the newest versions of currently available cuffed paediatric tracheal tubes within the airway of a large number of paediatric patients using different strategies for tracheal tube placement.

Methods

With ethics committee approval (Kantonale Ethikkommission Zurich BASEC-No 2015-00093), measured tracheal lengths from three previously published clinical studies all dealing with endoscopically and radiologically assessed tracheal tube position of an older (initial) version (2004) of the Microcuff Pediatric Endotracheal Tube (Microcuff PET, Microcuff GmbH, Weinheim, Germany) were pooled to a single database that included 426 patients.[7–9] Tracheal length-related patient characteristics included age, height, weight, and their age-related body height and weight percentiles. Data about tracheal length from patients aged from birth to 16 yr were included. Four patients from one study[6] had to be excluded because of ages higher than 16 yr. Overall, the individually measured tracheal lengths from 422 patients were included in this study.

Seven different, currently available cuffed paediatric tracheal tube brands with ID from 3.0 to 7.0 mm were ordered between March 2014 and January 2015 from their local distributors (Table 1).

The distance between the distal tracheal tube tip and the upper border of the tracheal tube cuff (A), and the distance between the distal tracheal tube tip and the lower border of the intubation depth mark, if available, (B) were measured. All distances were measured by two different investigators using a sliding calliper with the tracheal tube cuff inflated to a pressure of 20 cm H_2O, as confirmed by a manual cuff pressure manometer (Cuff Manometer, Mallinckrodt Medical, Athlone, Ireland). Both investigators repeated each measurement five times in two samples of each tracheal tube brand and size. Data are given as median. Median values were used for further calculations.

Assessments

The position of the tracheal tube tip and upper border of the tracheal tube cuff was mathematically assessed within each trachea of the 422 patients using the following five different tracheal tube placement strategies:

1) Tracheal tube placed with the lower border of the intubation depth mark at the vocal cord level.[8]
2) Tracheal tube placed at a calculated safety distance above the carina to prevent accidental bronchial intubation during potential head-neck flexion (safety distance in mm=0.83×age in years+9.3).[9]
3) Tracheal tube placed with the tracheal tube tip placed in the mid-trachea.[10,11]
4) Tracheal tube placed with the tube tip placed 2 cm above the carina in all patients.[12]
5) Tracheal tube advanced according to the tracheal tube's ID (3 cm for ID 3.0 and 3.5 mm; 4 cm for ID 4.0 and ID 4.5 mm; 5 cm for ID 5.0 and 5.5 mm; 6 cm for ID 6.0 and 6.5 mm, and 7 cm for ID 7.0 mm).[13]

Table 1 Investigated cuffed paediatric tracheal tube brands from different manufacturers

Tracheal tube brand	Manufacturer	Sizes ID (mm)	Reference number
Rüschelit Super Safety Clear Magill—cuffed	Teleflex Medical Europe Ltd. Athlone, Ireland	3.0–7.0	112480
Rüschelit Super Safety Clear Murphy—cuffed	Teleflex Medical Europe Ltd.	3.0–7.0	112482
Hudson RCI Sheridan/CF cuffed tracheal tube Magill type oral/nasal	Teleflex Medical Europe Ltd.	3.0–7.0[a]	5-10206 –5-10214
Hudson RCI Sheridan/CF cuffed tracheal tube Murphy eye oral/nasal	Teleflex Medical Europe Ltd.	3.0–7.0	5-10106–5-10114
KimVent Microcuff tracheal tube for paediatrics Magill Oral/nasal	Kimberly-Clark Global Sales, LLC, Roswell, GA, USA	3.0–7.0	35111–35119
Mallinckrodt Hi-Contour oral/nasal trachea tube cuffed Murphy eye	Covidien, Mallinckrodt, Athlone, Ireland	3.0–7.0	107-30–107-70
Curity tracheal tube low pressure cuff Murphy eye	Covidien, Mallinckrodt	3.0–7.0[a]	9430E –9470E

[a] Only tracheal tube sizes ID 3.0, 4.0, 5.0, 6.0, 6.5, 7.0 mm were provided by the manufacturer.