Resuscitation (2008) **77**, 369—373

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/resuscitation

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RESUSCITATION

CLINICAL PAPER

Endotracheal tube length for neonatal intubation☆

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Received 5 November 2007; received in revised form 3 January 2008; accepted 1 February 2008

KEYWORDS
Intubation, intratracheal;
Infant, newborn;
Bronchi;
Radiography, thoracic

Summary
Objective: In the newborn infant, accurate endotracheal tube (ETT) placement is essential for adequate ventilation and surfactant delivery. This study aimed to determine the relationship between gestation, weight and endotracheal tube length, and to evaluate the promotion of gestation-based guidelines for ETT length.
Design: A prospective audit of endotracheal tube placement, followed by an education drive to 24 hospitals, and a subsequent repeat audit.
Setting: Neonatal intensive care transfer service.
Patients: Infants referred for inter-hospital transfer between 33 neonatal units.
Interventions: Education drive to local hospitals to encourage use of standardised guidelines for ETT length based on gestation.
Measurements and main results: Endotracheal tube length, radiological position with respect to thoracic vertebral bodies and radiological complications were assessed by neonatal transport team staff. The association between satisfactory ETT length and gestation was linear, whereas the relationship with weight was non-linear.

In participating centres, use of gestation-based guidelines were associated with a reduction in tubes needing repositioning (8% vs. 53%, $p < 0.01$) and in the incidence of uneven lung expansion (3% vs.17%, $p < 0.05$). As use of gestation guidelines increased from 18% to only 32% overall, the intervention did not produce statistically significant changes in the entire patient population.
Conclusion: Use of gestation-based guidelines on ETT length for neonatal intubation was associated with a reduction in tube malposition and uneven lung expansion. A table of ETT length against gestation and weight is provided to assist those carrying out this procedure, which could be incorporated into neonatal resuscitation training.

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at doi:10.1016/j.resuscitation.2008.02.002.

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0300-9572/$ — see front matter
doi:10.1016/j.resuscitation.2008.02.002

Introduction

In the sick neonate, accurate positioning of the endotracheal tube (ETT) is essential for surfactant delivery and ventilation of both lungs. Minor differences in tube length may lead to intubation of the right main bronchus or extubation. In children clinical methods, such as auscultation of bilateral breath sounds, do not rule out intubation of the right main bronchus.[1] Radiological studies in neonates[2] demonstrate that a satisfactory mid-tracheal position correlates with the body of the first thoracic vertebra (T1), with the carina varying in position between the third and fifth thoracic vertebrae (T3—T5).

Although many methods have been suggested for estimating the length of the endotracheal tube, the most commonly recommended system in international resuscitation guidelines is derived from the weight of the patient in a simple linear formula.[3,4] This system (the 7-8-9 rule) recommends that the insertion depth of the tube at the lips in centimetres should be equal to the patient's weight in kilograms plus 6 cm.

In a previous study from our service, initial neonatal ETT placement in infants requiring inter-hospital transfer was frequently found to be too low and based on this study, guidance was provided on ETT length based on gestation.[5] The current study examines the effect of implementing this guidance on the incidence of malpositioned tubes, in addition to validating the guidelines on a cohort of over 200 babies.

Methods

The study examined ETT placement in infants referred to the Neonatal Transfer Service for London, which provides an intensive care inter-hospital transfer service for 33 neonatal units. Cases were eligible for inclusion if they were orotracheally intubated on the day of transfer; no patients were excluded. Most patients (96%) were intubated by local staff before the arrival of the transfer team; the method used to estimate initial ETT length was recorded individually for each patient. Transport teams recorded the ETT length, level with the patient's lips, and noted the ETT tip position against thoracic vertebral bodies on chest radiographs. Thoracic vertebral position was recorded as an interval scale to the nearest 0.5 vertebrae (e.g. T3 when the tip was level with the body of the third thoracic vertebra, T2.5 when it was level with the interspace between the second and third vertebrae). Tubes were adjusted if the tip was below the lower margin of the second thoracic vertebral body or above the upper margin of the first thoracic vertebra (T1), with final satisfactory ETT length recorded. Radiological lung expansion was classified as even or uneven against criteria in which staff were trained. Uneven lung expansion included differential aeration of lobes or lungs, lobar collapse, and at its most severe, complete collapse of the left lung. Weight at transfer was recorded and corrected gestation was calculated (gestation at birth plus postnatal age).

The interventions included measures to encourage staff to use gestation-based tables as a guide to ETT length. After the original study, recommendations were presented at the service's clinical meetings. In the current study, 24/33 hospitals participated in a specific education drive. The education package involved a regional training day lecture for nurses and junior doctors, distribution of gestation-based tables of ETT length as laminated pocket cards to staff in participating hospitals, and the issuing of posters to be displayed on resuscitation equipment in labour wards and neonatal units. This table gave recommendations on initial ETT length at various gestations to the nearest half-centimetre, based on our previous study.[5] These lengths were 5.5 cm at 23 weeks, 6 cm at 24—26 weeks, 6.5 cm at 27—29 weeks, 7 cm at 30—32 weeks, 7.5 cm at 33—35 weeks, 8 cm at 36—37 weeks and 8.5 cm at 38—40 weeks.

As an audit study, the study was approved by the Clinical Governance Committee of the Neonatal Transfer Service for London, Kent, Surrey and Sussex. Individual patient consent was not required.

Statistical analysis of proportions used χ^2 or Fisher exact test. The need for ETT repositioning was compared in three periods: the original audit, a pre-education and a post-education phase. The remaining measures were compared in the two phases of the current study. Thoracic vertebral position was analysed using single factor ANOVA, with two-factor ANOVA used to compare the effects of using gestation guidance in participating and non-participating centres. The effects of corrected gestation, weight, tube type, study phase and guidance method were assessed on thoracic position using multiple linear regression. The effect of these factors on the need for repositioning and on lung expansion was examined using logistic regression. The study was powered to detect a 20% reduction in numbers of tubes needing adjustment (from 58% in the previous study).

Results

Patient characteristics were similar in pre- and post-education phases (Table 1). The proportion of tubes needing to be repositioned decreased from 58% in the initial audit, to 44% in the pre-education phase and 36% in the post-education phase. There was a statistically significant difference between the original audit and the post-education phase ($p < 0.01$) but not between the pre- and post-education phases ($p = 0.31$).

There were 100 patients in the pre-education phase and 108 in the post-education phase. From pre- to post-education phases, use of gestation guidelines only increased from 18% to 32% ($\chi^2 = 5.7$, $p = 0.02$, Table 1), most staff still used clinical estimation. During the whole study, in participating centres, use of gestation guidelines resulted in a mean ETT tip position which significantly higher ($p < 0.05$, Table 2) and closer to the target range of T1—T2, with fewer tubes requiring repositioning ($p < 0.01$) and a reduced incidence of uneven lung expansion ($p < 0.05$).

In multiple regression, only use of gestation-based guidelines was significantly associated with thoracic vertebral ETT tip position ($r = -0.18$, $p < 0.01$). Similarly, in logistic regression analysis, only the use of gestation guidance was significantly associated with a reduced need for repositioning (OR 0.19, 95% CI: 0.09—0.44, $p < 0.001$) and a reduced incidence of uneven lung expansion (OR 0.09, 95% CI: 0.01—0.69, $p < 0.05$).