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Tracheal tube insertion is an essential part of modern paediatric anaesthesia and critical care: let us get it right

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'A clever person solves a problem. A wise person avoids it.'
Albert Einstein

This quote clearly defines the basis of correct airway management in paediatric anaesthesia and intensive care by modern experienced clinicians. However, nowhere in medicine is an error rate of 20–50% viewed as acceptable and yet insertion of a tracheal tube of the correct size and correct depth has been associated with large error rates, especially in children <1 yr of age. Many formulae exist to attempt to determine the correct depth of insertion of a tracheal tube (whether by oral or nasal route). The original formula [(age/4)+4] for selection of the size of tracheal tube (internal diameter in millimetres) seemed easy enough, if you accepted that ~30% of tracheal tubes would be exchanged. With the widespread introduction of cuffed tubes, a much lower rate is now expected.[1] Viewing and inserting the tracheal tube into the trachea rather than the oesophagus is facilitated by training and experience, with end-tidal capnography providing the gold standard of confirmation, providing the patient has cardiac output and pulmonary blood flow.[2 3]

The correct distance for tracheal tube insertion has proved problematic. With the exception of premature gestation-based recommendations,[4] current age-based formulae have long been recognized as inadequate. Newer weight,[5] length,[6] and anthropomorphic alternatives, such us foot length,[7] middle finger length,[8] and tragus to nares length,[9] have all been studied and found to be better alternatives for infants. Many of these studies were retrospective, and almost all excluded any significant anomalies and pathology. Relative to the age-based predictions, they all demonstrate superior performance, but there remains a 10–20% incidence of tracheal tubes that require adjustment.

Neunhoffer and colleagues,[10] in the March issue of the journal, offer body surface area as an alternative sizing coefficient. Infants (<1 yr of age) were designated as having a correctly placed tracheal tube if the tip was >0.5 cm above the carina (children, >1 yr of age, >1.0 cm) and not <0.5 cm not below the level of the larynx (children not <1.0 cm) on a supine chest X-ray with the jaw in the neutral position. One hundred and thirty-five infants and 102 children were evaluated retrospectively according to two standard formulae.[5] Correction was necessary in 51% of tracheal tubes inserted orotracheally in infants, 44% nasotracheally in infants, 27% orotracheally in children, and 22% nasotracheally in children. These patients were used to create new surface-based formulae and prospectively tested in a small pilot study of 123 patients, 85 infants, and 38 children. The incorrect placement in infants decreased from 46 to 25% in infants and from 26 to 10% in children. This paper confirms what is well known about intubating the small child; that with age and growth, tracheal length increases.[11] The expected depth increases with age, height, and body surface area (which is mathematically coupled to height), and the tracheal tube depth in infants is more difficult to predict than in older children.

The margin for error is small, and head movement can have significant consequences. The average distance from the carina to the larynx in a term newborn is 5.7 cm.[12] Movement of the tip with flexion and extension can be 1 cm towards or away from the carina, respectively, with considerable inter-individual variability depending upon age (size).[13] A similar magnitude of movement away from the carina has been described for rotation to the right and left.[14]

Clinical alternatives to anthropomorphic estimates have been evaluated, including palpation of the tip of the tube in the suprasternal notch[15] and deliberate bronchial intubation and withdrawal.[16] Tracheal tubes have been used to guide depth estimation; the preset rule of 'distance at the cords (in cm) derived from the nearest internal diameter in mm'[17] was reasonably predictive, but others, such as 'multiplying the internal diameter of the endotracheal tube by 3', were less successful than Broselow tape.[18] The use of a known length of black discoloration of the tracheal tube as a predetermined depth marker has been studied for both uncuffed and cuffed tracheal tubes.[19 20] Unfortunately, tracheal tubes are variably marked; this can cause considerable confusion.[21] The microcuff tube depth-marking-based deployment is the most well-studied method and, despite the tendency to reside more proximally with neck extension, appears safe.[13 20]

Having inserted the tracheal tube, there are a number of methods to determine the correct position. Bronchoscopy has evolved, and now there is increased availability of miniaturized neonatal devices.[22] Ultrasound continues to have an increased role in anaesthetics and intensive care and has been recommended to identify tracheal intubation and optimize position.[23] Finally, perhaps newer technologies using infrared technology[24] may be helpful.

Where does that leave the paediatric anaesthetist, intensivist, or emergency physician? We should have a detailed understanding of the specific tracheal tube we are about to use; the nature and position of its cuff (if present), whether the marks we see are for sight or depth, and if viewed at laryngoscopy, was the corresponding position at the lip, gum, teeth, or nares documented? We should understand the limitations of the formula we use; does it predict for a high or low tracheal tube, and will the positioning during surgery (flexed, extended, or rotated neck) tend to increase or decrease this risk? Most departments do not currently have easy access to small bronchoscopes for routine evaluation of every intubated infant, but we can measure the middle finger or gently palpate the front of the neck, and many do have access to ultrasound machines and have specialists increasingly skilled in their use. Clearly, the gold standard test for correct position for a tracheal tube is chest X-ray.

If the patient is to remain intubated for a long period of time for anaesthesia and surgery or mechanical ventilation, the likelihood of incorrect tracheal tube position and possible consequences outweighs the time, cost, and radiation exposure risk of a chest X-ray. For a brief procedure, one may monitor oxygenation and end-tidal CO_2, and assume that the tracheal tube is reasonably positioned; of course, this exposes the patient to risk of aspiration and accidental extubation or hypoxaemia, pneumothorax, and bronchial intubation. Increasingly, accurate documentation of the position of the tracheal tube is needed.

Declaration of interest

None declared.

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Insights into myocardial infarction after noncardiac surgery in patients with a prior coronary artery stent

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Physicians commonly encounter patients undergoing noncardiac surgery who have previously received a coronary artery stent.[1] Several large observational studies have demonstrated that patients who have a coronary artery stent within the six months before noncardiac surgery have an increased risk of perioperative myocardial infarction (MI).[2 3] MI is the most common major vascular complication after noncardiac surgery, and it substantially increases a patient's risk of 30-day mortality.[4 5]

Among patients with a coronary artery stent who undergo noncardiac surgery, uncertainty exists regarding the mechanism of MI and how to prevent this complication. Dr. Wasowicz and colleagues[6] report a study in the April issue of the British Journal of Anaesthesia that provides insights into these two important issues. These investigators have conducted one of the few prospective cohort studies evaluating patients who have a coronary artery stent and subsequently undergo noncardiac surgery.[6]

They performed perioperative platelet function testing using a Platelet Mapping Assay (PMA) to test their hypothesis that adequate platelet inhibition would reduce the incidence of the primary outcome of major adverse cardiac events (i.e. MI, congestive heart failure, in-stent thrombosis, coronary revascularization, or death) within 30 days after noncardiac surgery. Strengths of their study include: the systematic daily ECG and troponin measurements for five days after surgery; and blinding of outcome assessors to the PMA results. Their findings, of declining levels of platelet inhibition the longer anti-platelet drugs were held before surgery, support that PMA was measuring platelet inhibition.

Investigators at three Canadian hospitals included 209 patients who received a bare metal stent within two yrs, or a drug eluting stent within any time frame before noncardiac surgery. Eight patients were not tested and were therefore not included in the final analyses. Baseline therapy included dual antiplatelet therapy in 161 patients (80%); however, 66 patients (33%) stopped taking aspirin more than three days before surgery, and only 35 patients (17%) received clopidogrel within five days of surgery.

A major adverse cardiac event occurred in 40 patients (20%). Although the authors used a broad composite endpoint, most of the events were MI; 32 patients (16%) suffered a non-ST-segment elevation MI (NSTEMI), and four patients (2%) experienced an ST-segment elevation MI (STEMI). It is fortunate that MI dominated the primary outcomes (i.e. MI represented 90% of the primary outcomes), because the relationship between platelet inhibition and major adverse cardiac events may vary across the individual outcomes. Most MIs (21 of the 36 MIs, 58%) occurred within 24 h after surgery, and ECG localization suggested that 75% of the MIs occurred in the territory supplied by the stented coronary artery.

In contrast to the authors' hypothesis, multivariable logistic regression did not demonstrate an association between the percentage of platelet inhibition before surgery (evaluated as a continuous variable) and the primary outcome (i.e. odds ratio, 1.00; 95% CI, 0.99–1.02). Moreover, comparing patients who did and did not suffer a major adverse cardiac event, the authors demonstrated no difference in the median percentage of platelet inhibition based on aspirin and clopidogrel separately at three time points (i.e. just before surgery, in the post anaesthesia care unit, and the day after surgery), with one exception. The median percentage of clopidogrel platelet inhibition at 24±4 h after surgery was higher in patients who suffered the primary outcome compared with patients who did not suffer this outcome (56.9 *vs* 36.7, P=0.001).

Based on their finding that the majority of MIs were NSTEMIs, the authors suggest that this indicates a supply-demand mismatch mechanism; however, a diagnosis of NSTEMI is not pathognomonic of supply-demand mismatch. Intracoronary optical coherence tomography (OCT) is the most advanced intra-coronary imaging