Editorial

Cuffed tracheal tubes in children – things have changed

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Whether cuffed tubes should be routinely used in infants and small children has been extensively discussed in the past. However, opinions and recommendations were not based on scientific evidence but rather on empiricism. The basic function of a tracheal tube is to provide a reliable connection between the patient’s lung and the bag or ventilator. Ideally, this connection should be leak-proof without causing undue pressure to laryngeal or tracheal structures. If this connection is not reasonably tight or sealed, constant minute ventilation, precise respiratory monitoring and capnography, low fresh gas flow and prevention of pulmonary aspiration are not possible. In an emergency situation and in patients with severe lung disease good sealing becomes even more important.

Traditional teaching for the last 50 years was that in children under 8–10 years of age, this ‘sealing’ should be obtained with an uncuffed tracheal tube that would slip easily through the cricoid and leave some space for an air leak at 25 cm H2O airway pressure. Without any real evidence, cuffed tubes were not considered appropriate for children, in contrast with adults.

This teaching was based on the idea that the cricoid, the narrowest part of the pediatric airway up to 8 years, would be a circular structure (1). A tracheal tube fitting snugly through the cricoid and leaving an air leak at an inspiratory pressure of about 25 cm H2O would provide sufficient sealing without a cuff (2). To fulfill both requirements (leak and seal) an uncuffed tube must have precisely the correct size for that particular child. Because this claim is difficult to fulfill in daily practice, many different formulas for tube size selection have been put forward and despite these a high tube exchange rate to find an appropriately ‘fitting’ tube is usual (3). When a correct sized tube cannot be found, anesthetists have the dilemma to accept an uncuffed tube with a large gas leak or to insert an oversized tracheal tube. Oversized uncuffed tracheal tubes exert undue pressure on the laryngeal structures and are well known as the main cause of laryngeal injury from tracheal intubation (3, 4). Large air leakage with uncuffed tracheal tubes results in unreliable ventilation and oxygenation, imprecise capnography and lung function testing, high gas flow consumption, environmental pollution of anesthetic gases, as well as pulmonary aspiration (3). Nevertheless, in the last 50 years pediatric anesthetists have accepted, to live with the shortcomings of uncuffed tubes in children and have taught these myths to their junior colleagues without question.

Things have changed! Newer investigations in children revealed, that the cricoid lumen is not a round but mostly an ellipsoid structure (5). If a round uncuffed tracheal tube is inserted into the noncircular lumen of the cricoid, to give a reasonable seal (cricoidal ‘sealing’), considerable pressure on the lateroposterior walls of the cricoid occurs. The air leak at an inspiratory pressure of 25 cm H2O, supposed to prevent excessive mucosal pressure can arise exclusively from the anterior part of the cricoid lumen. Thus when an uncuffed tube reasonably seals the trachea and has a leak, the pressure exerted on some parts of the cricoid mucosa is unknown and may still be excessive. In cuffed tracheal tubes a smaller diameter is selected which does not wedge within the delicate cricoid and the airway is sealed within the trachea using a cuff (tracheal sealing). In contrast with cricoid ‘sealing’, tracheal sealing with a high-volume low-pressure (HVLP) cuff allows to estimate and adjust precisely

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the pressure exerted by the cuff on the tracheal mucosa. In addition, the U-shaped tracheal cartilages and muscular dorsal wall allow for some distension in contrast with the rigid cricoid ring. New pediatric cuffed tracheal tubes with correct design and excellent sealing properties have come on the market. As an innovation, tracheal tube cuffs made from polyurethane allow the construction of a very short HVLP cuff with improved sealing characteristics (6,7). Dullenkopf et al. reported on tracheal sealing in 500 children aged from birth to 16 years using a new cuffed pediatric tracheal tube and gave a recommendation for tube size selection (6). In this study, air leak with the cuff not inflated was <10 cm H2O inspiratory pressure in about 80% of children, which means that there was ample space around the tube in the cricoid. On the other hand, in 95% of patients the trachea was completely sealed with a cuff pressure of less than 15 cm H2O (mean cuff pressure 9.7 cm H2O) (6). The tube exchange rate was only 1.6%. Low tube exchange rates and a sealed airway without the use of an oversized tracheal tube are the main proven benefits of cuffed tracheal tubes in children. If the cuff pressure is held no higher than 20 cm H2O and the tube cuff is positioned in the trachea, there is no increased airway morbidity (6).

Official bodies such as the American Heart Association (AHA) and the International Liaison Committee on Resuscitation (ILCOR) state in their 2005 guidelines for pediatric resuscitation, that the use of cuffed tubes in infants and children is now an accepted alternative to uncuffed tubes (8,9). Golden, in a recent SPA newsletter, proposed that cuffed tube are suitable from size internal diameter 4.0 mm and larger for children and cuffed tracheal tubes are preferred in patients at risk of pulmonary aspiration, with low lung compliance (including laparoscopy, thoracoscopy, cardiopulmonary bypass) and in whom precise ventilation and CO2 control is important (10).

For a long time, cuffed tracheal tubes in pediatric were believed to be associated with increased airway morbidity and the majority of pediatric anesthetists still do not use a cuffed tube in children because of this (12). However, in the literature there are no studies at all demonstrating increased airway morbidity. The rare case report of airway injury because of a cuffed tube in children is related to inappropriate handling and inadequate equipment (13,14). As James wrote in 2001, “The little evidence we have is that cuffed tubes per se are not more dangerous than uncuffed tubes. Arguments against the use of cuffed tubes in children are intuitive and based on the early experience of laryngeal damage caused by using oversized uncuffed tubes” (3). In the meantime, evidence has accumulated that cuffed tracheal tubes can be used safely in children and they have proven benefits over uncuffed tracheal tubes (6,15,16). Even more clinical situations are now highlighted, where uncuffed tracheal tube should no longer be used (17). Several large pediatric centers have routinely used cuffed tracheal tubes in infants and children for many years without increased airway morbidity (11).

So are all concerns about cuffed tubes in children invalid? Like all medical devices cuffed tubes have general and specific problems and the user must observe directions for use. Thus far, all cuffed pediatric tubes have a smaller inner diameter, and are more expensive, but they are more cost effective. The smaller diameter can cause increased work of breathing and difficulty with tracheal suctioning. Although this is not a frequent problem in anesthesia practice, in the PICU it may become more important, but this is not apparent so far (16). Most cuffed pediatric tracheal tubes have inadequate design such as a too high positioned cuff, absence of clear or wrong intubation depth marking, only low-volume high-pressure cuffs up to a tube size ID of 4.5 mm and various outer diameters for identical internal diameters (14,18–20). Because active over-inflation or overexpansion by nitrous oxide diffusion may cause laryngeal damage, continuous and precise control and regulation of cuff pressure is mandatory. Anesthetists not yet willing to do so should not use cuffed tubes (7). Today simple cuff pressure release valves or automated cuff inflators are available to limit cuff pressure.

In conclusion, new evidence has accumulated that cuffed tracheal tubes can safely be used in children. They have proven benefits over uncuffed tracheal tubes in pediatric anesthesia, intensive care and emergency care. Only correctly designed
cuffed tubes with a definite intubation depth mark, a short high-volume low-pressure cuff and a reliable size selection recommendation should be used. When using such a cuffed tracheal tube, cuff pressure must be monitored and adjusted. With these conditions being met, a cuffed tracheal tube provides a reliable, leak-proof and safe connection with all the benefits between bag or ventilator and the child’s lungs.

Declaration of interest
In the author’s institution, cuffed tracheal tubes are routinely used in children from birth to adolescence since 2000.

PD Dr M. Weiss and Dr A Gerber are involved in the development and evaluation of new cuffed pediatric tracheal tubes in co-operation with Microcuff GmbH, Weinheim, Germany, TYCO Health Care, Athlone Ireland and Kimberly Clark, Health Care, Atlanta, IL, USA.

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