Perioperative quality of care and patient safety

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Chapter 5

Recommendations from a guideline- but how to do it?
Paediatric can’t intubate can’t oxygenate crisis.
The emergency paediatric surgical airway – a systematic review

“When you have to shoot, shoot, don’t talk”
The Good, the Bad and the Ugly. 1966

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Over the last decades airway related deaths in anaesthesia have declined significantly by use of improved monitoring, training and difficult airway algorithms. Failed airway management and secondary hypoxia in children, however, remain a significant cause of morbidity and mortality in paediatric anaesthesia and critical care.1-5 Recently, several publications have emphasised the importance of a difficult intubation algorithm for children.6,7 These guidelines provide anaesthesiologists with an invaluable framework during stressful, high-risk paediatric difficult airway scenarios. All difficult airway algorithms recommend performing a surgical airway in the paediatric can’t intubate, can’t oxygenate (CICO) crisis. Since this surgical airway is the last resort to save the patient and therefore only performed under extreme stress, a clear-cut plan for performing a surgical airway should be available. However, none of the guidelines recommend a particular surgical technique. This is because paediatric CICO is very rare and no current evidence regarding the best technique for performing a paediatric emergency surgical airway is currently available. The true incidence of paediatric CICO is not known. The incidence of unexpected difficult endotracheal intubation is between 0.15-1.4%8,9 the need for a surgical airway extrapolated from these numbers, will be thus be very low. No absolute cut offs for vital parameters can be given to indicate the need for establishing a surgical airway. However, ongoing deterioration with a continuing decline of oxygen saturation, bradycardia and ensuing haemodynamic compromise, in spite of all efforts to intubate or oxygenate the patient (i.e. laryngoscopy, fibreoptic or a supraglottic device and ongoing bag mask ventilation with 100% oxygen) and when waking up has failed or is deemed inappropriate because of the level of deterioration, indicates the need for a surgical approach.6 Since it is likely that there will be an intrinsic reluctance amongst anaesthetists to perform a surgical airway,10 especially in the absence of best practice recommendations, a significant delay or even inability to perform an emergency surgical airway
in a paediatric CICO will occur. Ultimately this could lead to serious patient harm and even death. In order to make a best practice recommendation to perform an emergency surgical airway in children, this study gives an overview of current literature with regard to the best technique to perform a surgical airway in paediatric CICO.

Methods

Search strategy and study selection
A systematic review of the literature regarding the surgical airway in children in the can’t oxygenate, can’t intubate scenario was conducted. We included original studies that looked at performing a paediatric surgical airway technique, either in a human, animal or artificial model, and reported the following outcomes: time to tracheal access (defined as visual confirmation or presence of end tidal CO₂ and/or time to reported effective oxygenation or ventilation), the success rate, complications and perceived ease of use of the technique. Studies reporting on adult techniques were excluded because of the technical differences between a surgical airway in children and in adults. Two authors (LK, DJ) performed a comprehensive literature search using the MEDLINE, EMBASE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), Google Scholar and LILACS databases with help of a clinical librarian at the authors institution. Search strategy included the terms: [(airway) OR (Airway Management) OR (Intubation, Intratracheal) or (airway obstruction) or (difficult airway) OR (Respiratory Insufficiency) OR (Tracheostomy) AND (surgery) OR (anaesth*) or (anesth*) OR (cricothyrotomy) OR (trach)] AND [(Emergency Treatment) OR (Resuscitation) OR (emergen*) OR (problem*) OR (trauma) OR (acute) OR (life-threatening) OR (complication)] AND [(Child) OR (Pediatric*) OR (Paediatric*) OR (child*) OR (infan*) OR (neonate*) OR (newborn)]

We did not limit the search by language, publication status or publication date as we expect the number of eligible studies to be limited. Additional literature was sought through hand searching via references of relevant articles, journals and authors known to be expert in the field, to identify further studies. Two review authors (LK, DJ) independently screened the titles and abstracts of all reports identified by electronic and manual searching. Articles that were evidently irrelevant were excluded at this stage. We retrieved and evaluated all potentially relevant studies, chosen by at least one review author, in full-text versions. Two review authors (LK, DJ) independently screened the full papers, identified relevant studies and assessed eligibility of studies for inclusion. We resolved disagreements on the eligibility of studies through discussion. A third review author was consulted (MFS) in case of disagreement. Details of irrelevant and thus excluded studies were recorded. Study identification
and selection is summarised in the PRISMA flow diagram (figure 5.1). Characteristics of the included studies can be found in table 5.1.

**Assessment of study quality**

Both review authors (LK, DJ) independently assessed risk of bias in the included studies using “The Cochrane Collaboration’s ‘Risk of bias’ tool” outlined in Table 8.5c of the Cochrane Handbook for Systematic Reviews of Interventions. The results of the risk of bias assessments of the included studies can be found in table 5.2. Blinding was not appropriate due to the nature of the intervention, so this was not considered an insurmountable criterion. We used the ROBINS-I for assessing the quality of the nonrandomised studies.
### Table 5.1 Characteristics of original studies

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Model (n, weight*)</th>
<th>Study type</th>
<th>Intervention</th>
<th>Operator</th>
<th>Reported outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holm-Knudsen 2012</td>
<td>(n=?) piglet cadavers +/- 8kg Tracheal Ø 10mm</td>
<td>Randomised cross-over study</td>
<td>Insertion of 2 transtracheal cannulas - jet ventilation catheter for children (14 GA), VBM Medizintechnik GmbH, Sulz am Neckar, Germany - BD Venflon™ Pro Safety (14 GA) Franklin Lakes, NJ, USA Tracheotomy - Scalpel, scissors, 3 towel forceps, endotracheal tube</td>
<td>32 anaesthesiologists median 12.5 (IQR 7-20) years of experience who attended paediatric difficult airway course</td>
<td>Time to tracheal access Success rate</td>
</tr>
<tr>
<td>Johansen 2010</td>
<td>10 piglet cadavers 8kg Tracheal Ø 10mm</td>
<td>Non-randomised cross-over design</td>
<td>Insertion of transtracheal cannula - BD Venflon™ Pro Safety (16/18 GA) Franklin Lakes, NJ, USA Tracheotomy - Scalpel, scissors, 3 towel forceps, endotracheal tube</td>
<td>30 physicians (10 for tracheotomy) who attended paediatric difficult airway course</td>
<td>Time to tracheal access Success rate</td>
</tr>
<tr>
<td>Metterlein 2011</td>
<td>10 rabbit cadavers 4.1 (IQR 3.5-5.4) kg Tracheal Ø 5.5 (5.1-6) mm</td>
<td>Non-randomised design*</td>
<td>Catheter-over-needle - Quicktrach baby™ VBM Medizintechnik GmbH, Sulz am Neckar, Germany</td>
<td>2 (1st, 4th year) anaesthesia residents</td>
<td>Time to tracheal access Success rate Complications</td>
</tr>
<tr>
<td>Prunty 2015</td>
<td>8 rabbit cadavers +/- 4kg Tracheal Ø accommodating tube 3.5-4 (=4.5-5.5mm)</td>
<td>Randomised cross-over design</td>
<td>Wire guided (Seldinger) - COOK 3.5 Melker Kit (Bloomington In, USA) Tracheotomy - Scalpel, bougie, endotracheal tube</td>
<td>2 consultant anaesthesiologists (experienced proceduralists)</td>
<td>Success rate Complications</td>
</tr>
<tr>
<td>Stacey 2012</td>
<td>5 rabbit cadavers 3.9 (IQR 3.2-5.3) kg Tracheal Ø 3.5 (3-4) mm</td>
<td>Non-randomised cross-over design</td>
<td>Insertion of 2 transtracheal cannulas - BD Insyte™ (14 GA) Franklin Lakes, NJ, USA - BD Insyte™ (18 GA) Franklin Lakes, NJ, USA Catheter-over-needle - Quicktrach baby™ VBM</td>
<td>2 consultant anaesthesiologists (experienced proceduralists)</td>
<td>Success rate Complications Ease of use</td>
</tr>
</tbody>
</table>

* study randomised on allocation of rabbits (albeit rabbit was standardised model), thus considered as non-randomised. Weight expressed in kilograms or median and interquartile range.
Data extraction and statistical analysis

During a pilot search, we identified that there were no high-quality randomised trials assessing the optimal devices used to perform a surgical airway. Due to the nature of these original studies it was therefore not possible to perform a meta-analysis and its coinciding statistics. In order to still organise the results in a meaningful way, data were reported as a SWOT-analysis to evaluate the strengths (S), weaknesses (W), opportunities (O) and threats (T) of the different surgical airway techniques in children. Strengths and weaknesses describe the intrinsic advantage and disadvantage of the techniques, respectively. The opportunities and threats describe the advantage and disadvantages of the techniques in the setting of a paediatric can’t intubate, can’t oxygenate scenario. We requested any missing variables from the authors of the original studies. The authors did not reply. We calculated the mean and SD from the reported medians and interquartile ranges by the method proposed by Wan et al.$^{14}$

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**Table 5.2 Risk of bias of original studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Random assignment</th>
<th>Allocation concealment</th>
<th>Blinding participants</th>
<th>Blinding outcome assessors</th>
<th>Incomplete outcome data</th>
<th>Selective reporting</th>
<th>Other bias</th>
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<tr>
<td>Holm-Knudsen 2012</td>
<td>unclear risk</td>
<td>unclear risk</td>
<td>high risk</td>
<td>unclear risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
</tr>
<tr>
<td>Prunty 2015</td>
<td>unclear risk</td>
<td>unclear risk</td>
<td>high risk</td>
<td>unclear risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Bias due to confounding</th>
<th>Bias due to participant selection</th>
<th>Bias in intervention classification</th>
<th>Bias due to deviations from intended interventions</th>
<th>Bias due to missing data</th>
<th>Bias in outcome measurement</th>
<th>Bias in selection reported result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johansen 2010</td>
<td>moderate risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
</tr>
<tr>
<td>Metterlein 2011*</td>
<td>moderate risk</td>
<td>moderate risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
</tr>
<tr>
<td>Stacey 2012</td>
<td>moderate risk</td>
<td>moderate risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
<td>low risk</td>
</tr>
</tbody>
</table>

* study randomised on allocation of rabbits (albeit rabbit was standardised model), thus considered as non-randomised.

Results

From 144 potential eligible studies, five\textsuperscript{15-19} studies were included. These five included studies described 251 interventions in both rabbit and piglet cadavers (range 3.2-8 kg). No studies retrieved involved human subjects. Four techniques were described: the catheter over needle (23 insertions), the wire-guided (16 insertions), cannula (154 insertions) and the scalpel technique (58 insertions). The catheter over needle technique is a technique with a plastic cannula that can be inserted over a metal needle for direct placement in the trachea (for example Quicktrach baby\textsuperscript{16}). The puncture site in the studies was the cricothyroid membrane, which was palpated. The needle was then advanced at a 45° angle through the membrane, once air was aspirated the device was advanced further and the cannula was placed over the mandarin. The metal needle was removed after insertion of the cannula.\textsuperscript{17} The wire guided insertion is a Seldinger technique. Although this technique is developed for use at the cricothyroid membrane the included study used it as a tracheostomy set, caudally from the cricothyroid membrane.\textsuperscript{18} The cannula technique is similar to the catheter over needle technique but uses a smaller diameter of plastic cannula and needle. Usually this is an intravenous cannula. Studies used a syringe and percutaneously punctured the trachea just below the cricoid cartilage in an angle of 45°. Aspiration of air was used to verify the position of the needle.\textsuperscript{15,16,19} These three techniques are all blind techniques, i.e. you do not visualise the trachea during the procedure and confirmation of intratracheal placement is only possible at the end of the procedure with capnography and, or improvement of vital signs. The only open procedure is the scalpel technique. Either a vertical incision was made through the skin and the subcutaneous tissue from the upper part of the larynx to the sternal notch. The trachea was stabilised using a towel forceps and a further vertical cut with sharp scissors was made in the trachea 1-2 cm caudal from the larynx after which a tube was inserted in the trachea.\textsuperscript{15,16} Or the trachea was incised horizontally and after turning the blade 90° to make space to allow for a bougie, a bougie and tube were inserted in the trachea.\textsuperscript{18} All animals in the studies were placed supine and were supported in this position.\textsuperscript{15-19}

Time to tracheal access

One study reported time to tracheal access for the catheter over needle technique. Two intervals were reported; time for preparation of the procedure (from decision to perform a surgical airway to actual insertion) which was a median time of 12 (IQR 9-14) seconds and procedural time which was a median of 31 (IQR 23-43) seconds.\textsuperscript{17} This resulted in a combined mean time of 44 seconds for the catheter over needle technique. The study on the wire-guided technique did not look at the outcome procedural time.\textsuperscript{18} Two studies reported procedural times for 3 cannula techniques, which were a median of 69 (IQR 29–121), 42 (IQR 26–121) and 68 (35–95) seconds.\textsuperscript{15,16} The mean time to insert an intratracheal cannula from
these studies was 67.3 seconds.\textsuperscript{15,16} Two studies reported procedural time for the scalpel technique, which were a median of 88 (IQR 76 – 128) and a median of 89 (IQR 71-200) seconds.\textsuperscript{15,16} The mean time to perform a surgical airway with a scalpel was 108.7 seconds from these studies.\textsuperscript{15,16}

**Success rate**

All studies that looked at the outcome time to tracheal access also defined a timeframe wherein a device had to be in place, otherwise the procedure would be considered to have failed. The allowed time for cannula technique was a maximum of 120 seconds,\textsuperscript{15,16} for insertion catheter over needle technique this was a maximum of 180 seconds,\textsuperscript{17} and for scalpel technique this was 240 seconds.\textsuperscript{15,16} Reported success rates for the catheter over needle technique where 10/10\textsuperscript{17} and 0/13.\textsuperscript{19} The overall success rate for the catheter over needle technique reported in the literature was 43% (10/23).\textsuperscript{17,19} For the wire-guided technique the reported rate was 100% (16/16).\textsuperscript{18} The cannula technique had reported success rates of 21/32,\textsuperscript{15} 22/32,\textsuperscript{15} 8/30\textsuperscript{16} and 36/60\textsuperscript{19} totalling at a rate of 56% (87/154).\textsuperscript{15,16,19} Success rates for the scalpel technique where 31/32,\textsuperscript{15} 8/10,\textsuperscript{16} and 12/16\textsuperscript{18} resulting in an overall success rate of 88% (51/58).\textsuperscript{15,16,18}

**Complications**

Complications were recorded in the studies either by direct visualisation with bronchoscopy\textsuperscript{15,17-19} or through anatomical examination.\textsuperscript{17-19} Failure rates were not counted as complications as they are represented in the outcome ‘success rate.’ Complications described for the catheter over needle technique were 1 injury to the posterior wall of the tracheal mucosa\textsuperscript{17} and 2 fractures of the cricothyroid cartilage with associated hematoma.\textsuperscript{17} This resulted in a complication rate of 33% (3/10).\textsuperscript{17} Studies assessing the wire-guided technique reported lateral and or posterior tracheal wall injury in 11/16 insertions accounting for a complication rate of 69%.\textsuperscript{18} Complications secondary to intratracheal cannula insertion were tracheal perforations in 14/27 and 25/60 insertions,\textsuperscript{15,19} vocal cord perforations in 2/37,\textsuperscript{15} and 14 misplacements of the catheter after 27 successful transtracheal placements.\textsuperscript{15} This resulted in an overall complication rate of 36% (55/151).\textsuperscript{15,19} Complications reported with the scalpel technique were a large tracheal defect with cartilaginous injury in 3/32\textsuperscript{15} and 15/16 injuries to the posterior tracheal mucosa\textsuperscript{18} resulting in an overall complication rate of 38% (18/48).\textsuperscript{15,18}

**Perceived ease of the technique**

Only 1 study reported on the ease of use of the cannula technique.\textsuperscript{19} Proceduralists in this study reported no significant difference in ease of use between the 18G and 14G cannula. However, data on this statement were not presented in the paper.
SWOT- analysis

Aggregated results for all studies can be found in table 5.3. From the available evidence the strength of the catheter over the needle technique is that it is fast which offers the advantage of establishing an airway rapidly in a paediatric CICO. Complication rate described is the lowest of all the techniques. However, it has a very high failure rate, so this technique has the disadvantage of a high likelihood of not being able to provide tracheal access at all. The wire-guided technique has a high first attempt success rate reported. Procedural time was not reported. The disadvantage of this technique is a high complication rate. The reported outcomes for the cannula technique indicate a low complication rate. However, from the available evidence this procedure has a high failure rate rendering uncertainty whether an airway can be established in a paediatric CICO. High success rates are described for the scalpel technique, complication rates are amongst the lowest between the 4 techniques. Reported procedural time is longer, however.

<table>
<thead>
<tr>
<th></th>
<th>Duration placement (mean sec)</th>
<th>Success rate</th>
<th>Complication rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter over Needle</td>
<td>44</td>
<td>43% (10/23)</td>
<td>34% (3/10)</td>
</tr>
<tr>
<td>Wire-guided</td>
<td>not reported</td>
<td>100% (16/16)</td>
<td>69% (11/16)</td>
</tr>
<tr>
<td>Cannula</td>
<td>67.3</td>
<td>56% (87/154)</td>
<td>36% (55/151)</td>
</tr>
<tr>
<td>Scalpel and Bougie</td>
<td>108.7</td>
<td>88% (51/58)</td>
<td>38% (18/48)</td>
</tr>
</tbody>
</table>

*Stacey et al.19 did not report complication rate as failure rate was 100%. ‡No time was reported for the wire-guided technique.

Discussion

In general, there is a lack of high-quality evidence regarding the best technique for an emergency surgical airway in the management of a paediatric can’t intubate can’t oxygenate crisis. There are no human data and the available data are heterogeneous and limited, thus the results of this study need to be interpreted with caution. The SWOT analysis of the 5 studies included in this systematic review15-18 allows for the following conclusions:

The strength of the catheter over needle technique is that it is quick, so it offers the opportunity for quick reestablishment of oxygenation and ventilation.17 A weakness however is that it has a high failure rate; so, a threat of this technique is that it will fail to restore oxygenation and ventilation during a paediatric CICO.17,19 Furthermore, the complications (i.e. tracheal wall injuries and fractures of the cricothyroid cartilage, tracheoesophageal fistula and secondary mediastinitis) described with this technique are significant1 and can be life-threatening themselves.
The strength of the wire-guided technique is the reported high success rate, offering the opportunity for effective reestablishment of oxygenation and ventilation. However, this success rate is based on limited number of insertions. The weakness of this technique is the high complication rate. There are no reported data on the insertion time for this device in the included studies. In an elective setting the mean procedural time was 1200 (SD 720) seconds in children and 149.7 (SD 44.2) seconds in 20 insertions in an emergency setting in adults. This is a longer procedural time (in a technically less challenging airway) than any of the reported procedural times for the other three techniques presented in this study.

Strengths of the cannula technique are the low complication rates and the fact that this technique is well known through training in advanced paediatric life support courses. Furthermore, in terms of reversibility it has been suggested that a cannula technique allows for a second attempt at a surgical airway (any kind) more easily than a scalpel technique. As the amount of tissue damaged by a surgical technique is for obvious reasons greater than through cannula or trocar technique, the opportunities of this technique are therefore the low complication rate and the lower threshold to perform the technique during a paediatric CICO. The major weakness of this technique is the high failure rate. It is furthermore only a temporising measure as it will not restore ventilation and hypercarbia will ensue. Complications like subcutaneous emphysema, pneumomediastinum, (tension)pneumothorax and lung injury can occur with the required oxygen flow rates even when cannula insertion in the trachea was successful, especially in children with a proximally obstructed airway. There are reports however, describing the use of the Ventrain® device for emergency percutaneous transtracheal ventilation in critically obstructed airways as being able to provide effective oxygenation and ventilation at low airway pressures for at least 15 minutes. Included studies furthermore showed a 52% (14/27) dislocation rate after initial successful intratracheal positioning. The major threat of this technique is failing to restore both oxygenation and ventilation with the superimposed risk of the above described complications when the technique is successfully performed.

Finally, the strength of the scalpel technique is its high success rate. It therefore offers the opportunity for effective reestablishment of oxygenation and ventilation. However, a weakness of this procedure is the longer procedural time and the potential for a high threshold for an anaesthetist to perform the procedure. Just as with the catheter over needle technique the complications described with this technique are significant (i.e. bleeding and tracheal injury) and can be life-threatening themselves. There were no data to comment on perceived ease of use of the different techniques.

A limitation of this study is that a quantitative assessment of publication bias was not performed due to the limited number of available studies. This study is further limited by the quality of evidence of available studies. It is questionable whether the animal models used
in these studies are robust translational simulations of the real world paediatric CICO. The included studies used both post-mortem rabbits and piglets. Most studies did not comment on the condition of their post-mortem models, two studies specifically stated that they used fresh cadavers. Tissues from frozen or embalmed models react very different than tissues from a living being. These post-mortem tissues would be less elastic, rendering the incidence of inadvertent oesophageal puncture lower, and the incidence of cartilage fractures higher. Also, the amount of bleeding and haematoma interfering with the procedure can’t be determined with a post-mortem model. Holm evaluated the similarity of their piglet model with the paediatric airway. The diameter of the trachea in the model was 10 mm, which is similar to the diameter of a trachea of a 5 to 10 year old child. However, the trachea was located 15 mm deeper and the larynx situated much lower in the neck than that of a young child. The studies using rabbit models describe the diameter of the tracheas of their models as 3-6 mm similar to that of infants and children up to 2 years. But the external landmarks and hyoid-to-sternum distance in rabbits are very different from those in young children. Additionally, it is likely that children that need a surgical airway might present with anatomical abnormalities (i.e. malformations, tumours, swelling and or haematoma) which these models do not account for.

Proceduralists in the studies range from 1st year anaesthesia trainees to difficult airway experts with 20 years of experience and although this is a representation of daily anaesthetic practice it makes it difficult to compare the success rates of the procedures. There are several issues to consider for a paediatric can’t intubate, can’t oxygenate crisis. Anaesthetists are reluctant to perform a surgical airway in general and in children in particular. This is partly because of the technical difficulty of the procedure. The identification of anatomical landmarks is troublesome because the hyoid bone and cricoid cartilages are often more prominent than the thyroid cartilage in children due to the amount of subcutaneous fat. The cricothyroid membrane in neonates is very small (about 2.6 - 3 mm) and the larynx is high in the neck so it can be very difficult to have enough room to position the needle. The paediatric trachea is furthermore very mobile and compressible, rendering inadvertent subcutaneous or oesophageal puncture and cannulation a likely complication, especially in techniques that require a blind, somewhat forceful puncture (catheter over needle, wire guided and cannula techniques). The reluctance to perform a surgical airway in children seems furthermore secondary to the lack of training and lack of appropriate standardised equipment. There are no numbers on how much training would be required to safely perform a surgical airway in a child. To achieve an adult intubation success rate of 90% with direct laryngoscopy, anaesthetic trainees need to perform 60 endotracheal intubations. Considering this, it is first of all questionable whether an airway failure rate of 10% is acceptable, and secondly it is unlikely that anaesthesia trainees or even paediatric anaesthesiologists would receive similar training numbers in paediatric surgical airways.
Equipment tailored to non-surgeons is often percutaneous in hopes of lowering the threshold for performing the procedure. However, most of this equipment is designed for the adult airway. But even in the technically less challenging adult cricothyroidotomy, the NAP4 audit\textsuperscript{32,33} found that the cannula technique had a failure rate of 65%. Some authors therefore advocate a scalpel technique in children under the age of 8 or suggest to expose the cricothyroid membrane with a scalpel and to cannulate under direct vision.\textsuperscript{7} Two case reports describe the need for a surgical airway in a child. Okada et al.\textsuperscript{34} describe a case of a CICO in a 3-year-old boy presenting in cardiac arrest with an airway obstruction after anaphylaxis or angioedema. A surgical airway using a cannula technique did not seemed feasible because there wasn’t enough working space (i.e. an angle) to perform the procedure through the cricothyroid membrane. A cricothyroidotomy was attempted with a scalpel and a tracheostomy tube with introducer (Mini-Trach II – Non Seldinger Kit; Smiths Medical, Minneapolis, Minnesota, USA) however this failed because of the small size of the cricothyroid membrane (3 mm in length). A second insertion attempt below the cricoid after a vertical skin incision, blunt dissection to the trachea and an incision into the trachea resulted in the successful establishment of an airway. Unfortunately, the child could not be revived after a total procedural time of 10 minutes. Santoro et al.\textsuperscript{35} describe a case of CICO in a four-year-old boy with fibrodysplasia ossificans progressiva after induction of general anaesthesia for a dislocated mandible secondary to temporomandibular joint disease. After all other attempts at achieving oxygenation were performed, a cannula cricothyroidotomy was attempted by an ENT surgeon present in the operating theatre. However, this manoeuvre failed, and a subsequent surgical tracheostomy was finally successful. Although there were no neurological sequelae in this child, he lost his ability to speak, likely due to the high placement of incision and large size of the tracheostomy tube. The authors from both case reports conclude that they would support the recommendation for an open surgical airway as a preferred first line rescue technique in the paediatric CICO.

The optimal technique for a paediatric surgical airway should be fast in establishing effective oxygenation (and ventilation) with minimal damage to the patients’ tissues. Based on the available evidence no specific surgical technique for performing an emergency surgical airway in children can be recommended. An argument can be made for abandoning cricothyroidotomy in small children and performing a surgical airway below the cricothyroid membrane.\textsuperscript{34,35} Ultimately, it is pivotal to formulate a local protocol and make a departmental decision on which equipment should be used for a paediatric CICO crisis. It should be stressed that unexpected difficult airway management training should first of all cover the basics, such as optimal positioning, expert operating skills and administration of muscle relaxants.\textsuperscript{36} A differentiated algorithm for non-invasive difficult paediatric airway should be trained and followed.\textsuperscript{7} However, if all other measures fail and the only other option is to let the child die without having attempted a surgical airway we would strongly feel this should be attempted.
Equipment for an emergency paediatric surgical airway should be standardised and available in a standardised (paediatric) difficult airway trolley allowing all materials to be found immediately during a CICO crisis. This is also described in the recent paper by Sabato et al.\textsuperscript{37} Expert help by an ENT specialist is often recommended in a paediatric CICO.\textsuperscript{6,7} When formulating a local protocol on paediatric CICO it should be taken into consideration whether ENT services are immediately available on all hours of the day. The success of all techniques will likely increase, and the reluctance to perform a surgical airway will decrease with regular training. Training should encompass both the technical skills of performing a surgical airway with the equipment of choice and the non-technical skills to manage a paediatric CICO.

**Conclusion**

The absence of best practice evidence necessitates further studies in a standardised format to provide a clear advice on best practice management for the paediatric emergency surgical airway in the “can’t intubate, can’t oxygenate” crisis.
References


