Paediatric Tracheostomy: Changing indications and key complications

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ABSTRACT

Background: Paediatric Tracheostomy is a procedure used to ventilate children through a hole in the trachea. Indications for the procedure were once primarily for acute upper airway obstruction due to infections but have now changed. Generally, there is poor knowledge surrounding tracheostomies and a limited knowledge of guidelines amongst health-care professionals.

Aim: The aim of this review is to discuss the basis of changes to the indications of paediatric tracheostomy. It will also investigate the key complications related to the procedure and discuss the importance of multidisciplinary teams being aware of the emergency algorithms for dealing with such complications.

Findings: Indications have changed due to advancements in medicine with increased life expectancy and survival rates for children with often life-threatening congenital conditions. Tracheostomies can offer these children long term ventilatory support. Upper airway obstructions due to infections are now infrequently indicated for tracheostomy due to successful vaccination programs. Complications today are because of obstructions and decannulations. Intra-operative complications are infrequent, due to refinements in surgical technique.

Conclusion: Paediatric Tracheostomy is a rapidly evolving field because of continuous advancements in neonatal and intensive care medicine. The indications and complications have changed together over the last four decades. A greater understanding of tracheostomy complications is required for successful management.

INTRODUCTION

Tracheostomy is a procedure where a hole is made into the trachea through the neck to allow a cannula to be passed for ventilatory support. Tracheostomy facilitates the weaning process of patients on endotracheal intubation and permits the suction of bronchial secretions. Such procedures have been dated back to ancient Egypt and are still used in both paediatric and adult patients to this day. Tracheostomy is used in both acute and chronic settings, from the management of upper airway obstructions to the long-term ventilation support of congenital conditions.[1] Paediatric tracheostomy (PT) has been performed with increased frequency due to paediatric critical care and neonatal care advancements.[2] The indications for PT have shifted significantly from emergency procedures, for upper airway obstructions due to laryngeal infections such as croup, epiglottitis and diphtheria, to ventilatory support for children with congenital disorders. This reflects the improvements in neonatal care which have decreased the mortality and morbidity of children who suffer from conditions previously considered life-threatening, such as Pierre Robin sequence and Treacher Collins syndrome.[3] This shift in indications has also occurred because of the change in the epidemiology of diseases such as epiglottitis, exemplified in an audit by The Hospital for Sick Children at the University of Toronto.[4]

The procedure on paediatric patients carries a greater level of technicality meaning a greater risk of complications. Despite improvements in the medical equipment in both operating theatres and intensive care units (ICU) the risk of complications remains.[5] An American paediatric tertiary centre reported an early complications rate of 11% and a late complications rate in 68.8% of patients. Common complications include blocked tubes, displacement of tubes and granuloma formation.[6] Alarming rates of knowledge gaps on the management of tracheostomy complications have also been reported. According to audits in the United Kingdom, 50% of airway related deaths in the ICU were due to tracheostomy complications, highlighting the importance of having confidence in handling emergencies.[7]

PAEDIATRIC AIRWAY ANATOMY AND TRACHEOSTOMY PROCEDURE

Understanding the differences between adult and paediatric patients is crucial when discussing PTs and the approach to airway management. Neonatal airways are considerably smaller than adults, the average diameter of the subglottis in a full-term baby is 3.5mm, increasing to 7mm in teenagers and 10-14mm in adults.[8] Children have shorter and wider necks, with the larynx situated more anteriorly and superiorly compared to adults. The larynx is initially at the level of the third or fourth cervical spine and only at the age of two does it begin to descend. Palpation of the anatomical landmarks can be more challenging in children due to the hyoid cartilage covering the thyroid cartilage notch. The thyrohyoid membrane in children is also shorter. The tracheal cartilages in infants are softer than adults which leaves them at greater risk of collapse. The mucosa of the subglottis and supraglottis regions are also more prone to oedema and inflammation.[2]

A surgical PT procedure is indicated in patients under the age of 12. This procedure involves the palpation of anatomical landmarks in order to locate the cricoid cartilage and sternal notch to allow a horizontal incision to be made between the two. The platysma would then be exposed and resected. Strap muscles would then be divided which allows visualisation of the thyroid isthmus. This may have to be divided to reveal the tracheal rings. Tracheal incisions can be either vertical or horizontal – between the second to fourth tracheal cartilage ring. Once the trachea has been incised a tracheostomy tube with an obturator is then inserted. The obturator is then removed, and the cannula inserted. Compared to the adult procedure, no cartilage rings are removed. Flexible bronchoscopy can then be utilised to visualise the tip of the tracheostomy as above the carina. In emergency situations a vertical incision may be opted for.[4, 9]

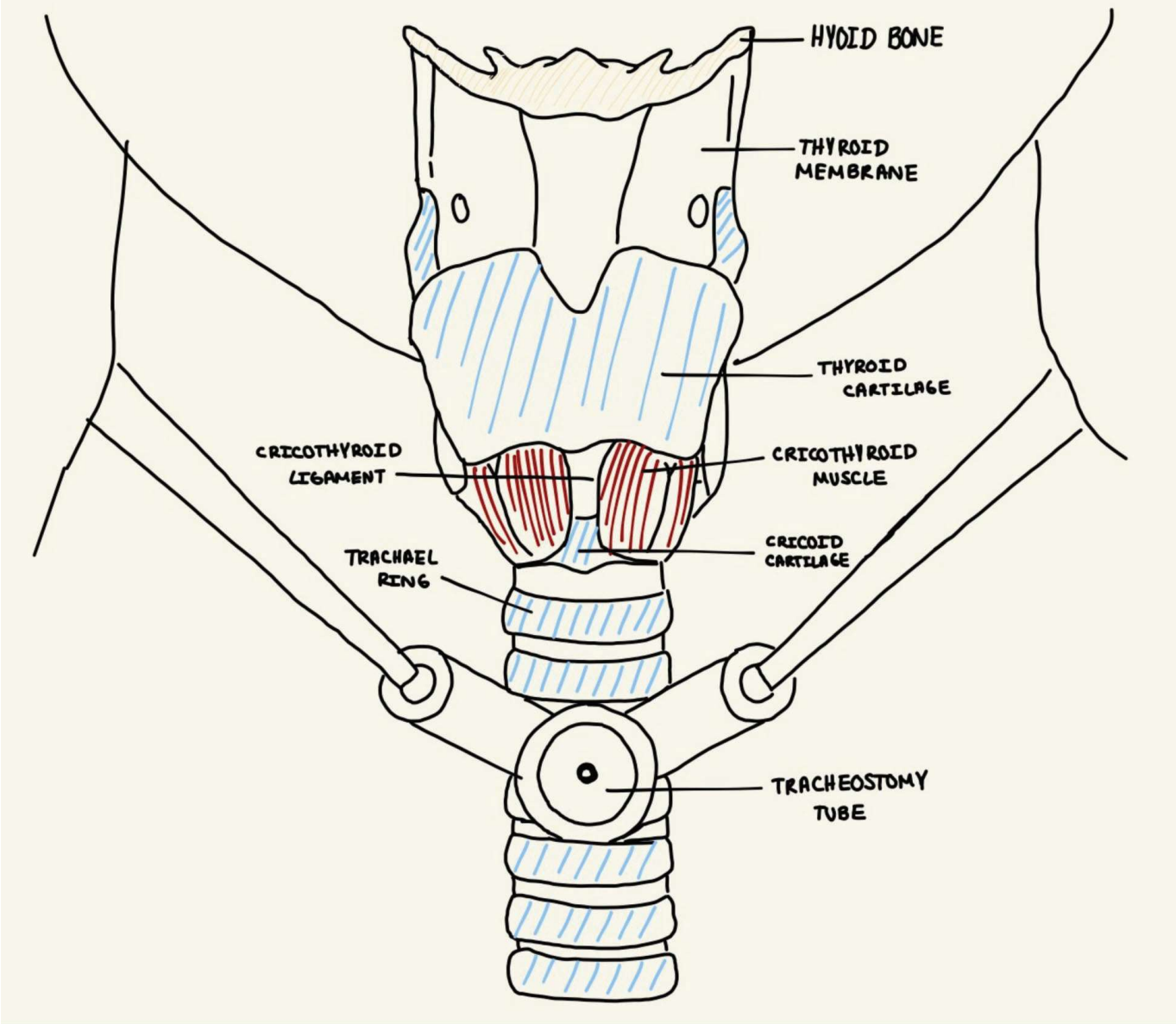


Figure 1: Illustrated is a paediatric tracheostomy in situ, to allow the visualisation of relevant anatomy discussed.[4, 10]

FINDINGS AND DISCUSSION

The Update in Indications

In both adult and paediatric patients, the general indications for tracheostomies include upper airway obstruction, long term ventilatory support, prevention of aspiration by tracheobronchial toilet, prevention of long term laryngotracheal stenosis, weaning from ventilators.[4] PTs in paediatric intensive care unit (PICU) settings are much less common than the adult procedure, accounting for only 3% of PICU patients. Paediatric patients are known to tolerate intubation for longer periods of time before tracheostomy is needed. Pre-term infants can be intubated for more than 3 months before the decision to offer tracheostomy is made, allowing more time for recovery. PT has also remained a surgical rather than a percutaneous procedure, which is absolutely contraindicated in patients under the age of 12.[2, 11]

Between 1960 and 1970 paediatric tracheostomies were indicated as an emergency procedure for upper airway obstruction caused by infections such as epiglottitis, diphtheria and croup.[12] There has now been a shift from the infectious aetiologies, due to the introduction of endotracheal intubation and vaccinations, which has greatly decreased the incidence of these diseases.[13] Vaccination programmes against pathogens such as *haemophilus influenzae* and *corynebacterium diphtheriae* have reduced the incidence of the infectious diseases such as epiglottitis and diphtheria.[14] Since then, indications have changed drastically, with today the main indications being due to prolonged orotracheal intubation, upper airway obstructions caused by craniofacial malformations including syndromes such as Pierre Robin sequence and Treacher Collins syndrome, laryngotracheal stenosis and neurological disorders. A primary study at the Royal Hospital for Sick Children in Glasgow supported these changes, their primary indication for PT being micrognathia, including Pierre Robin sequence. Their study investigated the successfulness of decannulation, so it is important to be aware that these were patients that

reached a decannulation stage, which means there may have been other PT patients with other indications that may have not survived up to this point. However, their research showed no PTs were indicationed because of infections.[15] A retrospective study by the Catholic University of Rome investigated indications between 1998 and 2004, results showing that primary indications were neuromuscular and respiratory conditions, followed by congenital malformations.[14] Advances in pre-natal medicine has decreased mortality in neonates with severe congenital abnormalities, allowing them to survive birth.[3] Indications for upper airway obstruction now have a primarily non-infectious aetiology, including laryngotracheal stenosis and bilateral vocal fold paralysis.[3, 16]

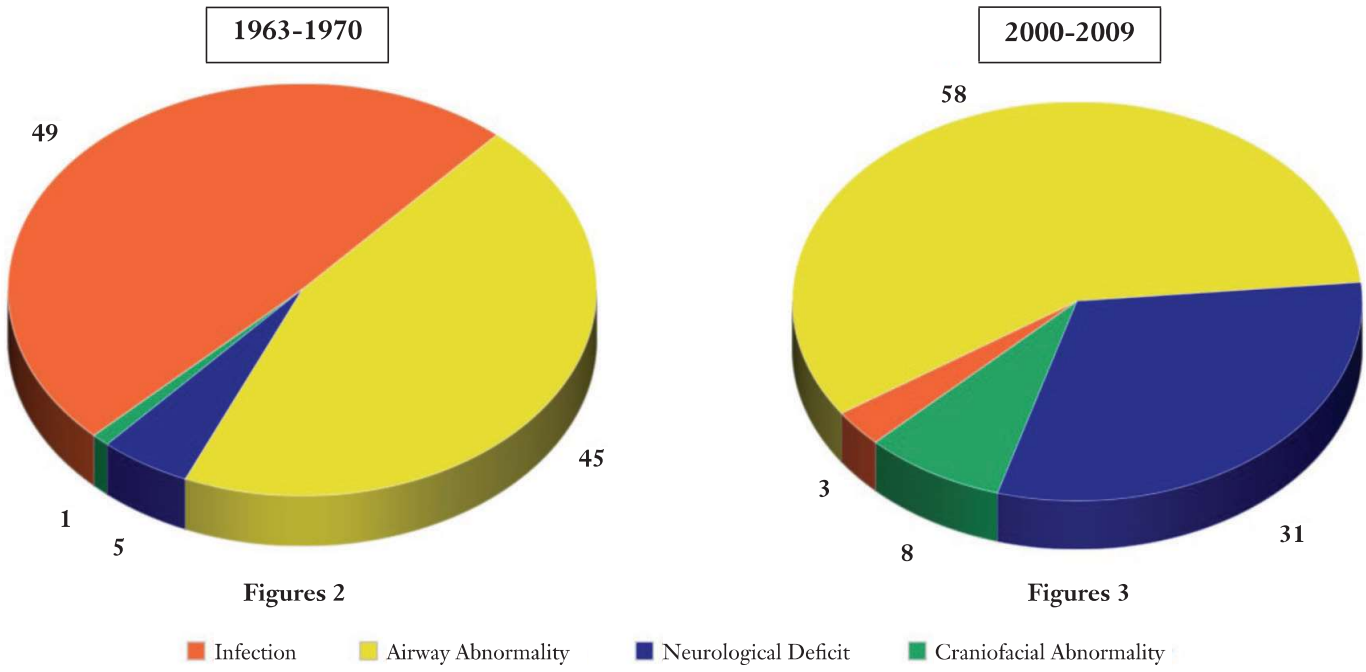
A retrospective study at the Boston Children's Hospital (BCH) concluded that PT procedures had increased in frequency and that between 1984 and 2015 the primary indications for the procedure at their organisation were mainly cardiopulmonary and neurological diseases. 202 patients out of 456 (44%) were premature. Their results are presented in table 1. It was reported that in the United Kingdom, PT indications have moved from infectious aetiologies to upper airway obstructions (non-infectious) and patients requiring long term ventilation aid. The study importantly recognised that the indications varied between countries. In their study which took place at the Boston Children's Hospital – their main indications were cardiopulmonary disorders, which included congenital heart and lung diseases.[12]

Table 1: BCH indications for paediatric tracheostomy between 1984–2015.[12]

Indications	Number of patients
Airway obstruction	93 (20.3%)
Cardiopulmonary disorders	147 (32.2%)
Craniofacial malformities	54 (11.8%)
Neurological impairment	143 (31.4%)
Traumatic injury	19 (4.1%)

Further research from an audit conducted at The Hospital for Sick Children at the University of Toronto showed that in their organisation, child tracheostomies had decreased in numbers but indications for the PTs carried out had changed. The reasoning behind the decreased frequency trends were explained by the opening of new tertiary paediatric centres, which may have reduced their patient load and possibly giving them less patients requiring a tracheostomy. More complex PT cases are also more likely to be referred to tertiary centres. This helps explain the different trends between the Hospital for Sick Kids in Toronto and other organisations, including BCH, where PTs were increasing in frequency.[4] Data from the British Columbia Children's Hospitals reported an increase in PTs at their organisation between 2001 and 2011. Their most prevalent indication was acquired subglottic stenosis, accounting for 33% of all PTs, followed by prolonged intubation at 15%.[17]

In data sourced between 1963 and 1970, PT due to infections accounted for 49% of indications. Compared to data sourced between 2000 and 2009, PT due to infection only occurred in 3% of cases. Indications due to neurological deficits also increased from 1% between 1963 and 1970 to 31% between 2000 and 2009. The changes in indication are presented in figures 2 and 3. This study could have provided more detailed results through the identification of subcategories of conditions.[4]



Figures 2 & 3: Show the changes in indication at The Royal Hospital for Sick Children in Toronto, Canada (values on the pie charts are %).[4]

KEY COMPLICATIONS AND MANAGEMENT ALGORITHMS

PT carries a greater risk compared to the adult procedure. During the procedure itself, the anatomical positioning of the lungs places children at a greater risk of pneumothorax and pneumomediastinum as pleural apices in children are higher, meaning they could be impacted and damaged more easily. According to a review conducted by Brazilian universities in Goais, pneumothorax and pneumomediastinum complications occurred at their highest rate between 1985 and 1994, but significantly decreased in the following decades. Between 1995 and 2005 their review indicated that the main cause of post-operative complications were granulomas, infections, tracheocutaneous fistulas and obstruction of the canula. Interestingly, these statistics do not match the reports of PT complications at this time which were reported to be canulla obstruction and decannulation. This was explained as a potential under-reporting of these complications as they are often not as life-threatening when compared to granulomas and infections.[5] The main complications have been summarised in table 2. Mortality associated with tracheostomy in the literature is stated to be between 0.5% and 3% and is usually associated with two complications; accidental decannulation and cannula obstruction.[18]

This change was explained by advancement in techniques which prevented acute intra-operative complications such as pneumothorax and pneumomediastinum and PTs becoming a long-term procedure, allowing more time for infections and decannulations to occur. The paper drew conclusions about different age groups and the ranges of complications within them, highlighting for example that boys were more pre-disposed to complications because males are more prone to congenital disorders. However, the paper was limited when looking at certain age groups of children and the different complications in each due to insufficient data on specific groups including premature babies.[5]

In a study carried out on fifty-eight patients under the age of 16 who underwent tracheostomies, complications occurred in 11 out of 56 patients (19%). The largest number of complications occurred one-week post-operation. The majority of complications were related to canula obstruction or cannula loss. There was only one report of pneumothorax.[3] These results are also supported by other primary studies including one at the Children's Hospital of Buffalo, where 43% of their cohort of 142 children lost their tracheostomy due to tube occlusion and decannulation related complications.[21] In a retrospective study conducted in 2010, tracheocutaneous fistulae occurred in 37% of patients, infections were acquired by 90% of patients and 1 death occurred due to a mucous plug.[22] All these studies show that complications are primarily post-operative, with very few intraoperative complications.[3, 21, 22]

A tracheostomy provides patients with essential oxygenation and any complication should be promptly recognised and managed to prevent desaturation, which in turn can lead to respiratory failure and cardiac arrest. The National Audit Project (NAP4), which investigated the major complications of airway management in the United Kingdom, recognised the impact of poor tracheostomy complication management, stating that tracheostomies were to blame for 50% of airway related deaths and brain damage in the ICU settings.[19] These statistics raise important questions on the quality of training and understanding of how to deal with these emergencies. Intensive care medicine trainees showed poor recognition of emergency algorithms, with only 55% being aware of established national guidelines. Furthermore the, "On the right trach?" review discovered that up to a quarter of hospitals had not offered staff adequate training for these emergencies. Improvements could be made from increased training days and creating visual representations of the algorithm.[20]

Multidisciplinary guidelines for the management of PT emergencies are essential in acute situations. Tracheostomy bed head signs have been indicated in order to establish types of tracheostomy, when they were performed and whether there were any airway abnormalities. These should be placed above tracheostomy patients (the algorithm is normally printed on the back of these for rapid access). PT red flags have also been

Table 2: Adapted table summarising intra-operative, early post-operative and late post-operative complications.[4]

Intra-operative	Early post-operative	Late post-operative
Haemorrhage	Haemorrhage	Stomal or tracheal granulation
Pneumothorax or pneumomediastinum	Dysphagia and aspiration	Suprastomal collapse
Oesophageal injury	Wound infection	Tracheal stenosis
Recurrent laryngeal nerve injury	Tube obstruction by blood clot or mucus plug	Tracheomalacia
Loss of airway	Accidental decannulation	Tracheoesophageal fistula
Creation of a false passage	Tube displacement into false passage	Tracheoinnominate fistula
Cardiac arrest and death	Subcutaneous emphysema	Tracheocutaneous fistula

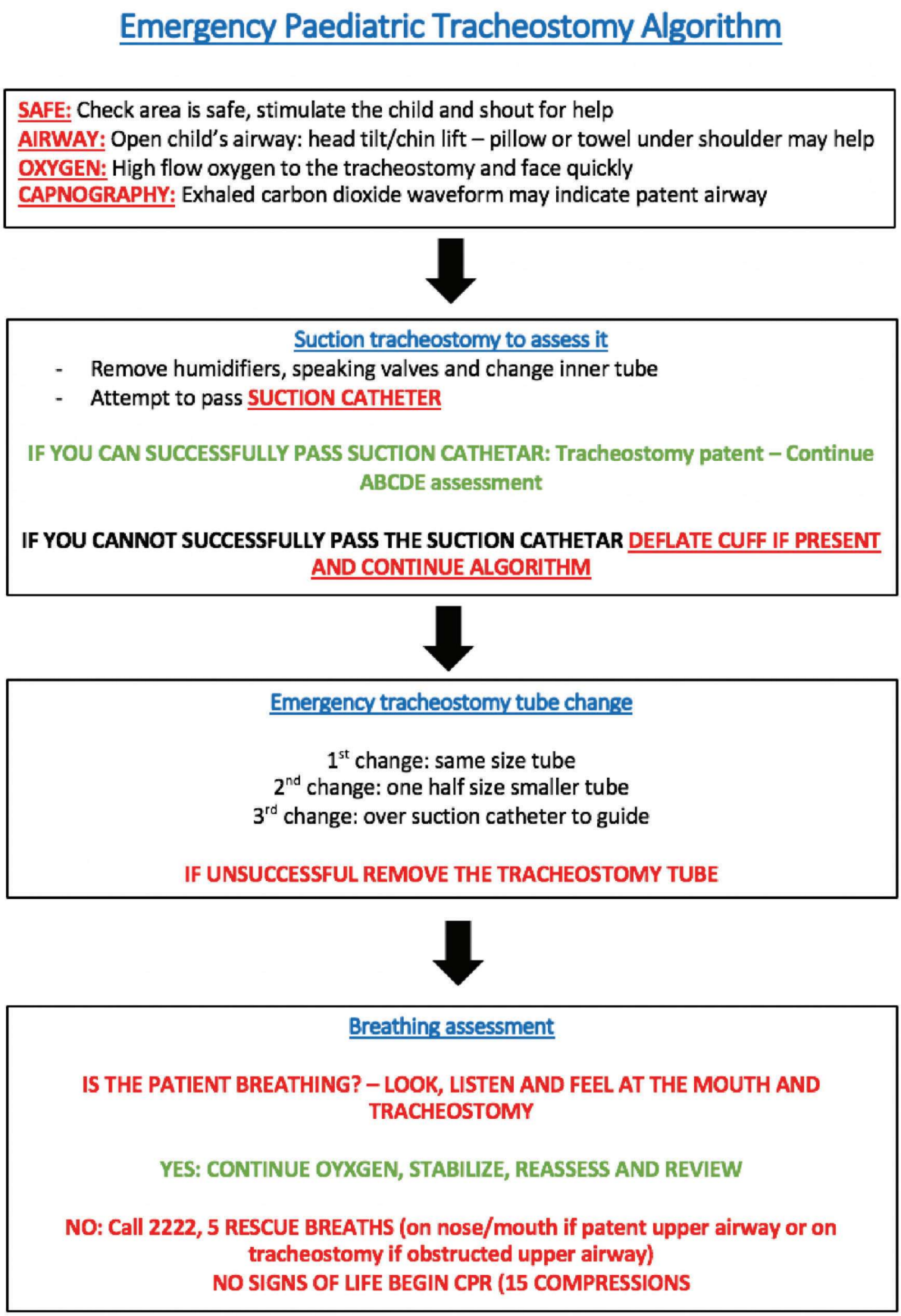


Figure 4: Adapted algorithm from the national tracheostomy safety project's emergency tracheostomy emergency management algorithm.[6]

identified to give health practitioners an idea of what to look for when presented with an acutely unwell PT patient. These signs include; visibly displaced tube, blood stained secretions and reports of pain. Routine observations such as heart rate, oxygen saturation, respiratory rate can also indicate deterioration. The emergency algorithm is presented in figure 2.[6]

There were differing results between the two studies, with the Brazilian Journal of Otorhinolaryngology not indicating granuloma-related complications but pointing at decannulation and obstruction. It should be noted that this study may have lacked breadth of data as there were only fifty-eight patients studied.[3] Complications of PT are poorly understood by health-care professionals according to the NAP4, which highlighted inappropriate levels of knowledge regarding how to manage these emergencies.[19]

CONCLUSION

This review demonstrates that PT is a rapidly evolving field. The indications have changed as a result of advancements in various sectors of medicine including pre-natal medicine, paediatrics and infectious disease. Vaccinations have played a large role in the reduction of infectious disease indications. Modern medicine's ability to bring foetuses who have severe developmental disorders to a viable stage has in turn increased the number of PTs performed, as long term ventilatory support is often required. The frequency and nature of complications have also due to advances and changes in the way we practice medicine. New surgical techniques mean that intraoperative complications such as pneumothoraxes are now infrequent. As PTs today are now indicated for long-term ventilation support and not for acute settings it has clearly affected the nature of the complications. Because children are able to spend longer periods of time on ventilators due to tracheostomies, they acquire complications related to long-term tracheostomy ventilation including infection, decannulation and blockages. This review also demonstrates how important an awareness of management protocols is. As more children are getting PTs due to changing indications itis essential that multidisciplinary health care teams are informed in the management of complications that may occur.

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