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Swallowing problems in children with a tracheostomy

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ABSTRACT

Children with a tracheostomy often present with swallowing disorders. Assessing the impact the presence of the tracheostomy tube has on swallowing function next to the underlying pathology can be very challenging. This article gives an overview of normal swallowing physiology and development, swallowing difficulties as encountered in various airway pathologies and addresses the mechanism by which the tracheostomy tube impacts swallowing. We discuss methods of investigating swallowing disorders and offer tools for management in everyday practice.

Introduction

Adequate swallowing function is essential for feeding, growing and thriving. Children with swallowing problems are at risk for malnutrition, behavioral delay, stressful interaction with caregivers and are at higher risk of post-operative complication.[1] When swallowing problems give rise to chronic and recurrent aspiration, the effects on lung development can be devastating with recurrent wheezing, pneumonias and severe lung impairment as a consequence.[2]

Any deficit in the upper and lower aerodigestive tract can potentially have a negative influence on swallowing function and consequently feeding ability. Next to the underlying pathology, surgery in the aerodigestive tract can have a major impact on swallowing function, for better or for worse. Any surgeon operating in the upper airway or upper digestive tract should have basic knowledge of swallowing physiology and function in relation to the pathology they are treating and the type of surgery they are performing.

A tracheostomy can be indicated for a number of reasons like severe airway obstruction, persistent need for pulmonary ventilation or severe neurological impairment. A pediatric tracheostomy can also be indicated in patients with severe swallowing disorders and aspiration to facilitate tracheobronchial toilet.[3] While the presence of the tracheostomy tube ensures a safe airway with easy access for bronchial toilet, it can also have a negative impact on swallowing function. This presents the clinician with a catch 22 situation: is the swallowing dysfunction secondary to the presence of the tracheostomy cannula or is the swallowing dysfunction the result of the underlying pathology which required the tracheostomy tube in the first place? And which impact does surgery in the aerodigestive tract with the aim to decannulate have on swallowing function? Will decannulation lead to improved swallowing or will surgery lead to a deterioration in swallow function? Unraveling this can be quite challenging for clinicians treating these patients.

Normal swallowing mechanism & development

Swallowing represents a conjunction of complex movements controlled by the brain stem, cortical central pathways and the enteric nervous system of the esophagus that control the smooth muscle segments. It involves the coordinated movements of many muscles innervated by different nerves. The normal physiological mechanism of swallowing can be divided in three phases: the oral phase, the pharyngeal phase and the esophageal phase.[1,4,5] In these three phases liquids and solids are formed into a bolus and transported into the stomach through the oropharynx and the esophagus. The oral phase of swallowing, which can be divided in a preparatory and early transfer phase, is the only conscious, voluntary phase of swallowing: The mouth is opened and sucking, biting and/or chewing occurs. A bolus is formed by the chewing movements and the addition of saliva. The bolus is then transported and passed to the pharynx by anterior and posterior movements of the tongue. Sensory receptors in the oropharynx and the tongue itself are stimulated, triggering the involuntary pharyngeal phase.

During the pharyngeal phase of swallowing, a number of coordinated movements happen in unison. The velum elevates and

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closes off the nasopharynx from the oropharynx to prevent liquids or food from entering the nasal cavity (nasal regurgitation). Elevation and anterior movement of the hyoid and larynx facilitate closure of the vocal cords, tilting of the arytenoids and descending of the epiglottis. Elevation of the larynx also contributes to airway protection and the anterior movement stimulates the relaxation and opening of the upper esophageal sphincter, which allows the bolus to move into the esophagus. The pharyngeal muscles contract to pass the bolus through the pharynx. Subsequently, the bolus is transported through the esophagus by peristaltic movements and gravity until the lower esophageal sphincter relaxes to pass the bolus into the stomach (esophageal phase).

Swallowing is a complex process which needs meticulous coordination since respiration, swallowing and phonation occur in same anatomical region. After birth, swallowing and feeding skills develop most strongly during the first year of life. In the first two to four months sucking and swallowing is highly automatic and reflexive. After this period, swallowing becomes more and more voluntary and adequate learning and training is essential to further develop swallowing skills. If these skill cannot be learned during this period, long-lasting problems in the voluntary oral phase of swallowing can arise which can have significant impact on quality of life for many years. Especially children with an extensive and severe medical condition in the first months of life are at risk of developing such swallowing disorders.[6] Next to this, the upper airway and larynx are subject to many major anatomical changes in the first years of life such as the descending of the larynx and epiglottis and a larger oral cavity. Therefore, the development and training of good oral skills and laryngeal function are necessary to develop a good swallowing mechanism and prevent aspiration[1,7,8]

Swallowing investigation

To assess the presence and nature of swallowing disorders, a number of different swallowing investigation are at our disposal.

All swallowing investigations usually start with an assessment by a speech and language therapist (SLT), preferably specialized in swallowing disorders in children. The investigation of the SLT, globally, consists of anamnesis, examination of the structures in the mouth area, assessing the (oral) motor skills and observation of drinking and feeding. The SLT assesses whether there is enough awareness and normal reflex activity, tone, and responsiveness for adequate intake. The SLT observes the swallowing phases during eating and drinking of the child with use of the “Neonatal Oral-Motor Assessment Scale”, “the Early Feeding Skills Assessment” and “the Observation List Spoon Feeding”, depending on the age of the child.[6,9-11] The SLT judges the oral and pharyngeal phase of swallowing with as many consistencies of drinks or food as the child is able/ willing to take during the assessment using the IDDSI-scale for standardization of the nutritional consistencies.[12] Observed features in the swallowing phases are opening of the mouth, preparing liquids or food for transport, transport of the bolus, swallow trigger, post-swallow stasis and suspicion of laryngeal penetration and/or aspiration. The definition of penetration is material entering the larynx but not passing the glottis, remaining on or above the vocal folds.[13] Aspiration is defined as material entering the airway and passing below the vocal folds. A stethoscope is used for laryngeal cervical auscultation to evaluate indirect signs of inefficiency of the pharyngeal phase. The sensitivity of cervical auscultation in experienced hands is high for penetration/aspiration in liquids, but not accurate in aspiration of solid food.[14] The modified Evans Blue Dye Test (MEBDT) can be carried out in children with a tracheostomy tube as a quick and easy screening tool for aspiration; The tracheostomy tube is suctioned after colored liquid or food has been offered to the child and is swallowed. Suctioning of colored mucus from the trach tube is proof of aspiration although one must be aware that absence of colored suctioning does not rule out aspiration.

If the above mentioned investigations do not give a clear assessment of the swallowing function a Flexible Endoscopic Evaluation of Swallowing (FEES) or Videofluoroscopy (VFS) can be done. FEES and VFS are considered the gold standard methods for evaluating oropharyngeal dysphagia.[10,15-17]

FEES is usually performed by a pediatric ENT-specialist and by an SLT and gives information on the pharyngeal phase of swallowing: stasis of saliva, liquids or food in the pyriform sinus, epiglottis and/or valleculae and penetration and/or aspiration can be detected by FEES.

A VFS or barium swallow study is usually performed by a radiologist and SLT and aims to assess the oral and pharyngeal phase of swallowing for transport of the bolus, prespillage of liquid or food (liquid of food passively entering the pharynx or larynx prematurely before a swallow is initiated), tethering of the larynx, residue in the pyriform sinus, epiglottis and/or valleculae, penetration and/or aspiration. A VFS also assesses the esophageal phase of swallowing: obstruction, fistulas, motility problems and gastro-esophageal reflux can be detected by VFS.

In case of difficulty in the esophageal phase of swallowing, a manometry can be considered as an advanced additional investigation.

Airway anomalies with frequent swallowing problems

In general, all children with a long-term postnatal period of intubation or intensive medical treatment such as the premature population are at risk of developing severe long-term swallowing difficulties because they have not been able to develop proper oral feeding skills at the already mentioned time points in the postnatal period. Prompt swallow therapy by a trained SLT is indicated in these children.

Congenital upper airway obstruction

Severe upper airway obstruction is present in children with Robin Sequence and craniofacial syndromes such as Nager syndrome, hemifacial macrosomia and Treacher Collins syndrome. Swallowing and feeding disorders are very common in these patients and mostly the oral phase is severely affected. In severe cases and/or in children with comorbidities the pharyngeal phase of swallowing can also be affected with subsequent risk of aspiration. Surgery like mandibular distraction osteogenesis aims to improve the upper airway obstruction but will also have a guaranteed effect on swallowing function. Swallowing function can improve, but in some cases deteriorates with an increase in aspiration due to the sudden opening of the oropharyngeal space which can bring to light or even worsen an underlying swallowing dysfunction.[18-20]

Laryngeal and tracheal anomalies

Swallowing interrupts breathing. It is therefore logical that infants with laryngeal pathologies such as laryngomalacia and vocal cord dysfunction are more prone for dysphagia and aspiration due to the difficulty they have in safely coordinating sucking, swallowing, and breathing. Patients with laryngomalacia are known to have coughing and choking during feeding, dysphagia, aspiration, failure to thrive, or worsening of stridor during feeding.[21]

Patients with laryngotracheal clefts usually present with aspiration. The severity of the clinical situation is related to the depth of the cleft (type I-IV) and concomitant co-morbidities. Type I clefts are most common and have a varying degree of aspiration, usually predominantly on thin liquids.[22]

Laryngotracheal and tracheal stenosis typically do not present with swallowing disorders. However, the surgical management potentially causes swallowing problems; placement of a posterior cartilage graft in laryngotracheal reconstructions can create a closure defect of the posterior glottis, while cricoid resections and extensive tracheal surgery like resections and slide tracheoplasties potentially damage recurrent laryngeal nerves.

Tracheomalacia as occurs in esophageal atresia patients typically causes swallowing disorders in the esophageal phase where the passing bolus can aggravate the malacic airway with subsequent increase of dyspnea, in some cases giving rise to ALTEs (Acute Life-Threatening Events). Next to this, long-term dysphagia occurs in up to 50% of repaired esophageal atresia and tracheoesophageal fistula patients.[23,24] In these children, the gastroesophageal reflux disease, the typical disturbance in normal esophageal peristaltic contractions and the possible presence of a stenosis at the site of the anastomosis cause impaired bolus movement to the stomach, which further aggravates this issue.

Swallowing problems in relation to the presence of the tracheostomy

The influence of a tracheostomy tube on swallowing function in the pediatric population is not well known, although more reports are emerging describing this phenomenon.[25] In the adult population, the influence of the placement and presence of a tracheostomy on swallowing is well described: the tracheostomy tube tethers the larynx and prevents laryngeal elevation. The tracheostomy tube potentially desensitizes the larynx and causes an ineffective cough mechanism, because it is impossible to build up positive subglottic pressure with an open tracheal tube. The absence of positive subglottic pressure during swallowing increases the risk of penetration and aspiration.

It is generally accepted that the described mechanisms in the adult population also apply to pediatric patients where the tracheostomy tube is even more bulky than compared to the adult population. In our own research, we found swallowing problems in a staggering 31 (70.5%) of the 44 investigated children with a tracheostomy. Eighteen (94.7%) of the nineteen patients with difficulties in the pharyngeal phase of swallowing also had aspiration, proven with MEBDT, FEES and/or VFS. However, the more shocking discovery was that half of the aspirating children showed silent aspiration, unknown to caretakers and clinicians until the time of swallow investigations. Not only is aspiration very common in the pediatric tracheostomized population, it can also be concealed from both clinicians and caretakers.

Typical findings of tracheostomy-related swallowing problems are sensitivity problems, unforceful swallowing, difficulty in elevating the larynx (tethering) and decreased relaxation of the upper esophageal sphincter. These can be readily identified during VFS and FEES. This manifests mainly in problems swallowing solid food and aspiration of thin liquids.

In general, any restoration of normal airway physiology has the potential to improve the swallowing mechanism when it is hampered by the presence of a tracheostomy tube. The use of a speaking valve, enabling expiration around the trach tube through the subglottis, larynx, and oropharynx while maintaining inspiration through the tracheal tube restores the necessary build-up of subglottic pressure and improves cough. This strongly improves swallowing function by reducing stasis in the valleculae, sinus piriformis, penetration and aspiration, due to preservation of the subglottic air pressure and improvement of cough mechanism.[26-30] Therefore, in children with a tracheostomy tube who accept a speaking valve we strongly advise assessment of swallowing to be carried out with and without speaking valve.[31-33] This will help clarify what part of the swallowing problems is caused by the presence of the tracheal cannula. In case the child tolerates capping of the cannula, we would advise to evaluate swallowing function with the capped cannula. In everyday care, when possible, we recommend using the speaking valve or capping the cannula during eating and drinking to improve swallowing function and decrease aspiration in tracheostomized children.

Conclusion

When assessing and treating children with a tracheostomy, clinicians should be wary of the high degree of swallowing problems and aspiration that exists in this patient group. Every child with a tracheostomy needs a thorough assessment of swallowing function at least once and swallowing status should be clear before any surgical intervention. The difficulty lies in keeping the swallowing dysfunction caused by the tracheostomy tube apart from the underlying medical condition of the child. Having an SLT on the airway team with extensive training and experience with patients with complex anomalies of the aerodigestive tract and a tracheostomy is paramount for adequate assessment and treatment. Assessment with and without a speech valve or capped cannula greatly aids in assessing these children.

References

1. Arvedson JC. Management of pediatric dysphagia. *Otolaryngol Clin North Am*. 1998;31(3):453–476.
2. Tutor JD, Srinivasan S, Gosa MM, Spentzas T, Stokes DC. Pulmonary function in infants with swallowing dysfunction. *PLoS One*. 2015;10(5).
3. Campisi P, Forte V. Pediatric tracheostomy. *Semin Pediatr Surg*. 2016;25(3):191–195.
4. Dodds WJ. Physiology of swallowing. *Dysphagia*. 1989;3(4):171–178.
5. Matsuo K, Palmer JB. Anatomy and physiology of feeding and swallowing: normal and abnormal. *Phys Med Rehabil Clin N Am*. 2008;19(4):691–707 vii.
6. van den Engel-Hoek L, van Hulst KC, van Gerven MH, van Haaften L, de Groot SA. Development of oral motor behavior related to the skill assisted spoon feeding. *Infant Behav Dev*. 2014;37(2):187–191.
7. Tutor JD, Gosa MM. Dysphagia and aspiration in children. *Pediatr Pulmonol*. 2012;47(4):321–337.
8. Delaney AL, Arvedson JC. Development of swallowing and feeding: prenatal through first year of life. *Dev Disabil Res Rev*. 2008;14(2):105–117.
9. da Costa SP, van der Schans CP. The reliability of the Neonatal Oral-Motor Assessment Scale. *Acta Paediatr*. 2008;97(1):21–26.
10. Hiss SG, Postma GN. Fiberoptic endoscopic evaluation of swallowing. *Laryngoscope*. 2003;113(8):1386–1393.
11. Palmer MM, Crawley K, Blanco IA. Neonatal oral-motor assessment scale: a reliability study. *J Perinatol*. 1993;13(1):28–35.
12. Cichero JA, Lam P, Steele CM, Hanson B, Chen J, Dantas RO, et al. Development of international terminology and definitions for texture-modified foods and thickened fluids used in dysphagia management: the IDDSI framework. *Dysphagia*. 2017;32(2):293–314.
13. Rosenbek JC, Robbins JA, Roecker EB, Coyle JL, Wood JL. A penetration-aspiration scale. *Dysphagia*. 1996;11(2):93–98.
14. Borr C, Hielscher-Fastabend M, Lucking A. Reliability and validity of cervical auscultation. *Dysphagia*. 2007;22(3):225–234.
15. Aviv JE, Kaplan ST, Thomson JE, Spitzer J, Diamond B, Close LG. The safety of flexible endoscopic evaluation of swallowing with sensory testing (FEESST): an analysis of 500 consecutive evaluations. *Dysphagia*. 2000;15(1):39–44.
16. Langmore SE. Evaluation of oropharyngeal dysphagia: which diagnostic tool is superior? *Curr Opin Otolaryngol Head Neck Surg*. 2003;11(6):485–489.
17. Rugiu MG. Role of videofluoroscopy in evaluation of neurologic dysphagia. *Acta Otorhinolaryngol Ital*. 2007;27(6):306–316.
18. Caron CJ, Pluijmers BI, Joosten KF, Mathijssen IM, van der Schroeff MP, Dunaway DJ, et al. Feeding difficulties in craniofacial microsomia: a systematic review. *Int J Oral Maxillofac Surg*. 2015;44(6):732–737.
19. Paes EC, de Vries IAC, Penris WM, Hanny KH, Lavrijsen SW, van Leerdam EK, et al. Growth and prevalence of feeding difficulties in children with Robin sequence: a retrospective cohort study. *Clin Oral Investig*. 2017;21(6):2063–2076.
20. van der Plas P, Yang S, Streppel M, Pullens B, Versnel SL, Koudstaal MJ, et al. Functional outcomes in patients with facial dysostosis and severe upper airway obstruction. *Int J Oral Maxillofac Surg*. 2020.
21. Simons JP, Greenberg LL, Mehta DK, Fabio A, Maguire RC, Mandell DL. Laryngomalacia and swallowing function in children. *Laryngoscope*. 2016;126(2):478–484.
22. Strychowsky JE, Rahbar R. Laryngotracheoesophageal clefts. *Semin Pediatr Surg*. 2016;25(3):128–131.
23. Acher CW, Ostlie DJ, Leys CM, Struckmeyer S, Parker M, Nichol PF. Long-term outcomes of patients with tracheoesophageal fistula/esophageal atresia: survey

results from tracheoesophageal fistula/esophageal atresia online communities. *Eur J Pediatr Surg*. 2016;26(6):476–480.
24. Baxter KJ, Baxter LM, Landry AM, Wulkan ML, Bhatia AM. Structural airway abnormalities contribute to dysphagia in children with esophageal atresia and tracheoesophageal fistula. *J Pediatr Surg*. 2018;53(9):1655–1659.
25. Streppel M, Veder LL, Pullens B, Joosten KFM. Swallowing problems in children with a tracheostomy tube. *Int J Pediatr Otorhinolaryngol*. 2019;124:30–33.
26. Bone DK, Davis JL, Zuidema GD, Cameron JL. Aspiration pneumonia. Prevention of aspiration in patients with tracheostomies. *Ann Thorac Surg*. 1974;18(1):30–37.
27. Cameron JL, Mitchell WH, Zuidema GD. Aspiration pneumonia. Clinical outcome following documented aspiration. *Arch Surg*. 1973;106(1):49–52.
28. Elpern EH, Jacobs ER, Bone RC. Incidence of aspiration in tracheally intubated adults. *Heart Lung*. 1987;16(5):527–531.
29. Ongkasuwan J, Turk CL, Rappazzo CA, Lavergne KA, Smith EO, Friedman EM. The effect of a speaking valve on laryngeal aspiration and penetration in children with tracheotomies. *Laryngoscope*. 2014;124(6):1469–1474.
30. Pannunzio TG. Aspiration of oral feedings in patients with tracheostomies. *AACN Clin Issues*. 1996;7(4):560–569.
31. Cho Lieu JE, Muntz HR, Prater D, Blount Stahl M. Passy-Muir valve in children with tracheotomy. *Int J Pediatr Otorhinolaryngol*. 1999;50(3):197–203.
32. Hull EM, Dumas HM, Crowley RA, Kharasch VS. Tracheostomy speaking valves for children: tolerance and clinical benefits. *Pediatr Rehabil*. 2005;8(3):214–219.
33. Zabih W, Holler T, Syed F, Russell L, Allegro J, Amin R. The use of speaking valves in children with tracheostomy tubes. *Respir Care*. 2017;62(12):1594–1601.