OPEN ACCESS ATLAS OF OTOLARYNGOLOGY, HEAD & NECK OPERATIVE SURGERY

SURGICAL TREATMENT OF PAEDIATRIC DROOLING

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Drooling is normal in children until 4 years of age. However, simple drooling can have negative social consequences, and chronic posterior drooling can have serious clinical sequelae.

Anterior drooling is characterised by unintentional saliva loss from the mouth, which has social and cosmetic consequences

Posterior drooling is when saliva spills over the tongue into the hypopharynx, which leads to chronic pulmonary aspiration (CPA) of saliva. Chronic pulmonary aspiration results in recurrent lower respiratory tract infections, antibiotics use, medical consultations, interventions, and hospitalisations. The severity and complications of aspiration depend on the quantity and quality of the aspirated material, the patients defence mechanisms and pulmonary status [1].

Assessment *(Figures 1, 2)*

Children are best evaluated by a multidisciplinary feeding team. The assessment of drooling and aspiration initially involves a history and examination and bedside tests which includes flexible nasendoscopy *(Figure 1)* and in selected cases a *Functional Endoscopic Evaluation of Swallow (FEES).*

Anterior drooling does not usually require extensive assessment. Most patients have adenotonsillar hypertrophy or delayed oromotor skills associated with neurodevelopmental pathology.

Posterior drooling may require investigation including imaging of the chest and a contrast swallow assessment. Patient with a tracheostomy may have a dye test.

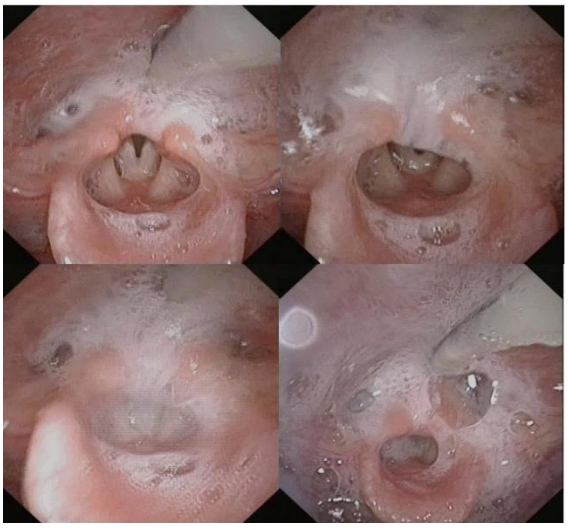

Figure 1: Serial flexible nasendoscopy images show salivary penetration through glottic inlet

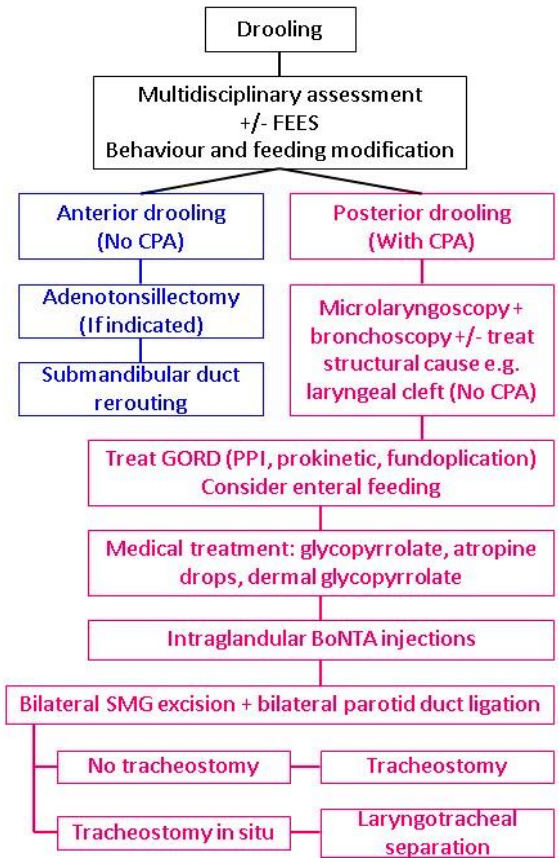

Figure 2: Management of drooling

Diagnostic microlaryngoscopy and biopsy are the investigations of choice for anatomical causes of CPA. Any structural abnormality that is identified, for example a laryngeal cleft, is then appropriately managed. Bronchial washings and brushings for microbiological assessment and histology for lipid laden macrophages may be performed.

Assessment and treatment of gastro-oesophageal disease should be considered, particularly in complex children, to reduce the risk of aspiration of gastric contents. Management is with proton pump inhibitors, prokinetic agents or thickened oral fluids. In severe cases fundoplication may be considered.

Management of Anterior Drooling

Patients with anterior drooling can be managed efficiently by *correcting the upper airway obstruction* (adenoidectomy or adenotonsillectomy) required for treatment of coexistent sleep disordered breathing.

Patients with *delayed oromotor skills* and those with *complex medical conditions* are *managed in a similar manner to the posterior drooling cohort*.

Some patients with *resistant anterior drooling without posterior drooling* may be managed with *submandibular salivary duct diversion*. However, this group of patients needs to be carefully assessed to exclude salivary aspiration before doing surgery, as the submandibular salivary duct diversion is likely to exacerbate aspiration.

Submandibular salivary duct diversion surgical technique

The *submandibular duct* is located immediately deep to the mucosa of the anterior and lateral floor of mouth and opens into the oral cavity to either side of the frenulum via a *puctum (Figures 3 & 4)*. Posteriorly the duct enters the superficial portion of the gland near the posterior border of mylohyoid muscle. The *frenulum* is a mucosal fold that extends between the floor of mouth and the ventral oral tongue, in the midline, between the *openings of the submandibular ducts (Figure 3)*.

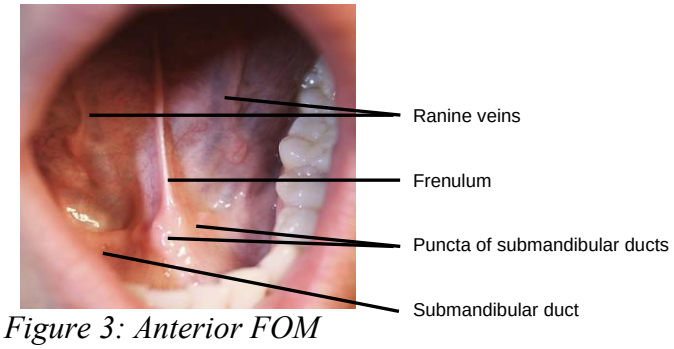

Figure 3: Anterior FOM

The paired *sublingual salivary glands* are located beneath the mucosa of the anterior floor of mouth, anterior to the submandibular ducts and above the mylohyoid and geniohyoid muscles *(Figures 4, 5, 6, 7)*. The glands drain via 8-20 excretory ducts of Rivinus into the SMG duct and also directly into the mouth on an elevated crest of mucous membrane called the *plica fimbriata* which is formed by the gland and is located to either side of the frenulum of the tongue *(Figures 4 & 5)*.

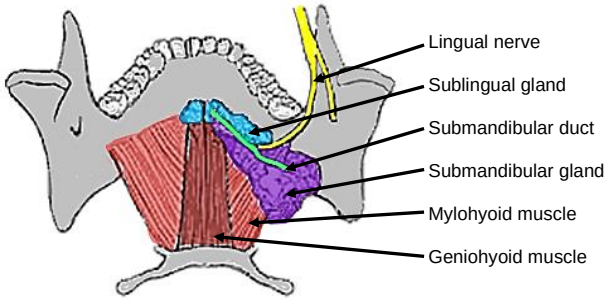

Figure 4: Superior, intraoral view of SMG, duct, lingual nerve and mylohyoid and geniohyoid muscles

The *lingual nerve* lies on the surface of the mylohyoid muscle, then crosses deep to the submandibular duct in the posterolateral

floor of mouth. It then runs on the surface of the hyoglossus, above the level of the duct, and is then distributed to the mucous membrane of the oral tongue. *(Figures 4, 5, 8)*.

Therefore, the entire length of the duct can be exposed from above without injuring the nerve. *Ranine veins* are visible on the ventral surface of the tongue and accompany the hypoglossal nerve *(Figures 3 & 9)*.

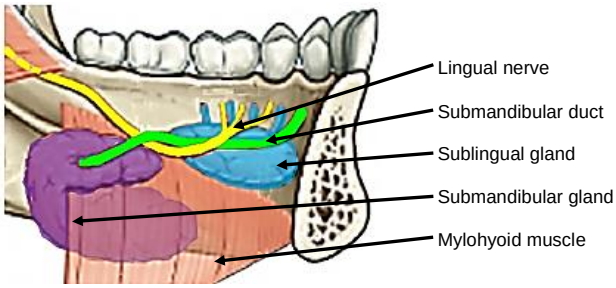

Figure 5: Intraoral view of left sublingual gland with ducts of Rivinus, SMG and duct, lingual nerve, and mylohyoid muscles

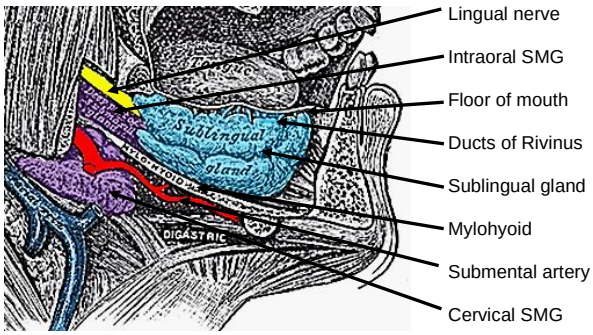

Figure 6: View of right sublingual gland

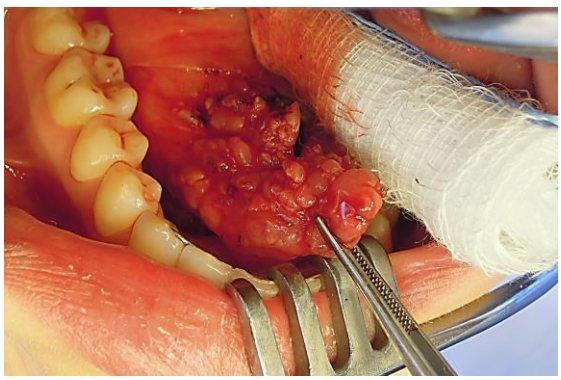

Figure 7: Right sublingual salivary gland

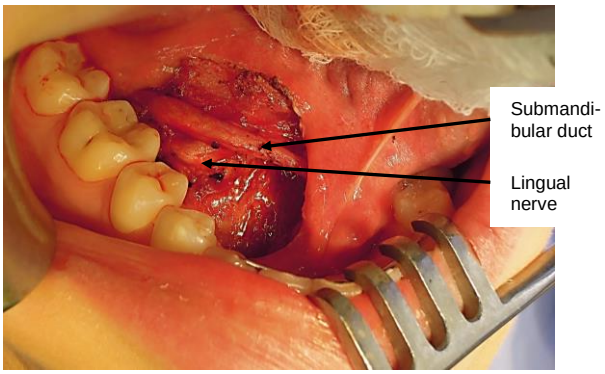

Figure 8: Lingual nerve and submandibular duct after removal of sublingual gland in operation done for a ranula

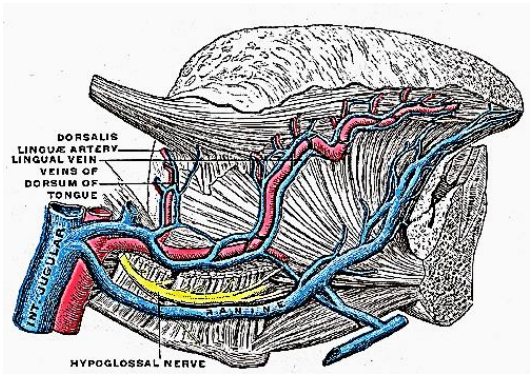

Figure 9: XIIn accompanied by ranine veins

Surgical steps

- General anaesthesia is administered, the patient is intubated transnasally and positioned supine with a head ring
- The jaw is held open with a bite-block and a stay suture is used to retract the tongue
- The submandibular duct orifice is identified and cannulated with a lacrimal probe
- The cuff of mucosa surrounding the duct orifice is infiltrated with local anaesthetic (xylocaine 1% with adrenaline)
- The mucosa around the duct is incised and the incision continued in a linear fashion, posterolaterally, for 1cm
- The cannula remains inside the duct, and the duct is dissected free from the

surrounding soft tissue, over a length of approximately 3cm
- A tunnel is made just deep to mucosa from the posterior limit of the incision to posterior to the glossopharyngeus muscle (anterior tonsillar pillar)
- A mucosal incision is made posterior to the glossopharyngeal muscle, in the mucosa of the tonsillar fossa (NB. Children with anterior drooling would usually have undergone previous adenotonsillectomy, as first-line treatment)
- The duct with the surrounding cuff of tissue is rerouted through the tunnel to emerge from the mucosal defect in the tonsillar fossa, secured using 4-0 vicryl
- The floor of mouth incision is closed
- The stay suture is removed
- Postoperative broad-spectrum oral antibiotics are administered

Management of Posterior Drooling

Children with posterior drooling without structural upper aerodigestive tract abnormality and CPA require a ***stepwise approach*** to management in a multidisciplinary team setting. The treatment goals are to reduce the incidence of lower respiratory tract infection, decrease hospitalisation, nursing care requirements and to improve quality of life. Management options for posterior drooling are nonsurgical or surgical

1. Non-surgical management

Behavioural modification and feeding programs

Initial conservative management involves allied health interventions which aim to improve oromotor function. Oral intake textures are modified, and positioning and feeding strategies are employed to reduce risk of aspiration. In children where oral intake is deemed unsafe, a feeding gastrostomy or jejunostomy tube are introduced.

Medications

Anticholinergic agents are the mainstay of systemic medical treatment for drooling. Glycopyrrolate is the first-line oral anticholinergic. At our institution, this is available as a liquid or crushable tablet. It is commenced at a low dose of 0.01mg/kg/dose twice a day, and increased to effect, with a maximum dose of 0.04mg/kg three times per day [2]. Oral atropine drops onto the tongue is another option. Dermal glycopyrrolate (scopolamine) patches are a well-tolerated option; patches can be trimmed to tailor the dose. Adverse effects of anticholinergic medications include irritability, restlessness, sedation, delirium, blurred vision, urinary retention, constipation and skin flushing. Side-effects limit their use in 20% of children.

Botulinum toxin injection

Intraglandular botulinum toxin type A (BoNTA) injections into the major salivary glands have proven very useful. Injections are administered to the major salivary glands, usually under ultrasound guidance to avoid intravascular injection. BoNTA blocks the release of acetylcholine at parasympathetic synapses, blocking parasympathetic innervation of the salivary glands and hence saliva secretion. The dose at our institution is 2units/kg total, given in divided doses amongst all the glands. Adverse effects are very rare. Salivary gland Botox is well-suited to children who are also having injections to their limbs under the same anaesthetic - in such cases the dose to the salivary glands is reduced. An uncommon but severe complication is spread of BoNTA to the pharyngeal musculature which can cause severe dysphagia [3]. The procedure is repeated at 3-6 monthly intervals.

Steps for Botulinum toxin injection

- General anaesthesia is administered
- The patient is positioned supine with a head ring
- The skin overlying both necks and the parotid regions are prepared and draped with sterile drapes
- The ultrasound probe is draped
- Botulinum toxin, type A purified neurotoxin complex powder is reconstituted, according to the manufacturer's instructions.
- Local guidelines should be consulted for the maximum cumulative dose in the paediatric patient. The maximum dose is divided amongst the four glands.
- Using a 25-gauge needle, under ultrasound guidance, Botulinum toxin is infiltrated into the parenchyma of both parotid and submandibular glands *(Figure 10)*

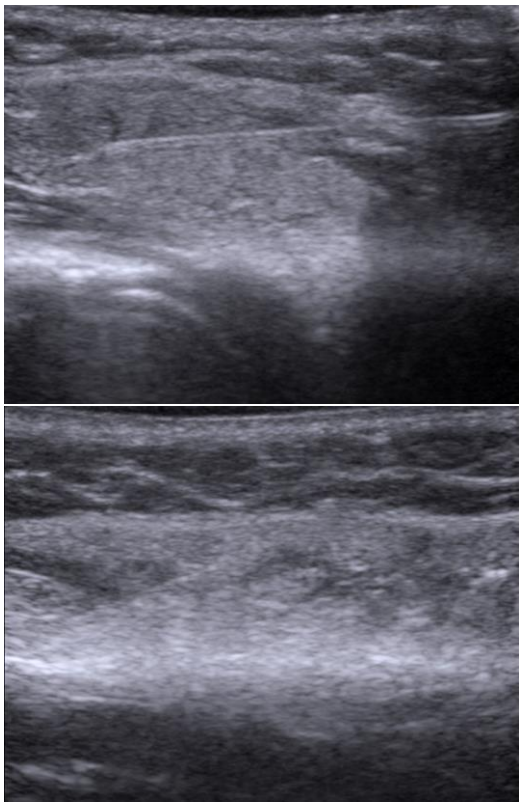

Figure 10: Ultrasound guided intraparotid Botulinum Toxin A injection. The parenchyma is infiltrated, avoiding vascular structures

- Post-procedure antibiotics are not required

2. Surgical management

Patients with drooling that has not responded to medical therapy and have chronic pulmonary aspiration (CPA) of saliva are considered for surgical management. Most of these children have neurological impairments. Surgical management addresses either salivary flow or definitively separates the trachea from the larynx, or tracheostomy alone.

Procedures to reduce salivary flow include:
1) Salivary duct ligation
2) Submandibular gland excision
3) Tympanic neurectomy: not recommended as it is ineffective, risks hearing loss and results in loss of taste [5]

Airway procedures include
1) Tracheostomy
2) Laryngotracheal separation

At our institution, children who fail medical therapy are offered bilateral submandibular gland excision and bilateral parotid duct ligation. Long-term side effects are rare, xerostomia being the most commonly encountered complication. This procedure has been shown to reduce readmission rates for children with chronic salivary aspiration [6,7].

Procedures to reduce salivary flow

1) Salivary duct ligation

- The salivary ducts of the submandibular (SMG) and parotid glands are amenable to ligation. Short-term morbidity includes sialadenitis and discomfort which is managed supportively as an inpatient,

until symptoms have improved. Parotid duct ligation reduces salivary gland secretions in response to food stimulation,[4] as the parotid produces more saliva in response to food than the other salivary glands. Ducts are ligated using a transoral approach. All four ducts can be ligated in the same procedure ('4-duct ligation').

Surgical steps

- General anaesthesia is administered
- The patient is intubated transnasally and positioned supine with a head ring
- Intraoperative cephazolin and metronidazole are administered
- The jaw is held open with a bite-block
- A stay suture is used for tongue retraction
- The parotid duct orifice is identified and cannulated with a lacrimal probe
- The mucosa surrounding the orifice is infiltrated with local anaesthetic (xylocaine 1% with adrenaline)
- The mucosa around the duct orifice is incised in an elliptical fashion
- The terminal duct is dissected free from the surrounding soft tissues
- The duct is ligated with a 3-0 silk suture
- The terminal duct and surrounding mucosa are amputated
- The duct is buried in the soft tissues
- The elliptical mucosal defect is closed with 4-0 vicryl
- The same is repeated on the contralateral side
- Attention then turns to the SMG duct orifice, which is identified and cannulated
- The mucosa surrounding the orifice is infiltrated with local anaesthetic (xylocaine 1% with adrenaline)
- The mucosa around the orifice is incised in an elliptical fashion (along the direction of the duct)
- The duct is dissected free over a length of <1cm
- The duct is ligated with a 3-0 silk suture
- The terminal duct and surrounding mucosa are amputated
- The duct is buried
- The elliptical mucosal defect is closed with 4-0 vicryl
- Postoperative broad-spectrum oral antibiotics are administered, and low dose amoxicillin is administered for 2 weeks postoperatively.

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2) Submandibular gland excision

Transcervical submandibular gland excision is utilised to treat drooling. It eliminates saliva production in the resting state, as 70% of resting state saliva production occurs from the SMG glands. (See *Figure 2*) This procedure results in 2-3cm unilateral or bilateral cervical scars. Complications are the same as with routine SMG excision. A detailed description of SMG excision can be read in the Open Access Atlas: https://vula.uct.ac.za/access/content/group/ba5fb1bd-be95-48e5-81be-586fbaeba29d/Submandibular%20gland%20excision.pdf

Airway procedures

1) Tracheostomy

Children with neurological impairment often have tracheostomy placement for pulmonary toilet and to manage multiple med-

ical comorbidities. In some cases, tracheostomy alone can be used to manage CPA secondary to drooling. This option requires intensive nursing care with regimented, very frequent tracheostomy tube suctioning.

2) Laryngotracheal separation/diversion

These are definitive surgical procedures for CPA cases that have proven to be unresponsive to all other management. They are offered to patients who are tracheostomy dependent, gastrostomy tube fed and non-verbal, and who continue to have CPA. These procedures completely separate the lower respiratory tract from the upper aerodigestive tract and eliminate any risk of aspiration. Children have a permanent tracheostomy tube and phonation is no longer possible. Both these procedures are potentially reversible, but it is best not to consider either option unless the need to reverse was considered only a remote possibility.

Laryngotracheal separation technique

- General anaesthesia is administered
- The patient is positioned supine with a head ring
- The skin overlying both necks are prepared and draped with sterile drapes
- Administer perioperative broad spectrum antibiotics
- Make transverse cervical skin incision
- Elevate subplatysmal flaps superiorly and inferiorly
- Separate the infrahyoid strap muscles
- Expose and divide thyroid isthmus
- Expose and bluntly mobilise the trachea with finger dissection or a blunt haemostat to the upper mediastinum
- Avoid injury to recurrent laryngeal nerves in the tracheo-oesophageal grooves
- Horizontally incise the trachea distal to 1st of 2nd tracheal rings; depending on the length of the neck the incision may be made lower between 2nd and 3rd rings or even more inferiorly
- Angle the tracheal incision superiorly to create a bevelled tracheostoma
- Carefully separate the posterior tracheal wall from oesophagus, taking care not to enter the oesophageal lumen
- Place a small anaesthetic tube through skin incision into the trachea to reroute gas administration from transoral to the stoma *(Figure 11)*

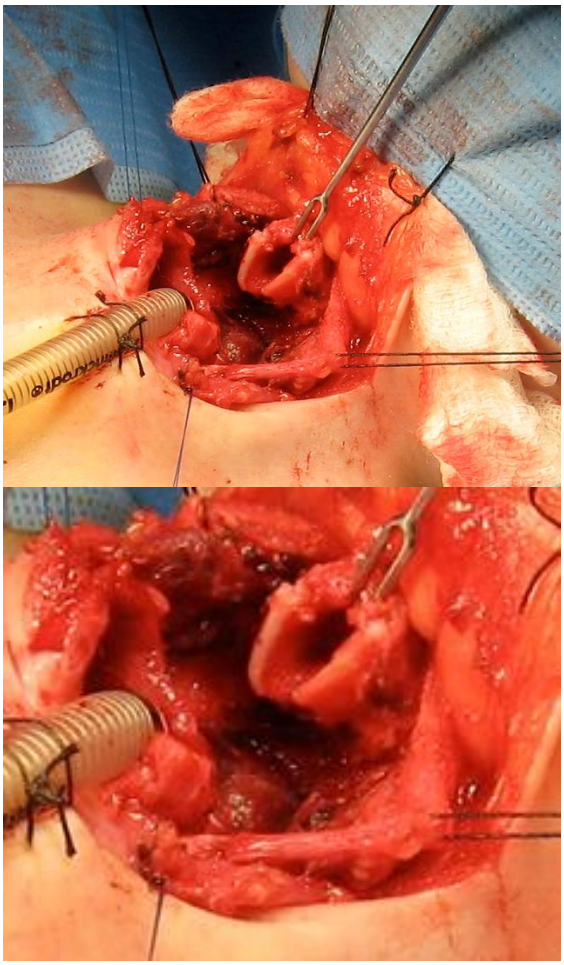

Figure 11: The trachea is separated, and the distal segment is intubated

- Make a circular skin incision in the anterior neck above the suprasternal notch
- Formalise the tracheostomy by suturing the distal trachea circumferentially to the lower circular skin incision using 3-0 vicryl deep and 4-0 chromic run-

ning in 4 separate quadrants in a similar fashion to a laryngectomy stoma

- Create a blind pouch of the superior tracheal end:
  - Remove the 2nd tracheal ring
  - Invert the underlying subglottic mucosa with interrupted 4-0 vicryl
  - Oversew with running 3-0 vicryl *(Figure 12)*
  - Reinforce the subglottic pouch with strap muscles and fibrin glue
- Insert a corrugated drain
- Close the skin is closed in layers.

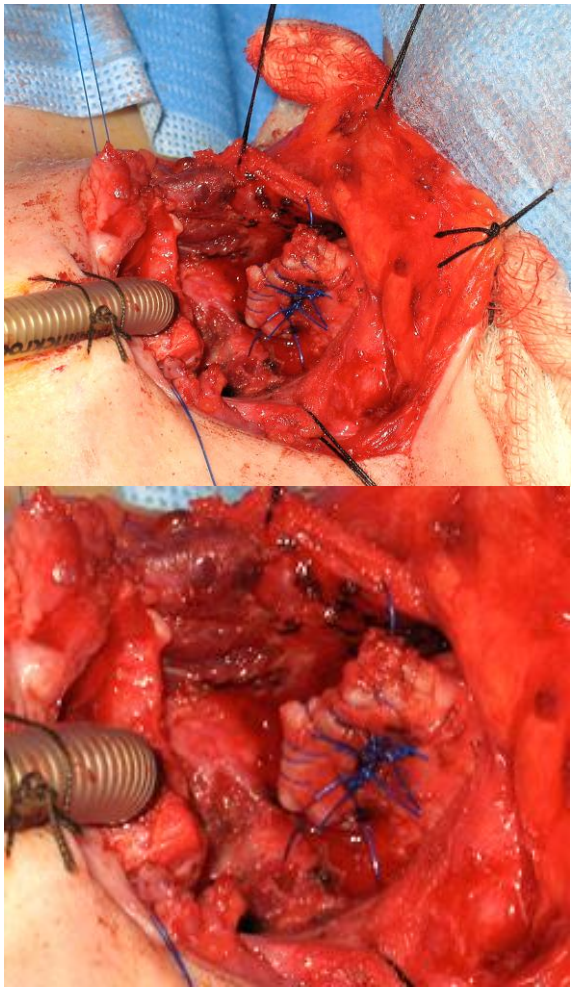

Figure 12: A blind pouch is created by removing 2nd tracheal ring, the subglottic mucosa is inverted and closed with interrupted 4-0 vicryl and oversewn with running 3-0 vicryl

Laryngeal diversion

The trachea is separated, and a cervical stoma is created as with laryngotracheal separation. However, the distal end of the proximal segment of trachea is anastomosed to an anterior oesophagostomy in an end-to-end fashion. Saliva is therefore diverted into the oesophagus. The risk of surgical complications is higher with diversion, due to the anastomosis between the proximal trachea and oesophagus.

Laryngectomy

Laryngectomy results in permanent separation of the trachea from the upper aerodigestive tract and is very rarely performed in children with CPA secondary to drooling. It is not reversible, and children are rendered aphonic.

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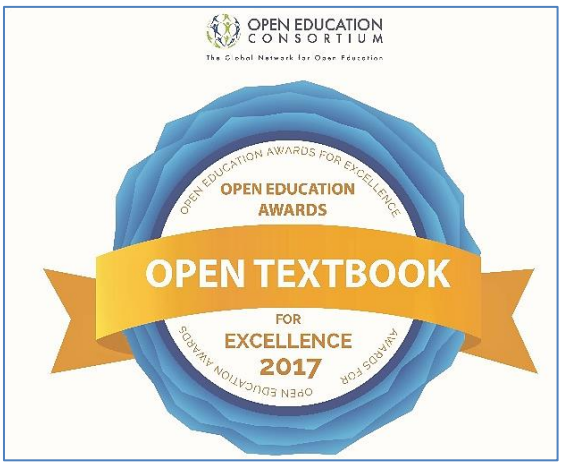

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