Drooling is a serious medical and social problem. Drooling is often used interchangeably with sialorrhea. Sialorrhea is defined as an increase in salivary flow that can be chronic or episodic. This condition should be differentiated from drooling. Patients who drool usually produce a normal salivary volume but cannot manage their saliva effectively. This is most commonly due to a neurological or muscular disorder. This results in accumulation of saliva in the anterior mouth which leads to drooling. Sialorrhea, or an increase in salivary flow, is often compensated for by patients by an increase in their rate of swallowing. However, it is possible that sialorrhea could lead to drooling if the rate cannot be compensated for. In addition, some neurological conditions, such as familial dysautonomia, can lead to drooling due to ineffective oral musculature which is also associated with an increase in the salivary flow rate.

In order to understand the causes and treatment of drooling, a review of the anatomy and physiology of the salivary glands is important. Saliva is produced by the salivary glands. These glands are controlled by the autonomic nervous system. There are three pairs of major salivary glands: the parotid, submandibular, and the lingual glands. One and one half liters of saliva is produced daily, most of which (70%) comes from the submandibular glands at a resting state. The other one third comes from the parotid glands (25%) and the lingual (5%) glands. Ingestion of food causes stimulation of the parotid gland to secrete a higher percentage of saliva. All of the glands have a dual nerve supply from the sympathetic and parasympathetic systems. Secretory innervation is primarily under parasympathetic control.

Preganglionic parasympathetic fibers to the submandibular and sublingual glands originate in the superior salivatory nucleus in the medulla. These fibers then travel with the nervus intermedius in the facial canal. They travel with the facial nerve at the geniculate ganglion and leave the mastoid segment of the facial nerve as the chorda tympani. The chorda fibers go through the petroympanic fissure and join the lingual nerve to the submandibular ganglion. In this ganglion, they synapse and become postganglionic fibers which go to the submandibular and sublingual glands.
The preganglionic parasympathetic fibers to the parotid gland originate in the inferior salivatory nucleus in the medulla. The leave the brainstem as part of the glossopharyngeal nerve. Jacobson’s nerve (the tympanic segment of CN9) travels through the middle ear on the promontory and supplies the middle ear mucosa. The fibers then continue as the lesser superficial petrosal nerve which joins the otic ganglion in the pterygopalatine fossa. The fibers synapse in the otic ganglion and continue as postganglionic parasympathetic fibers which travel with the auriculotemporal nerve to the parotid gland.

Stimulation of the parasympathetic system causes secretion of saliva from all of the salivary glands. Stimulation of the sympathetic system causes production of small amounts of saliva from the submandibular gland but has no effect on parotid gland saliva. The sympathetic system originates in the cervical ganglion and travels with the arteries that supply the salivary glands.

Saliva has many functions. It protects against dental and oral infections by its inherent pH and the immunoglobulin content in saliva. It is also important in swallowing by coating the bolus, digestion through the breakdown of carbohydrates by alpha-amylase, and speech.

Drooling is rarely seen in the normal child after the age of 18 months. The reported incidence of pathologic drooling varies widely. The causes of drooling are multiple and include acute and chronic forms. Acute drooling can be associated with infection such as epiglottitis, peritonisillar abscess, or neoplasm. These conditions can temporarily interrupt the normal flow of saliva. Chronic drooling is most often seen in patients with cerebral palsy. The etiology of drooling can also be classified as direct or indirect. Direct causes include conditions that interfere with the muscle tone of the oral cavity or stimulation of the salivary glands. Tranquilizers, anticonvulsants, and anticholinesterases can initiate drooling. Indirect causes include nasal obstruction, malocclusion, and large tongue size. The neurological disorder that is most commonly associated with drooling is cerebral palsy.

Ekedahl states that 10% of children with cerebral palsy in Sweden and 37% of children in Belgium with cerebral palsy have excessive drooling. Persistent drooling leads to major hygienic and psychosocial consequences for the patient. These include maceration of the skin around the mouth, chin, and neck, which can lead to secondary bacterial infections. In addition, constant soiling of clothes and furniture becomes a significant problem. Drooling also interferes with speech and feeding. Drooling can severely impact the affected person’s social situation.

The pathophysiology of drooling is multifactorial and is usually related to a primary defect in the oral phase of swallowing. This defect is usually caused by a combination of poor head control, an inability to close the mouth, poor lip control, abnormal tongue mobility, and a reduction of intra-oral sensation. As stated previously, drooling can also be associated with sialorrhea. Sialorrhea has been linked to gastroesophageal reflux disease, a variety of medications, irritating factory such as ill-fitting dentures, and some forms of seizure disorders.

The diagnosis of drooling is a clinical one based on the patient’s history and physical exam. During the history, an assessment of the severity of the drooling is made. The quantity of saliva and the peak time of drooling during a 24 hour period are important to note. Drooling is difficult to measure. It varies from day to day and influenced by factors including hydration, hunger,
emotional state, and the level of alertness. Associated factors can sometimes shed light on the etiology of the drooling patient. For example, a child with nasal obstruction leading to drooling will also have a history of chronic mouth breathing and may demonstrate adenoid facies. If the patient has a treatable condition such as rhinitis, sinusitus, or adenoid hypertrophy, this should be treated first.

In the case of a child, parental expectations should be evaluated. The parent must understand the goal of treating drooling is reduction in excessive salivary flow while maintaining a moist and healthy oral cavity. Avoidance of xerostomia is key. The patient’s full medical history should be obtained paying close attention to any neurological conditions which may play a role in the etiology of the drooling. In addition, other medical conditions may present a contraindication to a potential management option. For example, the presence of a unilateral hearing deficit may preclude a transtympanic neurectomy. In addition, surgery to decrease salivary flow should not be done in athetoid patients. In general, the resultant thickened saliva leaves a dark, gummy odoriferous residue in the patient’s oral cavity due to the athetoid movements of the muscles of the tongue and oral cavity.

The age of the patient is also an important consideration. Crysdale and Cotton recommend deferring surgery until a child is at least 5 or 6 years old. Cotton requires a minimal level of intelligence in his operative candidates that allows the patients to mix socially with their peers. However, Lew, et. al. believe there is a place for surgical management in severely retarded patients because it makes their care easier.

Physical examination is extremely important in the evaluation of the drooling patient. Attention should be directed to the head and neck looking at head posture, sores on the lower one third of the face, dental abnormalities, abnormal tongue size or movements, problems with swallowing, and the patency of the nasal airway. Anterior open bite malocclusion, hypoactive gag reflex, and decreased intraoral sensitivity are common in the drooling patient.

Lateral x-rays of the nasopharynx can be taken if adenoid hypertrophy is suspected. Audiometry should be performed if transtympanic neurectomy is being considered. Cotton recommends a barium swallow to evaluate for aspiration, spastic esophageal disease, or esophageal stricture. A salivary gland scan may be helpful in revision operations to determine the functional status of the glands.

Treatment options for drooling include pharmacological therapy, speech therapy, behavioral therapy, radiotherapy, and surgery. The initial approach in most cases is nonsurgical and thus reversible. Pharmacological therapy is usually used for temporary symptomatic relief. Anticholinergic drugs decrease saliva production. It is their side effects of sedation, constipation, urinary retention, blurred vision, xerostomia, and restlessness that prevents its long-term use. Blasco, et. al. favor the use of glycopyrrolate(Robinul) among the available anticholinergic drugs. They looked at safety, efficacy and dosing in a prospective study of 38 patients with neurological conditions resulting in drooling. They found a 90% response rate with the use of Robinul. The most common side effect was irritability They felt that Robinul was safe and effective in the long-term management of drooling. However, they stated that more blinded trials were necessary before definite conclusions could be drawn. Transdermal scopolomine has been
used with the advantage of requiring only one application for three days. Antihistamine drugs have also been used to decrease saliva production but are also not popular long term due to troublesome side effects.

There is a hypothetical role for antireflux medication in the cerebral palsy (CP) child with drooling and reflux. Many children with CP suffer from gastro-esophageal reflux due to esophageal dysmotility and decreased lower esophageal sphincter tone. However, in a study by Heine, et. al., treatment with antireflux medications did not significantly change the severity and frequency of drooling as noted by the parents.

The goal of speech therapy is to improve jaw stability and closure, increase tongue mobility, strength, and positioning, improve lip closure, and to decrease nasal regurgitation. By itself, it usually does not have a significant impact on the drooling patient. However, since it is noninvasive, a speech therapy evaluation is usually recommended prior to surgical consideration. Best results are achieved when therapy is begun as an infant. Limited results are achieved in the severely retarded patient. Oral prosthetic devices, such as a chin cup, may be of some benefit in the drooling patient undergoing speech therapy.

Behavioral therapy use combinations of cueing, overcorrection, and positive and negative reinforcement to help the drooling patient. Auditory electromyographic feedback has also been used to condition the orbicularis oris muscle to assist in the proper swallow. There are three phases to behavioral therapy. In the first or cognitive phase, the participant gains an overall idea of the skill to be acquired. In the second phase, the fixation phase, there is reorganization of the motor behavior. In the third or autonomous phase, the performance is automated and control of the behavior is moved from the higher to lower brain centers. Dunn, et. al. used cues and positive reinforcement to eliminate drooling in a 16 year old quadriplegic patients. Behavioral therapy is not used widely despite reports of its success due to the time intensive nature of the therapy and the requirement of a certain level of intelligence in the patient for cooperation. In addition, regression has been shown to occur once the therapy is discontinued.

Radiotherapy to the major salivary glands in doses of 6000 rad or more has been used to treat drooling. The side effect of radiation therapy limits its use. These include xerostomia, mucositis, caries, osteoradionecrosis, and development of radiation induced malignancy. Borg and Hirst looked at 31 patients treated with radiation therapy for drooling. Initially 82% of patients showed a satisfactory response. Five patients, however, relapsed within 6 months of treatment. Only 4 patients developed long term side effects. Response rates were superior in patients who had both their parotid glands and submandibular glands in the radiation field.

Surgery can be performed to remove the salivary glands, ligate the salivary gland ducts, and/or to interrupt the parasympathetic nerve supply to the glands. The history of surgical therapy for drooling dates back to 1964 when Theodore Wilkie, a Canadian plastic surgeon, transposed the parotid ducts to the tonsillar fossa in cerebral palsy patients. This required elevation of a mucosal flap based on Stensen’s duct and passing this through a submucosal tunnel to the tonsillar fossa. He based his management on cine radiographic studies of these patients. He concluded that these patients lacked the ability to cup the anterior tongue and form a trough for passage of fluid to the
oropharynx. Therefore, by rerouting he ducts, he delivered the saliva more posteriorly. Although Wilkie’s hypothesis was logical, it did not achieve satisfactory clinical results.

Wilkie and Brody theorized that it was necessary to remove the submandibular glands in addition to Wilkie’s procedure, as they produced 70% of the salivary outflow. This procedure combined with rerouting of the parotid ducts had a 85% success rate. The procedure was not popular due to the associated technical difficulty, external scars, tonsillectomy requirement, prolonged hospitalization, and postoperative morbidity including swelling and dysphagia. The complication rate was 35% and included postoperative cysts, parotid duct stenosis or fistulas, wound dehiscence, parotid swelling and parotitis, xerostomia, and an increase in dental and gingival infections. Three percent of patients required multiple procedures to correct drooling.

Parotid duct ligations have been used in many patients to control drooling. Submandibular duct ligations have not been used extensively because the submandibular saliva is more viscous, alkaline and contains a higher concentration of calcium and phosphate salts when compared to parotid duct saliva. This predisposes the submandibular gland/duct to stone formation. The submandibular duct also directs saliva against gravity which predisposes to lower flow rates and stone formation.

Patients undergoing submandibular gland removal and parotid duct ligation have results similar to the 85% success rate quoted by Wilkie and Brody. An elliptical incision is made around Stensen’s duct and the duct dissected for 1 cm then suture ligated and resected. The submandibular gland excision is performed in the usual manner through a neck incision.

Fagella and Osborn compared the risks and benefits of parotid duct repositioning and parotid duct ligation. In 22 patients, they transposed the parotid duct on the left and ligated the right parotid duct. In 16 patients, they transposed both parotid ducts and in 3 patients the ligated both ducts. All patients had bilateral submandibular gland excisions. In the first group, no change in the outward appearance of the patient was noted on either side which contradicts the thought that ligation of the parotid duct causes cheek depression due to atrophy. The second group experienced the following complications: wound dehiscence, parotitis, cyst formation, and transient parotid swelling. In the third group, xerostomia with thick secretions required intensive mouth care. Fagella and Osborn concluded that combination procedures were preferable to bilateral duct ligations alone which caused excessive dryness or to bilateral duct repositioning alone which caused increased complication rates.

Rerouting of the submandibular duct into the tonsillar fossa initially became popular in the 1970’s due to the success rate of 80-100% reported by Ekedahl, Guerin, Cotton, and Crysdale. A cuff of mucosa is dissected around the opening of the duct and the duct is dissected 3-4 cm or until the submandibular gland is reached. The mucosal cuff surrounding the ductal papilla is marked medially and laterally with a suture. The lingual nerve is identified and preserved. A submucosal tunnel is formed to the tonsillar fossa using a curved tonsil hemostat and the duct rerouted posterior to the anterior tonsillar pillar using the marking sutures placed previously. Crysdale originally advocated a tonsillectomy 2-3 months prior to rerouting of the ducts to avoid the risk of retrograde sialoadenitis caused by tonsillitis. Currently, he recommends examination of the tonsils at the time of surgery and if they are small, they can be left intact. If large, they are
removed at the time of the rerouting procedure. Other surgeons avoid this issue entirely by placing the new duct opening outside the tonsillar fossa in the base of the anterior pillar. The proposed advantages of this anterior procedure are that it is technically easier with a higher success rate. Crysdale now recommends that a sublingual adenectomy at the time of the original procedure as this decreases the rate of ranula formation without this procedure (8%).

Crysdale also gives the following basic guidelines for patient selection for submandibular rerouting surgery. First, the neurological status of the patient must be stabilized. Potential recovery from a neurological insult such as a cerebrovascular accident must be given time to occur prior to surgical consideration. He also states that no surgical intervention should occur in a cerebral palsy child due to neonatal anoxia until the age of six by which time maturation of the brain should have occurred. Cotton’s guidelines are similar with the minimum age of the operative candidate being 5 years old. Most patients treated by Cotton fell in the 8-12 year old range. He requires a certain level of minimum intelligence that allows the patients to mix socially with peers.

The advantages of submandibular duct rerouting versus excision include: no need for external incisions, less chance of complete dryness in the anterior mouth, less alteration in taste and sensation and swallowing. The required intraoral dissection can result in the following complications: significant swelling of the floor of mouth, submandibular glands, sialoadenitis, ranula formation, and duct obstruction. As stated previously, the risk of ranula formation is eliminated by excising the sublingual glands at the time of the rerouting. Post-operative success rates are similar to the 86-100% rates quoted for excision of the submandibular glands and rerouting of the parotid ducts.

A fifteen year follow-up study was conducted by O’Dwyer and Conlon which looked at 53 neurologically impaired children who underwent submandibular duct relocation (SMDR) in Dublin. Patients were followed up with a questionnaire to determine symptomatic improvement. 94% of the parents stated that their child benefited from the operation. One-half of the parents reported a complete cessation of drooling. The worst complication noted was aspiration pneumonia thought to be due to salivary aspiration which occurred in three children. These authors stated that children with severe oral motor dysfunction might not be good candidates for a rerouting procedure due to the risk of aspiration. However, they felt the risk of this could be reduced by leaving the nasotracheal tube in place until the cough reflex returns.

Another long-term follow-up study was conducted by Mankarious et. al. who looked at 59 patients undergoing SMDR and found that approximately 80% had marked to moderate improvement in their drooling and 20% had minimal to no improvement.

The most common complication was ranula formation which occurred in 7 patients. Only 1 out of the 7 patients required excision of the ranula. These authors do not recommend the routine removal of sublingual glands as they state the risk of lingual nerve damage and operating time are increased. If the lingual glands are not taken, attention must be paid to transect the ductules of the sublingual glands as they enter the submandibular ducts.
Similar success rates (80%) have been reported for treating drooling with transtympanic neurectomies. This procedure requires that both the chorda tympani and the tympanic plexus nerves are disrupted. The operation is not complicated and has the advantage of no external scars. A tympanomeatal flap is created and the nerves are transected. A thorough search for all the branches of the tympanic plexus on the promontory is conducted as failure to transect all branches will decrease the success rate. A hypotympanic branch of the plexus is present in 50% of patients. This branch is usually covered by bone and drilling down the inferior aspect of the promontory is necessary if this is the case. It is important to use a low speed drill to avoid perforating the promontory. Grewal reported that the success rate is higher in patients who underwent combination procedure of chorda tympani and tympanic plexus sectioning versus chorda tympani sectioning alone. Loss of taste in the anterior two thirds of the tongue is unavoidable and xerostomia is a potential complication. It is interesting to note that no loss or weight or appetite has been observed in patients with bilateral chorda tympani transections. This procedure has been associated with the production of thick, mucoid saliva. Other, more rare complications include otitis media, tympanic membrane perforations, and recurrence of drooling due to incomplete neurectomy or nerve regeneration. This procedure is contraindicated in any patient with a unilateral sensorineural hearing loss.

The successful management of drooling necessitates a multidisciplinary approach. It requires a thorough history and physical exam of the patient. Family member or caregivers should be questioned about their expectations. Noninvasive therapy such as speech or behavioral should be considered. In surgical management, the order of procedures recommended depends on which study is being referenced. Lew, et al., states that the simplicity of the transtympanic neurectomy make this procedure the first one of choice. If this fails, they recommend bilateral submandibular gland excisions. They believe that the submandibular gland should be addressed first as it is the major producer of salivary outflow. They do not routinely recommended parotid duct transfers or ligations due to the high morbidity associated with these procedures. Cotton, Richardson, and Myers, however, recommend bilateral submandibular gland excisions and parotid duct ligations as the procedure of first choice. Their studies have shown that this procedure produces consistently good control of drooling and is superior to submandibular duct reroutings alone. In conclusion, the recommendations on which surgical modality to try first are controversial and should be tailored to the individual patient under consideration. The surgeon should be clear of the patient’s and the caregiver’s expectations. Any procedure attempted should be stressed as a first stage procedure. If satisfactory control is not achieved, other procedures should be considered. Regardless of the therapy chosen, the goal of it is usually to diminish the drooling, not completely eliminate it.

Bibliography


