Drooling in children

Alexander KC Leung MBBS FRCPC FRCP(Lond) FRCP(Edin) FRCP(Glasg) FRCPI FRCPCH FAAP FRSH DCH(Lond) DCH(Irel) FHKAM FHKPaed[1,2], C Pion Kao MD FRCPC[2]
[1]*Department of Pediatrics, University of Calgary;* [2]*Alberta Children's Hospital, Calgary, Alberta*

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Although drooling may occur in healthy children under two years of age, it is commonly observed in neurologically impaired children and carries a considerable social stigma. Drooling can be socially embarrassing, and at times may cause serious medical complications. Drooling may result from the hypersecretion of saliva or, more commonly, the impairment of swallowing. Most of the causes of drooling can be diagnosed from a history and physical examination of the patient. Laboratory investigations are usually unnecessary. Treatment should be directed at the underlying cause whenever possible. No active management is necessary for patients who have little functional and psychological impairment from their objectively mild or intermittent drooling. Treatment options for moderate and severe drooling include physiotherapy, behavioural or biofeedback modification, pharmacotherapy and surgery.

Key words: *Drooling; Salivary secretion; Sialorrhea*

Les enfants qui bavent

Bien que les enfants de moins de deux ans puissent baver, on observe souvent ce phénomène chez les enfants atteints de lésion cérébrale, et il est considéré comme un important handicap social. Il peut être embarrassant de baver en société, et le fait de baver peut parfois provoquer des complications médicales graves. Ce problème peut provenir d'une hypersécrétion de la salive ou, plus souvent, d'une anomalie de la déglutition. On peut en diagnostiquer la plupart des causes à partir d'une anamnèse et d'un examen physique du patient. D'ordinaire, les examens de laboratoire sont inutiles. Dans la mesure du possible, le traitement devrait porter sur la cause sous-jacente. Il n'est pas nécessaire d'entreprendre un traitement actif dans le cas des patients qui présentent peu de troubles fonctionnels ou psychologiques en raison de leur problème de bave qui, en toute objectivité, demeure léger ou intermittent. Les traitements possibles en cas de problème de bave modéré à grave comprennent la physiothérapie, les techniques de modification du comportement comme la rétroaction biologique, la pharmacothérapie et la chirurgie.

Drooling or sialorrhea refers to an unintentional loss of saliva and other oral contents from the mouth (1). Although drooling may be encountered in healthy children, it is commonly observed in neurologically impaired children and carries a considerable social stigma. In addition to cosmetic and hygienic considerations, serious medical complications and psychosocial consequences may arise from this situation. Despite this, there is a paucity of information in the paediatric literature on drooling. This article reviews the physiology of saliva production and the etiology of drooling, and suggests an approach to the management of this problem.

PHYSIOLOGY OF SALIVA PRODUCTION

At rest, approximately 65% to 70% of the saliva is produced by the submandibular glands, 20% to 25% by the parotid glands, 5% by the sublingual glands and the remainder by the minor salivary glands located on the palate, buccal mucosa and tongue (1-3). In the resting state, the rate of salivary secretion has been estimated to be 0.3 to 1 mL/1.7 m^2/min (3).

The production of saliva may increase sixfold in a stimulated state, with approximately 70% of the total saliva produced by the parotid glands (3,4). The parotid secretions are largely serous in consistency. This is in contrast with the secretions of the submandibular glands, which are both serous and mucosy.

The secretory innervention of the salivary glands is primarily under the control of the parasympathetic nervous system. Parasympathetic stimulation of the salivary glands results in increased activity of the acinar and ductal cells leading to increased salivation. Parasympathetic preganglionic fibres that arise from the superior salivatory nucleus emerge from the brainstem and travel with the facial nerve into its vertical position in the mastoid, where they subsequently separate to run across the mid-

Correspondence: Dr AKC Leung, Alberta Children's Hospital, 1820 Richmond Road Southwest, Calgary, Alberta T2T 5C7. Telephone 403-230-3300*, fax 403-230-3322*

dle ear as the chorda tympani nerve (5). After exiting from the middle ear, the chorda tympani nerve joins the lingual nerve. The preganglionic fibres then synapse in the submandibular ganglion, where postganglionic fibres leave to innervate the submandibular and sublingual glands.

Parasympathetic preganglionic fibres arising from the inferior salivatory nucleus leave the brainstem with the glossopharyngeal nerve. The fibres then leave the glossopharyngeal nerve to ascend in the middle ear as the Jacobson nerve (5). The fibres then join sympathetic nerves from the carotid system to form the tympanic plexus. The fibres of the plexus leave the middle ear as the lesser superficial petrosal nerve and synapse in the otic ganglion. Postganglionic fibres then follow the auriculotemporal nerve to the parotid glands.

The salivary glands are also innervated by the sympathetic nervous system. Sympathetic fibres arise in the upper thoracic segments of the spinal cord and synapse in the superior cervical ganglion. Postganglionic fibres leave the superior cervical ganglion, and innervate the acini, ducts and blood vessels. Thus, the sympathetic nervous system can influence the blood flow to the salivary glands and activate myoepithelial cells with resulting expulsion of saliva from the glands.

ETIOLOGY

The causes of drooling are listed in Table 1. Drooling may result from the hypersecretion of saliva or, more commonly, impairment of swallowing.

Developmental causes: A mild degree of drooling is normal during infancy. The problem seems to be more prominent around five to six months of age when salivation increases to its full capacity. Drooling occurs because of the infant's limited ability to swallow, the lack of front teeth to serve as a dam and the adaptation of the infant's mouth in the opening position. Drooling normally disappears by two years of age as a consequence of physiological maturity of oral motor function.

Physiological causes: Drooling is a common sign of teething (6). The salivary reflex is stimulated by eruptions of teeth with resulting hypersecretion of saliva.

Hypersecretion of saliva occurs with nausea presumably due to reflexes originating in the stomach and intestines. The salivatory nuclei are excited by both taste and tactile stimuli from the tongue and other areas of the mouth. Ingestion of certain foods, particularly sour or spicy ones, may increase salivary flow. Salivation can also be stimulated by impulses arriving in the salivatory nuclei from higher centres of the brain. As such, marked salivation may occur when a person smells or eats his or her favourite foods.

Hypersecretion of saliva may also occur with pleasurable sensation or anticipated pain, presumably through activation of higher centres.

Central nervous system and muscular disorders: Drooling is a common occurrence in children with central nervous system and muscular disorders, such as cerebral palsy, facial nerve palsy, myasthenia gravis and polymyositis. It has been estimated that 25% to 35% of children with cerebral palsy drool to varying degrees and 10% of these children have embarrassing drooling (7,8). A significant number of these patients have dysfunction in the oral and pharyngeal phases of swallowing, insufficient sensory appreciation of external salivary loss, or a structural or functional inability to close the lips during the oral phase of swallowing (4,9). Dysfunction in the oral and pharyngeal phases of swallowing may be secondary to uncoordinated tongue movements, high tonus and spastic contraction of the pharyngoesophageal sphincter, dyscoordination between the pharynx and sphincter, and a lack of coordinated control of head and neck musculature (4,10).

TABLE 1: Causes of drooling

- Developmental
- Physiological
  - Teething
  - Nausea
  - Foods
  - Emotional stimuli
- Central nervous system and muscular disorders
- Mental retardation
- Oropharyngeal lesions
- Esophageal lesions
- Gastroesophageal reflux
- Drugs and chemicals
- Familial dysautonomia (Riley-Day syndrome)
- Wilson disease
- Rett syndrome

Mental retardation: Drooling occurs in approximately 10% of children with mental retardation (8). Drooling may be secondary to a delay in the development of coordinated swallowing movement, inefficient and infrequent swallowing, lack of awareness of oral incompetence, and incomplete lip closure during swallowing (1,11). Many droolers have an infantile tongue thrust, which may cause problems with eating and swallowing (12).

Oropharyngeal lesions: Acute infections involving the mouth or throat such as gingivostomatitis from herpes simplex virus or coxsackievirus may cause hypersecretion of saliva. Other oropharyngeal lesions may cause drooling because of pain or difficulty in swallowing. These include severe tonsillitis, peritonsillar or retropharyngeal abscess, epiglottitis and damage to the oral or pharyngeal mucosa from caustic ingestion or direct trauma (13).

Esophageal lesions: Drooling may result from esophageal obstruction such as may occur with esophageal stricture or a foreign body in the esophagus (14). Drooling may also result from the ingestion of caustics or corrosive acids with injury to the esophagus (15).

Gastroesophageal reflux: Episodic hypersalivation and

drooling may result from gastroesophageal reflux. It is believed that stimulation of the esophagus by gastric acids excites an esophagosalivary reflex (16).

Drugs and chemicals: Drugs that may cause hypersalivation include morphine, pilocarpine, methacholine, haloperidol and clozapine (17). Drooling secondary to the use of benzodiazepines such as nitrazepam can be explained by drug-induced cricopharyngeal incoordination with impaired swallowing (18).

Hypersalivation is a prominent feature of poisoning with mercury, selenium and organophosphate compounds (3). Drooling may also result from cocaine or phencyclidine intoxication (19). In the neonatal period, drooling may be a sign of withdrawal from maternal substance abuse.

Familial dysautonomia (Riley-Day syndrome): Drooling is common in children with familial dysautonomia (Riley-Day syndrome). Drooling in familial dysautonomia is often due to difficulty in swallowing. Mass et al (20) studied 13 children with familial dysautonomia and found an increase in basal secretion of major salivary glands in children with familial dysautonomia. The authors postulated that denervation supersensitivity of partially denervated salivary glands could play a role in the hyperfunctioning of salivary glands in familial dysautonomia (20).

Wilson disease: Wilson disease (hepatolenticular degeneration) can present with a variety of symptoms and signs. The most frequent ones are, in order of frequency, jaundice, dysarthria, clumsiness, tremor, drooling, gait disturbance, malaise and arthralgia (21). Drooling in Wilson disease can be ascribed to dysfunction in the oral and pharyngeal phases of swallowing.

Rett syndrome: Rett syndrome is a progressive neurological disorder estimated to affect 1:10,000 to 1:15,000 of live females. Drooling is common in children with Rett syndrome. Drooling can be accounted for by hypersalivation as well as a difficulty with swallowing saliva (22).

CLINICAL EVALUATION

A thorough history and physical examination are important in the evaluation of children with drooling.

History – *Age of onset:* Drooling in the neonatal period should alert the physician to the possibility of esophageal atresia or withdrawal from maternal substance abuse. A mild degree of drooling is normal during infancy.

Chronicity: An acute onset suggests an infection or drug intoxication. Drooling of long duration may be developmental or secondary to a structural lesion, neuromuscular disorder or mental retardation.

Severity: Severe drooling can lead to social embarrassment. The severity can be gauged by the frequency of bathing, wiping and need for bibs or clothing changes.

Precipitating factors: Any precipitating factors such as ingestion of food and teething should be noted.

Associated symptoms: Fever, agitation, aphonia, dyspnea and stridor suggest epiglottitis. Fever, sore throat and dysphagia suggest peritonsillar abscess. A history of choking, gagging, coughing, vomiting and dyspnea suggests a foreign body in the esophagus. A history of regurgitations, especially since the neonatal period, is suggestive of gastroesophageal reflux (23). Lacrimation, sweating, headache, dizziness and cramps suggest intoxication with organophosphates. Feeding difficulties, excessive sweating, syncope, insensitivity to pain, slurred speech and seizures are features of familial dysautonomia. Developmental stagnation, altered communicative ability, loss of active play interaction, social withdrawal, stereotypic movements, periodic apnea, intermittent hyperventilation, constipation, weight loss, apparent insensitivity to pain, digit sucking or biting, and night-time laughing suggest Rett syndrome (22).

Developmental history: A thorough developmental history is of extreme importance. Generalized delay in all aspects of developmental milestones suggests mental retardation.

Drug use: A detailed drug history is important because the use of medication such as haloperidol, pilocarpine and diazepines may lead to drooling.

Psychosocial history: Any psychosocial or emotional stress should be noted as a potential cause of the drooling. In addition, the impact of drooling on the child and family should be noted.

Perinatal history: The perinatal history should include maternal illness during the pregnancy, gestational age at birth, birth weight, perinatal trauma, asphyxia and infections.

Past history: Significant illnesses such as cerebral palsy, facial nerve palsy, myasthenia gravis and gastroesophageal reflux should be noted.

Family history: A family history of Wilson disease, Rett syndrome or familial dysautonomia suggests the corresponding disorder.

Physical examination – *General:* Weight, height and head circumference should be plotted on standard growth charts. Poor growth may indicate a chronic disorder such as Rett syndrome or intrauterine growth retardation. Vital signs such as temperature, respiratory rate, heart rate and blood pressure should be noted. If the patient has a fever, the fever may indicate an underlying infection. Intermittent hyperventilation suggests Rett syndrome. Postural hypotension is suggestive of familial dysautonomia. The patient's clothes should be inspected for wetness or staining. Particular attention should be paid to tongue control, ulcers in the oral cavity and evidence of dental problems. A comprehensive developmental assessment should be done if mental retardation is suspected (24).

Associated signs: Dysmorphic features may suggest certain syndromes associated with mental retardation (24). Fever, trismus, a swollen and inflamed tonsillar area, and deviation of the uvula to the opposite side suggest peritonsillar abscess. Toxicity, fever, respiratory distress with inspiratory stridor, flaring of the alae nasi and inspiratory retractions of the suprasternal notch suggest epiglottitis. Spasticity, hyperreflexia, ankle clonus, extensor plantar

response, dysarthria, athetosis, ataxia and contractures suggest cerebral palsy. Inability to close the eye and drooling at the corner of the mouth point to facial nerve palsy. Jaundice, dysarthria, clumsiness, tremor, gait disturbances and the presence of Kayser-Fleischer rings point to Wilson disease (21).

DIAGNOSTIC STUDIES

Laboratory tests are usually not necessary in the majority of children with drooling; tests should be ordered only when indicated by a history or physical examination. A complete blood count is useful if an infection is suspected. Anteroposterior radiographs of the neck using a soft tissue technique are very useful for localizing a radioopaque foreign body, detecting increased thickness of the prevertebral soft tissue and confirming or ruling out a swollen epiglottis. An upper gastrointestinal series may be considered to rule out the possibility of esophageal stricture or gastroesophageal reflux (23).

The Denver Developmental Screening Test should be performed if mental retardation is suspected (24). Those children who are found to be abnormal by a screening test require more definitive testing with one of the standardized and validated tests of intelligence. The most widely used intelligence tests to assess the intellectual and adaptive functioning of a child are the Standford-Binet Intelligence Scale, the Bayley Scales of Infant Development, the Wechsler Intelligence Scale for Children-Revised, and the Wechsler Preschool and Primary Scale of Intelligence (24).

A method for quantitative measurement of drooling using radioisotopes has been described (25). The procedure consists of injecting a radioisotope into the subject, having the radioisotope excreted in the saliva and sampling the saliva periodically. From the measured radioactivity in the bibs and the salivary samples, the amount of drooled saliva can be calculated (25). The use of radioisotopes to quantify drooling is mainly of academic interest. Occasionally, it is used before surgery in some patients and may, in certain cases, provide a tool to measure the change in salivary flow following a surgical intervention.

COMPLICATIONS

Complications of drooling range from mild embarrassment and discomfort for the intellectually intact patient with minimal drooling to gross emotional and physical impairment for the severely affected individual. Drooling produces an unhygienic condition that may be associated with a disagreeable odour. Drooling patients may soil their clothes, toys and books, which may interfere with both play and school work. The frequent changes of clothing may be a burden for those involved in the care of these children.

Drooling is cosmetically unappealing and may lead to social isolation and rejection. This may have a profound psychological impact on the child.

Drooling facilitates the transmission of infection. Chronic drooling may lead to perioral maceration, and a loss of fluids and electrolytes. Rarely, it may be so severe as to cause dehydration (26). Drooling can also impair articulation (27).

MANAGEMENT

The underlying cause of drooling should be treated whenever possible. Epiglottitis should be treated with parenteral antibiotic therapy. Esophageal atresia or stricture should be corrected surgically. Drugs that may cause or aggravate drooling should be discontinued. The use of a barrier cream is recommended for children who have dermatitis resulting from drooling.

A mild degree of drooling is normal in early life. Normal children usually stop drooling by two years of age. As such, no treatment is necessary for these children. No active management is necessary for patients who have little functional or psychological impairment apart from their objectively mild or intermittent drooling (28). Likewise, no active treatment is necessary if the child's neurological status has not plateaued for at least six months. Improvement in the child's drooling may occur as the child recovers from a neurological insult (4).

Referral to a drooling clinic with a multidisciplinary team approach is often necessary for moderate to severe drooling. Because positional and oral functional problems predispose a child to drool, programs designed to improve body position and posture as well as oral motor skills may play an important role in the management of drooling. Physiotherapy may markedly reduce drooling by improving jaw stability and closure; increasing tongue mobility, strength and positioning; improving lip closure, especially during swallowing; and decreasing nasal regurgitation during swallowing (29). Physiotherapy has the best chance of success if started early. It is of limited benefit if the child is severely retarded.

Children who have only a moderate drooling problem and have normal or close to normal intelligence and high motivation may benefit from behavioural or biofeedback modification (4). Behavioural or biofeedback modification programs have used various combinations of cuing, positive reinforcement and punishment. One method involves a number of sessions during which the patient is conditioned to swallow in response to an auditory cue emitted by an electronic device (4). Parental reminding to swallow is also effective.

Oral administration of anticholinergics such as benztropine mesylate (Cogentin, Merck Sharpe & Dohme Canada, Kirkland, Quebec) and benzhexol hydrochloride (Artane, Wyeth-Ayerst Canada Inc, St-Laurent, Quebec) have been used to control the volume of salivary secretions. However, unpleasant side effects such as blurring of vision, dryness of mouth, constipation and urinary retention preclude their long term use (29). Transdermal scopolamine has been used with some success and has minimal side effects with short term use (30). Recently, glycopyrrolate (Robinul, Wyeth-Ayerst Canada Inc), a quaternary ammonium compound structurally related to atro-

pine, has been found to be very effective in the treatment of drooling (31,32). The recommended dose is 40 to 100 μg/kg per day to be given once or twice daily (32). To obtain optimal results, dosage should be adjusted to the individual patient's response. The drug is long-acting, does not cross the blood-brain barrier and has minimal side effects (31,32). It is inexpensive and can be bought over the counter. Glycopyrrolate is five to six times more potent than atropine in its antisialogogue effect (32). In one study, it reduced drooling in 36 of 38 patients (31).

Surgery should be considered for patients five years of age and older with severe drooling or patients with moderate drooling in whom a minimum of six months of conservative treatment fails to effect a significant change in the patient's drooling status (4). Various surgical approaches have been used, singly or in combination, for the control of drooling. These approaches include glandular excision, division of parasympathetic nerve supply, ductal ligation or ductal rerouting.

Glandular excision is definitely an option in the treatment of sialorrhea. Submandibular gland excision is a relatively simple procedure. Care has to be taken so as not to damage the mandibular branch of the facial nerve, the lingual nerve and the hypoglossal nerve. Excision of the submandibular gland leaves a visible scar, which is cosmetically unsightly. Parotidectomy is generally not recommended because of the risk of facial nerve injury (33).

The parasympathetic nerve supply to the submandibular gland and sublingual gland can be interrupted by sectioning of the chorda tympani nerve and that to the parotid gland by sectioning of the tympanic plexus. The procedure, which can be done via a tympanotomy approach to the middle ear, is easy to perform and has few complications. Denervation by tympanic neurectomy has a success rate of 50% to 90% (33). The long term failure rate has been estimated to be 25% to 50% (34). Regrowth of preganglionic fibres is believed to be the cause of late failures (29,35). The loss of taste to the anterior two-thirds of the tongue is insignificant when unilateral, but can be quite upsetting to the patient when bilateral. Because of the otological risks, the procedure is contraindicated in patients with unilateral sensorineural hearing loss (29). The procedure is best avoided in children with secretory otitis media (29).

Surgical ligation of the salivary ducts is easy to perform, and the results are immediate. However, postoperative facial swelling and pain may occur, particularly when the patient is eating. Other complications include recurrent infection in the affected glands, xerostomia and fistula formation (27,36).

Rerouting of the salivary ducts to the tonsillar fossa is easy to perform, and is the surgical treatment of choice (33). The procedure allows the affected individual to bypass the oral phase of swallowing and permits automatic pharyngeal swallowing (28,36). The sense of taste and the amount of saliva produced are not affected (29). Bilateral submandibular duct transposition has a high success rate with low morbidity (29). It leaves no external scars. Rerouting of the parotid ducts can be performed, if necessary, as a second stage procedure (37). Complications of rerouting of salivary ducts include ranula formation and stenosis of the transposed duct (33,35).

CONCLUSION

Drooling has many causes. Because it can be uncomfortable, embarrassing and even lead to physical skin damage, and rarely dehydration, the problem should be addressed by the paediatrician. Initially, treatment should include the use of a barrier cream and biofeedback or behavioural modification techniques. Glycopyrrolate and anticholinergic medications may be tried, and, in rare cases, surgery has been effective but does have occasional unpleasant complications.

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