The evaluation and management of velopharyngeal dysfunction

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The velopharynx is a dynamic anatomic structure essential to normal breathing, eating, and speaking. Although a dysfunctional velopharynx impairs separation of the nasal and oral cavities during swallowing and specific oral consonant articulations, the upper airway is only impaired iatrogenically, from interventions to remedy velopharyngeal dysfunction (VPD). The challenge for the health care professionals who evaluate and manage VPD, therefore, is to improve functional naso-oral separation without compromising the upper airway. This article addresses that challenge.

Velopharyngeal anatomy and function

The velopharynx is a space that, at rest, is roughly rectangular: the anterior border is the velum (soft palate), the posterior border is the posterior pharyngeal wall, and the lateral borders are the right and left lateral pharyngeal walls. The tissues that enclose this space contain muscles that are capable of diminishing the space with contraction. These active tissues comprise the velopharyngeal sphincter. The usual movements of the borders of the velopharynx are as follows: an unimpaired velum moves posteriorly and superiorly, the posterior pharyngeal wall can move ventrally diffusely or as a well-defined shelf (known as Passavant’s ridge), and the lateral pharyngeal walls move mesially (toward the midsagittal midline). The adenoids, residing on the posterior pharyngeal wall, and the pharyngeal tonsils, on the lateral pharyngeal walls, may augment or interfere with the function of those walls in velopharyngeal closure. The composite of the movements of the structures bordering the velopharyngeal space closes the velopharyngeal port for eating (to prevent nasal regurgitation) and speaking (to produce oral consonants), whereas the relaxation of the closure musculature opens the port for breathing and specific nasalized articulations. The failure of the velopharyngeal sphincter to perform these functions properly is dysfunction of the sphincter. (There is a lack of consensus on the preferred term to describe such dysfunction. Velopharyngeal incompetency, velopharyngeal insufficiency, and velopharyngeal inadequacy are frequently used terms. The current author, however, prefers the term velopharyngeal dysfunction (VPD), because it connotes physiologic impairment without attempting to denote etiology) [1–3].

A brief history of velopharyngeal dysfunction management

An interest in the evaluation and management of VPD seems to have arisen following development of surgical techniques for repair of cleft palate in the 19th century. Contrary to initial expectations, successful palatoplasty (meaning closure of the palatal cleft without dehiscence or fistula) did not necessarily result in intelligible speech. For the past 150 years, surgeons have modified palatoplasty techniques in two major directions: to increase the length of the palate (“pushback” and Z-plasty) or to improve...
palatal muscle function (intravelar veloplasty and Z-plasty). Although the literature documents a diminution of the frequency of VPD following palatoplasty over the past 50 years, the factor or factors responsible for the improved functional outcome are uncertain. Synchronous with alterations in surgical technique have been the following changes: performance of palatoplasty at earlier ages (<18 mo); the development of cleft speech–specific proactive and remedial speech/language therapy programs; the acceptance of interdisciplinary team care for individuals with clefts; the increasing centralization of cleft care, with a small number of providers managing a large number of patients; and improved diagnostic capabilities, which reduce the number of patients getting inappropriate treatment. The evaluation and management of individuals with VPD remains a significant component of cleft team care because no technique of palatoplasty yields 100% normal velopharyngeal function and there are some individuals with VPD who do not have a cleft palate.

**Velopharyngeal management algorithm 1 (Fig. 1)**

*Patients with possible velopharyngeal dysfunction*

Impaired velopharyngeal function usually is perceived by family members of the affected individual and strangers because it produces “different” speech, often impairing intelligibility, and, at times, unusual facial movements (facial grimacing). Although nasal regurgitation during eating may occur from VPD, it is uncommon. The perception, therefore, of the symptoms and signs of VPD does not require a sophisticated observer. The differentiation of the causes of VPD, the documentation of the magnitude of VPD, and the selection of a therapeutic regime for management of VPD, however, do require much sophistication.

The evaluation begins with a perceptual speech evaluation performed by a speech/language pathologist with specific expertise in velopharyngeal function [4]. (Although it is appropriate for non-speech/language professionals on the cleft team to also assess speech, the definitive comment on and description of speech should be done by the speech/language professional.) “Perceptual” means that the examiner uses his or her auditory and visual input to evaluate the subject’s verbal communication. The perceptual sampling should include spontaneous speech and a provocative sample, designed to emphasize those phonemes that require velopharyngeal function in increasing complexity [5–7]. The fundamental question to be answered by the speech/language pathologist is whether the patient has sufficient articulatory integrity to allow reliable instrumental assessment of the velopharyngeal sphincter (fluoroscopic or endoscopic). Although there is some disagreement within the speech/language community, most speech/language pathologists agree that instrumental assessment of the velopharynx is unreliable without proper articulatory effort for at least some of the oral consonants. Therefore, if the patient lacks at least some correctly articulated oral consonants, he or she is referred to speech therapy to acquire those articulations correctly. Further velopharyngeal evaluation is deferred until that goal is achieved.

**Velopharyngeal management algorithm 2 (Fig. 2)**

*Patients with correct articulation of at least some velopharyngeal closure phonemes*

After the patient has at least some correct articulations for velopharyngeal closure phonemes, the perceptual speech evaluation is completed. If the patient has pervasive signs and symptoms of VPD (eg, hypernasality, nasal turbulence, facial grimacing), he or she is referred for instrumental velopharyngeal functional assessment [8]. If the patient does not have any signs or symptoms of VPD, he or she is referred for speech therapy to address any non-VPD issues. If the patient has intermittent signs and symptoms of VPD, a decision is made between continuing additional speech therapy focused on resonance or referral for instrumental velopharyngeal functional assessment. This decision is made depending on the cooperation of the child, the quality of the speech services available, the accessibility of speech services,
and the magnitude of the psychosocial sequelae of the VPD. An immature child who regularly receives appropriate speech services will usually be returned to speech therapy, with deferral of the instrumental velopharyngeal functional assessment. A mature child, one whose speech services are suboptimal in both quality and regularity or one who is having major psychosocial issues because of the VPD, is more likely to be referred directly for instrumental velopharyngeal functional assessment.

**Velopharyngeal management algorithm 3 (Fig. 3)**

*Patients with intermittent perceptual velopharyngeal dysfunction referred for additional speech therapy*

Patients who have intermittent signs and symptoms of VPD and who are recommended to continue speech therapy focused on velopharyngeal function will either have resolution or persistence of the VPD. With resolution, no further VPD management is indicated. If the VPD persists despite appropriate speech therapy, the patient is referred for instrumental velopharyngeal functional assessment.

**Velopharyngeal management algorithm 4 (Fig. 4)**

*Patients at risk for velopharyngeal dysfunction but who do not have velopharyngeal dysfunction*

Patients at risk for VPD, who either never developed VPD or have had a successful response to speech therapy, should continue to be monitored for velopharyngeal function longitudinally, at least through the age of adenoid involution, to be certain that VPD does not recur. If signs and/or symptoms of VPD develop, a perceptual and, if indicated, instrumental velopharyngeal evaluation should be performed followed by treatment as required.

**Velopharyngeal management algorithm 5 (Fig. 5)**

*Patients with pervasive or intermittent perceptual velopharyngeal dysfunction*

For an instrumental evaluation of velopharyngeal function to be accurate, patients must have at least some intact oral consonant articulations (see previously) and be able to cooperate with the examination. In addition, the examiner must be familiar with a structured speech sample to maximally stimulate the velopharyngeal mechanism for its full range of function. If the patient is too immature to tolerate the
instrumental examination, speech therapy focused on articulation of velopharyngeal closure phonemes and oronasal resonance should be continued until the child is capable of being instrumentally evaluated.

**Velopharyngeal management algorithm 6 (Fig. 6)**

*Instrumental evaluation of the velopharynx*

Although auditory perceptual speech evaluation can separate the results of normal from abnormal velopharyngeal function, it can neither identify the cause of nor quantify the dysfunction; instrumental velopharyngeal evaluations, therefore, are used for this purpose. The identification of the cause of VPD is based on observation of velopharyngeal function during standardized speech tasks. The observation may use visible light by means of an endoscope or radiographic shadows by means of fluoroscopy [9]. Each of these visualizations has a jargon acronym: VNE (videonasendoscopy) [10] and SVF (speech videofluoroscopy) [11]. Technologies that have been used both for research and clinical applications to quantify velopharyngeal function can be divided into those that assess sound (acoustic) [12,13] and those that assess airflow (aerodynamic; Box 1) [14].

The instrumental assessment of velopharyngeal function should distinguish among three possibilities for speech tasks that normally require velopharyngeal closure: the velopharynx never closes, velopharyngeal closure is inconsistent, or the velopharynx closes consistently. If the velopharynx never closes, the patient is referred for velopharyngeal management. If velopharyngeal closure is inconsistent, the patient is referred either for additional speech therapy focused on resonance or for velopharyngeal management.

Speech therapy, which may include augmentative techniques such as biofeedback and continuous positive airway pressure, is recommended when closure occurs more often than not and the psychosocial liability of the VPD is minimal. Velopharyngeal management is recommended when closure is infrequent and the VPD significantly impairs speech intelligibility or attracts unfavorable attention. If the velopharynx closes consistently, the problem is other than VPD and the diagnostic process needs to be reassessed to make an accurate diagnosis and then choose appropriate therapy.

**Velopharyngeal management algorithm 7 (Fig. 7)**

*Patients who require management of velopharyngeal dysfunction*

After it has been decided that the patient requires velopharyngeal management other than speech therapy, a choice must be made between a speech prosthesis and surgery [15]. A subset of patients are not surgical candidates because of the following factors: unacceptable anesthetic risk, the upper airway is unstable and cannot be stabilized, the VPD is associated with a progressive or unstable neurologic condition, there is a complex speech/language disorder and it is unclear if correction of the VPD will make enough of a difference to warrant surgery, or there is parental/patient refusal to undergo surgery. These patients are referred for prosthetic management. The prosthesis is easily reversible and does not infringe on the nocturnal airway. It does, however, require patient cooperation for both fitting and use. The remaining patients who require velopharyngeal management are referred for surgery. Surgical VPD management is not easily re-
versed and creates a permanent, unphysiologic, subtotal, ideally, obstruction between the nasal and oral cavities. Other than entering the operating room, surgery does not require patient cooperation for its execution or for postoperative retention and use.

**Box 1. Secondary evaluations for VPD according to acoustic or aerodynamic assessment**

*Acoustic assessment*

- Listener judgment
- Sound spectography
- Nasometry
- Accelerometry
- Acoustic rhinometry

*Aerodynamic assessment*

- Listener judgment
- Airflow detection
- Air pressure detection
- Orifice area estimation

*Courtesy of J. Moon, PhD (Iowa City, Iowa) [38].*

**Velopharyngeal management algorithm 8 (Fig. 8)**

*Patients referred for prosthetic management of velopharyngeal dysfunction*

A velopharyngeal speech prosthesis can elevate the velum (lift), fill the residual velopharyngeal gap (obturator), or both (lift-orator). A velar lift (usually referred to as a “palatal lift”) is usually effective in patients with a long, supple velum and a normal velar length–nasopharyngeal depth ratio with myoneural dysfunction, such as is usually seen in VPD secondary to neurologic disorders [16,17]. A velopharyngeal obturator is usually necessary when the velum is short and scarred, and the velar length–nasopharyngeal depth ratio is excessive, such as may be seen in some patients with a repaired cleft palate. A combined prosthesis is useful when elevation of the velum alone is not sufficient to achieve closure. Speech prostheses are fit under endoscopic control with an interdisciplinary team that includes a prosthodontist, a speech/language pathologist, and an endoscopist [18].

**Velopharyngeal management algorithm 9 (Fig. 9)**

*Patients referred for surgical management of velopharyngeal dysfunction—upper airway assessment*

The most significant morbidity and occasionally cause of mortality associated with surgical velopharyngeal management is obstructive sleep apnea (OSA) [19]. To minimize the risk of surgically induced OSA, a careful assessment of the upper airway is done before performing velopharyngeal surgery. This assessment consists of patient history to elicit symptoms and signs of OSA, physical examination to assess quiet and active breathing and mandible and tongue size and position, and formal sleep study to clarify the presence and nature of hypopnic and apneic events and quantify their physiologic significance. If the upper airway is not stable, surgical velopharyngeal management is postponed until the...
The airway is stabilized. If the airway cannot be stabilized, prosthetic VPD management is recommended.

**Velopharyngeal management algorithm 10**

(Fig. 10)

Patients referred for surgical management of velopharyngeal dysfunction—tonsils and adenoids

The status of the tonsils and adenoids must be considered before surgical velopharyngeal management is undertaken, because these tissues can interfere with velopharyngeal closure, velopharyngeal surgery itself, or the postoperative result [20]. If the tonsils or adenoids are hypertrophic, they are removed before a definite decision regarding the choice of surgical velopharyngeal management. Occasionally, removal of large, obstructive tonsils that are herniated into the velopharyngeal port can cure the VPD. The surgeon who performs the surgery, usually an otolaryngologist who may or may not be a member of the cleft interdisciplinary team, should be informed of the need to preserve the tonsillar pillars so that a sphincter pharyngoplasty can be performed if indicated by the velopharyngeal closure pattern. Unlike the “partial” adenoidec- tomy, which often is performed to facilitate eustachian tube patency in patients with concerns about velopharyngeal competence, a complete adenoidec- tomy is performed for the patient known to require surgical velopharyngeal management because the major cause of failure in sphincter pharyngoplasty is inserting the flaps too low on the posterior pharyngeal wall. The presence of friable, hemorrhagic adenoid tissue compromises adequately cephalic insertion of the sphincter pharyngoplasty’s myomucosal flaps. In addition, with either sphincter pharyngoplasty or pharyngeal flap, residual adenoid tissue can hypertrophy cephalad to the surgically narrowed velopharyngeal port or ports and cause obstruction of the nasal airway. This obstruction can range from a minor nuisance to life-threatening OSA. Removal of such lymphoid tissue following sphincter pharyngoplasty or pharyngeal flap becomes a surgical challenge.

When tonsillectomy and adenoidec- tomy are performed in preparation for velopharyngeal management, the instrumental velopharyngeal assessment is repeated 3 months following the surgery. This procedure is necessary because some patients will change their pattern of velopharyngeal closure, which, in turn, will affect the choice of surgical technique (see following section).

**Velopharyngeal management algorithm 11**

(Fig. 11)

Determination of velopharyngeal management

Closure of the velopharyngeal sphincter proceeds from maximum to minimum opening in several geometric patterns that were initially described by means of fluoroscopic visualization of the dynamic velopharyngeal space and reiterated with nasendoscopy [21]. Although most individuals have one pattern of closure, some patients with VPD exhibit several patterns that may be phoneme specific. It is not uncommon for the pattern of closure to change following surgical removal of the tonsil and adenoids or velopharyngeal surgery (sphincter pharyngoplasty or pharyngeal flap). These patterns are used to determine the VPD management. Archival audiovisual record-
ing, originally on tape and now digital, of the instrumental evaluations is essential to preclude ambiguity about interpretation, to communicate effectively with the patient/parent, and for outcome assessment. In addition, a standard method of written description and documentation of the nasendoscopic and fluoroscopic examinations is necessary: the current author uses a modification of the recommendations of the Multidisciplinary Task Force on Velopharyngeal Reporting [22].

Differential management based on differential diagnosis of VPD has become a popular concept. The pairings of residual velopharyngeal gap size and shape advocated here are the current author’s preference [23–26], based on 25 years of experience with annual intramural outcome assessment and less frequent peer-reviewed publications; others may prefer different pairings. To date, the literature has lacked rigorous comparative studies of such pairings to determine if one set is better or worse than another [27–30].

When the residual velopharyngeal gap, with maximum effort on properly articulated phonemes that require velopharyngeal closure, is small and central, the status of the musculus uvulus is assessed [31]. If there is an elevated bulge in the midline of the nasal surface of the velum, the muscle is assumed to be intact and functional. In this case, a moderately wide, lined, superiorly based pharyngeal flap is performed to optimize on the active pharyngeal lateral wall motion and minimize the obstruction of the airway. If the musculus uvulus bulge is not present, a “radical” intravelar veloplasty, as advocated by Sommerlad et al [32], is performed. Some surgeons perform a Furlow “double Z-plasty” [33,34] for this condition, but the current author has no experience with this procedure.

When the residual velopharyngeal gap, with maximum effort on properly articulated phonemes that require velopharyngeal closure, is moderately sized and central or oriented sagittally, a moderately wide, lined, superiorly based pharyngeal flap is performed to optimize on the active pharyngeal lateral wall motion and minimize the obstruction of the airway.

When the residual velopharyngeal gap, with maximum effort on properly articulated phonemes that require velopharyngeal closure, is a large central gap or a coronally oriented gap with (“bow tie”) or without midline contact to the posterior pharyngeal wall, or the velopharynx is adynamic, a sphincter pharyngoplasty is performed [35]. The current author ceased performing wide obstructive pharyngeal flaps in 1989, when he began performing sphincter pharyngoplasty, because of their morbidity for the airway. Contrary to the expectation and experience of some, the current author and others have found sphincter pharyngoplasty to be an effective means of managing the paretic velopharynx (the so-called “black hole”) [36,37]. The reason for this discrepancy in outcome may reflect the difficulty of standardizing a particular operation among geographically separated surgeons.

**Velopharyngeal management algorithm 12**

*Fig. 12*

**Determination of velopharyngeal management**

Patients who have undergone surgical velopharyngeal management should have both short- and long-term follow-up of velopharyngeal function. This follow-up can be done within the context of the cleft multidisciplinary team or through isolated standard-
ized velopharyngeal evaluations. These evaluations should include speech, swallowing, and breathing assessments. Successful velopharyngeal management connotes normal nasal resonance for speech, absence of nasal regurgitation on eating, the ability to chew and swallow with one’s mouth closed while breathing through the nose, and free egress of nasal secretions into the oropharynx without OSA. Although, with currently available operations, some patients require symptomatic obstruction of the nasopharynx to achieve satisfactory resolution of hypernasal interference, this does not mean that surgeons and other cleft care professionals should be complacent about the morbidity and potential mortality of such interference. A patient with intranasal retention of secretions, the inability to eat, the inability to breathe through the nose, and, especially, OSA can soon forget the benefit to speech from the operation and become crippled by the secondary morbidity.

Summary

Several interventions are available for management of VPD. Using an approach of differential management based on differential diagnosis, VPD can be effectively treated in most patients. The current challenge for the VPD care team, however, is to resolve the signs and symptoms of VPD without exchanging them for a different but an equally, or more morbid set of signs and symptoms.

References