Resonance Disorders and Velopharyngeal Dysfunction: Assessment and Intervention Strategies for School-Based SLPs

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Normal Velopharyngeal Function

Voice and Resonance

- Sound begins with vocal fold vibration
- Sound energy travels in a superior direction through the pharynx
- Resonance results from sound vibrations in the cavities of the vocal tract (pharynx, oral cavity, and nasal cavity)
- The quality of resonance is determined by the size and shape of the resonating cavities, and the function of the velopharyngeal valve.

Velopharyngeal Valve

- Closes off nasal cavity from oral cavity during speech
- Closes for oral sounds, opens for nasal sounds
- Particularly important for pressure-sensitive sounds (plosives, fricatives, affricates)
- Also closes off the nasal cavity from the oral cavity during swallowing, vomiting, blowing, sucking and whistling

Structures Active in Velopharyngeal Closure (See Figure 1 and Figure 2)

- **Velum (soft palate) -** The velum moves in a superior and posterior direction and has a type of "knee action" as it bends. It moves to contact the posterior pharyngeal wall or lateral pharyngeal walls during closure.
- **Lateral Pharyngeal Walls (LPWs) -** The lateral pharyngeal walls move medially to close against the velum or just behind the velum.
- **Posterior Pharyngeal Walls (PPW)** – The posterior pharyngeal wall moves anteriorly toward the velum. In some speakers, there is a muscular contraction on the posterior wall during phonation. This results in a bulge, called a Passavant's ridge. It is usually below the area of velopharyngeal closure so it may not contribute to closure.

Variations in VP Closure

- **Non-Pneumatic Closure** - swallowing, gagging, and vomiting
  Closure is high in the nasopharynx and is exaggerated.
- **Pneumatic Closure** - sucking, whistling, blowing, speech
  Closure may be complete for non-pneumatic activities, but may be insufficient for speech and other pneumatic activities.

Patterns of VP Closure among Normal Speakers

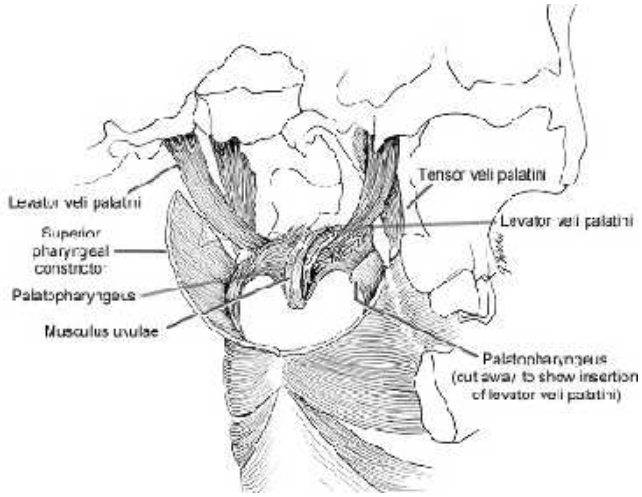
The relative contribution of the velum, LPWs and PPW varies from person to person, as a result of different basic patterns of closure. These basic patterns are as follows:

- **Coronal Pattern** – Closure occurs with movement of the velum and PPWs. There is little contribution of the LPWs.

- **Sagittal Pattern** – Closure occurs with medial movement of the LPWs. There is little contribution of the velum or PPW.
- **Circular Pattern –** All structures contribute to closure, which occurs in a "purse string" or sphincter-type pattern. Often includes a Passavant's ridge.

Velopharyngeal Muscles

- **Levator Veli Palatini** – acts as a sling to pull the velum up and back toward the posterior pharyngeal wall.
- **Tensor Veli Palatini** – opens the Eustachian tube during swallowing.
- **Musculus Uvulae** – forms the velar eminence on the nasal surface of the velum, adding bulk in the midline to assist with closure.
- **Superior Constrictor** – constricts the pharyngeal walls against the velum.
- **Palatopharyngeus** - narrows the pharynx .by pulling the lateral pharyngeal walls upward and medially.
- **Palatoglossus** – brings the velum down for nasal consonants.



Motor Nerves of Velum

- Glossopharyngeal (IX)
- Vagus (X)
- Accessory (XI)
- Trigeminal (V)
- Facial (VII)

Sensory Nerves of Velum

- Vagus (X)
- Glossopharyngeal (IX)

Velopharyngeal Dysfunction

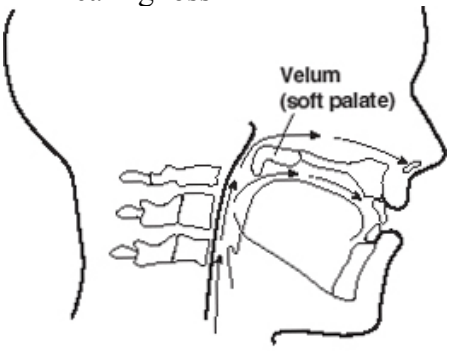
Velopharyngeal dysfunction (VPD) can be caused by a history of cleft palate, or by other factors. There are several types of VPD, based on the underlying cause. These are as follows:

Velopharyngeal Insufficiency (VPI) (See Figure 3)
Caused by anatomical defects, such as the following:
- History of cleft palate or submucous cleft (overt or occult)
- Short velum or deep pharynx (cranial base anomalies)
- Irregular adenoids
- Enlarged tonsils

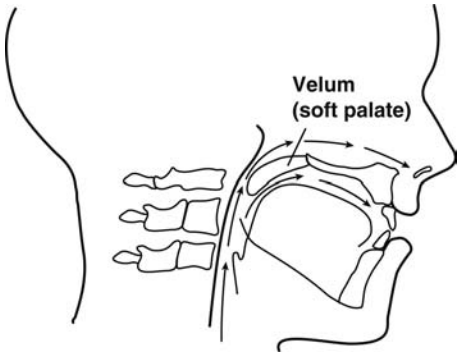
Following surgery or treatment:
- Adenoidectomy
- Maxillary advancement (Le Fort or distraction)
- Treatment of nasopharyngeal tumors (surgical or radiation)
- Cervical spine surgery through the mouth

Velopharyngeal Incompetence (VPI) (See Figure 4)
Caused by physiological defects, such as the following:
- Poor muscle function due to a history of cleft or submucous cleft
- Pharyngeal hypotonia
- Velar paralysis or paresis due to brain stem or cranial nerve injury
- Neuromuscular disorder- Myasthenia gravis
- Dysarthria due to a central insult
- Apraxia due to congenital or acquired neurological causes

Velopharyngeal Mislearning
- Abnormal posterior or nasal articulation of certain sounds, particularly sibilants; can cause phoneme-specific nasal air emission (PSNAE)
- Conversion disorder
- Hearing loss



Velopharyngeal Insufficiency



Velopharyngeal Incompetence

Velopharyngeal Dysfunction and Upper Airway Obstruction: Effects on Speech and Resonance

Hypernasality

- Occurs when there is too much sound resonating in the nasal cavity during speech
- Is particularly perceptible on vowels, since these sounds are voiced and relatively long in duration
- Can also affect the production of voiced oral consonants
- Severity depends on the size of the opening, the etiology, and even articulation.

Hyponasality

- Occurs when there is not enough resonance in the nasal cavity due to upper airway obstruction (nasal congestion, enlarged adenoids, deviated septum, stenotic nares, nasal polyps or maxillary retrusion).
- Particularly noticeable on nasal consonants and on vowels
- Intermittent hyponasality can be due to timing errors in lowering the velum for the production of nasal sounds
- Denasality refers to the total lack of nasal resonance

Cul de Sac Resonance

- Occurs when the sound resonates in the pharynx or nasal cavity, but it is not released due to obstruction
- Has a muffled quality and has been called “potato-in-the-mouth speech”
- Causes include enlarged tonsils, velopharyngeal dysfunction with nasal obstruction, and other causes of blockage in the cavities of the vocal tract

Mixed Nasality

- Occurs when there is a mix of hypernasality or nasal air emission on oral consonants and hyponasality on nasal consonants
- Cause includes any form of nasopharyngeal obstruction (such as enlarged adenoids) and velopharyngeal dysfunction, or apraxia

Nasal Air Emission

- Occurs when there is audible emission of the air stream through the nasal cavity during consonant production
- Occurs during the production of "pressure sensitive" sounds
- Unobstructed form- high frequency, low intensity sound. Affects oral pressure
- Obstructed form- high frequency, high intensity sound. Results in nasal rustle due to turbulence. Does not affect oral pressure.
- Nasal grimace often accompanies nasal air emission

Weak or Omitted Consonants

- Nasal air emission **r**educes intra-oral breath pressure, causing consonants to become weak in pressure or even omitted
- The greater the nasal emission, the weaker the consonants

Short Utterance Length

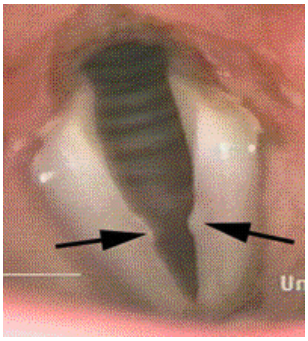
- Significant leak of air pressure results in the need to increase respiratory effort and take more frequent breaths to compensate
- More frequent breaths causes utterance length to be short

Compensatory Articulation Productions

- When there is a lack of oral pressure, patient learns to produce sounds in an alternate way by using the air pressure in the pharynx
- Manner usually maintained, but placement sacrificed (moved posteriorly)
- See section on Compensatory Errors for description of types

Dysphonia

- Characterize by hoarseness, breathiness, low intensity and/or glottal fry
- Due to the use of glottal stops as a compensatory articulation production or due to the development of vocal nodules as a result of strain in the vocal tract to achieve closure
- Breathiness may be a compensatory strategy to reduce nasal air emission or to mask the sound of the nasal air emission and hypernasality



Vocal Nodules

Compensatory and Obligatory Productions

Compensatory Productions:

Glottal Stop (Plosive)
- Produced with a forceful adduction of the vocal folds and the buildup of air pressure under the glottis
- Ventricular folds (false vocal folds) often approximate with the forceful closure of true folds
- Vocal folds are suddenly opened, releasing the air pressure to produce a grunt type sound

Pharyngeal Plosive (Stop)
- Produced when the base of the tongue moves backward to articulate against the posterior pharyngeal wall and dorsum of the tongue is concave and low in the oral cavity
- Usually substituted for velars (k, g)
- Due to difficulty in producing this phoneme, there is often a longer duration than usual between the consonant and vowel

Pharyngeal Fricative
- Produced when the tongue is retracted so that the base of the tongue approximates, but does not touch the pharyngeal wall
- Friction sound occurs as the air pressure is forced between the small opening between the base of the tongue and pharyngeal wall
- Velopharyngeal port remains open resulting in nasal air emission.

Pharyngeal Affricate
- Produced as combination of the pharyngeal plosive and pharyngeal fricative
- As with pharyngeal fricative, there is nasal emission

Velar Fricative
- Produced with the back of the tongue in the same position as for the production of a /y/ sound
- Friction occurs as air is forced through that small opening between back of tongue and velum

Posterior Nasal Fricative
- Produced with back of tongue articulating against the velum as for the production of /ng/
- Air pressure builds in the pharynx and blows the velopharyngeal valve open
- Results in a loud, friction sound which is similar to a nasal rustle due to turbulence

Nasal Sniff
- Produced by a forcible inspiration through the nose
- Usually substituted for sibilant sounds, particularly the /s/, in the final word position

Generalized Backing

- There is an attempt to valve for articulation where there is maximum air pressure, before the air pressure is lost through the velopharyngeal port
- Phonemes are produced with the back of the tongue against the velum or against the posterior pharyngeal wall

Mid Dorsum Palatal Stop (Palatal-Dorsal Production)

- Produced when the dorsum of the tongue articulates against the palate
- Can be substituted for the lingual-alveolars (t, d, n, l), velars (k, g, ng), and sibilant sounds (s, z, sh, ch, j)
- Can be caused by crowding in the oral cavity (due to a Class III malocclusion, anterior crossbite, deep bite or low palatal arch) or an attempt to compensate for a fistula

Obligatory Productions:

Nasalized Phonemes

- Usually associated with the presence of hypernasality due to a moderate to large velopharyngeal opening
- Is an obligatory error since the nasal cognate of voiced plosives is a nasal phoneme
- Placement of the phoneme is preserved, but manner is necessarily changed from oral to nasal due to the open velopharyngeal port

Weak Consonants, Short Utterance Length

- Obligatory errors due to loss of air pressure with air nasal emission

Evaluation of Velopharyngeal Dysfunction

Perceptual Assessment

Resonance:
The following speech samples can be used:
- Best assessed by evaluating connected speech (spontaneous or reading)
- Can also use prolonged vowels, particularly /ah/

Need to determine:
- Type of resonance (normal oral resonance, hypernasality, hyponasality, cul de sac resonance or mixed resonance).
- Severity (mild, moderate or severe)

Nasal Emission, Weak Consonants, Compensatory/Obligatory Errors, Etc:
The following speech samples can be used:
- Articulation test
- Repetition of pressure-sensitive phonemes (pa, pa, pa, pa, etc.)
- Repetition of sentences that are loaded with pressure-sensitive phonemes
- Counting from 60-70
- Connected speech (spontaneous or reading)

Need to determine:
- Presence and type of nasal emission (unobstructed or obstructed)
- Consistency of nasal emission and whether it is phoneme-specific
- Effect on pressure consonants and utterance length

Supplemental Methods:
- Use straw or listening tube
- Determine stimulability with change in articulation

Straw

Listening Tube

Intra-Oral Exam

- Can evaluate oral structure and function
- Cannot assess velopharyngeal function
- Say /aaaaah/, not /ahhhhh/ and have patient stick the tongue out and down as far as possible
- Look for:
  - presence of an oronasal fistula (if there is a history of cleft palate)
  - stigmata of a submucous cleft (if there is no history of cleft palate)
  - velar length and mobility during phonation
  - position of uvula during phonation (skewed indicates either enlarged tonsil or unilateral paralysis/paresis)
  - enlarged tonsils
  - dental or occlusal abnormalities
  - sign of oral-motor dysfunction (particularly if patient is syndromic)

Intra-Oral Exam
Say /aaah/, not /ah/

Instrumental Assessment

Nasometer (Kay/PENTAX, A Division of PENTAX Medical Company, 2 Bridgewater Lane, Lincoln Park, NJ 07035-1488; Tel: (973) 628-6200)

- Analyzes acoustic energy emitted through the oral cavity and nasal cavity during the production of speech
- Computes a ratio of the acoustic data acquired by the two microphones.
- Ratio is called nasalance (the acoustic correlate of perceived nasality) and is displayed as a percent, with higher percentages representing increased nasalance.
- Nasalance score can be compared to normative data

Aerodynamic Instrumentation

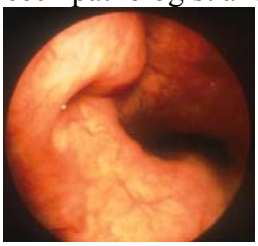
- Uses pressure transducers and flow transducers
- Can be used to measure air pressure and airflow during production of a small speech segment
- Gives an estimate velopharyngeal orifice size during speech production

Videofluoroscopy

- A multi-view, radiographic procedure which uses a lateral, anterior-posterior, base, and sometimes other views to assess velopharyngeal closure during speech
- Studies are interpreted by both a radiologist and a speech pathologist

Nasopharyngoscopy

- An endoscopic procedure that allows the examiner to view the nasal surface of the velum and the velopharyngeal port during speech
- Requires a flexible fiberoptic nasopharyngoscope and best to also have a camera, monitor and recorder
- Can be done by a physician or speech pathologist who is trained in this procedure
- Interpretation should be done by speech pathologist and the surgeon



Nasal surface of Velum. Note Eustachian tube on the left.

Treatment of Velopharyngeal Dysfunction

Surgery

Retropharyngeal augmentation
- Injection of a substance in the posterior pharyngeal wall
- Can use fat, collagen (Demalogen, Simetra) or Radiesse (hydroxyl apetit)
- Good for small, localized gaps or irregularities of the posterior pharyngeal wall

Pharyngeal flap
- Flap is elevated from the posterior pharyngeal wall and sutured into the velum to partially close the nasopharynx in midline
- Lateral ports are left on either side for nasal breathing
- Good for midline gaps or deep (AP) gaps

Sphincter Pharyngoplasty (sphincteroplasty)
- Posterior faucial pillars, including the palatopharyngeus muscles, are released and sutured together on the posterior pharyngeal wall to form a sphincter
- A posterior flap may also be raised to further narrow the port
- Good for lateral gaps (due to bowtie closure) or narrow coronal gaps

Prosthetic Devices

Palatal Obturator
- To close or occlude an open cleft or fistula

Palatal Lift
- To raise the velum when velar mobility is poor
- Used for velopharyngeal incompetence, as in dysarthria

Speech Bulb Obturator
- To occlude nasopharynx
- Can be combined with an obturator
- Used with velopharyngeal insufficiency

Limitations of Prosthetic Device:
- requires insertion and removal
- needs to be replaced periodically with kids to compensate for growth
- can be lost or damaged
- is often uncomfortable, so compliance can be a problem
- improves but doesn't correct the problem

Many centers use prosthetic devices only on a temporary basis or when surgery is not an option.

Speech Therapy- See Therapy Handout

For more information:
Kummer AW. *Cleft Palate and Craniofacial Anomalies: Effects on Speech and Resonance*. Clifton Park, NY: Thomson Delmar Learning, 2001.

Or for more handouts, go to:
http://www.cincinnatichildrens.org/svc/find-professional/k/ann-kummer.htm