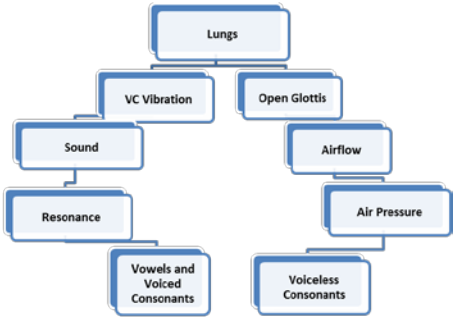
Speech & Resonance Disorders due to Velopharyngeal Dysfunction: Assessment and Intervention

Ann W. Kummer, PhD, CCC-SLP
Cincinnati Children's Hospital Medical Center

Normal Resonance

- Resonance for speech results from the modification of the sound that is generated from the vocal cords through selective enhancement of the frequencies as the sound travels through the vocal tract (See the left side of the schema below.)
- Resonance provides the *quality* of perceived sound during speech
- Resonance is determined by:
  - Size and shape of the cavities of the vocal tract
    - Shorter/smaller cavities: enhance higher formants
    - Longer/larger cavities: enhance lower formants
  - Function of the velopharyngeal valve
- Resonating cavities: pharynx, oral cavity, nasal cavity
- Resonance is affected by the following:
  - Length and volume of pharynx
  - Size and shape of oral cavity
  - Configuration of nasal cavity
- Vowels are "resonance sounds." They are produced by altering the shape of oral cavity and thus, the resonance of the voiced sound.



Schema of resonance and airflow for speech

Resonance Disorders

Hypernasality

- Occurs when there is too much sound resonating in the nasal cavity during speech
- Usually due to velopharyngeal insufficiency/incompetence or an oronasal fistula
- Is most perceptible on vowels, because these sounds are voiced, relatively long in duration, and produced by altering oral resonance
- Voiced oral consonants become nasalized (m/b, n/d, ŋ/g) which is an obligatory distortion
- Other consonants may be substituted by nasals (i.e., n/s), which is a compensatory production
- Severity depends on the size of the opening, the etiology, and even articulation

Hyponasality

- Occurs when there is not enough nasal resonance on nasal sounds (m, n, ŋ)
- Due to nasal cavity obstruction (nasal congestion, enlarged adenoids, deviated septum, stenotic nares, nasal polyps, or maxillary retrusion which restricts pharyngeal cavity space)
- Nasal phonemes sound similar to their oral cognates (b/m, d/n, g/ŋ)
- Also noted on vowels
- Intermittent hyponasality can be due to timing errors in lowering the velum for the production of nasal sounds (as in apraxia)

Cul-de-Sac Resonance

- Occurs when the sound resonates in a cavity (oral, pharyngeal, or nasal cavity), but cannot get out due to obstruction at the cavity's exit point
- Voice sounds muffled and low in volume
- Three types: oral, nasal and pharyngeal cul-de-sac resonance

Oral Cul-de-Sac Resonance

- Sound is mostly in the oral cavity
- Due to small oral cavity size or small mouth opening (microstomia)
- Parents describe speech as "mumbling" (which is not opening the mouth very much)

Nasal Cul-de-Sac Resonance

- Sound is mostly in the nasal cavity
- Due to VPI and nasal obstruction (deviated septum, stenotic nares, etc.)
- Common with cleft palate and craniofacial anomalies

Pharyngeal Cul-de-Sac Resonance

- Sound is mostly in the pharynx
- Common in patients with very large tonsils, which block sound transmission to oral cavity
- Has been called "potato-in-the-mouth" speech (enlarged tonsils are the "potatoes")

Mixed Nasality

- Occurs when there is hypernasality and/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

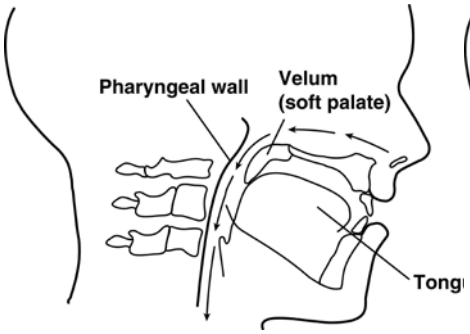
---

Speech and Resonance Disorders due to Velopharyngeal Dysfunction:
Assessment and Intervention
Ann W. Kummer, PhD, CCC-SLP

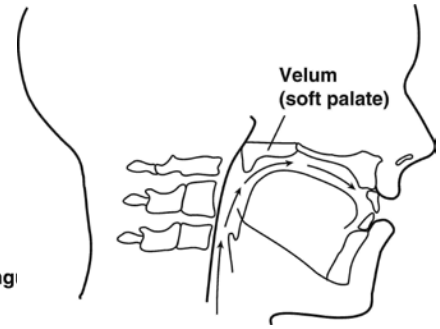
Normal Velopharyngeal Function

Structures Active in Velopharyngeal Closure

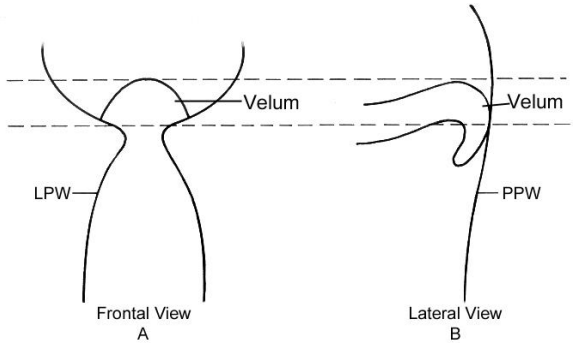
- **Velum (soft palate) -** The velum moves in a superior and posterior direction and has a type of "knee action" as it bends. It moves to contact the posterior pharyngeal wall or lateral pharyngeal walls during closure.
- **Lateral Pharyngeal Walls (LPWs) -** The lateral pharyngeal walls move medially 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, forming a Passavant's ridge. It is usually below the area of velopharyngeal closure so it may not contribute to closure.



Velum at rest



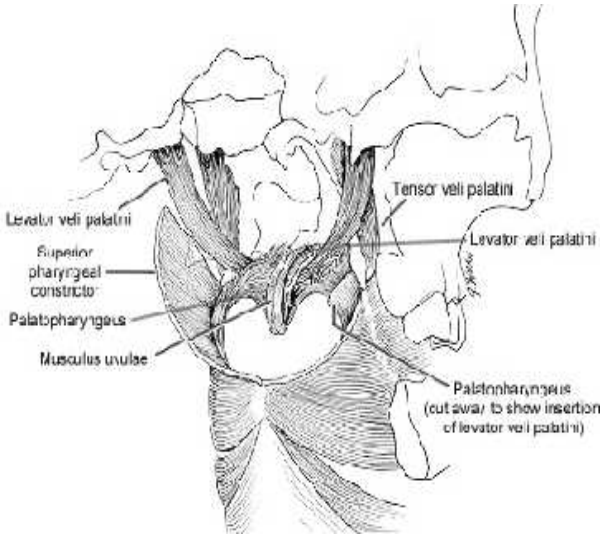
Velum during Speech



LPWs move against the velum

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.



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 PPW. 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.

Variations in VP Closure

- **Non-Pneumatic Closure** - swallowing, gagging, and vomiting
  Closure is high in the nasopharynx and is exaggerated.
- **Pneumatic Closure**
  - Positive (+) pressure: blowing, whistling, speech
  - Negative (-) pressure: sucking, kissing
- Closure may be complete for non-pneumatic activities and some pneumatic activities, but may be insufficient for speech.
- ***Blowing and sucking are not the same as speech. Therefore, don't use these for therapy!!!***

Effects of Velopharyngeal Dysfunction on Speech

Velopharyngeal dysfunction can cause any of the following general characteristics:

- Hypernasality (involves sound) (See above.)
- Nasal air emission (involves airflow) (See below.)
- Dysphonia (involves sound) (See below.)

Nasal Air Emission

- Air leaks through the valve during consonant production
- Occurs on high pressure consonants (plosives, fricatives, affricates)
- Particularly noted on *voiceless consonants,* because they are higher in pressure and do not have voicing (hypernasality) to mask the sound of nasal emission
- Occurs with or without hypernasality

- **Small VP opening:** This usually causes an inconsistent *nasal rustle,* which is also called *nasal turbulence* (although the sound is actually produced by *bubbling of secretions* as air is forced through the small opening). The distortion is loud and distracting. There is no effect on the strength of consonants or utterance length. It usually does not cause hypernasality
- **Large VP opening:** There is little impedance to the airflow, so the nasal emission may be low in intensity or even inaudible. Also, hypernasality masks the sound of nasal emission. The loss of air pressure causes:
  - **Weak or omitted consonants**: The greater the nasal air emission, the weaker the consonants will be due to loss of oral air pressure.
  - **Short utterance length**: The leak of air causes a need to increase respiratory effort and take more frequent breaths. Therefore, utterance length becomes shortened.
  - **Nasal grimace**: There is a contraction seen at side of nose or at nasal bridge as an overflow muscle reaction to effort in achieving closure.
  - **Compensatory articulation errors and obligatory distortions:** See below.

Compensatory Articulation Errors

Compensatory errors for VPI:

- **Glottal stop**: The vocal cords adduct and then open suddenly, resulting in a voiced plosive that sounds like a grunt. This can be co-articulated with oral placement.
- **Pharyngeal plosive:** The base of the tongue articulates against the posterior pharyngeal wall. This is usually substituted for velars (k, g).
- **Glottal fricative:** The air is forced through the open glottis to produce an /h/ sound.
- **Pharyngeal fricative:** The tongue is retracted so that the base of the tongue approximates the pharyngeal wall. The friction sound occurs as the air is forced through the small opening between the base of the tongue and pharyngeal wall. The air stream is released through the velopharyngeal port, resulting in nasal air emission.
- **Posterior nasal fricative:** The back of the tongue articulates against the velum (as an /ŋ/ placement). Air pressure builds in the pharynx and is released through the velopharyngeal valve. This results in a loud, bubbling-type sound, which is similar to a nasal rustle.
- **Nasal sniff:** The sound is produced by forcible inspiration through the nose. This is usually substituted for sibilant sounds, particularly the /s/, in the final word position.

Compensatory errors for an oronasal fistula:

- **Velar plosives:** The back of the tongue articulates against the velum (as in /k/ or /g/) before air is lost through the fistula. Use of velar sounds for anterior sound is also called “backing.”
- **Velar fricatives:** The back of the tongue is in the same position as for the production of a /j/ sound. Friction occurs as air is forced through the small opening between back of tongue and the velum. This is also a sound used with “backing.”

- **Palatal-dorsal production (mid dorsum palatal stop):** The mid-dorsum of the tongue articulates against the fistula in order to prevent the leak of air into the nasal cavity during production of anterior sounds.

Compensatory errors for anterior oral cavity crowding:

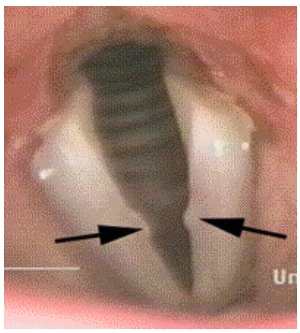
- **Palatal-dorsal production (mid dorsum palatal stop):** The dorsum of the tongue articulates against the palate because the teeth interfere with tongue tip production. This can be substituted for the lingual-alveolars (t, d, n, l) and/or sibilant sounds (/s/, /z/, / ʃ/, /ʒ/, /ʧ/, /ʤ/).

Obligatory Distortions due to VPI

- Distortion occurs due to a structural anomaly rather than abnormal articulation
- Includes hypernasality, nasal emission, nasalized plosives (i.e., m/b, n/d, ŋ/g)
- Cannot be corrected with speech therapy; requires physical management

Dysphonia

- Characterize by hoarseness, breathiness, low intensity, glottal fry and/or abnormal pitch
- Causes:
  - Vocal nodules as a result of strain in the vocal tract to achieve closure
  - Laryngeal anomalies with craniofacial syndromes
  - Compensatory strategy: Breathiness and low volume mask hypernasality and nasal emission.



Vocal Nodules

Causes of Velopharyngeal Dysfunction

There are several types of VPD, based on the underlying cause. These are as follows:

Velopharyngeal Insufficiency (VPI)
Caused by anatomical defects, such as the following:

- History of cleft palate or submucous cleft (overt or occult)
- Short velum
- Deep pharynx (cranial base anomalies)
- Irregular adenoids
- Enlarged tonsils in the pharynx

Following surgery or treatment:

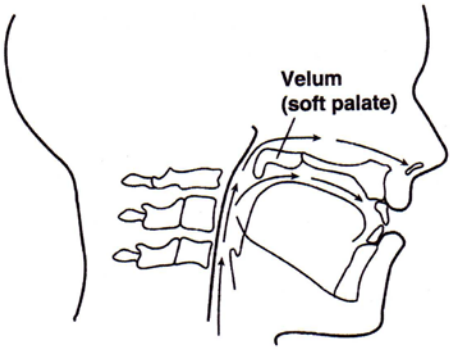
- Adenoidectomy
- Maxillary advancement (Le Fort I or distraction)
- Treatment of nasopharyngeal tumors (surgical or radiation)
- Cervical spine surgery through the mouth

Velopharyngeal Incompetence (VPI)
Caused by a neurophysiological disorder:

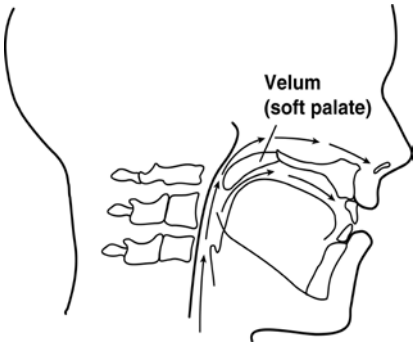
- Cranial nerve damage causing velar paralysis or paresis
- Central neurological dysfunction
- Injury (head trauma, cerebral palsy, stroke)
- Neuromuscular disorder (i.e., myasthenia gravis, muscular dystrophy, etc.)

Neurophysiological disorder may cause:

- Hypotonia
- Dysarthria due to a central insult. Primary characteristic is hypernasality.
- Apraxia due to congenital or acquired neurological causes



Velopharyngeal Insufficiency



Velopharyngeal Incompetence

Velopharyngeal Mislearning

- Hearing loss
- Secondary to VPI: Learned compensatory productions because of VPI
- Secondary to mislearning: Misarticulations that *cause* nasal emission unrelated to a VPI

Hypernasality due to Misarticulations

- High vowels can be nasalized if the back of tongue is too high. Often occurs on the vowel /i/.
- Substitution of nasal consonants for oral consonants (i.e., ŋ/l, ŋ/r) causes perception of hypernasality in connected speech.

Nasal Emission due to Misarticulation

- Due to use of pharyngeal or posterior nasal fricatives, which results in an open VP valve
- Causes *phoneme-specific nasal air emission* (PSNAE)
- Usually occurs on sibilants, particularly s/z

Recommendations for VP Mislearning

- Speech therapy (not surgery!) because this is a speech sound (articulation) disorder
- Differential diagnosis is very important!

Perceptual Evaluation of Velopharyngeal Dysfunction

Need to determine:

- Compensatory errors versus obligatory distortions
- Presence of nasal emission or nasal rustle
  - Consistent, inconsistent, or phoneme-specific
  - Effect on pressure-sensitive consonants and utterance length
- Cause of a nasal rustle
  - If due to abnormal structure, it will occur inconsistently on all pressure-sensitive phonemes and often increases with utterance length or fatigue
  - If due to misarticulation, it will occur consistently on certain sounds, most often sibilants, particularly /s/
- Effect of a fistula versus VPI: Compare the degree of nasal emission on anterior sounds (i.e., /p/and /t/) with posterior sound (/k/) in repetitive syllables; if higher on anterior sounds, the cause is the fistula
- Type of resonance (normal, hypernasal, hyponasal, cul-de-sac, mixed)

Speech and Resonance Disorders due to Velopharyngeal Dysfunction:
Assessment and Intervention
Ann W. Kummer, PhD, CCC-SLP

Speech Samples

- Single word articulation test is NOT good.
- Prolongation of sounds
  - Oral sound to test hypernasality: vowels, particularly /ɑ/ and /i/
  - Oral sounds to test nasal emission: prolonged /s/
  - Nasal sounds to test hyponasality: /m/, /n/
- Repetition of syllables
  - Use pressure-sensitive phonemes with a low vowel and then a high vowel (pɑ, pɑ, pɑ, and pi, pi, pi, etc.) to evaluate for hypernasality and/or nasal emission
  - Use nasal phonemes to evaluate for hyponasality (mɑ, mɑ, mɑ and nɑ, nɑ, nɑ, etc.)
- Counting
  - From 60-70 to evaluate for hypernasality and nasal emission
  - From 90-99 to evaluate for hyponasality
- Repetition of sentences- Example sentences:
  - p/b: Popeye plays baseball. Buy baby a bib.
  - t/d: Take Teddy to town. Do it for Daddy.
  - k/g: Give Kate the cake. Go get the wagon.
  - f/v: Fred has five fish. Drive the van.
  - s/z: I see the sun in the sky. We freeze at the zoo.
  - ʃ: She went shopping.
  - ʧ: I ride a choo choo train.
  - ʤ: John told a joke to Jim.
  - r: Run down the road. I have a red fire truck. The doctor and teacher are here.
  - l: Look at the lady. I like yellow lollipops.
  - blends: splash, sprinkle, street

Supplemental Methods:

- Use a straw or listening tube to listen for hypernasality and nasal emission during production of oral sounds
- The straw or tube amplifies the sound, just like a stethoscope
- Determine stimulability with change in articulation, particularly if nasal emission is phoneme-specific

Straw

Listening Tube

Intra-Oral Exam

- Can evaluate oral structure and function, but not velopharyngeal function because it is above the oral level
- Have the child say /æ/ (as in "hat") and stick the tongue out and down as far as possible

Look for:

- Dentition and occlusion
- Oral cavity size
- Position of the tongue tip relative to the alveolar ridge
- Presence of a fistula
- Signs of a submucous cleft
- Position of the uvula during phonation
- Size of the tonsils
- Signs of upper airway obstruction
- Signs of oral-motor dysfunction

Instrumental Assessment

Nasometer (KayPENTAX)

- Analyzes acoustic energy from the oral cavity and nasal cavities during the production of speech
- Computes an objective ***nasalance*** score (ratio of oral/total (oral + nasal) energy
- Nasalance represents perceived nasality and is displayed as a percentage, with higher percentages representing increased hypernasality/audible nasal emission.
- Nasalance score can be compared to normative data for a particular speech passage

Pressure-Flow Technique

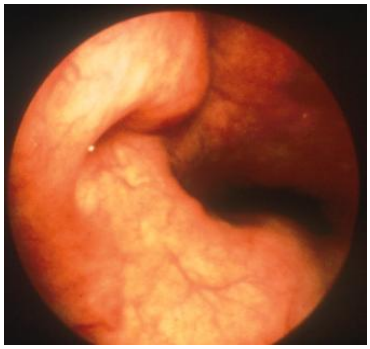
- Uses aerodynamic instrumentation (pressure transducers and flow transducers)
- Can be used to measure air pressure and airflow changes during production of a small speech segment (usually the /mp/ in the word "hamper")
- Gives an estimate velopharyngeal orifice size during speech production

Videofluoroscopy

- A multi-view, radiographic procedure which usually includes lateral, frontal and base 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 entire velopharyngeal port during speech
- Requires a flexible fiberoptic nasopharyngoscope. Best to also have a camera, monitor, and video 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 the Eustachian tube on the left (patient's right) side.

Treatment of Velopharyngeal Dysfunction

Surgery

Pharyngeal augmentation

- Injection of a substance in the posterior pharyngeal wall
- Can use fat, collagen, Radiesse (hydroxyapatite), or Deflux
- Good for small, localized gaps or irregularities of the posterior pharyngeal wall

Furlow Z plasty

- Often used as a primary palate repair but can be used as a secondary repair to slightly lengthen velum
- Appropriate for narrow, coronal gaps

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 and production of nasal sounds
- Good for midline gaps or deep (anterior-posterior) gaps

Sphincter Pharyngoplasty

- Posterior faucial pillars, including the palatopharyngeus muscles, are released at their base, brought posteriorly, and sutured together on the posterior pharyngeal wall to form a sphincter
- Good for lateral gaps (due to bowtie closure) or narrow coronal gaps

Prosthetic Devices
Used if surgery is not an option

Palatal Obturator
- To close or occlude an open cleft, palatal defect or fistula

Speech Bulb Obturator (Speech Aid)
- To occlude nasopharynx when the velum is short (velopharyngeal insufficiency)
- Can be combined with a palatal obturator

Palatal Lift
- To raise the velum when velar mobility is poor (velopharyngeal incompetence)
- Commonly used with dysarthria

Limitations of a Prosthetic Device
- Can be expensive and not covered by insurance
- Requires insertion and removal
- Has to be redone periodically due to growth
- Can be lost or damaged
- May be very uncomfortable
- Compliance is often poor
- Doesn't permanently correct the problem

Most centers use prosthetic devices only if surgery is not possible.

Speech Therapy- See handout entitled: **Speech Therapy Techniques: For Errors related to Cleft Palate or Velopharyngeal Dysfunction**

Referrals: Refer to a cleft palate or craniofacial center with ***specialists*** in the area of VPI— not to a community ENT or surgeon.

For more information:

Kummer, A.W. (2014). ***Cleft Palate and Craniofacial Anomalies: The Effects on Speech and Resonance***, 3rd Edition. Clifton Park: Cengage Learning.
http://www.cengagebrain.com/shop/en/US/storefront/US;CMGTJSESSIONID=dy19THwNZMm2X2vPr8G0TymhzHKm9zKzwtmB5QpvT0pMHyQh2vqS!158469931?cmd=CLHeaderSearch&entryPoint=storefront&messageType=CLHeaderSearch&fieldValue=kummer

Note: Print version includes access to online resources, including:
- 240 short videos of types of disorders and evaluation and treatment techniques
- Cleft Notes
- Handouts for patients/families
- PowerPoints for professors