

## Resonance Disorders & Velopharyngeal Dysfunction

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### 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.

#### 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 this for therapy!!!*
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## **Velopharyngeal Dysfunction (VPD)**

Velopharyngeal dysfunction (VPD) is a general term that does not denote causality. The specific terms are as follows:

- **Velopharyngeal Insufficiency (VPI):** VP insufficiency is a type of VPD that is due to a structural abnormality, such as cleft palate. In this case, the velum may move well, but is too short somewhere along the coronal plane to achieve closure. Causes include cleft or submucous cleft palate, deep pharynx, irregular adenoids, and some surgical procedures (e.g., adenoidectomy, maxillary advancement, or oral tumor removal).
- **Velopharyngeal Incompetence (VPI):** VP incompetence is a type of VPD that is due to a neuromotor disorder and is typically associated with dysarthria. In this case, the velum may be normal in structure, but it doesn't move well due to a neurological condition. Causes include head trauma, stroke, cerebral palsy and neurological diseases/disorders.
- **Velopharyngeal Mislearning:** VP mislearning is an articulation disorder where nasal sounds (/m, n, or ŋ/) or pharyngeal sounds are substituted for oral sounds. Causes include development of compensatory productions for VPI or an isolated articulation disorder.
  - 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 VPI (both types):** Physical management (surgery or a prosthetic device).

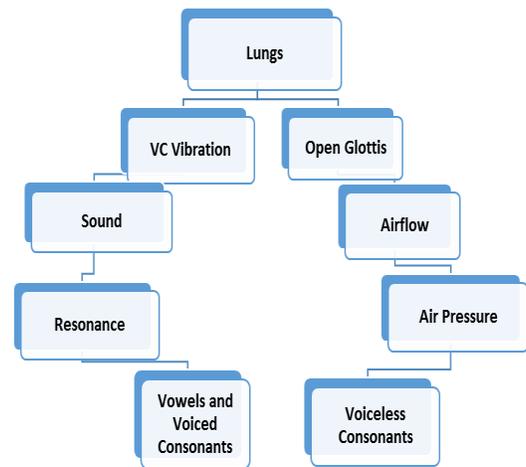
**Recommendations for velopharyngeal mislearning:** Speech therapy, preferably after surgical treatment if VPI is that is a cause.

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## Resonance and Airflow for Speech

### Resonance

- Resonance for speech results from the modification of the sound that is generated from the vocal cords through selective enhancement of the frequencies.
- Resonance provides the *quality* of perceived sound during speech.
- Resonance is important for vowels and voiced consonants.
- 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.



### Airflow

- Air from the lungs flows in a superior direction through an open glottis and then the hypopharynx.
- Velopharyngeal closure redirects the air from the oropharynx into the oral cavity.
- The articulators block and release the flow, or narrow the opening to produce plosives, fricatives and affricates.
- Abnormal airflow particularly affects voiceless consonants.

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## 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
- 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
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## **Effects of VPI on Speech**

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

## **Airflow**

- Airflow (with or without sound) is needed for pressure-sensitive consonants (plosives, fricatives and affricates).

## Nasal Air Emission

- Air leaks through the velopharyngeal valve during consonant production and can cause audible nasal emission, with or without hypernasality.
- Occurs on high pressure consonants (plosives, fricatives, affricates), and is most audible on *voiceless consonants*
- 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 occur with hypernasality
- Large VP opening: There is little impedance to the flow 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:
  - Low volume: Sound is absorbed in the pharynx and nasal cavity, causing the volume of speech to be reduced.
  - 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 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 plosives:** 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. This 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 called “backing.”

- **Palatal-dorsal production (mid dorsum palatal stop):** The 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. This can be substituted for the lingual-alveolars (t, d, n, l) and/or sibilant sounds (/s/, /z/, /ʃ/, /ʒ/, /tʃ/, /dʒ/).

### **Obligatory Distortions due to VPI**

- Distortion occurs 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

### **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.

## **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, will occur inconsistently on all pressure-sensitive phonemes. Often increases with utterance length or fatigue
  - If due to misarticulation, will occur consistently on certain sounds, most often sibilants, particularly /s/
- Effect of a fistula versus VPI: Compare the degree of nasal air emission for anterior sounds (i.e., /p/, /t/) with posterior sound (/k/) in repetitive syllables
- Type of resonance (normal, hypernasal, hyponasal, cul-de-sac, mixed)

### **Speech Samples**

- Single word articulation test is NOT good.
- Prolongation of sounds
  - Oral sound to test hypernasality: vowels, particularly /a/ 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 (pa, pa, pa, and pi, pi, pi, etc.) to evaluate for hypernasality and/or nasal emission
- Use nasal phonemes to evaluate for hyponasality (ma, ma, ma and na, na, na, etc.)
- Counting
  - From 60-70 to evaluate for hypernasality and/or nasal emission
  - From 90-99 to evaluate for hyponasality
- Repetition of sentences
  - p/b: Popeye plays baseball.
  - t/d: Take Teddy to town. Do it for Daddy.
  - k/g: Kate eats the cake. Go get the wagon.
  - f/v: Fred has five fish. Drive the van.
  - s/z: I see the sun in the sky.
  - j: She went shopping.
  - tʃ: I ride a choo choo train.
  - dʒ: John told a joke to Jim.
  - r: Run down the road. I have a red fire truck
  - l: Look at the lady.
  - blends: splash, sprinkle, street

### **Supplemental Methods:**

- Use straw or listening tube to listen for hypernasality or nasal emission during production of oral sounds
- Determine stimulability with change in articulation, particularly if nasal emission is phoneme-specific

### **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 (PENTAX Medical)**

- 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)
- Ratio is called (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 for a particular speech passage

### **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.
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For more information, see chapters entitled **Speech/Resonance Disorders and Velopharyngeal Dysfunction, Speech and Resonance Assessment, Orofacial Examination, and Overview of Instrumental Procedures** in the following text:

Kummer, A. W. (2020). *Cleft Palate and Craniofacial Conditions: A Comprehensive Guide to Clinical Management*, 4<sup>th</sup> edition. Burlington, MA: Jones & Bartlett Learning. (Available online and in print in September, 2018)