High-Flow Nasal Cannula: Impact on Dysphagia

ST Journal Club 3/31/21

High-Flow Nasal Cannula

- Delivers warm compressed air and humidification at high flow rates
- Tolerated better than face mask
- Provides precise adjustments of airflow up to 60mL/min
- FiO2 settings range from .21 to 1.0 (or 21% - 100%)
- Thought that there is at least .5-1.0 cm H2O nasopharyngeal pressure increase for every 10 LPM increase in flow

At Grant

- Have 2 varieties
  - Optiflow – "old school" – flow meter and O2 with dials
  - Airvo – newer – push buttons to set up
- Why no travel for MBS?
  - No battery back-up
  - If flow rate is >40 L/min, then only alternative is Bi-Pap or NRB mask
  - If flow rate is 30-40 L/min, pts may be able to travel on oxymizer

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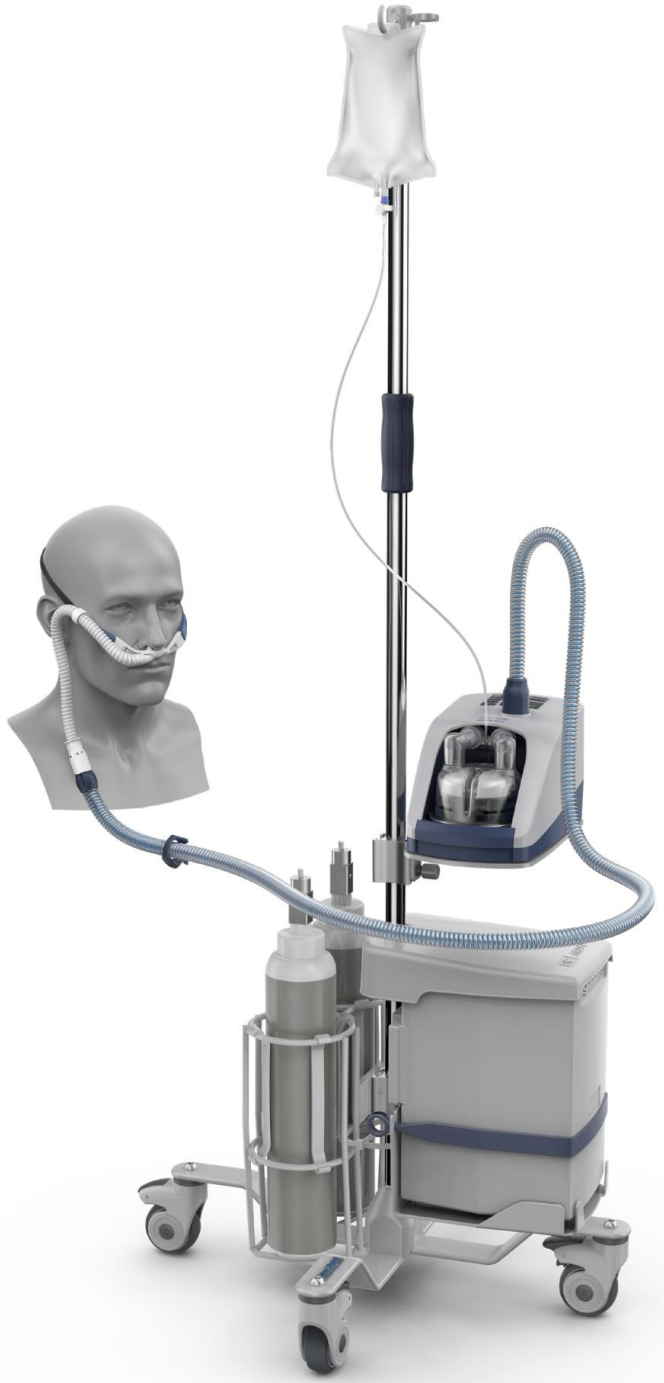


Physiologic Benefits of HFNC

- Continuous airway pressure – thought to stent airway open >35 LPM
- Constant FIO2 (inconsistent w/ other devices & generally lower than expected); well oxygenated, even in mouth breathers
- Reduced nasopharyngeal resistance - non-humidified air increases airway resistance in order to protect lungs from dry/cold inspired air by reduced air flow in upper airway
- Mobilization of secretions via humidification of inspired gases
- CO2 is washed out of anatomical dead space and not re-breathed
- Alveolar recruitment
- Decreased breathing frequency and work of breathing
- Reduced need for escalation of respiratory support

Concerns for Swallow Safety While Using HFNC

- Reduced respiratory-swallow coordination impacts timing, duration and pattern of airway closure
  - ***The mechanism of swallowing involves reconfiguring the oropharynx from a respiratory tract to a swallowing (alimentary) pathway for a period of less than one second, an event that occurs over 600 times daily. This is a highly complex act requiring sensorimotor integration and coordination with other physiologic functions (i.e., respiration, mastication), as well as rapid and precise coordination of more than 25 muscle pairs and six cranial nerves.*** - Vose & Humbert, 2019
- Decreased sensation of residue and aspiration
- Decreased respiratory drive

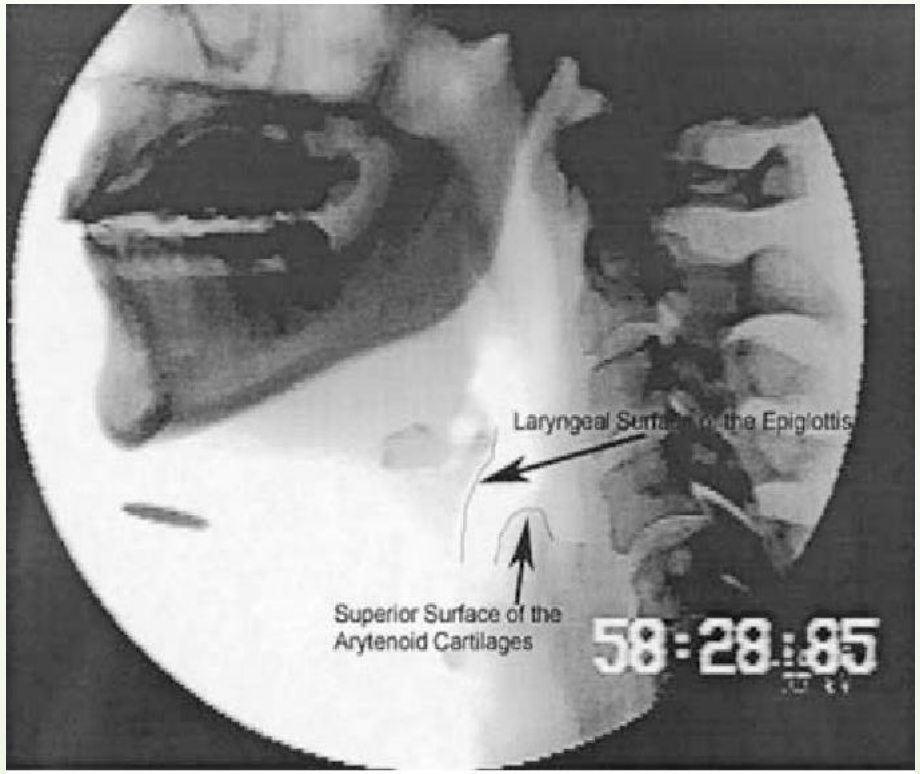
Easy to see how a quite medically compromised person could have trouble compensating for the increased airflow rates and nasopharyngeal pressures generated by HFNC, whereas younger, healthy people can adapt to the perturbation to normal state that HFNC causes

Prior Research

- Prior studies limited in quantity, limited in populations studied (mostly healthy, mostly with limited N), with subpar designs, and over-stated findings
- Conflicting results – worsen vs. improve vs. no effect
- Oomagari et al, 2015 – Healthy adults showed overt difficulty swallowing at flow rates >40 lpm - at minimum, BSE warranted if flow rate >40 lpm
- Leder et al, 2015 – neonates and adults in ICU – HFNC should not preclude PO intake but should be 1 consideration in ST decision making
- Flores et al., 2019 – In fairly high functioning group, 5 of 10 pt studied had silent aspiration

The Influence of Airflow Via HFNC on Duration of Laryngeal Vestibule Closure

- Purpose: Investigate influence of airflow via HFNC on duration of laryngeal vestibule closure (dLVC) & Penetration-Aspiration Scale (PAS) scores



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REVIEW ARTICLE

"Hidden in Plain Sight": A Descriptive Review of Laryngeal Vestibule Closure

Alicia Vose[1,2,3] · **Ianessa Humbert**[1,2]

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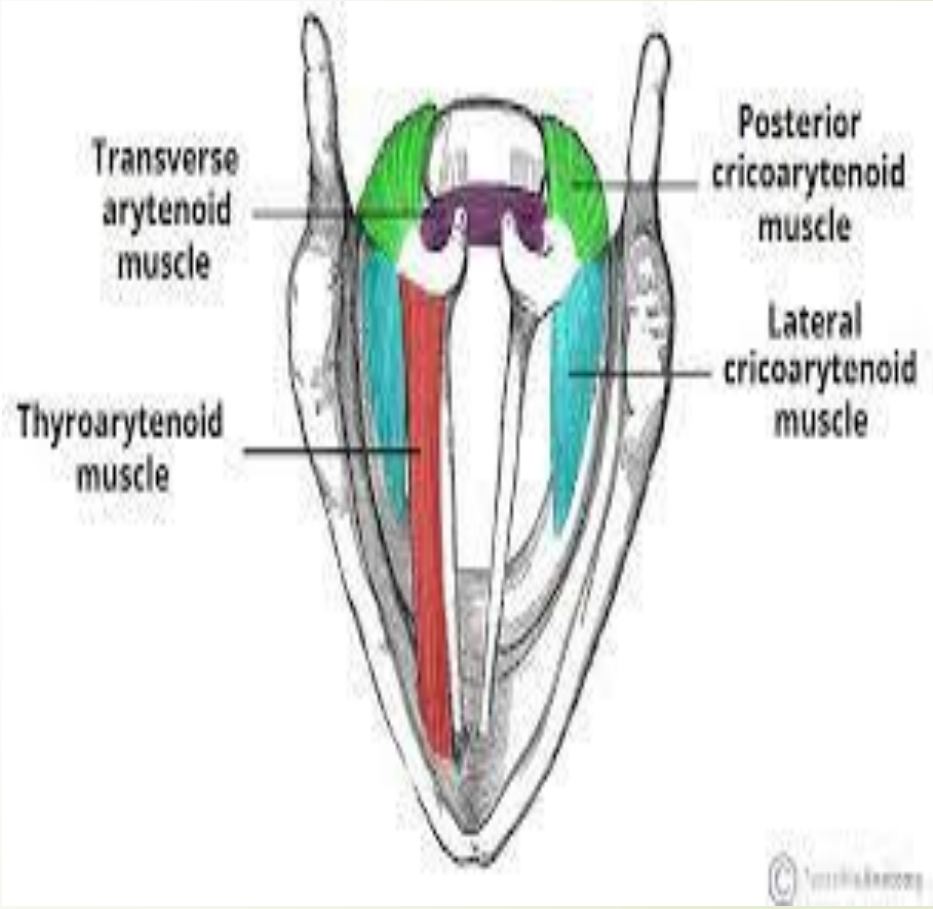
- LVC is 1st line of defense against airway invasion, distinct from true & false vocal fold closure which is 2nd line of defense
- Full LVC occurs when there is complete contact of the arytenoids to the base of the epiglottis and full epiglottic inversion over the base of the arytenoids
  - On MBS, no air or contrast seen in the vestibule
- Multiple structures/actions involved – unclear if each is equally valuable or if one more critical than others – might allow for multiple fail-safes and ability to compensate
- Both ROM/degree of closure AND timing (duration closed, how quickly it closed) are important

Duration of Laryngeal Vestibule Closure

- Ranges between 310 and 1070 ms depending on swallow condition
  - Volume – LVCd tends to increase w/ increasing bolus volume
  - Bolus consistency – ultra-thin liquid vs ice vs frozen/warm pudding v mixed: Ultra-thin liquid was longest and mixed was shortest
  - Mode of delivery – some healthy maintain LVC throughout sequential swallows & some use alternate closed-open position of LVC throughout sequential swallows
  - Support that LVC is highly responsive to sensory input
- Delayed, short, or absent dLVC associated with increased penetration or aspiration
  - Mistimed vs. delayed
  - Incomplete vs. reduced

Laryngeal vestibular closure – Act 1

- Adduction and anterior pivoting of the arytenoids
  - Adductors = lateral cricoarytenoids, transverse and oblique arytenoids and thyroarytenoid
  - Anterior tilting = lateral cricoarytenoids and aryepiglottic muscle
    - Accounts for 1/2-1/3 of LVC



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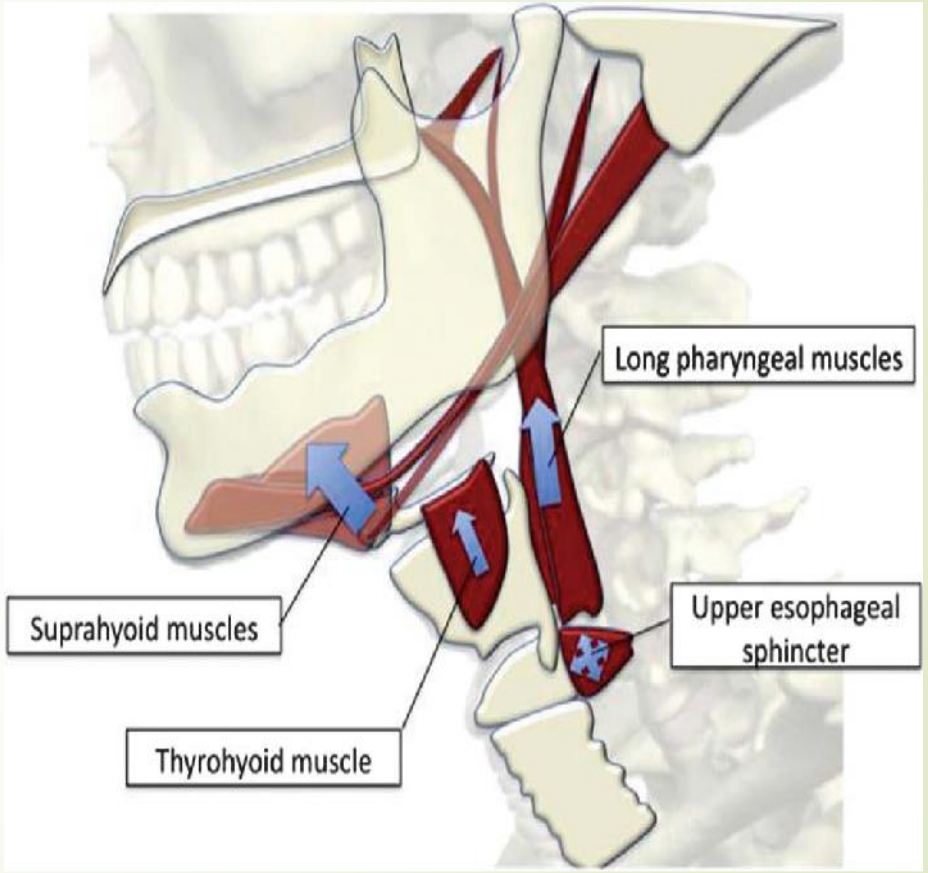
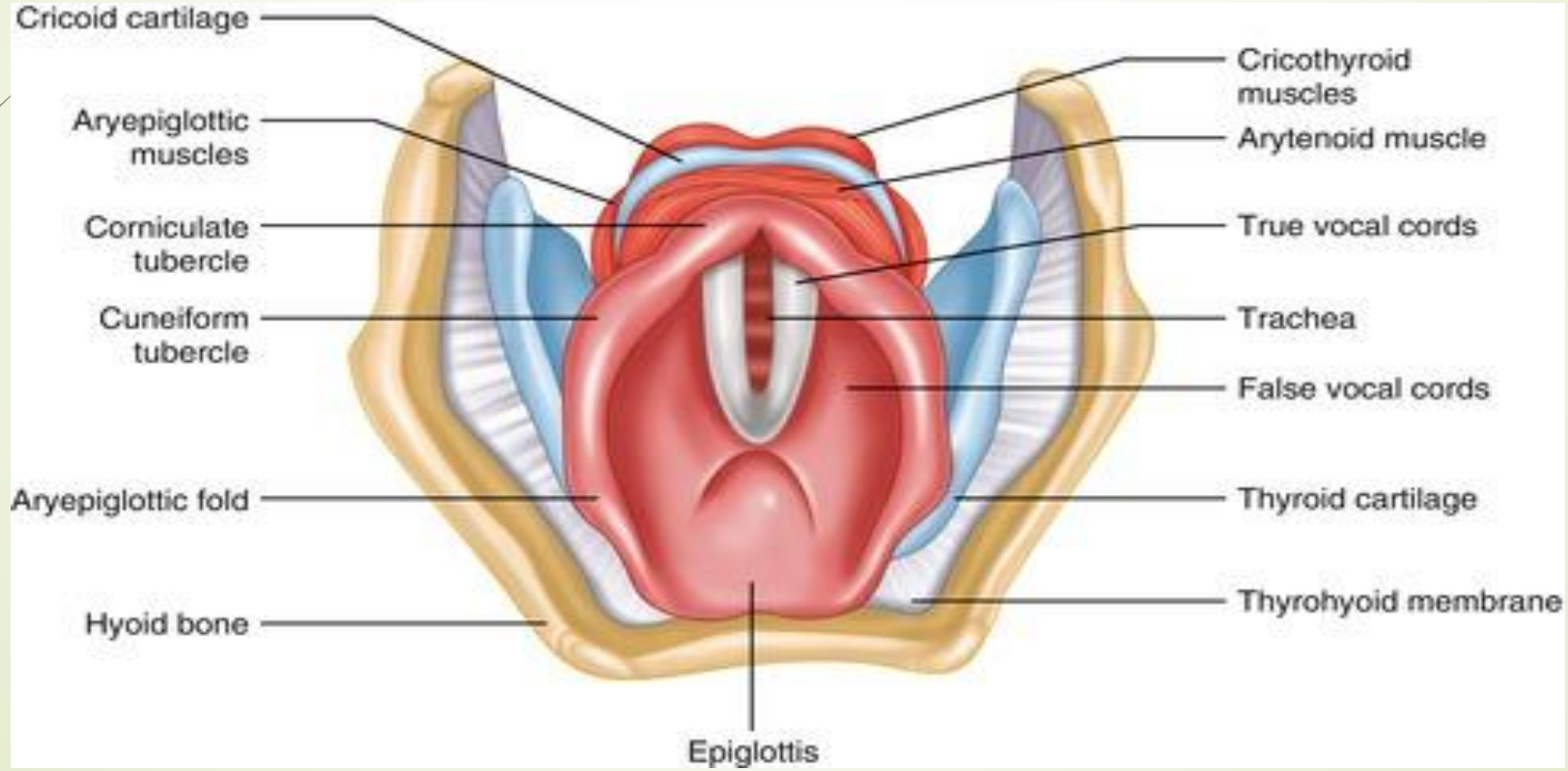
Laryngeal vestibular closure – Act 2

- Superior and anterior movement of hyoid and larynx
  - Forward movement due to contraction of submental muscles
  - Upward movement due to shortening of longitudinal pharyngeal muscles
  - Positions the epiglottis superiorly and anteriorly against base of tongue
  - Narrows the LV and widens the pharynx for bolus passage



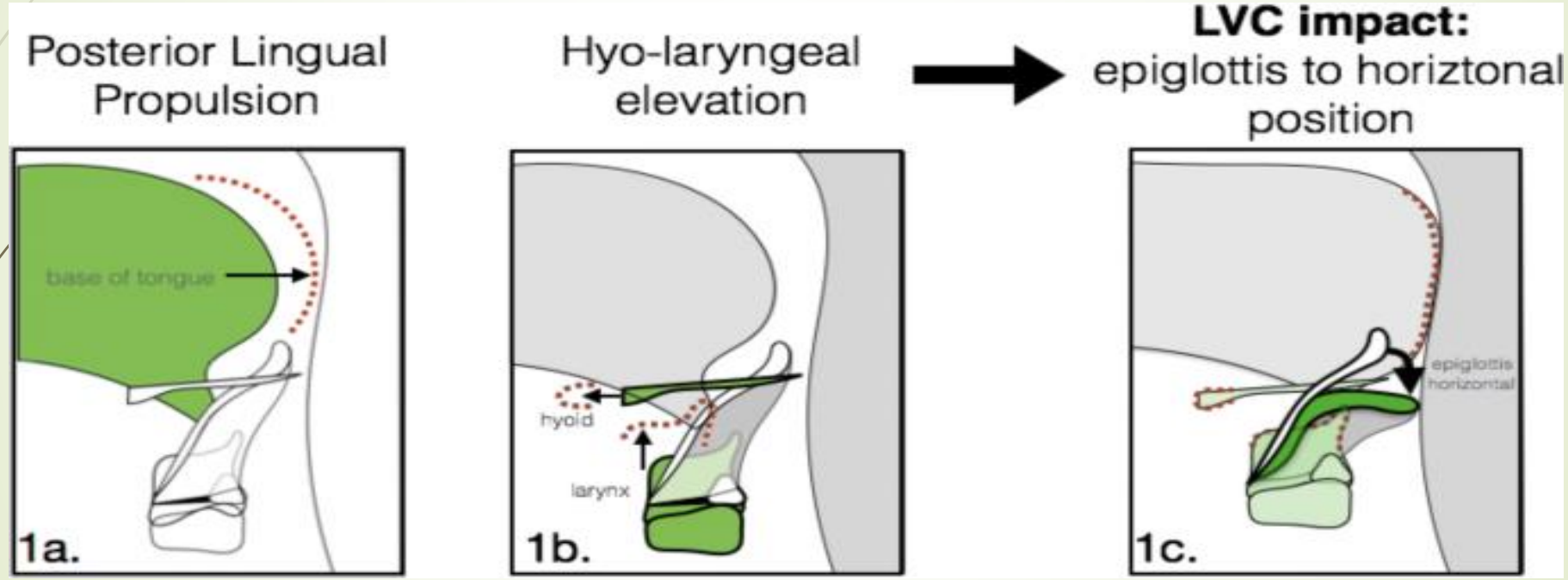
Laryngeal vestibular closure – Act 3

- Adduction of the aryepiglottic fold
  - Aryepiglottic muscle contraction tightens the laryngeal inlet
  - Bolus is directed laterally around the airway



Laryngeal vestibular closure – Act 4

- Inversion of the epiglottis
  - HLE positions EG base closer to TB, EG tilts to horizontal, TB pushes EG back/down



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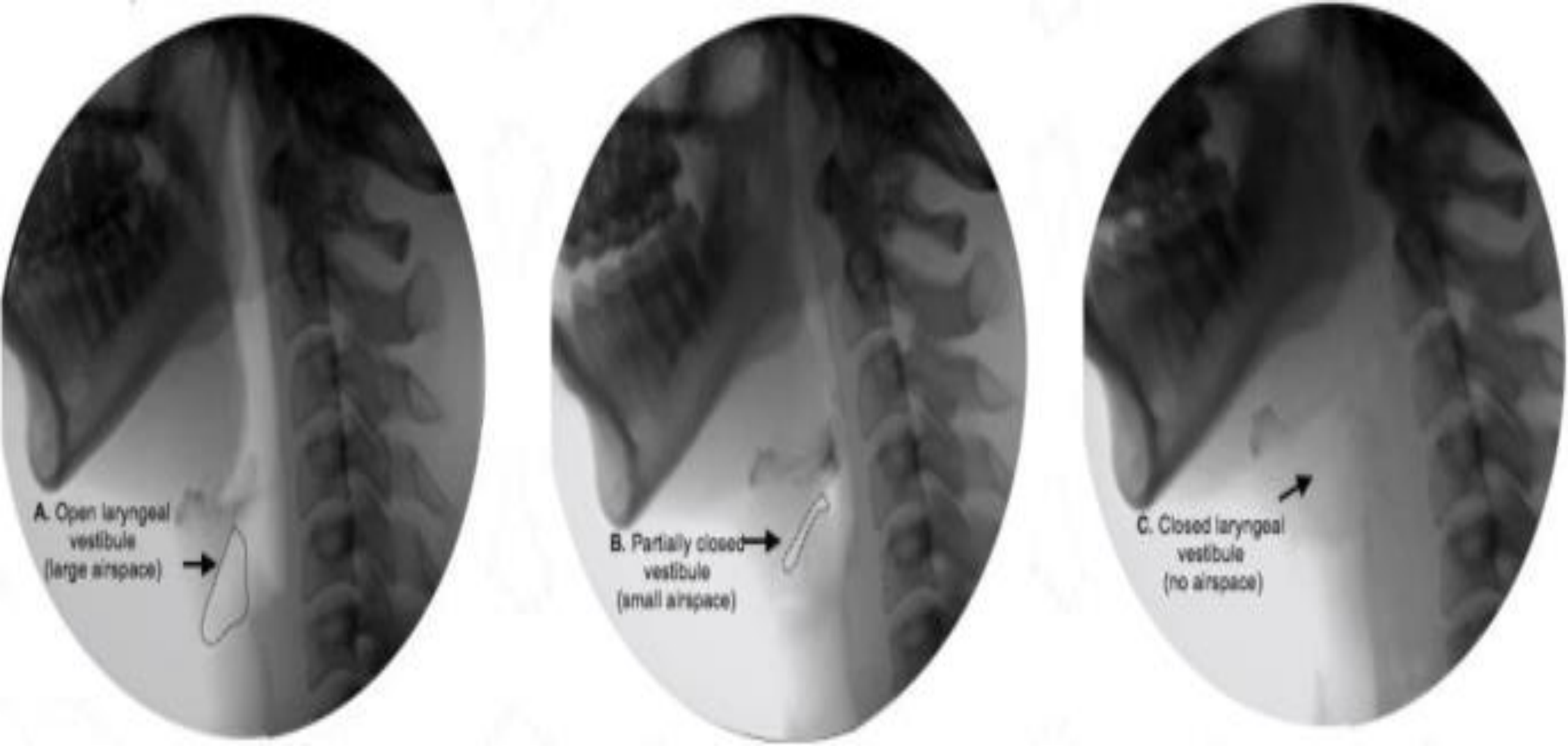

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Methods

- Any healthy adult volunteer eligible; n = 29 (23 females, 6 males), all <60 yrs
- Oxygenation was held constant at room air
- Volunteers swallowed a 20 mL thin liquid bolus at each of the tested airflow rates: 0, 10, 20, 30, 40, 50, 60 LPM
  - Blinded to flow rates which were randomized and counterbalanced
- Instructed to take entire volume & hold in mouth until told to swallow, then swallow entire contents in one swallow
- 5 blinded raters used frame by frame analysis in Swallowtail to measure dLVC and determine PAS scores
- 812 swallows were rated

Results

- LVC was complete on all swallows
- The amount of airflow via HFNC significantly influenced dLVC: when airflow increased, dLVC increased
- PAS score and airflow rate were not associated
  - No aspiration observed; >99% swallows were PAS 1, 2, 4 (considered normal during swallowing)

Penetration-Aspiration Scale

PA Scale Score	Description
1	No contrast enters the airway.
2	Contrast enters the airway, remains **above** the vocal folds, and **is ejected** from the airway (not seen in the airway at the end of the swallow).
3	Contrast enters the airway, remains **above** the vocal folds, and **is not ejected** from the airway (is seen in airway after the swallow).
4	Contrast enters the airway, **contacts the vocal folds**, and **is ejected** from the airway.
5	Contrast enters the airway, **contacts the vocal folds**, and **is not ejected** from the airway.
6	Contrast enters the airway, **crosses the plane of the vocal folds**, and **is ejected** from the airway.
7	Contrast enters the airway, **crosses the plane of the vocal folds**, and **is not ejected** from the airway despite effort.
8	Contrast enters the airway, **crosses the plane of the vocal folds**, **is not ejected** from the airway and there is **no response** to aspiration.

Discussion

- Change in dLVC in response to varied airflow rates thought to be due to healthy subject's ability to adapt to swallow conditions as needed to protect the airway – Will our pts be able to adapt?
- Subjects did have greater variability of dLVC at the highest airflow rates which may be evidence for increased difficulty trying to maintain closure
- Many participants reported subjective difficulty swallowing when flow rates were at highest levels
- Reinforces that aspiration as an outcome in HFNC studies is too narrow a focus, encourages focus on other kinematics of the swallow

Table 4 Frequencies of PAS scores per airflow condition

	0 LPM	10 LPM	20 LPM	30 LPM	40 LPM	50 LPM	60 LPM
PAS 1	24	24	19	25	22	19	21
PAS 2	121	118	124	120	121	125	122
PAS 3	0	2	1	0	2	1	2
PAS 4	0	1	1	0	0	0	0
PAS 5	0	0	0	0	0	0	0
PAS 6	0	0	0	0	0	0	0
PAS 7	0	0	0	0	0	0	0
PAS 8	0	0	0	0	0	0	0

PAS Penetration-Aspiration Scale, *LPM* liters per minute

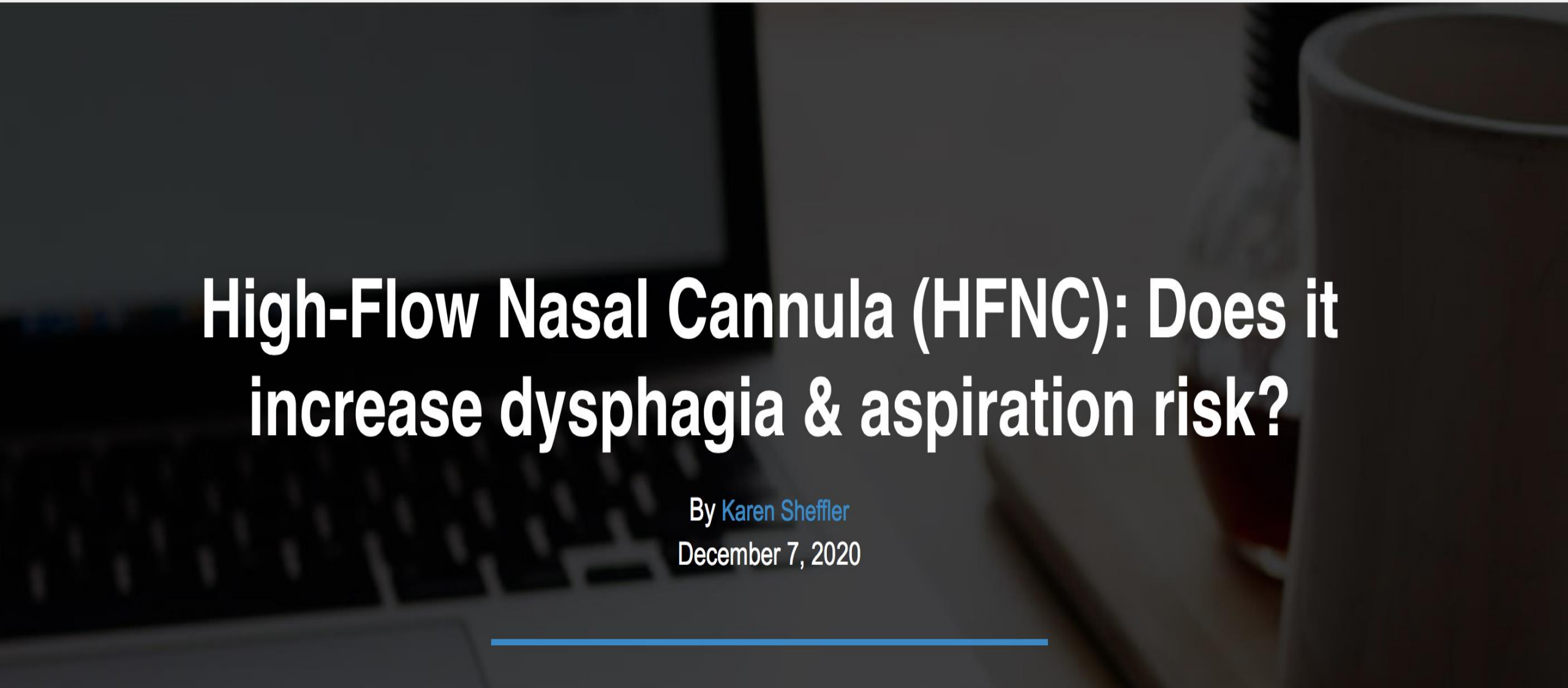
PAS 2 ~80% of time – Is it normal to be so much more frequent than PAS 1?,,,Overall frequency of PAS scores similar to NL adult swallowing in literature. Or is there influence of HFNC?

Measuring LVC

- Should we measure LVC timing? – requires recording at 30 fps & frame-by-frame analysis
  - Duration to LVC - time btwn first frame of hyoid burst and first frame of LVC
  - Duration of LVC – time btwn 1st frame of LVC & 1st frame of LV re-opening
  - There are published norms

Limitations

- Can't generalize to older adults who are known to exhibit longer durations of swallowing
- Can't generalize to unhealthy – how would a patient with already impaired LVC respond to high flow rates
- Mostly female – there may be gender and body size differences
- PAS interrater reliability was low



High-Flow Nasal Cannula (HFNC): Does it increase dysphagia & aspiration risk?

By Karen Sheffler

December 7, 2020

MBS Review Practice

Anticipating the effects of COVID-19 on long-term outcomes

Issues	COVID Treatments / policy changes	What we're seeing in COVID-19	What we know from other ICU populations (e.g., SARS, MERS, ARDS)	SLP considerations
Treatment	Dexamethasone[RCT]	↓ 28-day mortality 0.83 [0.75 to 0.93]; larger effect for MV	Corticosteroids associated w/ weakness	ICUAW, ↑ risk of dysphagia
Respiratory failure	Mechanical ventilation	% invasive: 23%[SR] Duration: median 13 days[O]	Risk factor for ICUAW Barrier to mobilization	ICUAW, fatigue, ↑ risk of dysphagia
	Sedation	Duration: median 5 days[O] Delirium: 80% CAM-ICU+[O]	Delirium Barrier to mobilization	↓ cognition, ICUAW, ↑ risk of dysphagia
	Proning	Awake proning[SR]: RCTs ongoing	If sedated & paralyzed: ↑ weakness	↑ risk of dysphagia
	Neuromuscular blockers	In MV pts: 84%[O] Duration: median 5 days[O]	ARDS: Associated w/ weakness	↓ cognition
ICU admission	Visitation policies	Mortality: 26% (Canada)[O] LOS: median 5 to 19 days[SR]	Patients: PICS Families/caregivers: PICS-F	↓ motivation and adherence d/t PTSD, depression, anxiety
Hospital admission	Visitation policies	Mortality: 13% (International)[SR] LOS: median 4 to 53 days (survivors)[SR]; 40% return to work[O]	Hospitalized adults less likely to mobilize	↑ risk of atrophy, ↑ risk of dysphagia

**Adapted with permission from M. Kho*

Legend: MV: Mechanical ventilation ICUAW: ICU-Acquired weakness; LOS: length of stay; SR: systematic review; R: randomized clinical trial; O: observational study; PICS: Post-intensive care syndrome; PICS-F: Post-intensive care syndrome-family