Oxygen Therapies and Swallow Considerations

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WHEN 35L HFNC ISN’T ENOUGH

OXYGEN DEVICES

- Nasal cannula
- High flow nasal cannula
- Oxymizer
- Simple mask
- Aerosol face mask
- Venturi mask aka Venti mask
- Non-rebreather mask
- Heated high flow NC (Opti-Flow)
- CPAP
- BiPAP

TERMINOLOGY

- Flow- liters per minute
- FiO2- percent of oxygen (natural air ≈ 21% FiO2)
- High flow nasal cannula- green nasal cannula tubing ranging from 7-15LPM
- Heated/humidified high flow- what Duke uses is called Opti-Flow
  - Some articles call this “high flow nasal cannula”
  - Some articles call this “heated humidified high flow”
  - We will call it “HFNC” during this presentation
- Minute ventilation- volume of gas inhaled/exhaled per minute. This is different per person and depends on respiratory rate, tidal volume of each breath, etc.
- NPPV- non-invasive positive pressure ventilation (i.e. BiPAP, CPAP)
- Dead space- the volume of air inhaled that does NOT take place in gas exchange because it either remains in the conducting airways (nasopharynx, trachea, bronchii), OR reaches poorly/not perfused alveoli
NASAL CANNULA

• The range of flow for a simple nasal cannula is 1 to 6 LPM. FIO2 range of 24%-44%.

• Approximate FiO2 on a nasal cannula is calculated easily by starting at 20% and adding 4% for every liter of O2. i.e. 3 LPM = 20% + (3 x 4%) = FiO2 of 32%

• FiO2 is not precise due to factors like changes/variation in minute ventilation.

HIGH FLOW NASAL CANNULA

• The range of flow for a high flow nasal cannula is 7 to 15 LPM. FIO2 range of 48%-80%.

• Some facilities would use Opti-flow instead of high flow nasal cannula tubing as an option since Opti-flow can set an exact FiO2.

OXYMIZER

• Reservoir/Pendant
• O2 Flow up to 12LPM
• O2 Bolus on inspiration
• Lower LPM flow needed
• FiO2 not precise
SIMPLE MASK

- FIO2 35%-65%. FIO2 is not precise due to room air entrainment through side ports.
- Liter flow of 6-12 LPM
- No less than 6 LPM flow
- Often seen in PACU

AEROSOL FACE MASK

- Delivers from 28% - 96% FIO2 of nebulized, aerosolized & oxygenated air.

VENTURI FACE MASK AKA VENTI MASK

- Delivers a precise FIO2
- FIO2 can be set in a range from 24% to 50% with model used here
- Can also be used for transports on a trach collar
- Indications: Mouth breather, precise FIO2 needed, increased flow demand, patient unable to wear NC
USING A VENTI MASK ON TRACH

- Only use for patient transports or if patient is ambulating and needs portable oxygen
- This is what Duke Rehab Institute patients use when in the gym

NON RE-BREATHER MASK

- Delivers approximately 60% to 90% FiO2 when set at 15 LPM
- Bag should not deflate more than 1/3 during inspiration
- NO SLP evaluation with non-rebreather mask

HFNC (Opti-Flow) on a healthy subject
HFNC/OPTI-FLOW

- Flow (LPM) and FiO2 are adjusted independently of each other.
- Precise FiO2 is set (up to 100%)
- Flows up to 60 LPM
- The gas is humidified and heated
- Used in adult and pediatric patients

BENEFITS OF HFNC/OPTI-FLOW

- Patient can eat and drink
- Reduces use of NPPV
- Precise FiO2 can be set
- Provides heated humidity
- Produces extrinsic PEEP
- Meets high flow demand
- Eliminates most of the anatomic dead space
- Reduces risk for facial ulcers

WHO NEEDS FLOW, WHO NEEDS FI02?

FLOW
- Flow does 3 things:
  - Creates extrinsic PEEP = increases oxygenation
  - Washes out dead space (removes CO2)
  - Matches respiratory demand
  - Hypoxic patients that need some PEEP
  - CO2 retainers
  - Patients that are SOB, have increased WOB, not getting adequate tidal volumes with each breath

FiO2
- FiO2 treats hypoxia and perfusion issues (of any cause)
- Example: if a patient has an obstructive lung issue (i.e. PE, ILD, Pulm fibrosis) and their lungs are otherwise healthy, Flow would not "pass" through the PE and participate in gas exchange. FiO2 is needed to help the lungs perfuse better.

PATIENTS NEED BOTH, but some need more FiO2 than flow or vice versa
LET'S REVIEW SOME LITERATURE

BASIC REVIEW OF NORMAL BREATHING & SWALLOWING

Inhale ~350-500 mL of air with each breath

swallow after onset of exhalation

completes exhale after the swallow

(Hiss, Treole, & Stuart, 2001; Klahn & Perlman, 1999; Leslie, Ditman, Ford, & Wilson, 2005; Shaker et al., 1992)

BASIC REVIEW OF NORMAL BREATHING & SWALLOWING

Since alveoli are collapsing toward their resting position during exhalation, the pressure in the airway when the larynx closes during swallowing is **higher** than atmospheric pressure (Gross et al., 2008)

Higher pressures = ability to clear post-swallow penetrate or aspirate
IN HEALTHY SUBJECTS, ALTERED RESPIRATORY CONDITIONS AFFECT THE SWALLOW

- Gross et al reported shortened pharyngeal activity durations and more frequent airway compromise at functional residual capacity and residual lung volumes (end of expiration)

- Nishino et al found that induced hypercapnia led to swallowing during the inhalation phase, swallowing rate reduction, and clinical signs of aspiration

- Nishino et al found during a nasal CPAP paradigm, CPAP inhibits the swallowing reflex with increased swallowing latency, decreased rate, as well as clinical signs of airway compromise

- Boden et al found that when respiration is altered, shortened apneic periods and decreased glottis closure durations increase the probability of airway vulnerability

“HIGH-FLOW OXYGEN ADMINISTRATION BY NASAL CANNULA FOR ADULTS AND PERINATAL PATIENTS”

J. Ward article summary on the benefits of High Flow Nasal Cannula:

- HFNC can be used to treat patients with moderate levels of hypoxemic respiratory failure

- A single device can be used and titrated appropriately based on response vs having to change to other devices

- Independent adjustment of FiO2

- Heated and humidified gas provides improved comfort and better tolerance, compared to mask devices which may also allow for possibility of eating/drinking, clear speech, frequent expectoration

COMPARISON OF HFNC & CPAP

As a reference, treatment of OSA with CPAP uses between 4 cmH2O and 20 cmH2O of POSITIVE AIRWAY PRESSURE

DME providers who sell/rent CPAP equipment have warnings about not eating and drinking while using CPAP ("you are likely to inhale the food or drink into your lungs")
HIGH FLOW OXYGEN THERAPY CREATES POSITIVE AIRWAY PRESSURE

The following studies evaluated positive airway pressure created by HFNC:
Parke et al. (2009)
- HFNC with mouth closed: +2.7 cmH2O
  - Range = 1.54 cmH2O to 6 cmH2O
  - Mouth closed is most common swallowing posture
- HFNC with mouth open: +1.2 cmH2O
- Facemask (comparison): ~1 to .03 cmH2O with mouth open and closed (basically no change compared to atmospheric pressure)

Groves and Tobin (2007)
- Mouth closed at 20 LPM: +3.7 CMH20
- Mouth closed at 40 LPM: +7.2 CMH20
- Mouth closed at 60 LPM: +8.7 CMH20
- Mouth open at 20 LPM: +1.4 CMH20
- Mouth open at 40 LPM: +2.2 CMH20
- Mouth open at 60 LPM: +2.7 CMH20

Coghlan and Skoretz (2017)
Again, explains CPAP effect with HFNC- citing that pressure in the oropharynx are estimated at ~1 cmH2O per 10 LPM
- Example: 55LPM would create ~5.5 cmH2O POSITIVE AIRWAY PRESSURE in oropharynx
DISCUSSION

Positive airway pressure is generated using HFNC which has important clinical indications related to respiratory status:

- improved oxygenation, improved ventilation perfusion matching, reduced airways resistance, reduced work of breathing, and balancing of intrinsic PEEP

DISCUSSION/SUMMARY

But, those benefits for respiration can be detrimental to swallowing as HFNC is shown to have a CPAP effect

Comparison

- HFNC WITH MOUTH CLOSED AT 20 LPM: +3.7 cmH20
- HFNC WITH MOUTH CLOSED AT 35 LPM: +1.54 - 6 cmH20
- HFNC WITH MOUTH CLOSED AT 40 LPM: +7.2 cmH20
- HFNC WITH MOUTH CLOSED AT 60 LPM: +8.7 cmH20

Treatment of OSA with CPAP uses between 4 cmH20 and 20 cmH20 pressure

HFNC & SWALLOWING: FRIENDS OR FOES

“It is important to draw on what we know about the biomechanical intimacy between respiration and the swallow and how a suboptimal state of one half of this union may precipitate the unraveling of the other.” (Caghlan)
“SWALLOWING FUNCTION DURING HIGH-FLOW NASAL CANNULA THERAPY”

(Oomagari et al, 2015)

32 healthy subjects underwent high-flow nasal cannula therapy at different flow rates chosen at random (0, 10, 20, 30, 40, and 50 L/min).

All subjects underwent the 30-mL water swallow test (WST) and the repetitive saliva swallowing test (RSST).

Difficulty swallowing water during the WST was evaluated using a visual analog scale.

The swallowing time and number of swallows in 30 seconds were evaluated during the RSST.

RESULTS

WST: 5 subjects (15.6%) choked at flow rates of 40 and 50 L/min
  * The change in the swallowing time was significantly associated with difficulty swallowing at 40 and 50 L/min

RSST: > 20 L/min had lower number of swallows during the RSST and greater difficulty swallowing than a flow rate of 0 L/min.
“Oral Alimentation in Neonatal and Adult Populations Requiring High-Flow Oxygen via NC”

(Leder et al 2015)

Prospective cohort study investigating the impact of HFNC use on oral alimentation in neonatal and adult ICU patients.

100 consecutive inpatients, 50 neonates, 50 adults

NEONATES

• 17/50 neonates medically appropriate to begin PO – this was decided by neonatologist and RN using certain criteria

• 33/50 NPO given medical fragility

• 100% (17/17) of appropriate neonates began PO successfully, though not necessarily adequate nutrition

ADULTS

• 39/50 adults medically appropriate to begin PO – this was decided by medical intensivist, SLP, and RN using the following criteria:
  • Stable respiratory status on 10-50LPM HFNC
  • Adequate mental status to participate in meal times
  • Passing the Yale Swallow Protocol. If failed, FEES performed immediately.
  • Ability to handle oral secretions

Important note: The most common flow rate was 26.6LPM / 66%FiO2
ADULTS

- 5/39 failed YSP and had FEES indicating the need for thickened liquids and compensatory techniques
- 100% (39/39) of appropriate adults began PO successfully; 5 of these having a FEES given failed screening criteria
- 11/50 - NPO given medical fragility/severe respiratory issues

AUTHOR’S THOUGHTS

They suggested: it is not the use of HFNC, but rather the patient specific determinants of feeding and swallowing readiness and their underlying medical conditions that impact readiness for PO
- Patient specific determinants = their inclusion criteria?

DISCUSSION/STUDY LIMITATIONS

11/50 patient excluded from study- who were these people?
+ 5/39 included patients needed a FEES
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16/50 patients were either not appropriate for PO or aspirated on a FEES

34/39 "successful" with starting a diet after passing the YSP. This was defined by:
- Swallowing without overt sx of dysphagia (cough or respiratory issues)
- Not adequacy of oral intake (i.e. need feeding tube)

Our question is HOW LONG was this monitored? What was the follow up?
DISCUSSION/STUDY LIMITATIONS

We suspect that the excluded patients were the people who would be negatively impacted by positive pressures created by high flow rates in the oro-pharynx.

Reminder: HFNC can produce up to 6cmH2O positive pressures in the oro-pharynx when flow is 35LPM. This is close to a PEEP of 5 on vented patients.

INCLUDED patients were only receiving a mean of 26LPM.

THE TAKEAWAY...

When you receive a consult, it’s important to know WHY they have respiratory failure and/or WHY they need HFNC.

- Aspiration pneumonia
- COPD
- ARDS
- PE, ILD, Pulmonary fibrosis
- OSA
- Recent extubation/mucociliary clearance

THE TAKEAWAY...

Know who is not ready for evaluation, who is ready to proceed with a clinical, who needs an instrumental and when this would be appropriate.

- Do they really need that much flow? Can their LPM be weaned?
- Talk to the MDs and RTs
- If the patient may improve in the next day or two, consider holding off

There should be a higher consideration of performing a FEES on this population – fatigue them, challenge them.
THE TAKEAWAY...

If a patient is visibly fragile, has increase RR, lower O2sats, etc. they may be more likely to be negatively impacted by HFNC/increased positive pressures in the shared breathing/swallowing tracts.

If a patient is relatively stable and comfortable on HFNC, they should be appropriately evaluated by the SLP. HFNC itself should not preclude our evaluations.

THE TAKEAWAY...

We all love “rules/protocols” for when or when not to evaluate a patient, but there is no research looking at how much flow/FiO2 is the “cut off”. We need to use our expertise and clinical judgment using the research that is available.

Patient selection is key.

EXAMPLE #1
REFERENCES


