Oxygenation Options and Considerations for Northern communities

DR CORY MCFARLANE
Sioux Lookout Meno Ya Win Health Center

DR AZAD MASHARI
Department of Anesthesia & Pain Management
Toronto General Hospital, University Health Network

Disclosure of Competing Interests

Cory McFarlane

- Research Collaboration with Glia inc. (pro-bono) and University Health Network to develop respiratory support equipment for use in the North

Azad Mashari

- Scientific Consultant for **Glia inc**. (pro-bono)
  Open-Source Medical Device Development Company affiliated with London Health Science Center
- Research Funding and Support from
  - Toronto General and Western Hospital Foundation
  - UHN/SHS Academic Medical Organization
  - Peter Munk Cardiac Center
  - UHN/SHS Anesthesia Associates
  - University of Toronto

Oxygen Therapy Protocol Covid-19

LEVEL 1 - Contact/Droplet Precautions

Always use oxygen concentrator when available unless required flow exceeds 10L/min OR maximum flow volume of concentrator.

****Place surgical mask over oxygen devices****

Contact/Droplet Precautions

- Bouffant
- Face Shield
- Surgical Mask
- Gown
- Gloves

SP02 <92% apply nasal prongs (NP) 2L/min then surgical mask & **CONSULT MD** titrate to MAX 6L/min

If patient not tolerating nasal prongs

Apply simple face mask 5L/min then surgical mask & titrate to MAX 10L/min

If patient is on nasal prongs or face mask for >24 hrs

Apply oxymizer nasal prongs then surgical mask & titrate to MAX 8-10L/min

Oxymizer

If Sp02 remains <92% OR RR>30 OR patient distress

- Call MD & Alert ORNGE
- R/A Goals of Care
- Escalate to **Level 2** Oxygen therapy if available

LEVEL 2 Contact/Droplet AND Airborne Precautions

Consider awake proning of patient while maintaining previous 02 therapy

If SP02 < 92%

Apply Hi-Ox mask with viral filter then surgical mask at 6L/min and titrate to MAX 8L/min

If Hi-Ox mask is unavailable

STOP* - INITIATE AIRBORNE PRECAUTIONS BEFORE NEXT STEP

Apply Non-rebreather(NRB) mask (over disconnected nasal prongs left in place) at 8L/min to MAX of 10L/min Apply surgical mask over NRB

If Sp02 remains <92% OR RR>30 OR patient distress

Call MD. Alert ORNGE. R/A Goals of Care. Escalate to Level 3 Oxygen Therapy if available.

LEVEL 3 - Airborne Precautions

*****Place surgical mask over oxygen devices*****

Airborne Precautions

If SP02 < 92% NRB over nasal prongs then surgical mask. NP 6L/min NRB to MAX 15L/min. Requires 02 tank if flow rate exceeds 10L/min. Consult MD to lower SP02 target 88-92%

If SP02 < 92%

Consider High-Flow Nasal Cannula (HFNC) if available with MD consult

If SP02 < 92%

Consider CPAP if available with MD consult

If Sp02 remains <92% OR RR>30 OR patient distress

- Call MD STAT
- Initiate ORNGE virtual emergency services if available
- R/A Goals of Care
- Consider Palliative Care

Take a deep breath

- Key principles
  - Protect yourself and others
  - Assess the patient
    - WOB, LOC, Fluid status, Hemodynamics
  - Give Oxygen if needed
    - Only 3 proven drugs so far in Covid (O2, steroid, anticoagulation?)
  - Positioning
    - Improve V/Q matching (send blood to ventilated alveoli)
  - Phone a friend
    - Doctor on call, Respiratory Therapy, RCCR

Protect Yourself: PPE

Each level builds on the previous

1. **Contact** Precaution: Gloves, Regular gown
2. Contact + **Droplet** Precautions: + Fluid resistant gown, Level 2 mask, Face Shield, Cap
3. Contact + Droplet + **Airborne** Precautions: + N95 respirator mask

The known unknowns

1. Does O_2 flow rate and device type effect amount of aerosols produced or area of spread?
   - We assume higher flow = higher aerosolization (not the full story- lots of factors)

2. Where to put covid patients? (isolation, ER, home monitoring)

Aerosolization with different devices

(Simmonds 2010; Rule 2018)

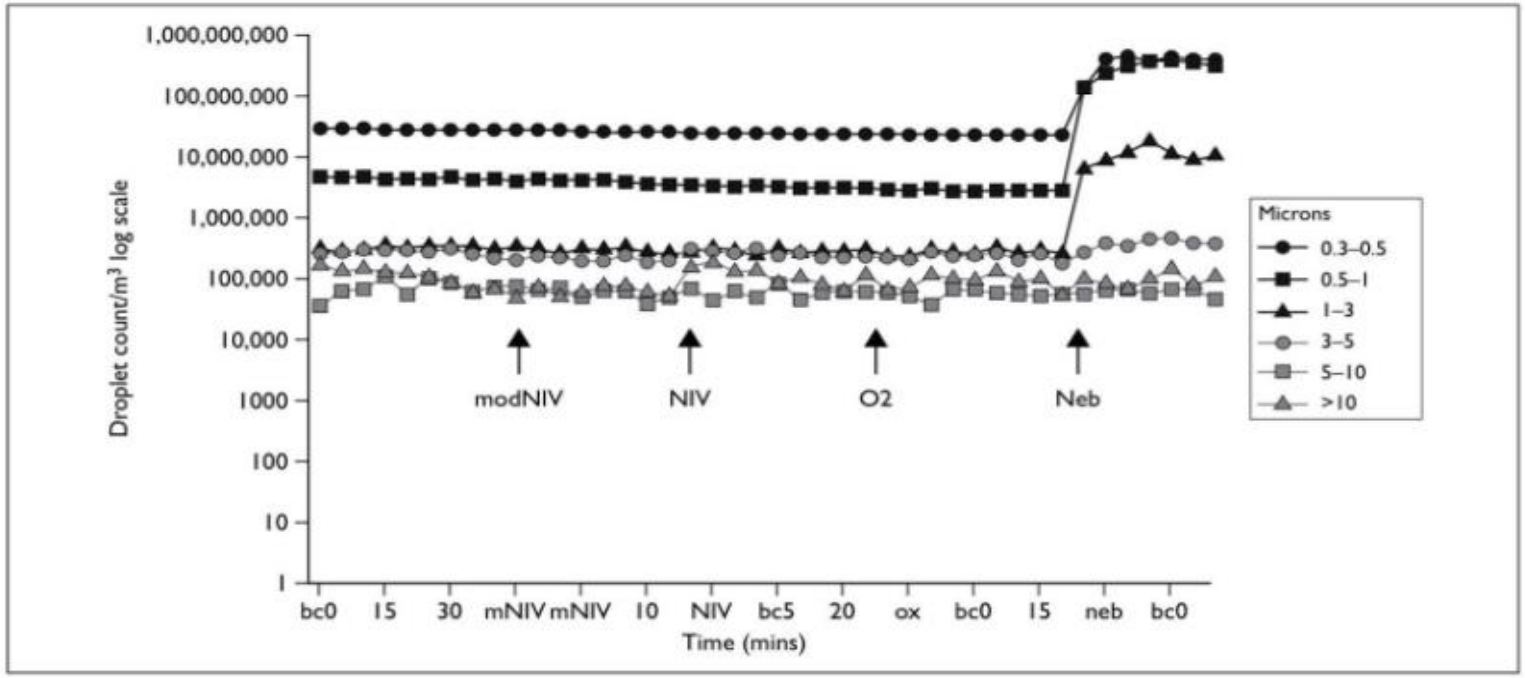
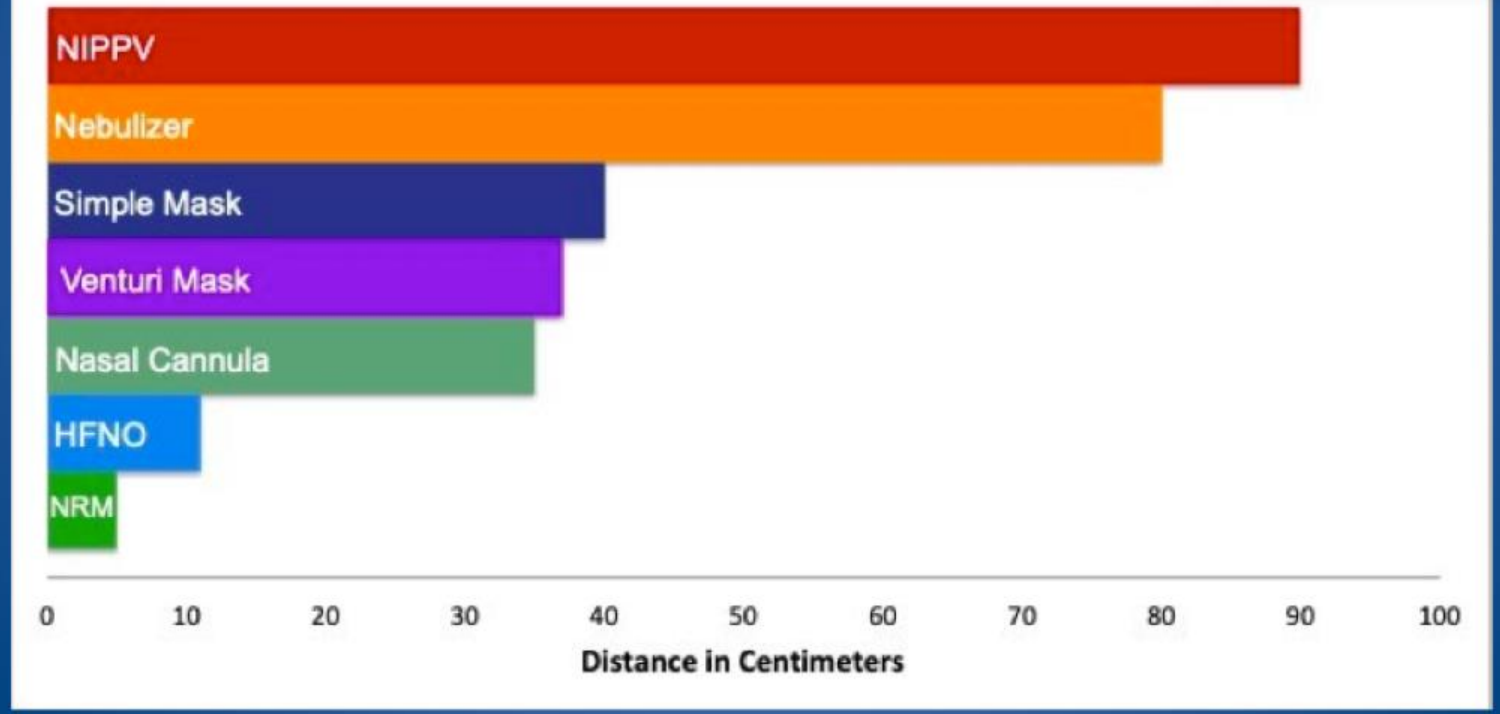


FIGURE 1 *Example of coryzal subject experimental run. bc, baseline count; mNIV, modified NIV; neb, nebuliser; ox, oxygen therapy.*

Figure 1 from Simmonds 2010. Although noninvasive ventilation and oxygen mask did not increase the number of aerosols being produced, the baseline rate is incredibly high.

What is the Risk to HCW with Various Treatmen

**Figure 1. Comparison of aerosol dispersion differences (c
various treatment modalities.**



Non Aerosolising Medical Procedures

CAEP | ACMU

- Oxygen therapy < 5 liters/minute by nasal prongs
- Oxygen therapy < 15 liters by Venturi masks and non-rebreather masks
- Collection of nasopharyngeal or throat swab
- Chest tube removal or insertion (unless in setting of emergent insertion for ruptured lung/pneumothorax)
- Oral hygiene
- Any procedure done with regional anaesthesia
- Chest physiotherapy (outside of breath stacking)
- Intranasal medication administration, such as naloxone

Unclear Aerosol Generation

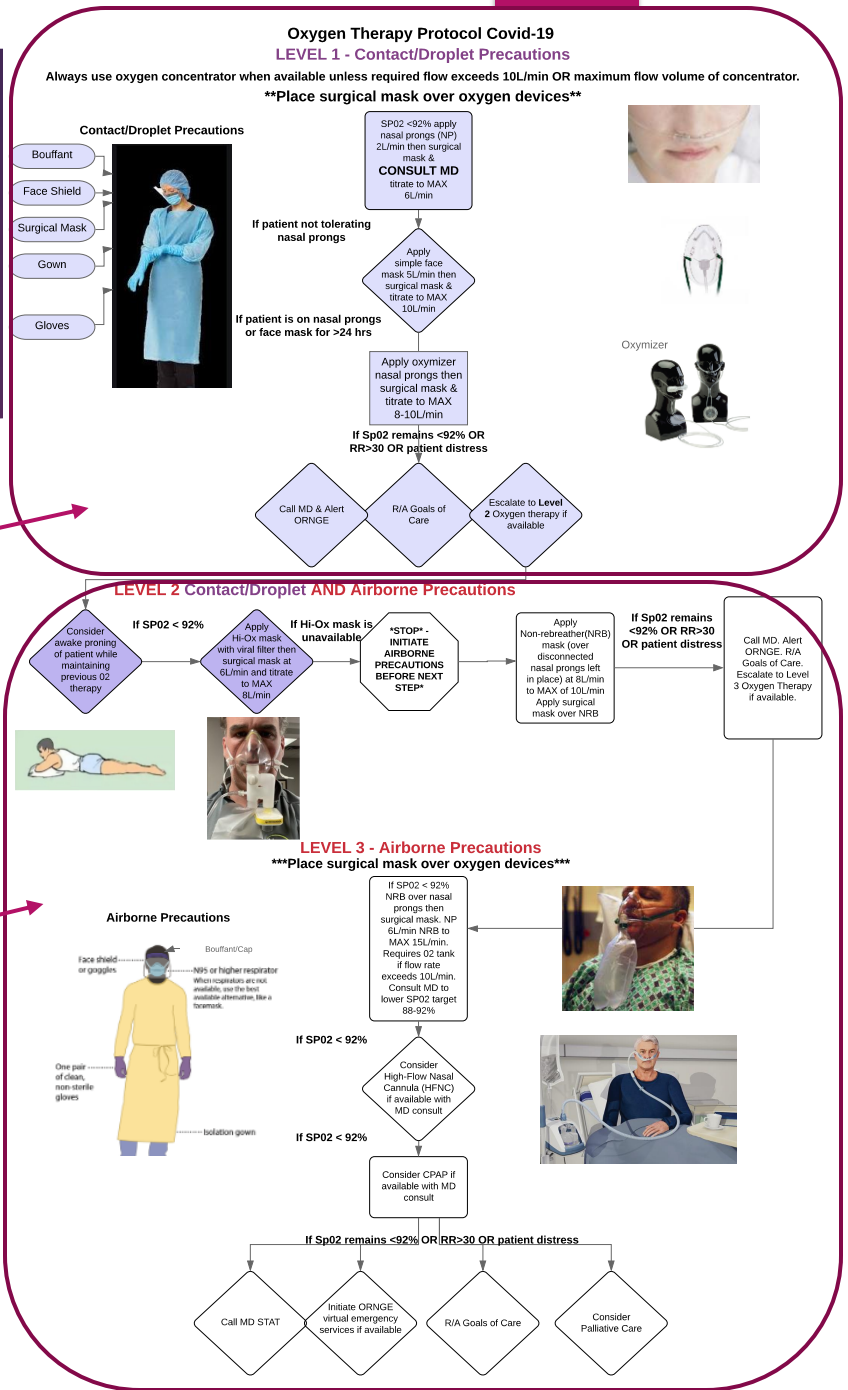
CAEP | ACMU

- Ventilator circuit disconnect
- Chest compressions in a non-intubated patient
- Oral suctioning
- Defibrillation of a non-intubated patient
- Thoracostomy and other trauma management procedures
- Nasogastric tube insertion in a non-intubated patient

Line	Aerosol-Generating Procedure Group	Frequency Count
1	intubation and extubation procedures	114
2	airway suctioning	92
3	bronchoscopy	89
4	non-invasive ventilation	78
5	nebulized or aerosol therapy	75
6	cardiopulmonary resuscitation	66
7	sputum induction	60
8	tracheostomy and tracheostomy procedures	57
9	manual ventilation	52
10	autopsy	33
11	high-flow oxygen therapy	32
12	oral and dental procedures	31
13	high-frequency oscillatory ventilation	27
14	chest physiotherapy	23
15	surgery/post-mortem procedures with high-speed devices	14
16	nasopharyngeal aspirate	13
17	nasopharyngoscopy or laryngoscopy	12
18	breaking closed ventilation systems (intentionally or unintentionally)	11
19	coughing	10
20	nasopharyngeal and oropharyngeal swabbing	9
21	mechanical ventilation	8
22	handling soiled laundry	5
23	manipulation of masks	5
24	upper GI endoscopy	5
25	lung function testing	4
26	nasogastric tube insertion	4
27	prone positioning	4
28	thoracic surgery and procedures	4
29	ENT and neurosurgery	3
30	mechanical insufflation and exsufflation	3
31	suction of body fluids (not further specified)	3
32	GI endoscopy (not further specified)	2
33	intra/extra pulmonary high-frequency oscillation devices	2
34	toilet use and flushing	2
35	vacuum cleaning	2
36	colonoscopy	1
37	supraglottic airways	1

Protect Yourself: PPE

1. **Contact** Precaution: Gloves, Regular gown
2. Contact + **Droplet** Precautions: + Fluid resistant gown, Level 2 mask, Face Shield, Cap
3. Contact + Droplet + **Airborne** Precautions: + N95 or equivalent respirator



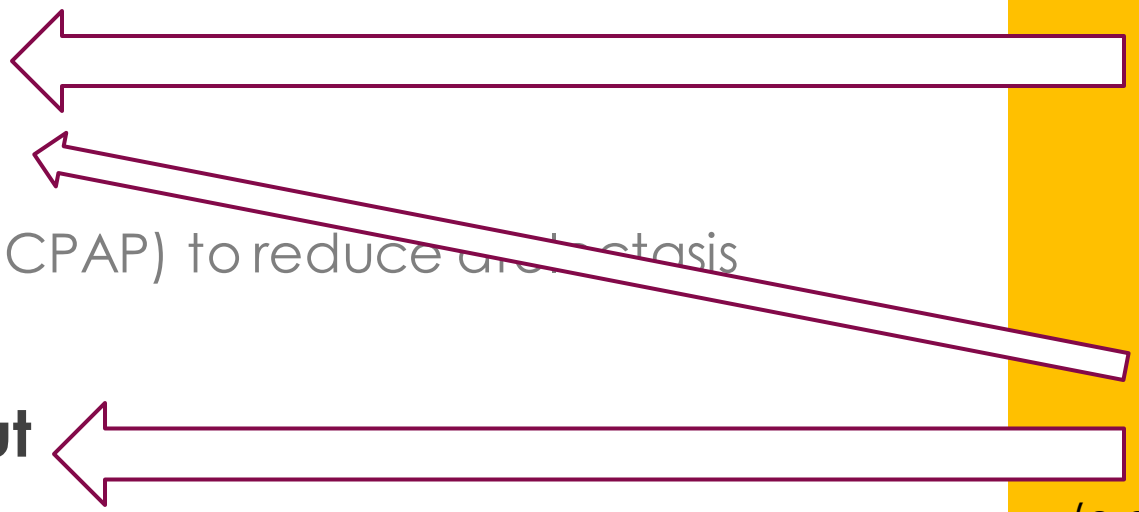
Breathing & Respiratory Support: 2 Components

Getting O_2 In

- FiO_2
- Pressure (PEEP, CPAP) to reduce atelectasis
- Ventilation

Getting CO_2 out

- Ventilation (Tidal volume, Respiratory Rate)



Oxygen

Pressure

(e.g. PEEP, CPAP, Ventilation)

LEVEL 3 - Airborne Precautions

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Oxygen

Pressure

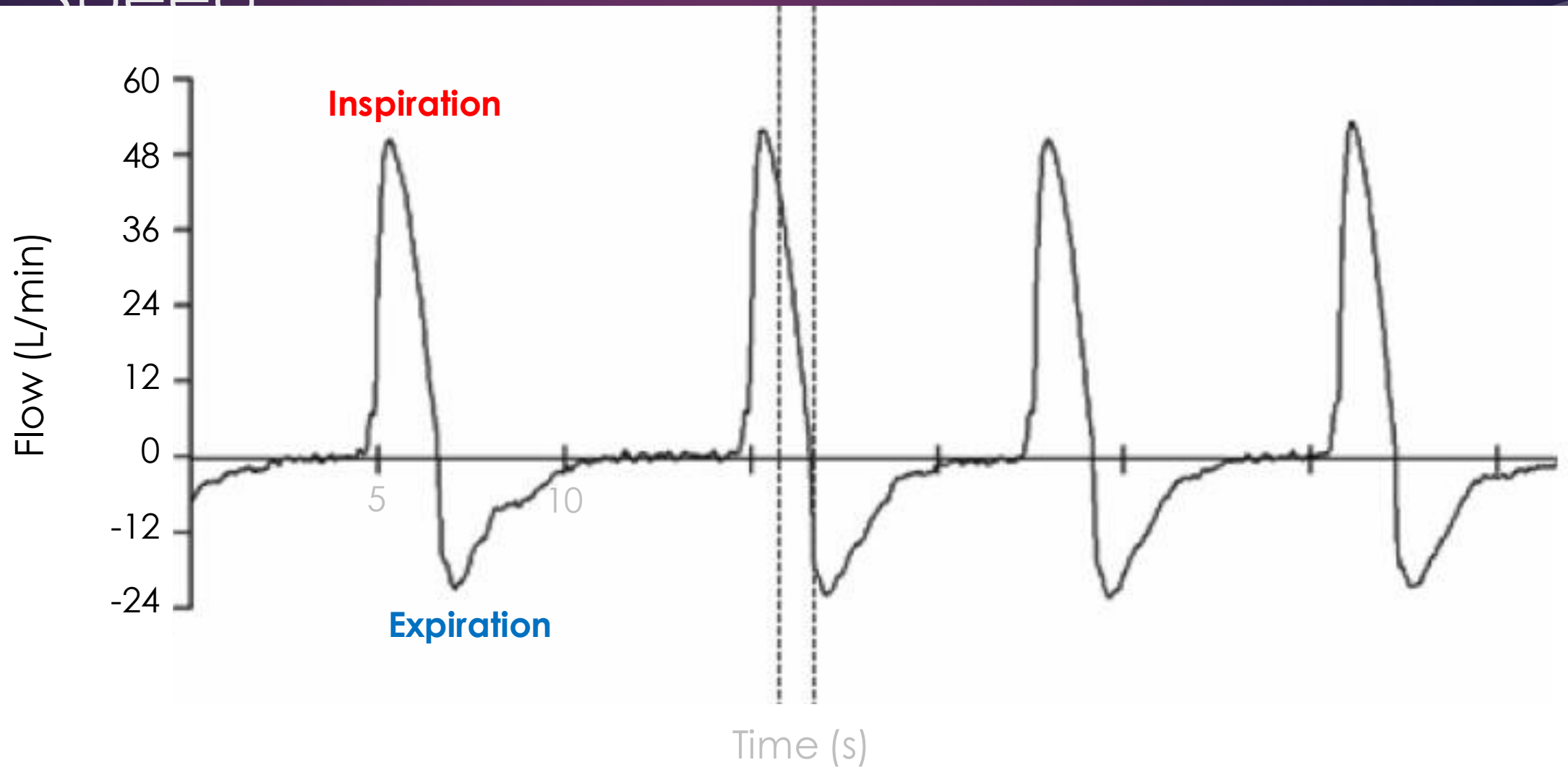
(e.g. PEEP, CPAP, Ventilation)

FiO_2 vs Oxygen Flow: Depends on Device

2 Estimating FiO_2

Method	O_2 flow (l/min)	Estimated FiO2 (%)
Nasel cannula	1	24
	2	28
	3	32
	4	36
	5	40
	6	44
Nasopharyngeal catheter	4	40
	5	50
	6	60
Face mask	5	40
	6-7	50
	7-8	60
Face mask with reservoir	6	60
	7	70
	8	80
	9	90
	10	95

Spontaneous Breathing – Air Flow Speed



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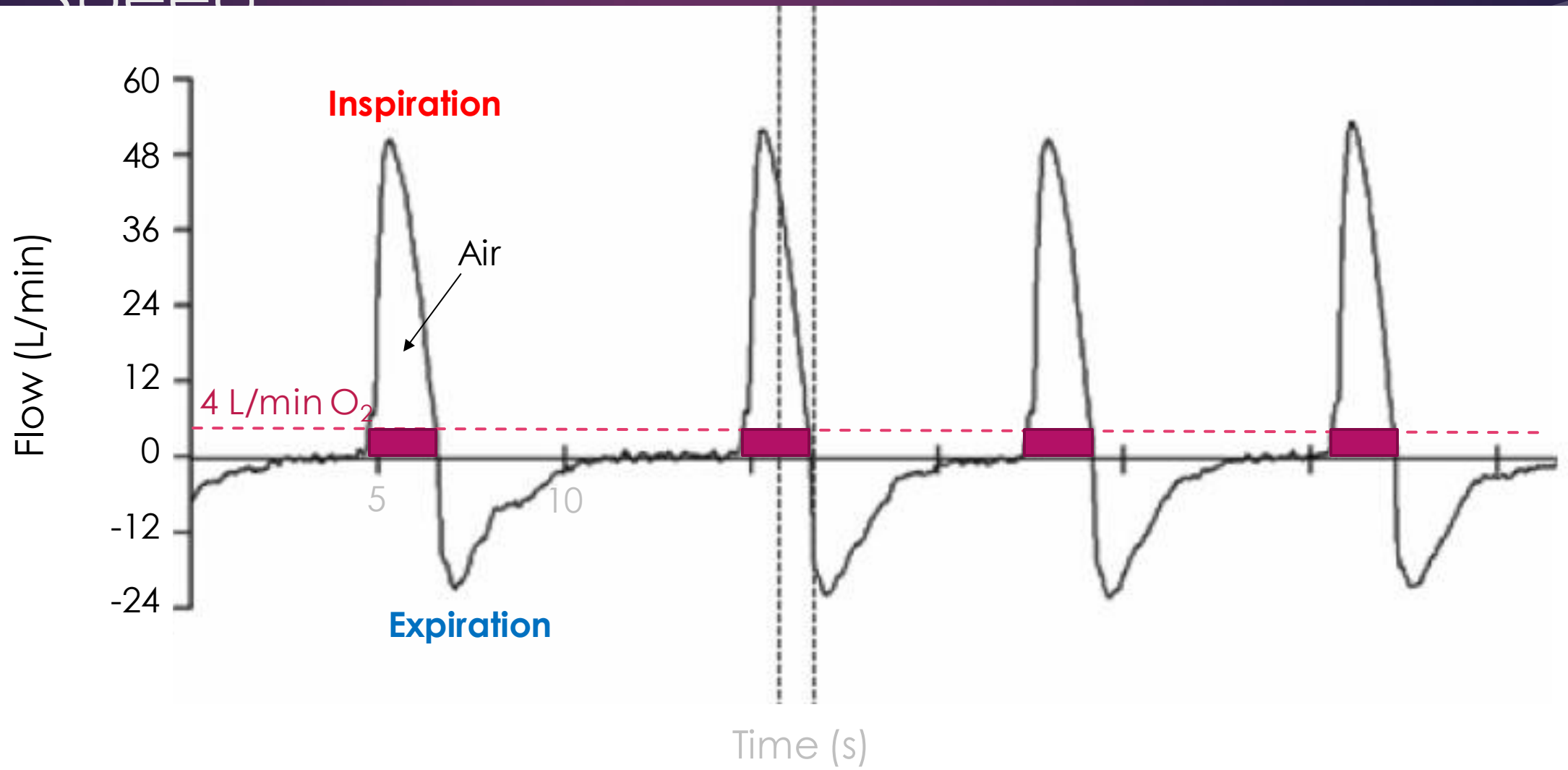
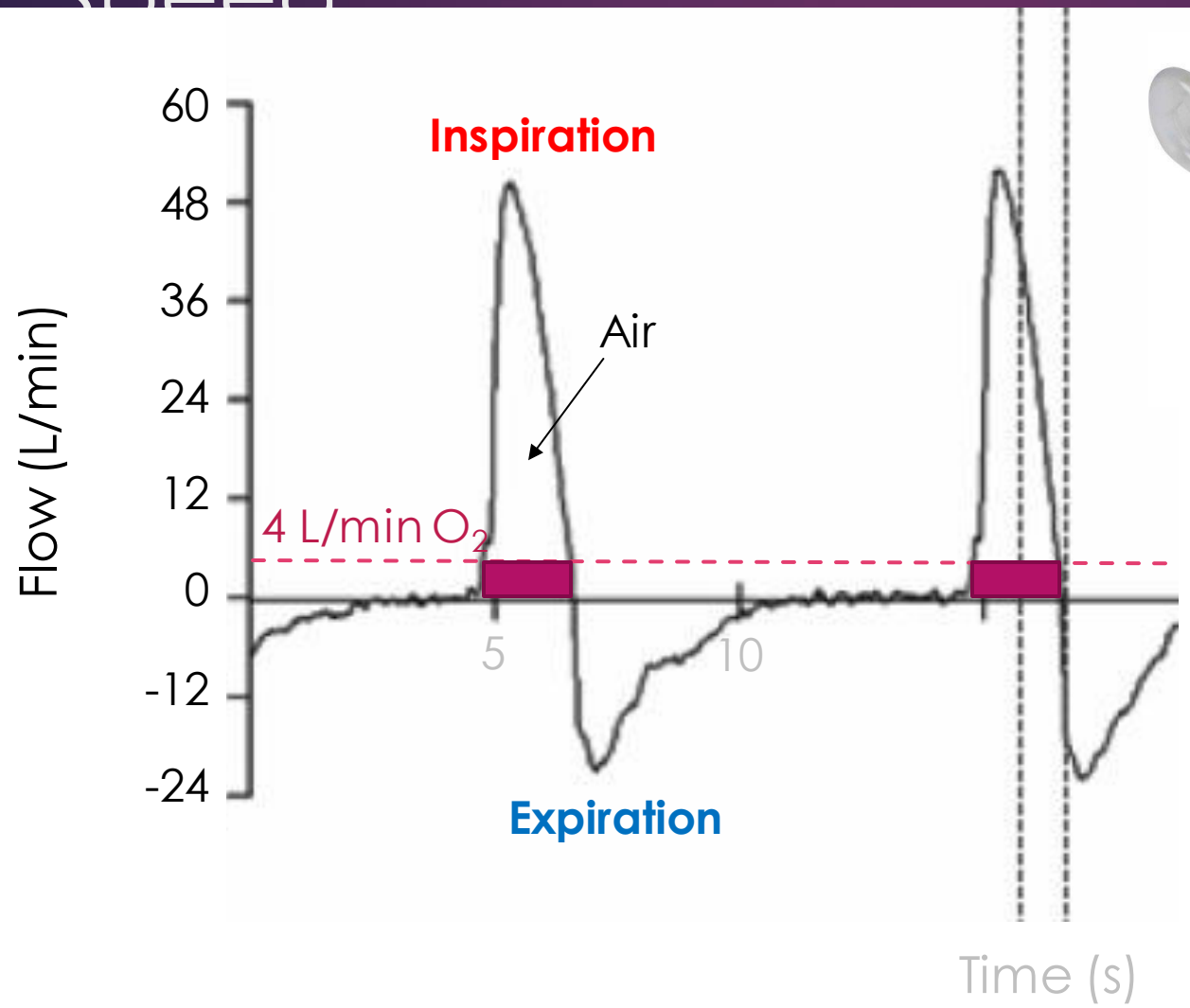


Spontaneous Breathing – Air Flow Speed



Oxygen devices

- Nasal prongs
- Simple mask
- Nonrebreather
- Noninvasive ventilation
- Invasive ventilation
- Oxygen concentrators

Nasal prongs + Oxymizer

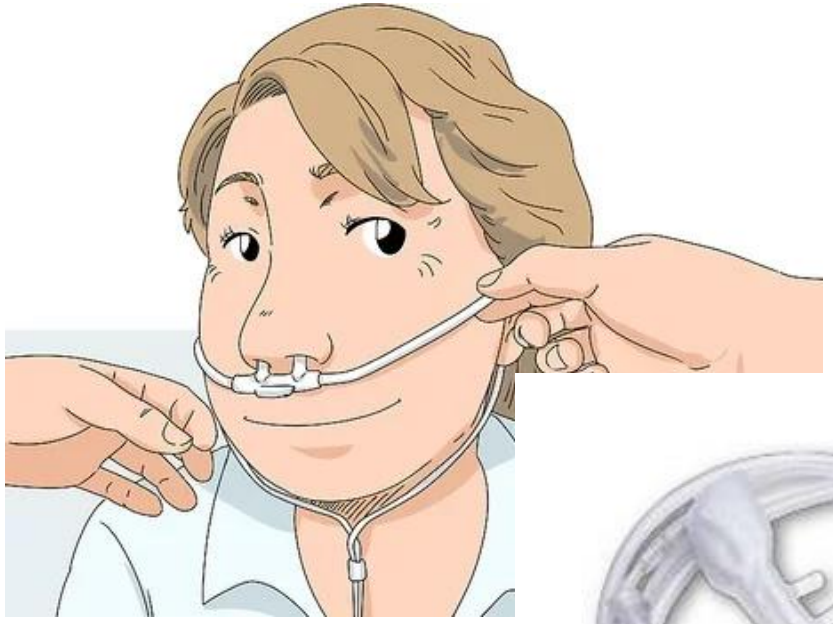
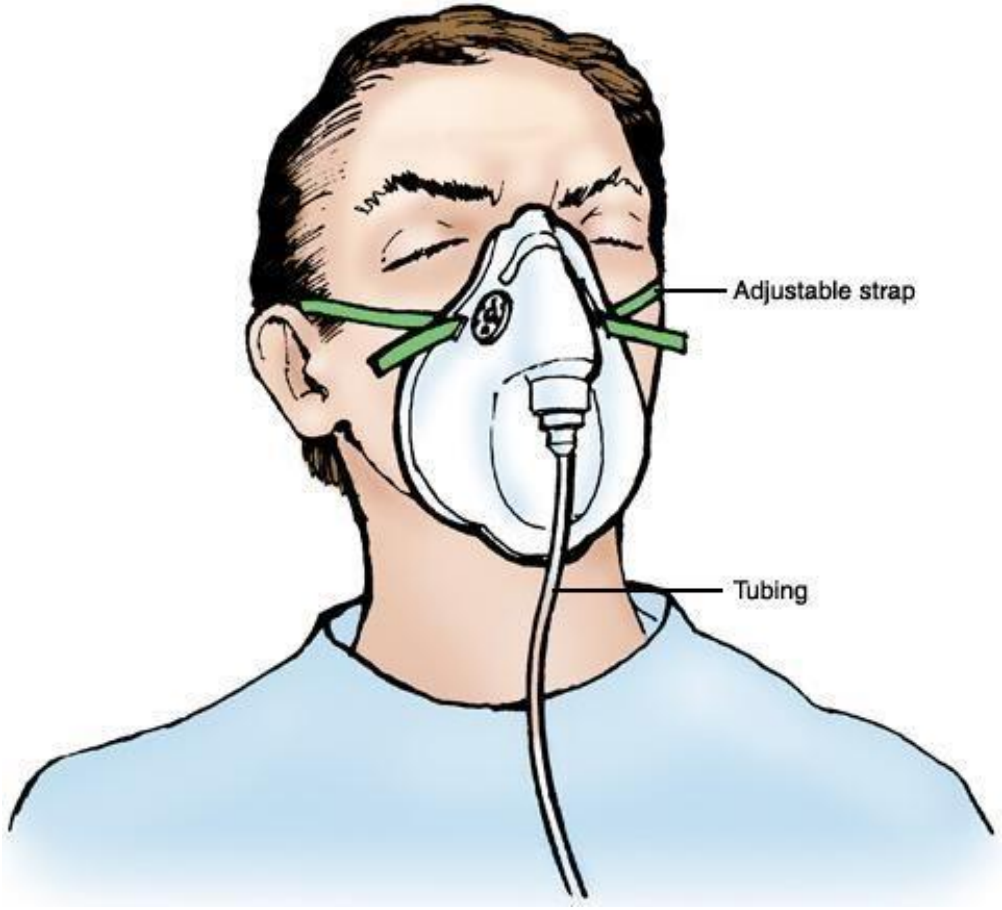


Table 1 Comparison of oxygen delivery by standard cannula versus reservoir cannula

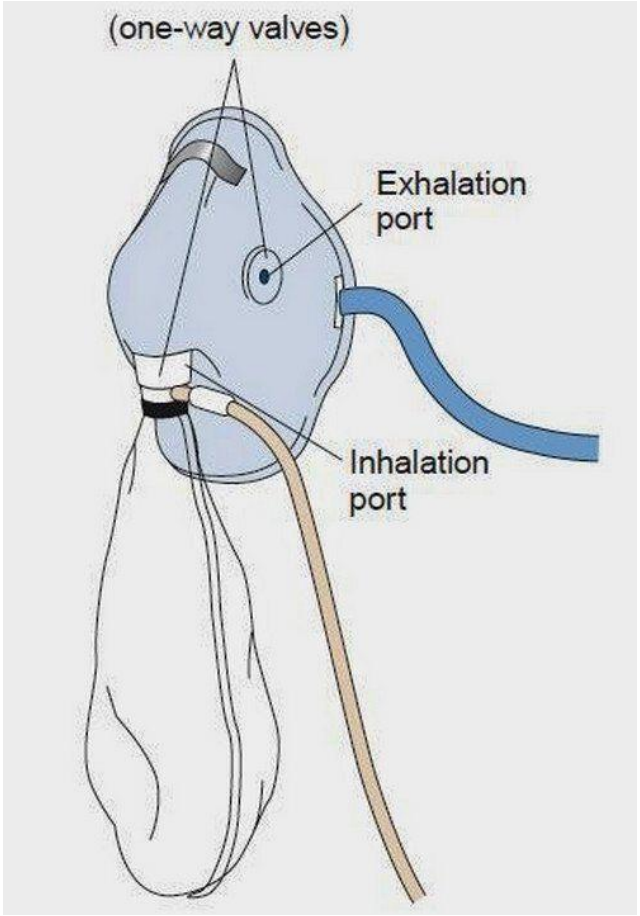
	Flow, L/min								
Parameter	**Air**	**0.5**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Fraction of inspired oxygen delivered via									
Standard cannula	0.21	0.23	0.24	0.28	0.31	0.34	0.37	0.41	0.44
Reservoir cannula	0.21	0.29	0.31	0.35	0.38	0.41	0.45	0.48	0.51
Savings ratio	4:1	3:1	2:1	1.7:1	1.5:1	1.4:1	1.3:1	ND	ND
Percent savings	75	67	50	41	33	29	23	ND	ND

*Calculations are based on a respiratory rate of 20 breaths/min and an inspiratory to expiratory ratio of 1:2. Values through 2 L/min have been experimentally confirmed.[7] ND indicates not determined.

Simple mask

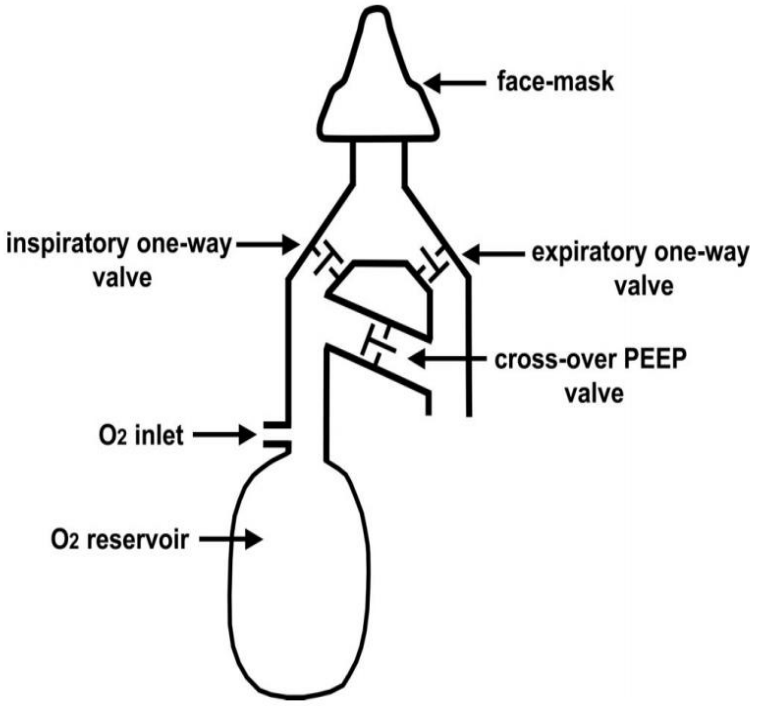


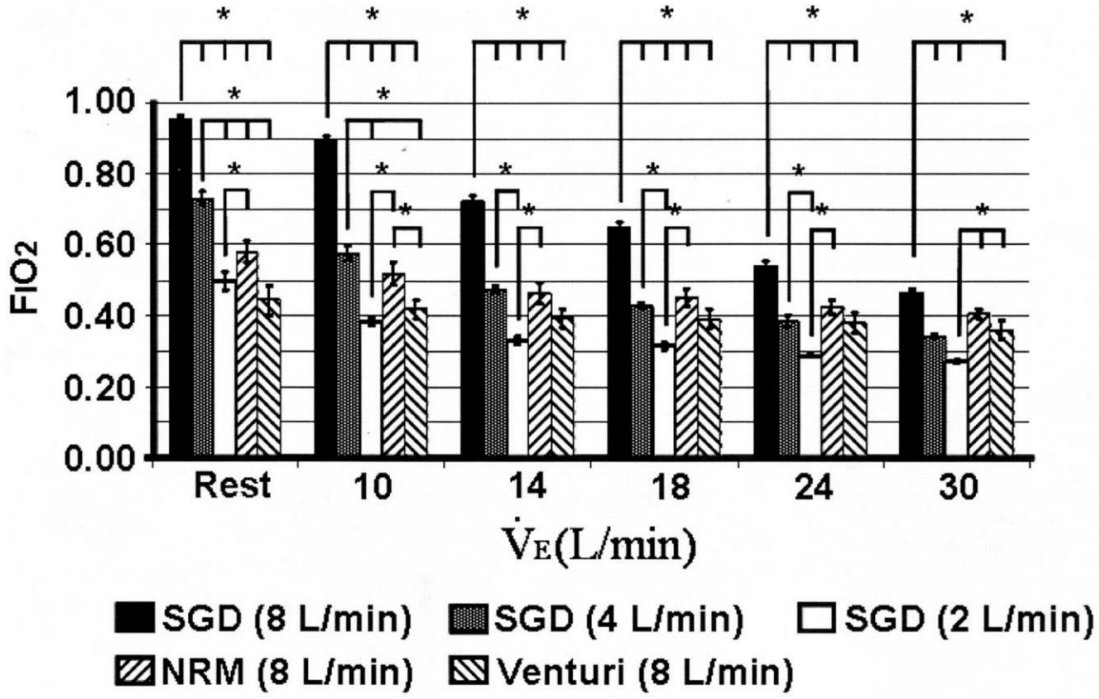
Nonrebreather



Tavish Non-rebreather
(Respan Co.)

Sequential Gas Delivery Mask (Hi-Ox™)





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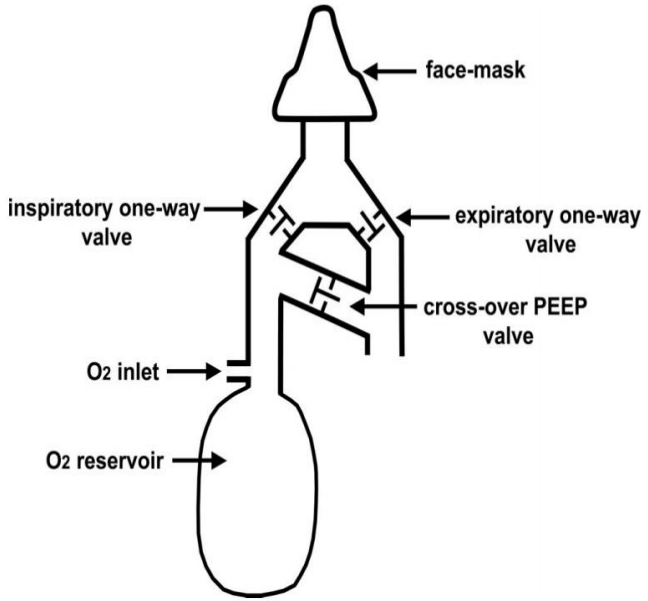
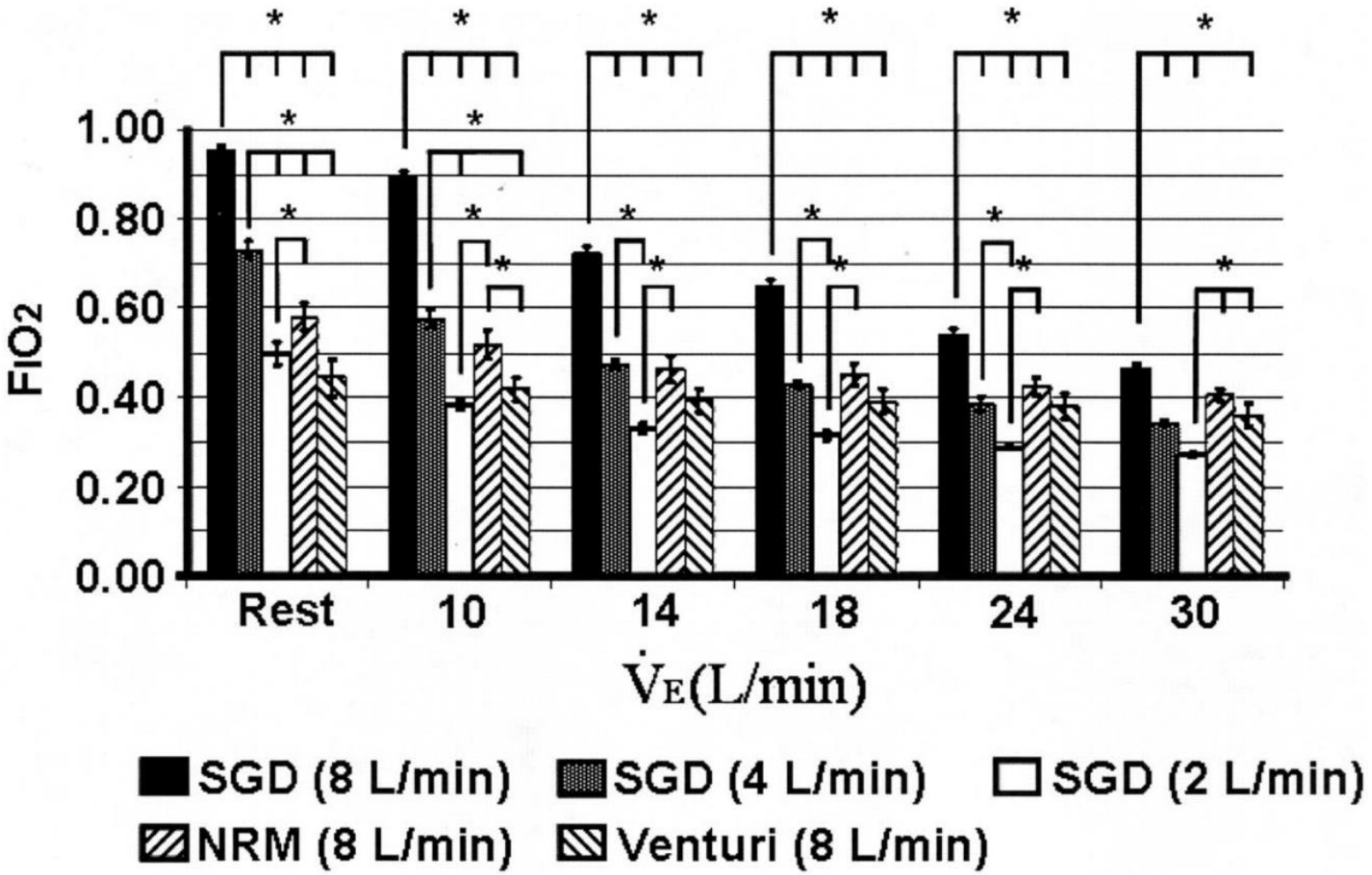
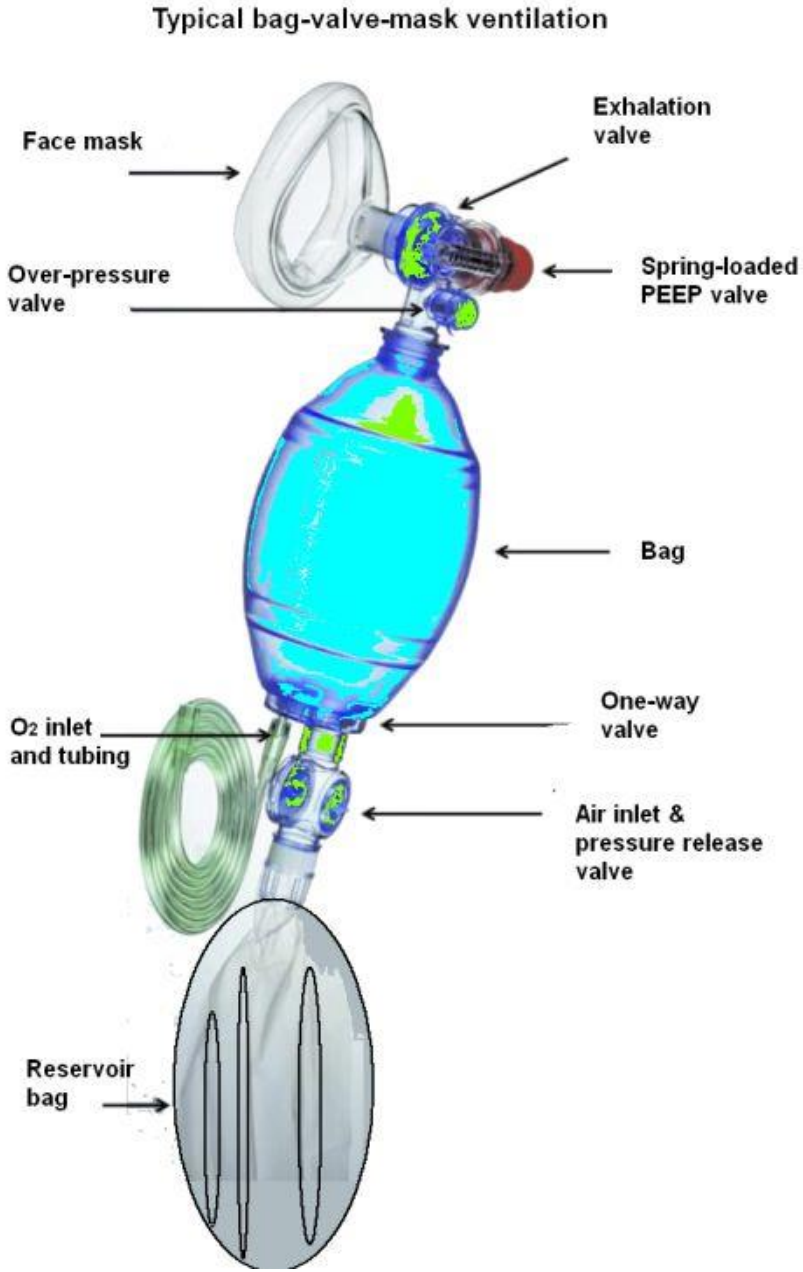




Slessarev et al. Crit Care Med. 2006
doi: 10.1097/01.CCM.0000201877.82049.C3.
PMID: 16505664.

Bag Valve Mask



High Flow Nasal Cannula – Adds pressure (CPAP) not just Oxygen BUT …

H: Humidified

I: Inspiratory Flow matching

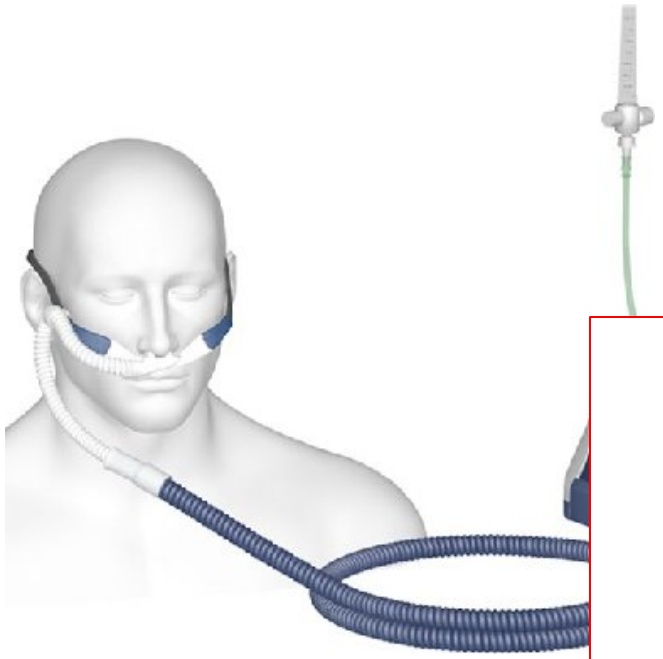
F: Improved FRC (10Lpm ~1cmH_2O PEEP)

L: Lighter than Cpap mask

O: oxygenation up to FiO2 100%

W: Wash out dead space

High Flow Nasal Cannula – Adds pressure (CPAP) not just Oxygen BUT …



H: Humidified

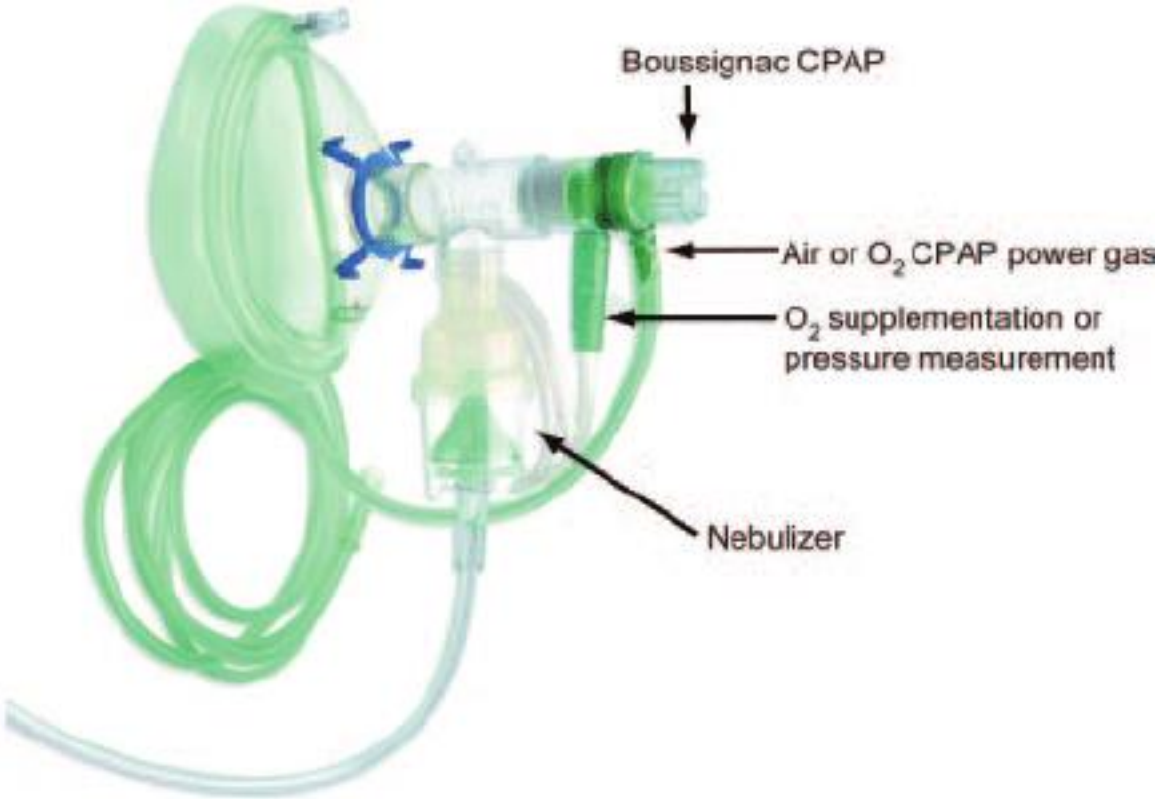
I: Inspiratory Flow matching

F: Improved FRC (10Lpm ~1cmH_2O PEEP)

L: Lighter than Cpap mask

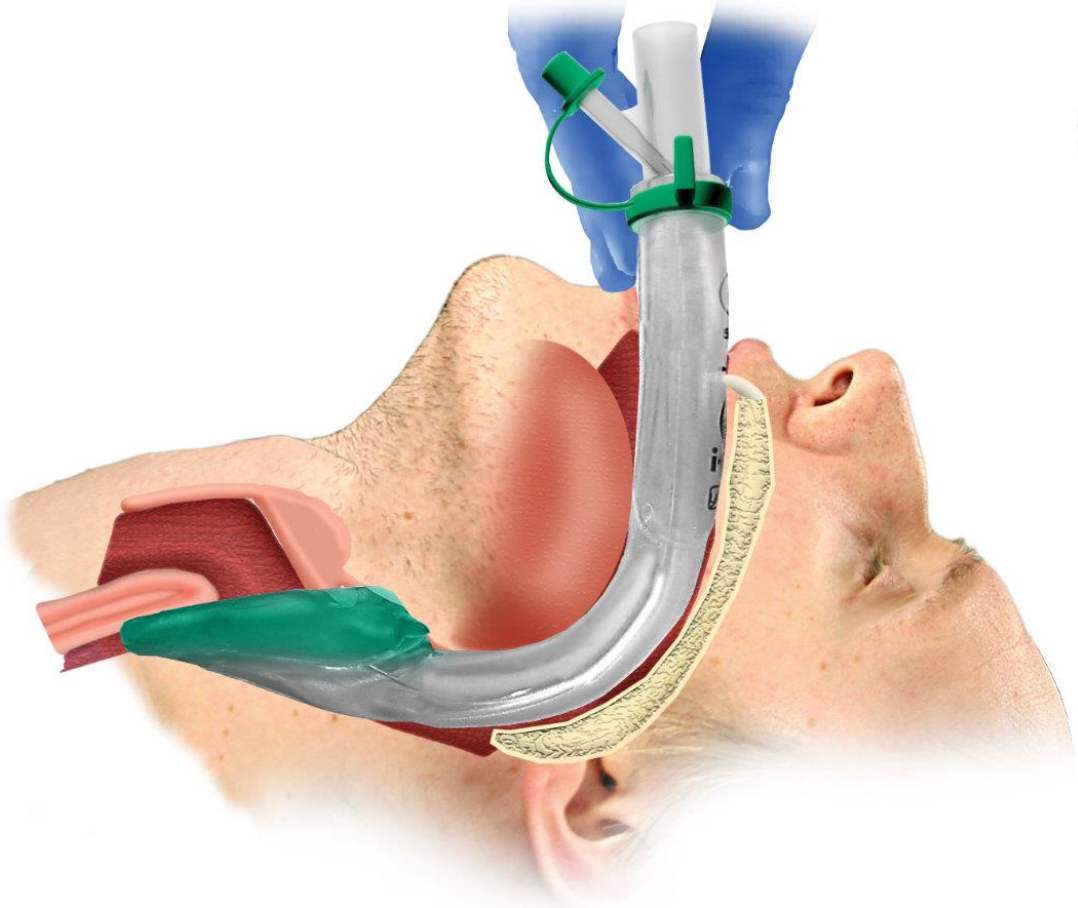
USES
LOTS & LOTS
OF OXYGEN

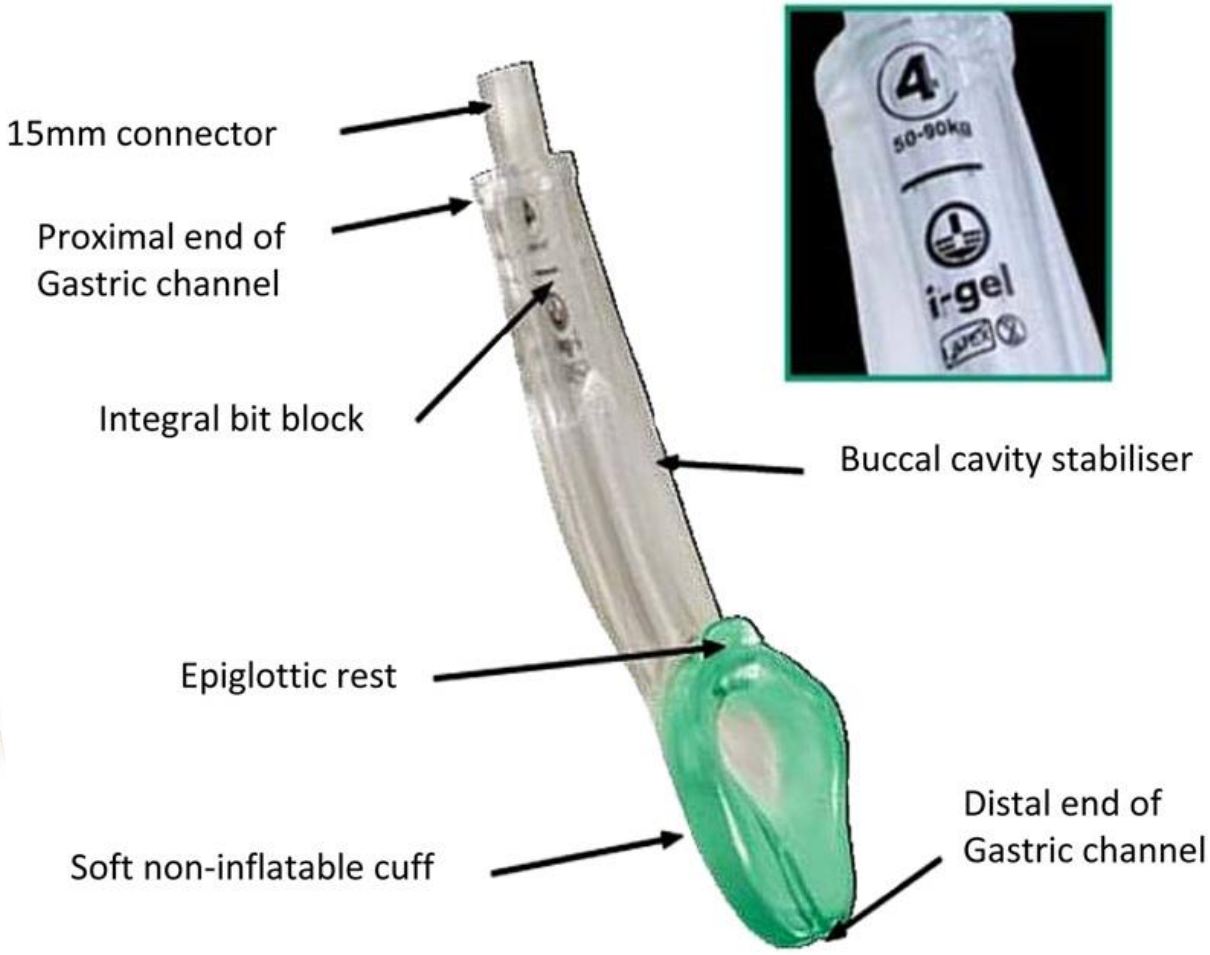
Non invasive



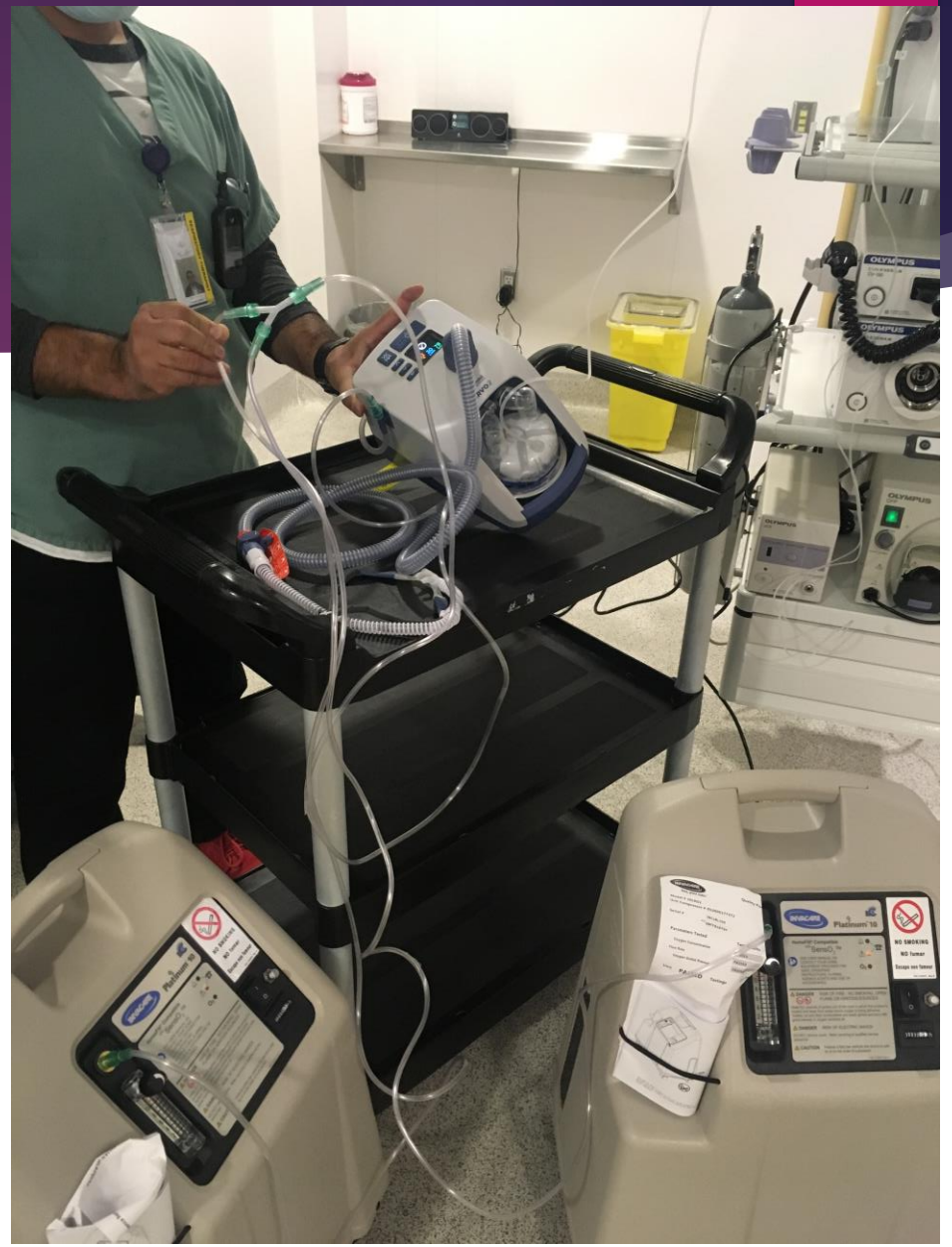
Non invasive- Bipap (coming soon?)

Invasive Ventilation





Oxygen Concentrators



Acknowlegements/ Resources

- All photos taken from internet google searches or used with permission of involved persons
- Newer OXYGEN DELIVERY METHODS in Northern Nursing Stations/Health Centres- PDF
- COVID-19 Northern Ontario Nursing Station Triage Guideline, J. Butt MD Candidate, O. Lovrics MD Candidate,M. Kirlew MD, and M. Koval MD: FIRST EDITION Updated: 22-04-2020
- Virology, transmission, and pathogenesis of SARS-CoV-2, Muge Cevik, , Krutika Kuppalli, Jason Kindrachuk, Malik Peiris; BMJ 2020;371:m3862 | doi: 10.1136/bmj.m3862
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- Public health Ontario: https://www.publichealthontario.ca/-/media/documents/ncov/ipac/report-covid-19-aerosol-generation-coughs-sneezes.pdf?la=en
- Classification of Aerosol-Generating Procedures: A Rapid Systematic Review Online Appendices Jackson T, et al. BMJ Open Resp Res 2020; 7:e000730. doi: 10.1136/bmjresp-2020-000730: file:///Users/corymcfarlane/Downloads/bmjresp-2020-October-7-1--inline-supplementary-material-1%20(1).pdf