Ontario Critical Care Clinical Practice Rounds (OC3PR): COVID-19

November 26 2020

Respiratory Management Pre-Intubation

Chaired by Dr. Dave Neilipovitz

Presenter Dr. Stephen Lapinsky

Meeting Etiquette

- Due to attendee numbers, participants will be muted and are encouraged to use the chat function to submit questions during the allocated Q&A time.
- Participants will be able to submit questions to the hosts only.
- The chat will be opened to all participants for the last 5 mins for networking.

Hosted by

CCSO | SMPCO

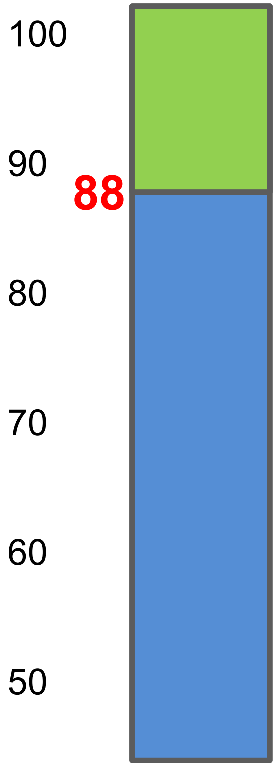
Respiratory management pre-intubation in COVID-19

Stephen Lapinsky

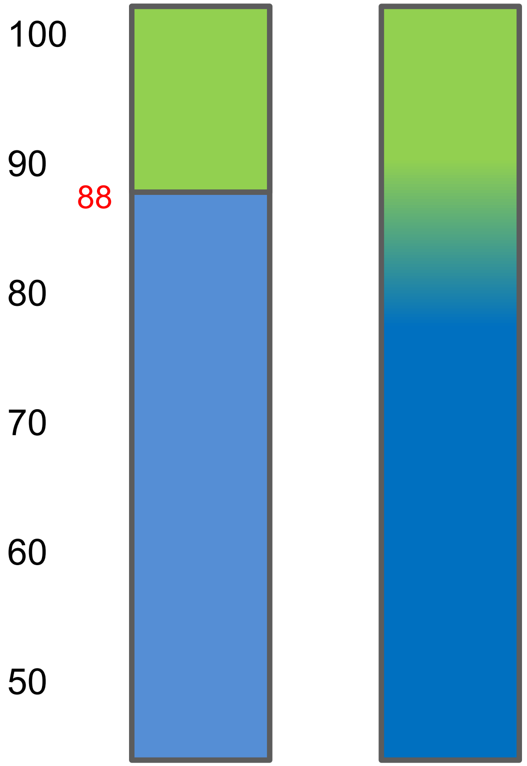
Outline

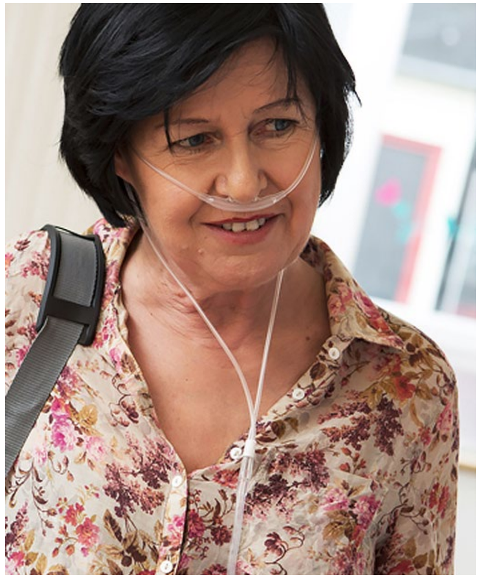
- Oxygen & hypoxemia
- Airborne transmission of virus
- Modes of oxygen therapy
- HFNO & NIV
- Decision to intubate

Hypoxia – how low can you go?



Hypoxia – how low can you go?





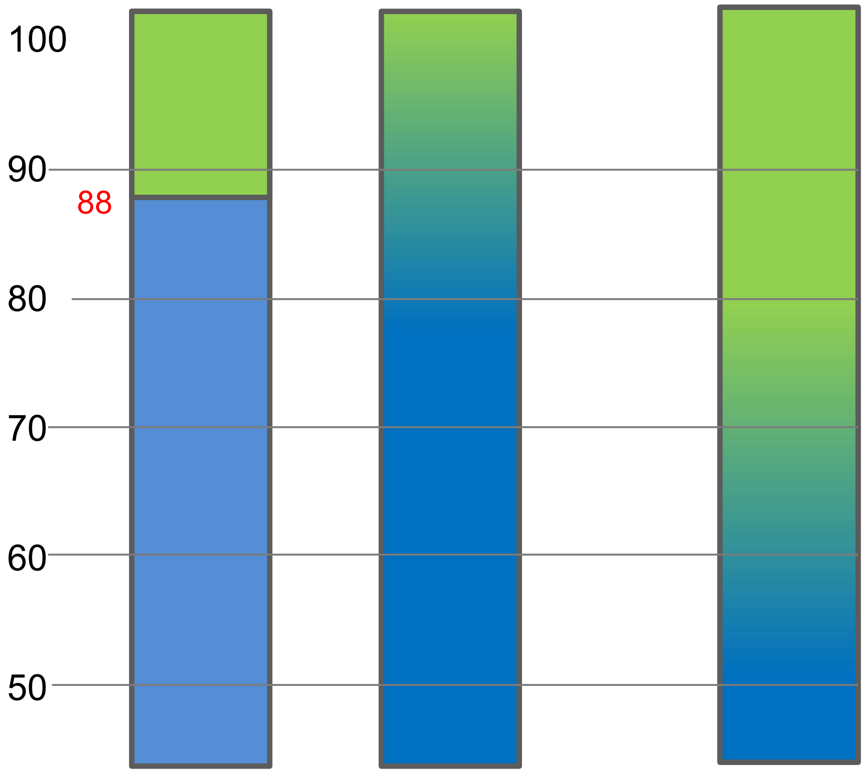
The Lancet · Saturday 28 March 1981

LONG TERM DOMICILIARY OXYGEN THERAPY IN CHRONIC HYPOXIC COR PULMONALE COMPLICATING CHRONIC BRONCHITIS AND EMPHYSEMA

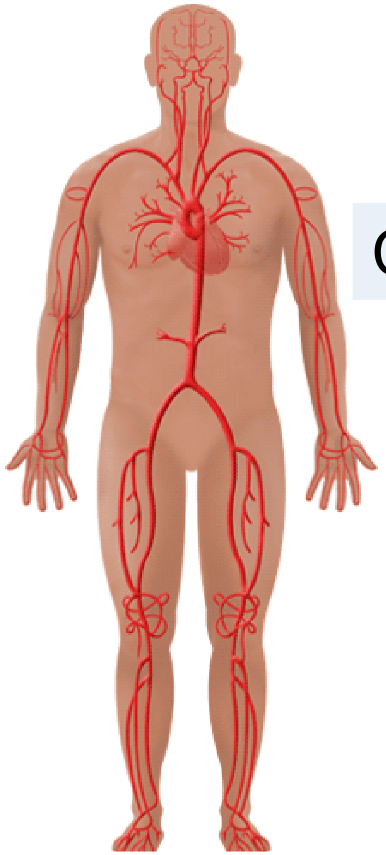
Report of the Medical Research Council Working Party*

over a long period by domiciliary oxygen therapy reduces pulmonary hypertension[9-14] and secondary polycythaemia[9-14] in these patients, but the value of this treatment has not so far been assessed by a controlled clinical trial. In 1973 the Medical Research Council set up in the U.K. a multicentre controlled trial of long term oxygen therapy in such patients

Hypoxia – how low can you go?



Oxygen delivery =



Cardiac output

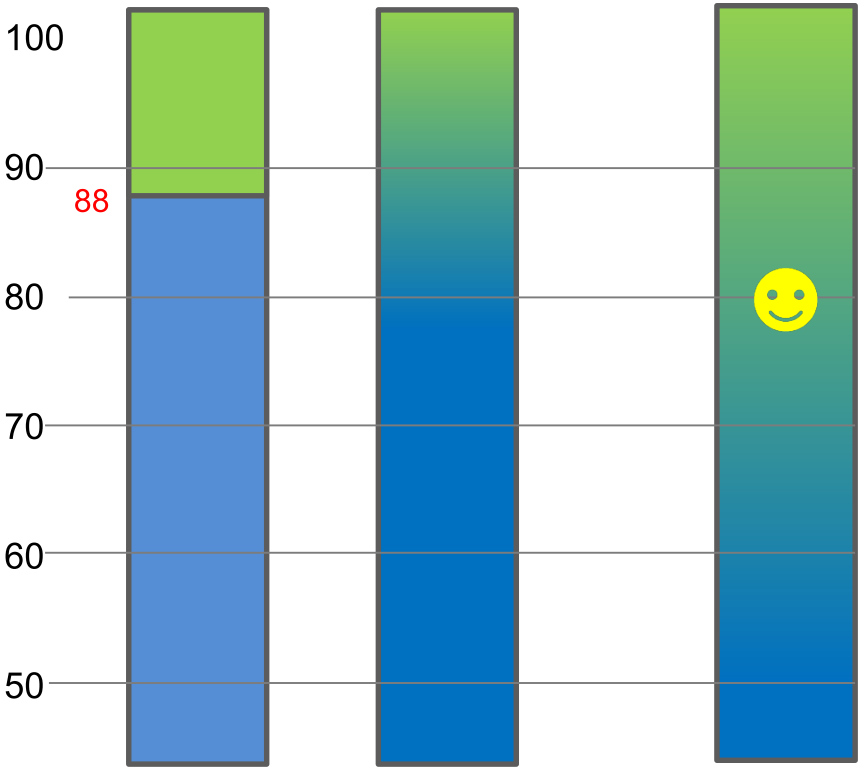
x

Hemogobin

x

SaO_2

Hypoxia – how low can you go?



Oxygen delivery =

Cardiac output

x

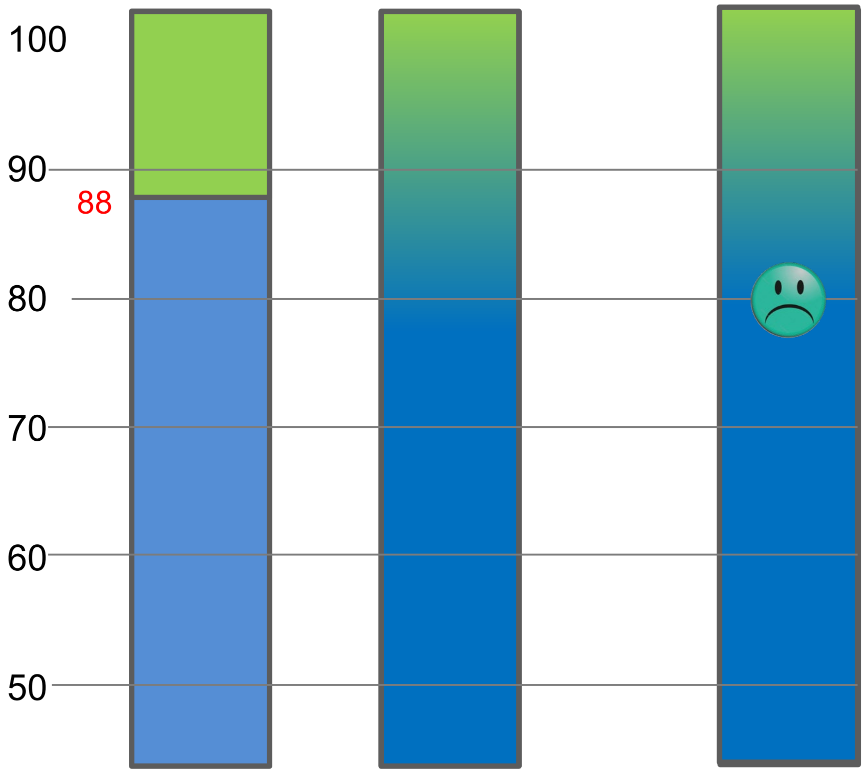
Hemogobin

x

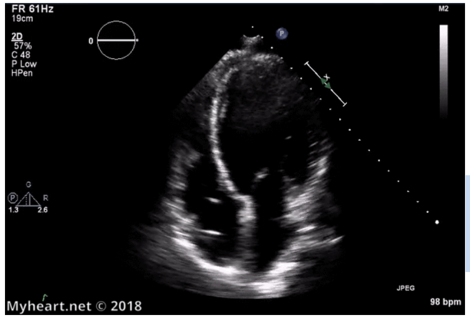
SaO_2

Cardiovascular compensation

Hypoxia – how low can you go?



Oxygen delivery =



Cardiac output

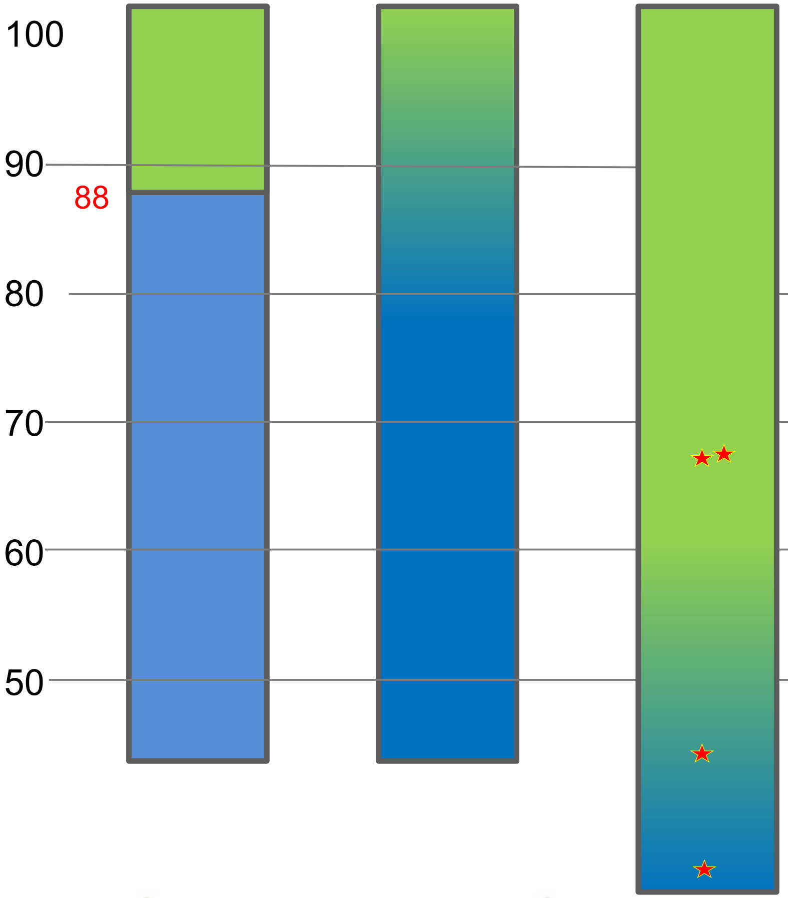
x

Hemogobin

x

SaO_2

Hypoxia – how low can you go?

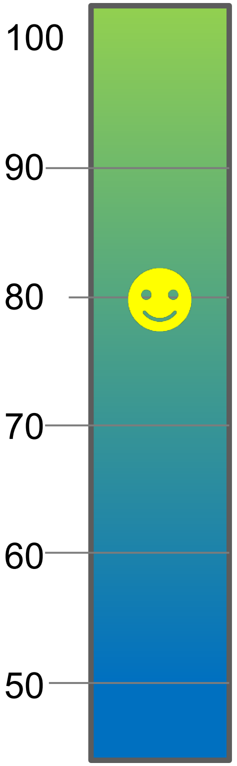


Variable	Subject No. 1	2	3	4
pH	7.55	7.45	7.52	7.60
PaO_2 (mm Hg)†	29.5	19.1	21.0	28.7
$PaCO_2$ (mm Hg)†	12.3	15.7	15.0	10.3
Bicarbonate (mmol/liter)‡	10.5	10.67	11.97	9.87
Base excess of blood‡	–6.3	–9.16	–6.39	–5.71
Lactate concentration (mmol/liter)	2.0	2.0	2.9	1.8
SaO_2 (%)‡	68.1	34.4	43.7	69.7
Hemoglobin (g/dl)§	20.2	18.7	18.8	19.4
Respiratory exchange ratio¶	0.81	0.74‖	0.72	0.70
P_AO_2 — mm Hg†**	32.4	26.9	27.4	33.2

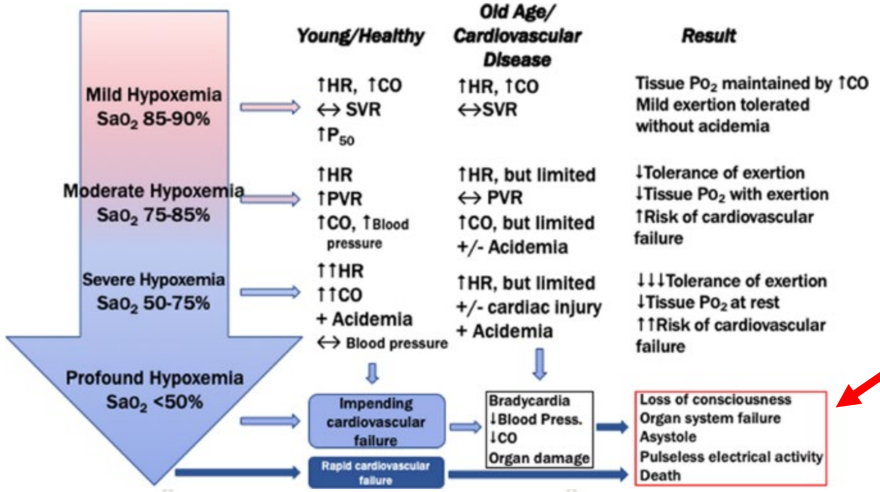
Grocott et al, N Engl J Med 2009; 360:140

Hypoxia – how low can you go?

“**Happy hypoxia**”



- Hypoxemia as a stimulus for drive to breathe:
  - variable response
  - hypoxic ventilation decline (loss of chemoreceptor sensitivity)
- V/Q mismatch & shunt increases hypoxia, not hypercapnia
- Hypocapnia decreases drive to breathe
- Good lung compliance reduces work of breathing



CV decompensation can occur suddenly

Tobin et al. Respiratory Research; 2020 21:249
Reynolds et al, AJRCCM 2020; 202:1037
Bickler et al. Anesthesiology 2020; Oct 2020
Jounieaux et al. Am J Respir Crit Care Med 2020 Aug 19

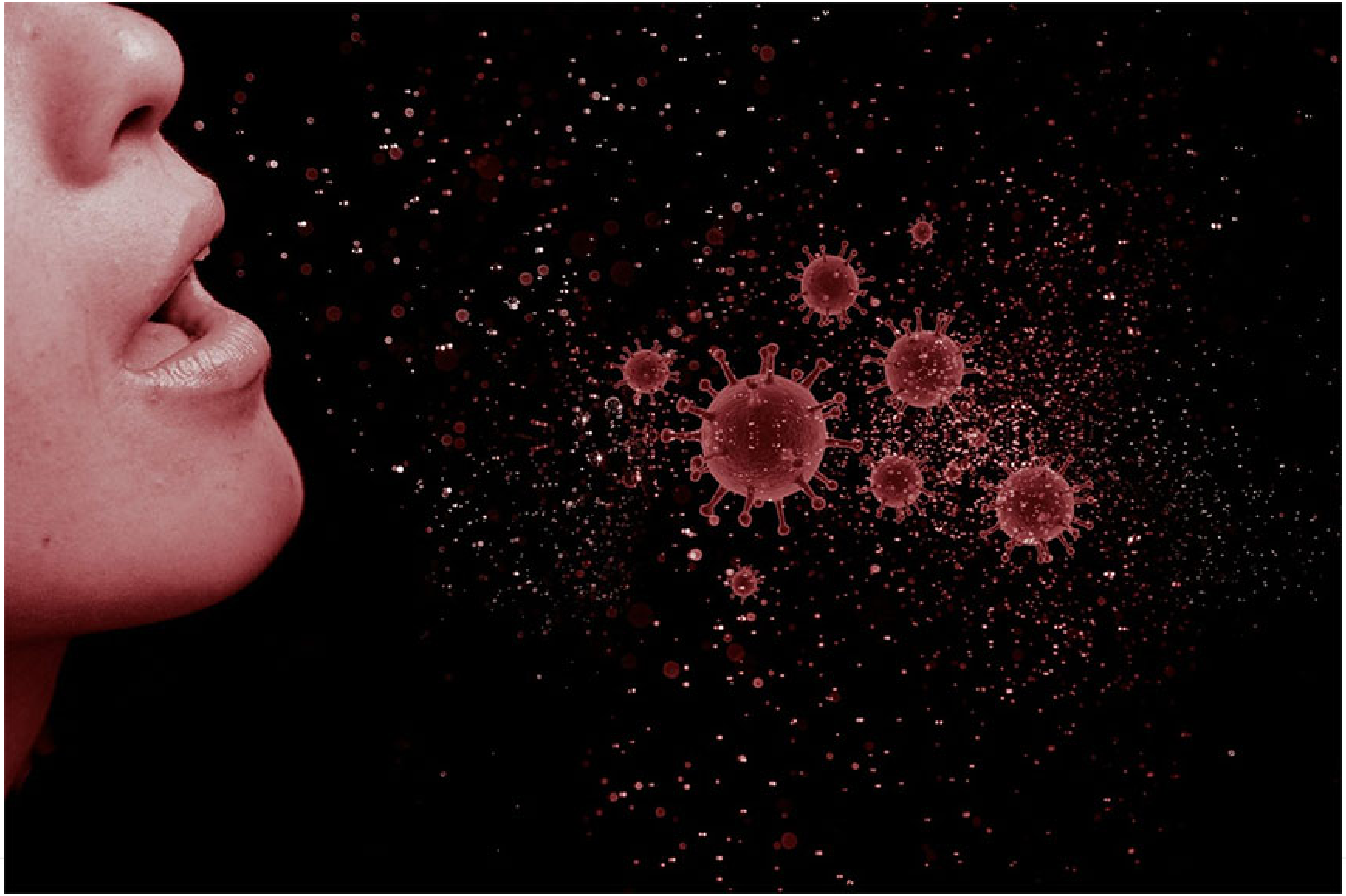
Hypoxia – how low can you go?

Oxygen saturation < 88% should not be a dichotomous cutoff

Even lower may be tolerated:

- individualize
- assess the patient:
  - respiratory rate
  - accessory muscle use
  - diaphoresis
  - hemodynamics
  - level of consciousness

“Aerosol generating procedures”



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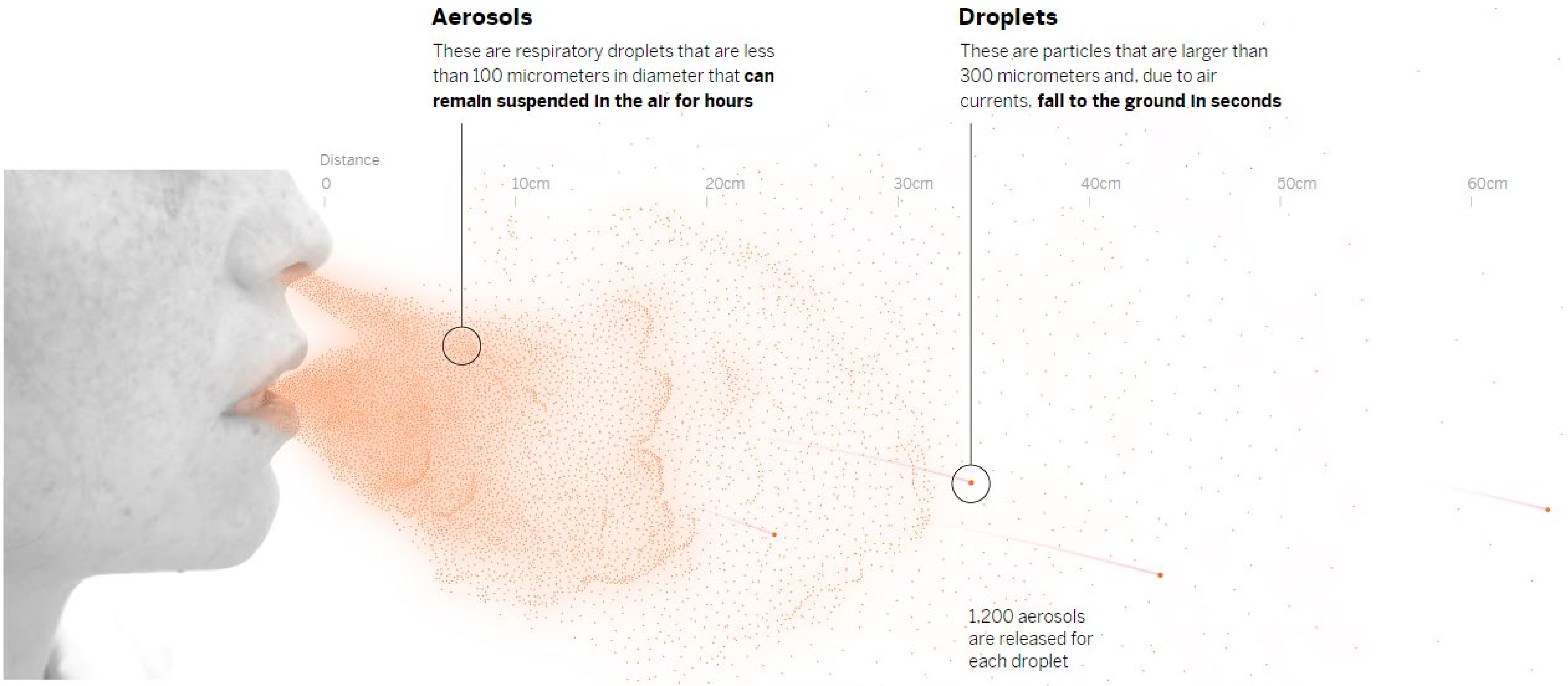


Aerosols, droplet and exhaled particles

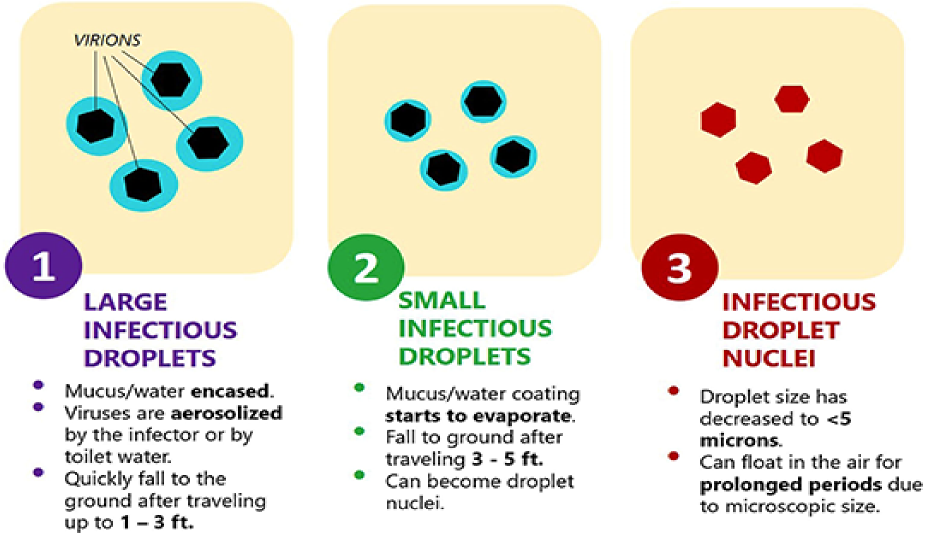
Particles emitted by breathing, coughing and respiratory devices:

- A spectrum from small to large, with evaporation, large become small

- Particle size remaining suspended ("aerosols"): varies from 5 μm to 100 μm

- concentration of particles decreases with distance from source

- air movement & ventilation affects small droplets more than large



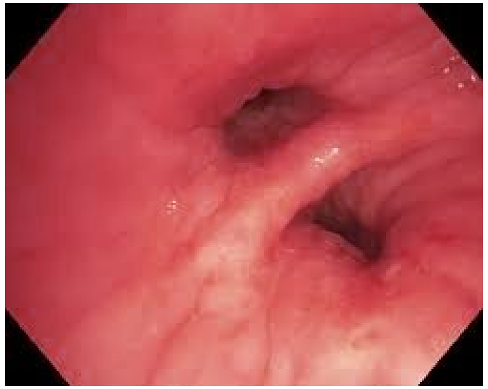
Airborne respiratory viral particle formation

Mechanisms:

1. Open-close cycling of glottic structures
2. Shearing forces due to high velocity gas flow
3. Open-close cycling of terminal bronchioles

Contributing factors:

- Inflamed mucosa
- Turbulent flow
- Airway collapse
- Coughing



Wilson et al. Anaesthesia 2020; 75(8):1086

Aerosols, droplet and disease transmission

Inhalation of small particles is more likely than larger particles *Li et al 2020*

SARS-CoV-2 in aerosols remains infectious for up to 3 hr *Von Doremalen et al NEJM 2020, 382, 1564*

In a hospital room scenario, infectious aerosols found 4.8m away *Lednicky et al 2020*

Ventilation dilutes out suspended particles:

Room Air Exchanges per hour (ACH) is an important measure

Time (min) to achieve clearance

	ACH	90% EFFICIENCY	99% EFFICIENCY	99.9% EFFICIENCY
	2	69	138	207
	4	35	69	104
	6	23	46	69
	8	17	35	52
	10	14	28	41
Minimum >	12	12	23	35
Preferred >	15	9	18	28
	20	7	14	21
	50	3	6	8

Modified from Table B.1, CDC Guidelines for Environmental Infection Control in Health-Care Facilities, 2003.[5]

Public Health Agency of Canada's Canadian Tuberculosis Standards, 2007

Aerosol generating procedures?

Main reason for defining AGMP: use of N95 respirator

Rapid systematic review to identify evidence base & consensus:

ICU Procedures	% sources that classified this as AGMP
Intubation/extubation	96
Bronchoscopy	95
Manual ventilation	93
Airway suctioning	89
CPR	89
Noninvasive ventilation	88
HNFO	86
Nebulizer therapy	82
Mechanical ventilation	53

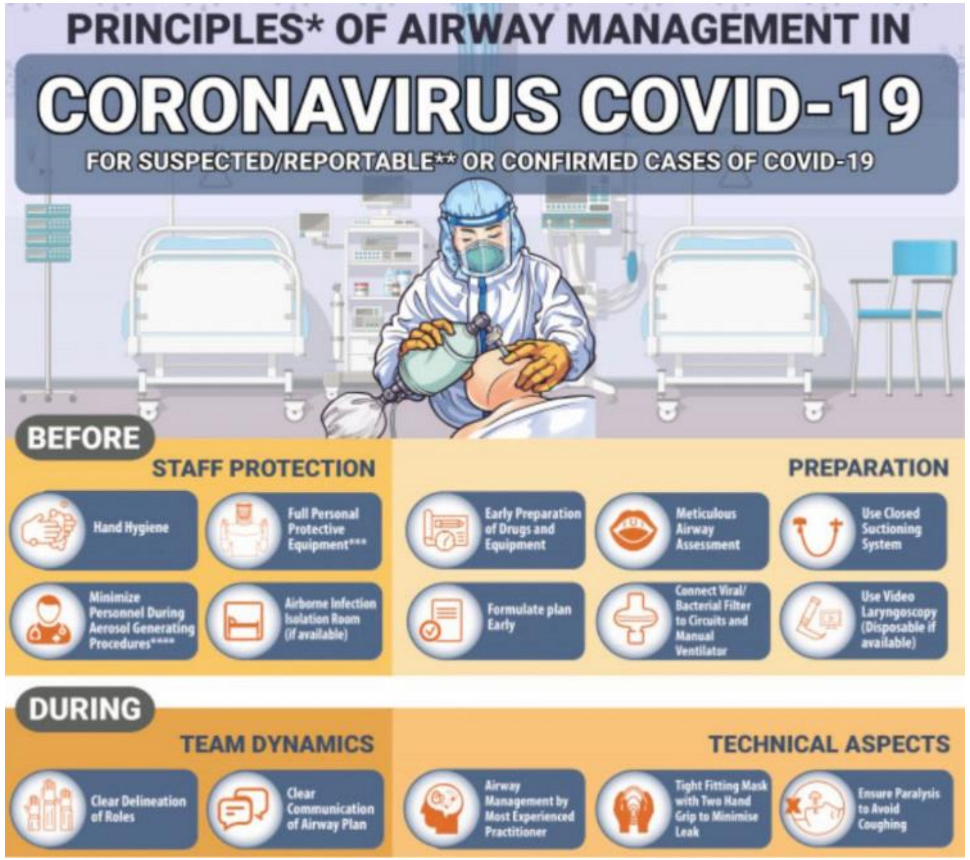
Jackson T, et al. BMJ Open Resp Res 2020;7:e000730.

Table 1 Procedures graded by risk of aerosol generation.

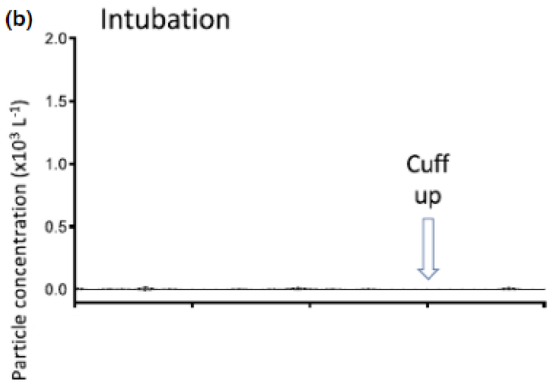
Aerosol generator	Applied physiology	Clinical evidence	Estimated risk of aerosol generation
Bronchoscopy	High airway pressures and distal airway collapse	Increased viral aerosols in H1N1 [35, 47]	Extreme
Percutaneous tracheostomy with bronchoscopy	High airway pressures and distal airway collapse with tracheostomy patent for unfiltered aerosols	Limited	Extreme
Bag-valve mask ventilation	Aerosol generation with high pressures and airway collapse	Associated with HCW transmission of SARS-CoV-1 [2, 4]	Technique-dependent
CPR	Airway collapse, shear forces from CPR, high airway pressures for ventilation	Strongly associated [6]	Extreme
Suctioning	Shear forces from significant negative pressure and flows. Causes coughing	Increased viral aerosols in H1N1 [47]	High
Frequent cough	Natural aerosol generator	Associated with HCW transmission of SARS-CoV-1 [1, 2, 4]	High
Dyspnoeic spontaneous respiration	Likely natural aerosol generator	Association with HCW transmission of SARS-CoV-1 [1, 2, 4]	High
Extubation	High risk due to coughing and distal airway collapse	Not studied	High
Laryngoscopy	Unlikely to cause aerosols per se	None showing rise in viral aerosols. Associated with HCW transmission of SARS-CoV-1 [2, 4]	Dependent on peri-intubation period
Oxygen facemask	De-humidified cold gas could promote viral viability.	Adjustment of mask strongly associated with risk of transmission of SARS-CoV-1 [2–4]. Increased dispersal [24].	High – moderate
High-flow nasal cannula	Possibly reduce viral aerosols through decreased airway collapse and airway pressures. Unsealed circuit	Associated in limited quality studies. Used as part of Chinese COVID-19 protocol. Increased dispersal [53, 55, 56]	High – moderate
Non-invasive ventilation	Possibly reduce viral aerosols through decreased airway collapse and pressures. Sealed mask and circuit beneficial. High positive pressure may lead to leak	Association in limited quality studies. Used safely in small study [3]. Increased dispersal [24].	High – Moderate
Nebulisers	Alter the composition of RTLF and viscosity. Subject-dependent effect (24). Could reduce shear	Associated in low quality studies. Increased dispersal [24].	High – Moderate

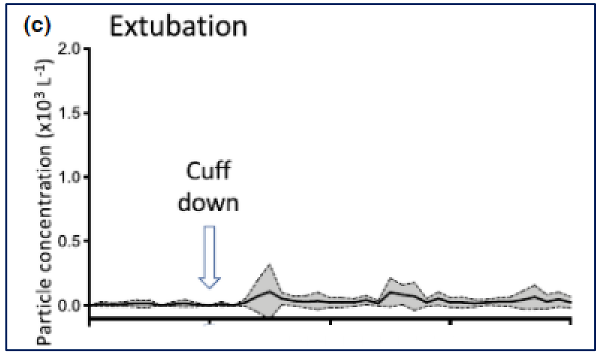
Wilson et al. Anaesthesia 2020; 75(8):1086

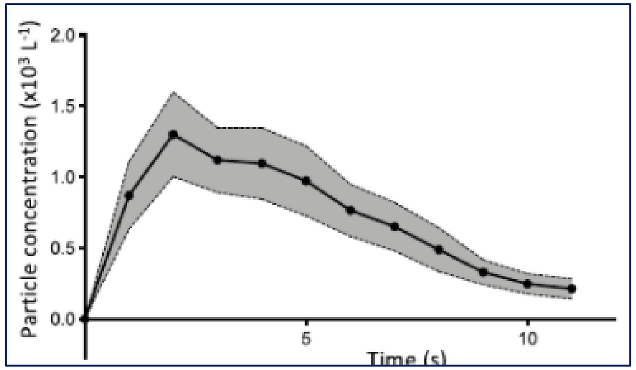
Data versus dogma - intubation



Data versus dogma - intubation





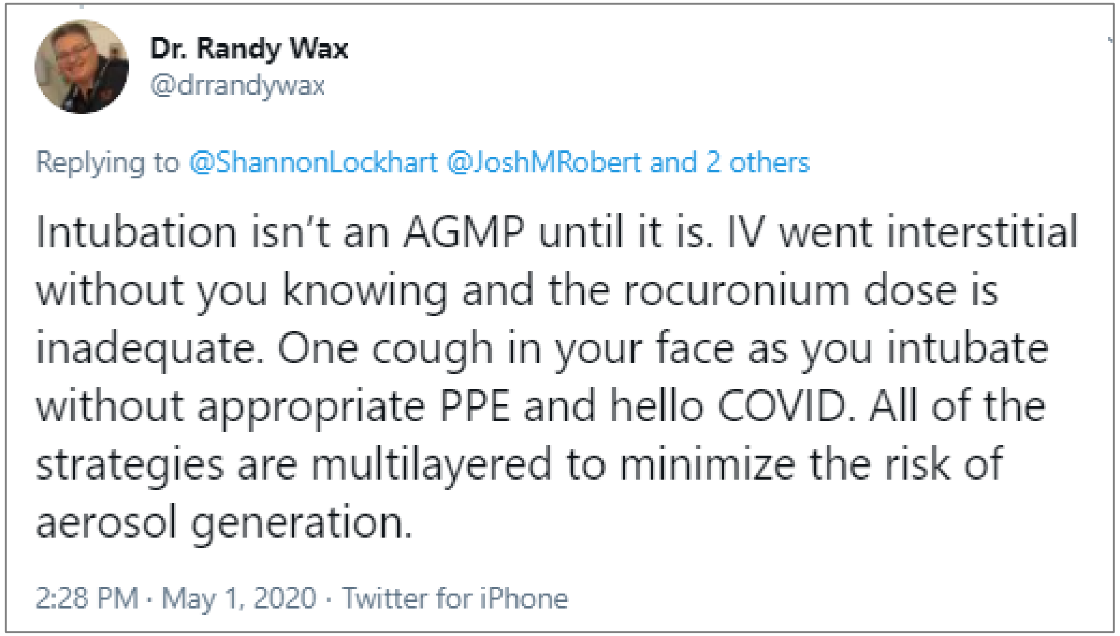


BUT: patients with normal lungs!

Brown et al, Anaesthesia, Oct 6, 2020

~~Data versus dogma~~ - intubation

common sense

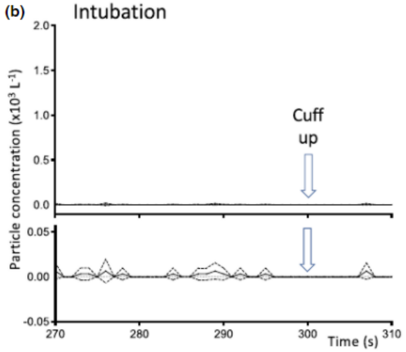


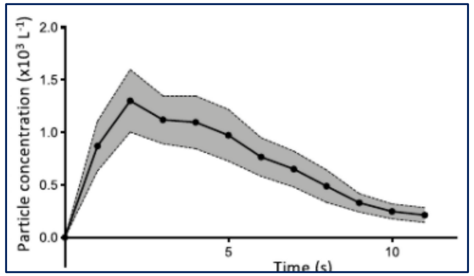
Dr. Randy Wax
@drrandywax

Replying to @ShannonLockhart @JoshMRobert and 2 others

Intubation isn't an AGMP until it is. IV went interstitial without you knowing and the rocuronium dose is inadequate. One cough in your face as you intubate without appropriate PPE and hello COVID. All of the strategies are multilayered to minimize the risk of aerosol generation.

2:28 PM · May 1, 2020 · Twitter for iPhone



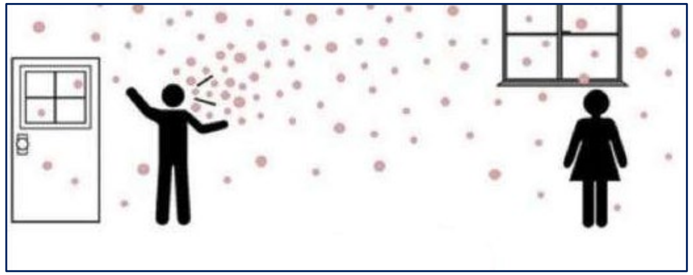


HCW and AGMP – the risk

Contributing factors:

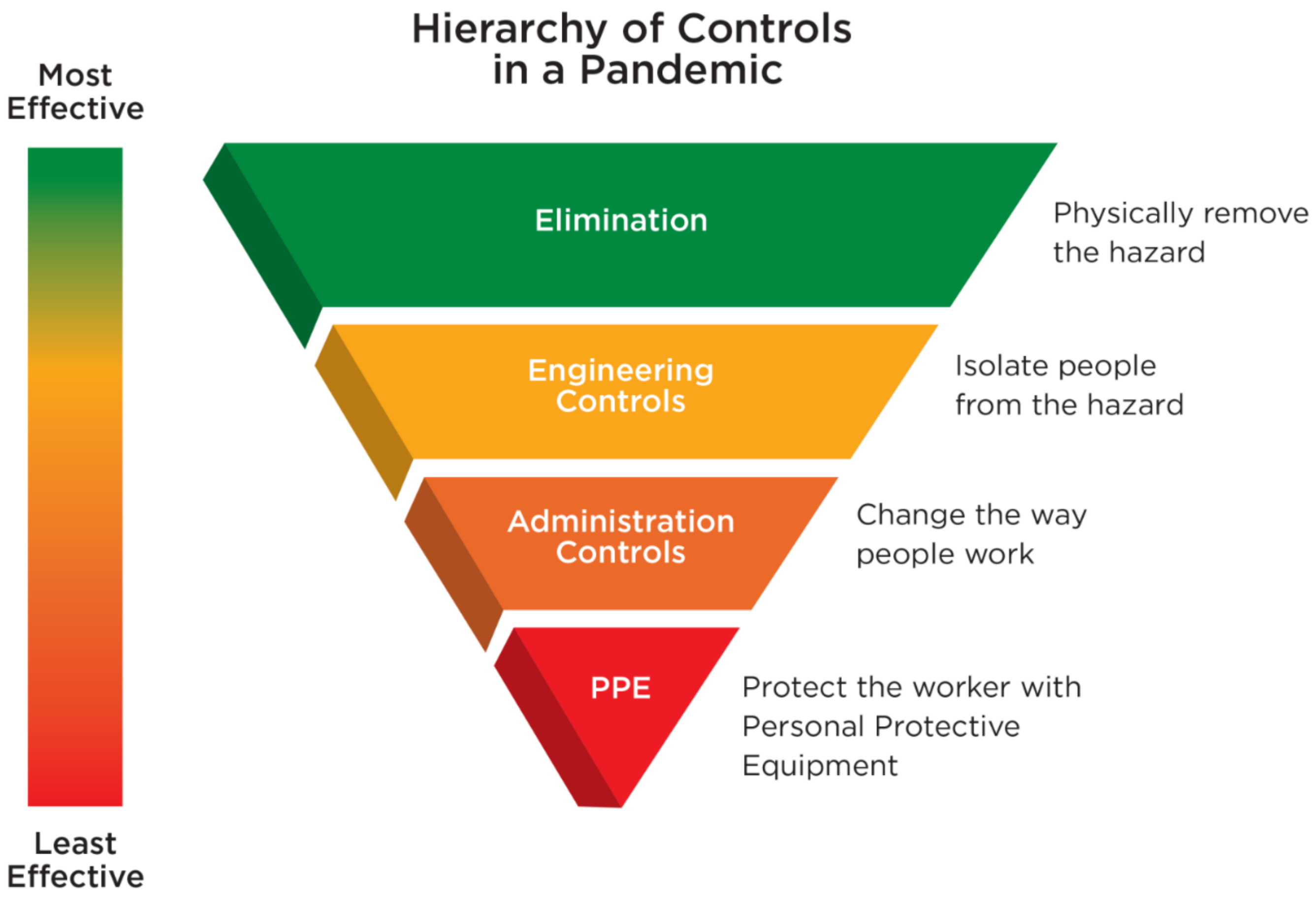
1. Production of aerosol particles – “AGMP?”
2. Distribution and concentration of aerosol particles
3. HCW factors

$$\textbf{HCW risk} \propto \frac{\text{Particle concentration} \times \text{HCW minute ventilation} \times \text{time exposed}}{\text{Mask efficiency}}$$



Wilson et al. Anaesthesia 2020; 75(8):1086

Mitigation strategies



Limit staff in room

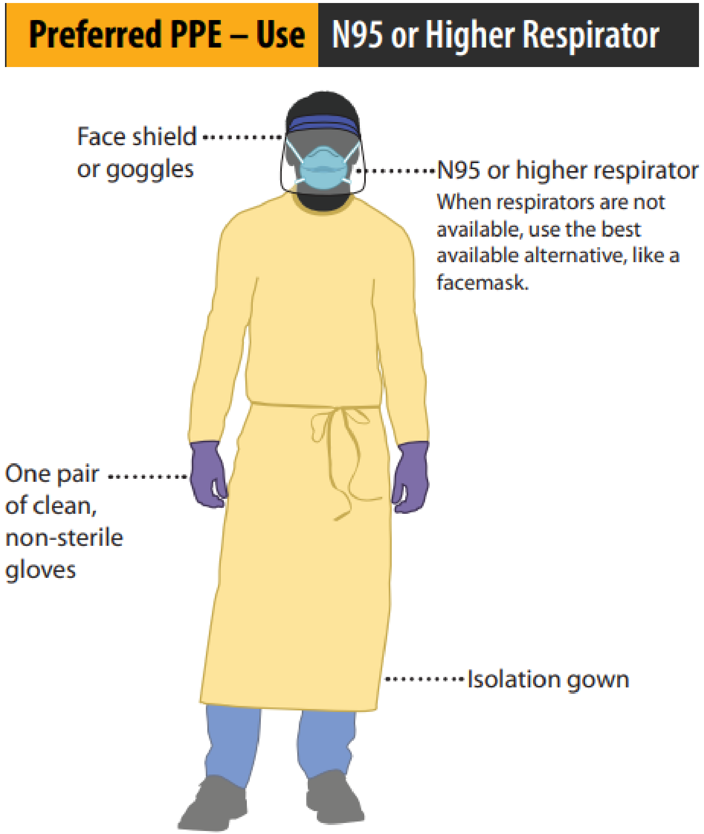
High room air exchanges
Exhalation viral filters

Avoid bag-mask ventilation
RSI for intubation

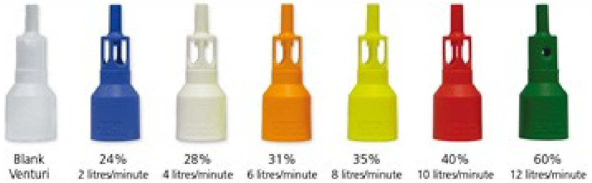
N95 masks

Personal Protective Equipment

- This is the domain of the Infection Control expert
- Hospitals may vary in their approach



Oxygen administration

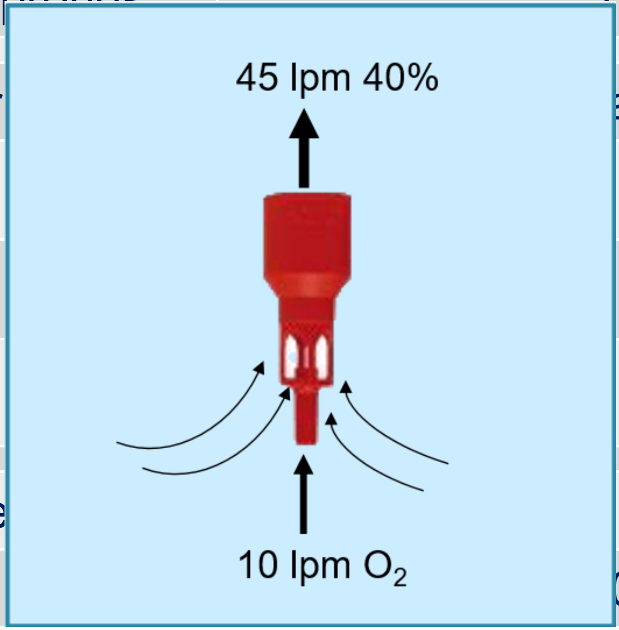


Flow rates

Mechanisms:

1. Open-close cycling of glottic structures
2. **Shearing forces due to high velocity gas flow**
3. Open-close cycling of terminal bronchioles

Device	Flow rate (litre/minute)		AGMP?
Nasal prongs	1 – 10		> 6 LPM?
Ventur	all flow	Total flow	
	4-6	~50	No
	0-12	~45	No
	2-15	~30	No
Non-re	0-15		Yes
HFNO	0 - 60		Yes



Flow rates

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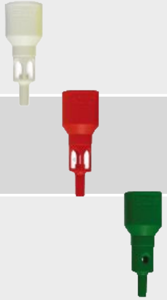
Device	Flow rate (litre/minute)			AGMP?
Nasal prongs	1 – 10			> 6 LPM?
Venturi mask	% O2	Wall flow	Total flow	
	 28	4-6	~50	No
	40	10-12	~45	No
	60	12-15	~30	No
Non-rebreather	10-15			Yes
HFNO	20 - 60			Yes

High Non-rebreather mask

Viral filters

TAVISH MASK

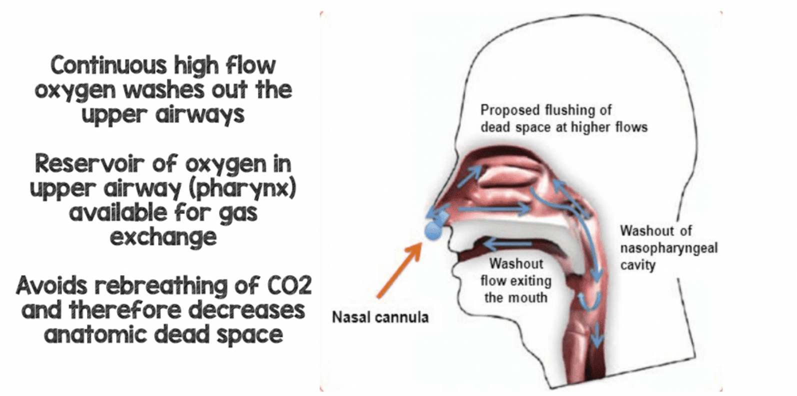
High flow nasal oxygen

Benefits ?
AGMP risk?

High flow nasal oxygen - benefits

1. Comfortable

2. Flush of nasopharynx deadspace CO_2



$\downarrow CO_2 \rightarrow \downarrow$ P-SILI?

3. Positive pressure generated

Table 2. Airway Pressure During Nasal High-Flow Oxygen With the Optiflow System

Flow (L/min)	Mouth Closed ($cm\ H_2O$) mean ± SD	Mouth Open ($cm\ H_2O$) mean ± SD	*P*
30	1.93 ± 1.25	1.03 ± 0.67	.046
40	2.58 ± 1.54	1.30 ± 0.80	.03
50	3.31 ± 1.05	1.73 ± 0.82	< .001

Park et al, Respir Care. 2011;56:1151

High flow nasal oxygen

- Non-COVID acute hypoxemic respiratory failure
- HFNO v. non-rebreather (10L/min) v. NIV (PEEP 2-10, 8hr/d)

Mode	intubation	90d mortality
Standard Oxygen	47%	23%
NIV	50%	28%
HFNO	38%	12%

Frat et al, NEJM 2015; 372:2185

- Systematic review in COVID-19:
  - No studies of COVID-19 patients
  - Low certainty evidence that HNFO may reduce invasive ventilation
  - No difference in mortality or length of stay

Agarwal et al Can J Anesth 2020; 67:1217

High flow nasal oxygen

- **Clinical Practice Guideline**

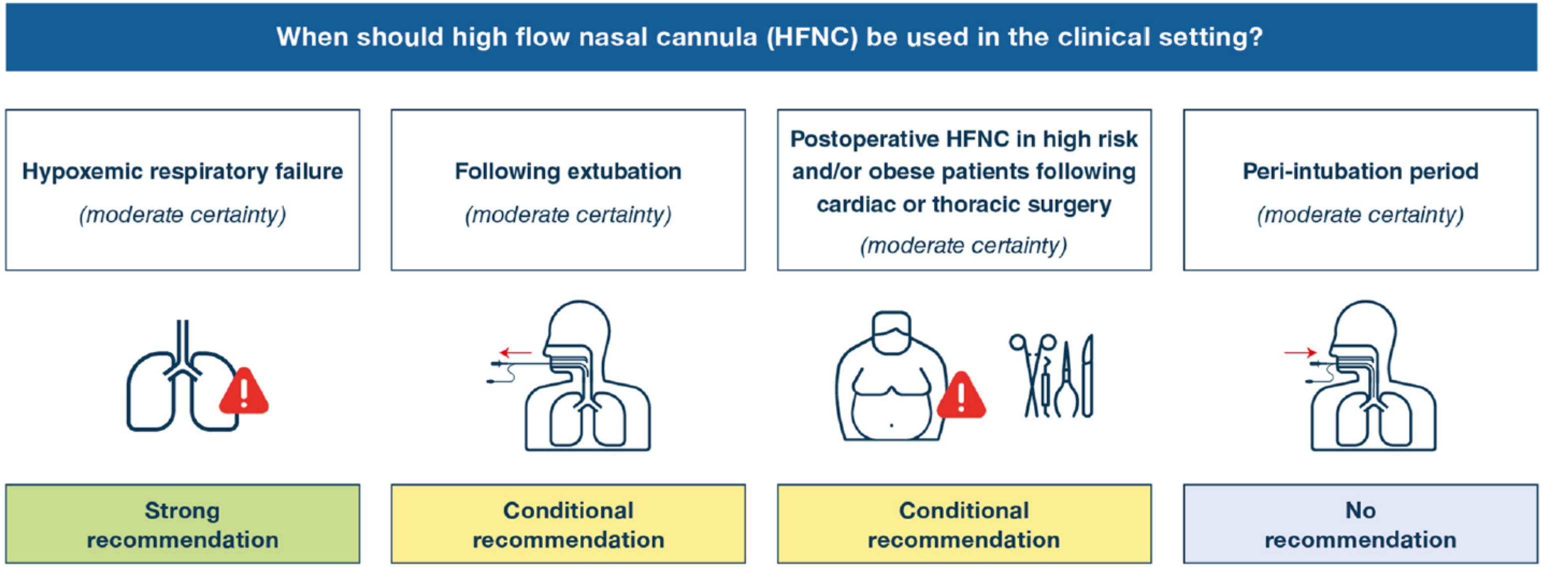


Fig. 1 Scheme of recommendations

NOT COVID related

Rochwerg et al. Intensive Care Med 2020, Nov 17

High flow nasal oxygen - risks

- Significant variation in use: used extensively in Wuhan, not in Seattle
- Significant dispersion of exhaled air (different oxygen mask?)
- Dispersion depends on size of cannulae and fit in the nose

TABLE 1 Summary of exhaled smoke dispersion distances with different oxygen devices

Oxygen device	Flow rate $L \cdot min^{-1}$	Dispersion distance cm	Ref.
HFNC	60	17.2±3.3	[6]
	30	13.0±1.1	[6]
	10	6.5±1.5	[6]
Simple mask	15	11.2±0.7	[7]
	10	9.5±0.6	[7]
Non-rebreathing mask	10	24.6±2.2	[7]
Venturi mask at F_{IO_2} 0.4	6	39.7±1.6	[7]
Venturi mask at F_{IO_2} 0.35	6	27.2±1.1	[7]

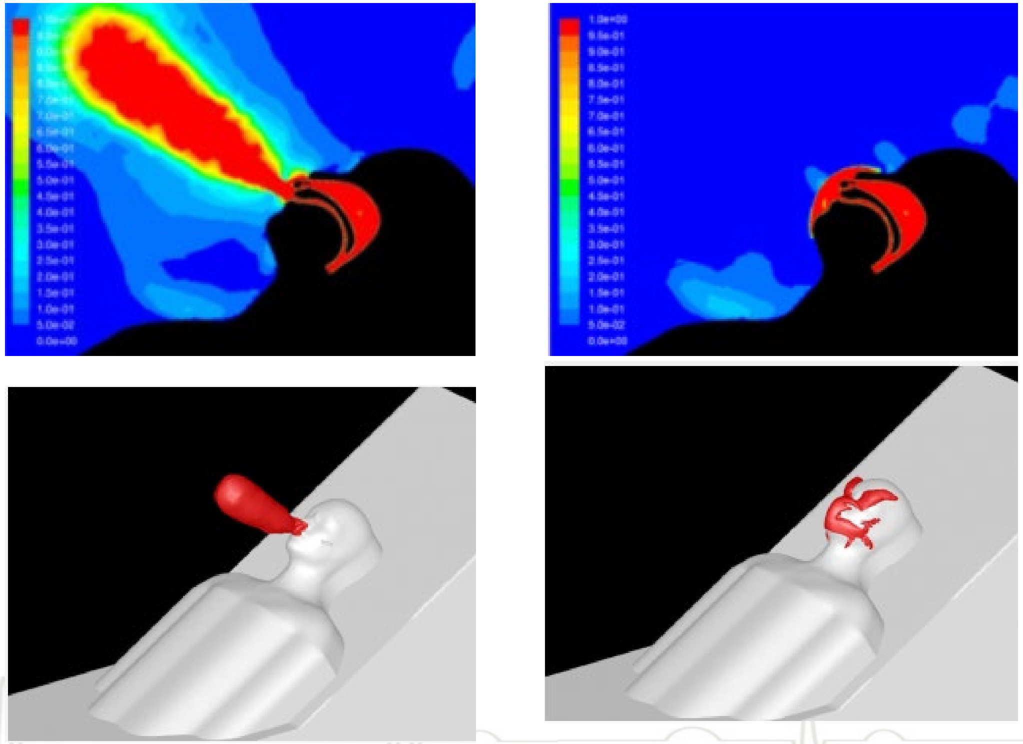
Summary of studies evaluating oxygen delivery devices using a high-fidelity human simulator with smoke particles of <1 μm (an aerosol of solid particles). The smoke was illuminated by a laser light-sheet and high-definition video was used to measure dispersion distance away from the manikin. Indicated dispersion distances give an idea of proximity of contaminated bio-aerosols, to which healthcare workers may be directly exposed. HFNC: high-flow nasal cannula; F_{IO_2}: inspiratory oxygen fraction.

Li et al. Eur Respir J. 2020;55:2000892

High flow nasal oxygen - risks

- Dispersion can be reduced by placing a surgical mask or oxygen mask over cannulae: - well tolerated
  - no change in $PaCO_2$ *Montiel et al. Ann Intensive Care 2020; 10:125*

Without mask With mask

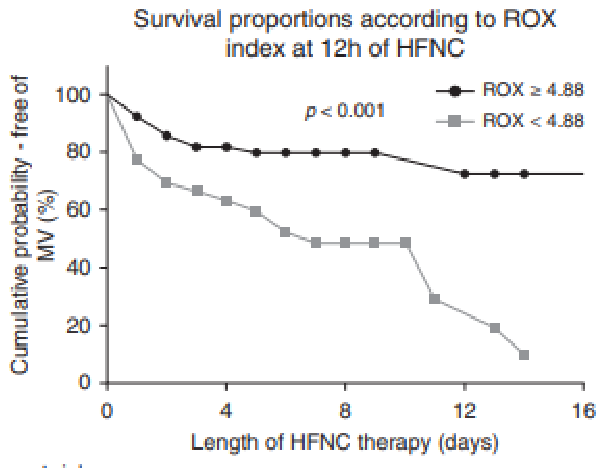


Vapotherm website

High flow nasal oxygen

Can intubation be inappropriately delayed?

- Risk of progressive fatigue, despite good oxygenation
- **ROX index** = $(SpO_2/FiO_2)/RR$ to predict respiratory failure



> 4.88 = little risk of failure

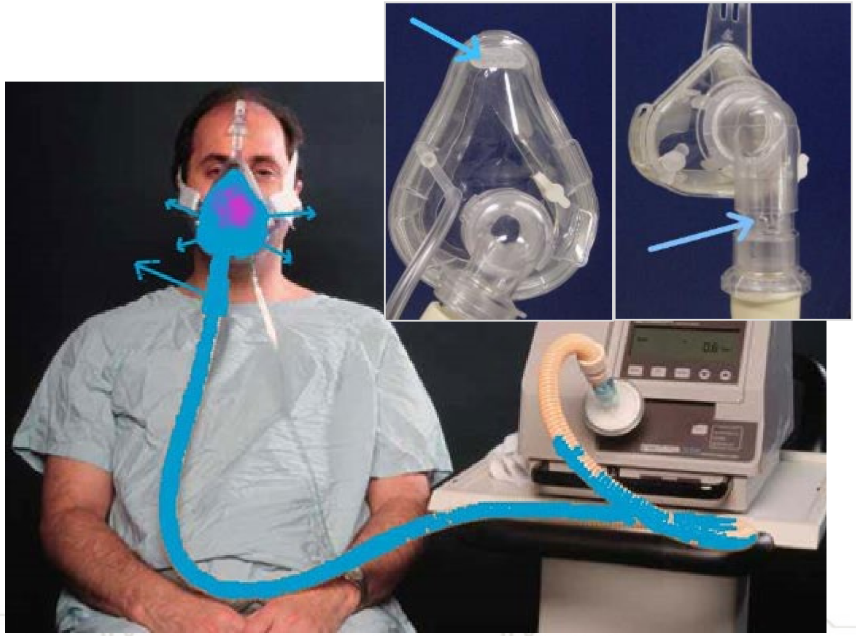
Risk of failure:
<2.85 at 2 hr
<3.47 at 6hr
<3.85 at 12hr

+ usual clinical judgement

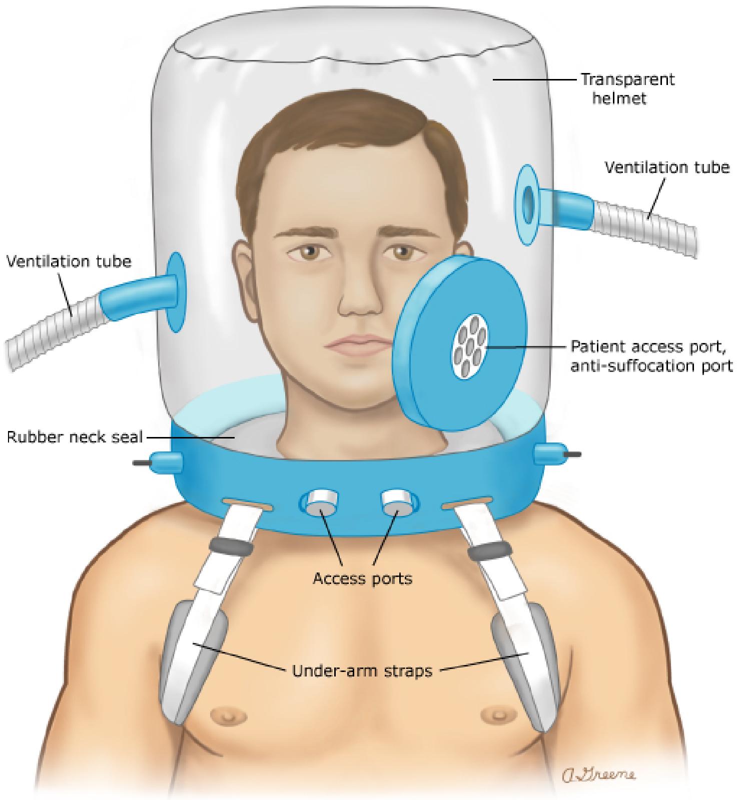
Roca et al, AJRCCM 2019; 199:1368

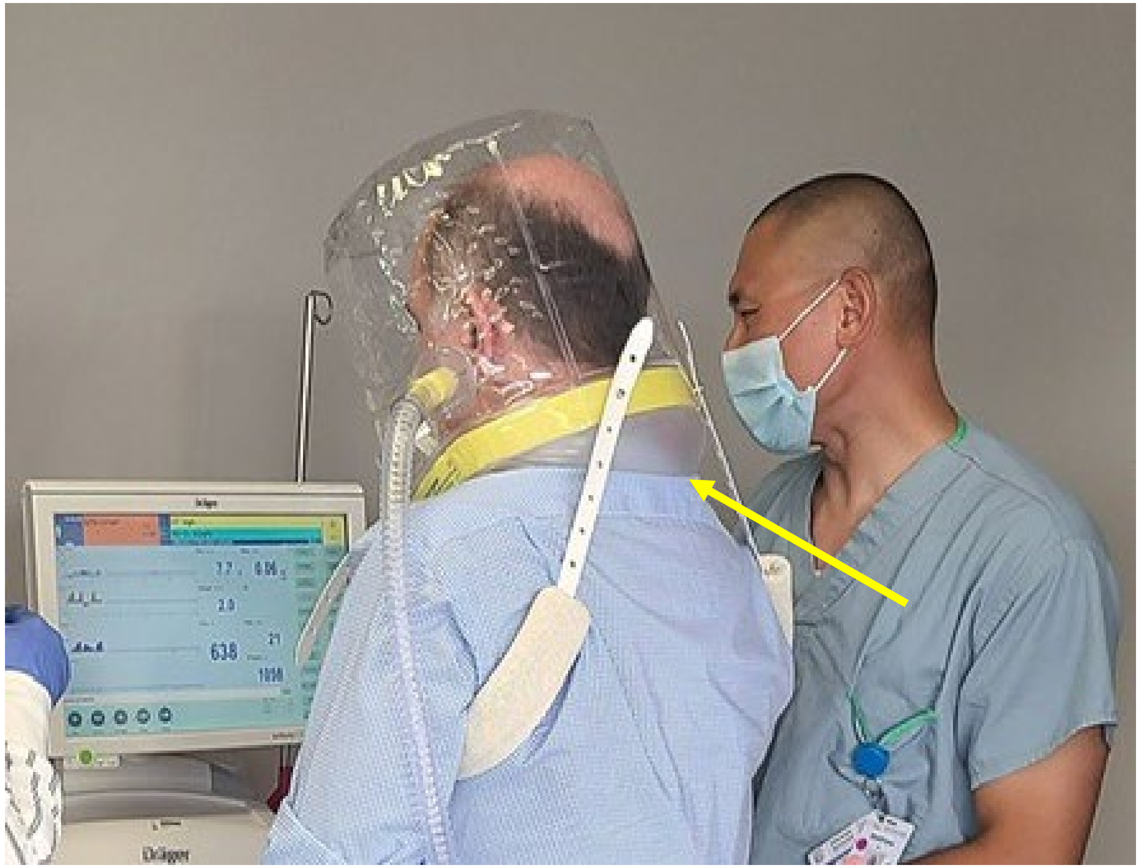
Non-invasive ventilation

- Major role is in COPD and cardiogenic pulmonary edema.
- May avoid intubation in hypoxemic respiratory failure
- Case series in COVID: success in 44/61 (72%) *Avdeev et al. Am J Emerg Med 2020; online*
- Considered an “AGMP” - potentially significant dispersion of aerosol
  - some systems safer than HFNO *Honore et al. Crit Care 2020; 24:482*

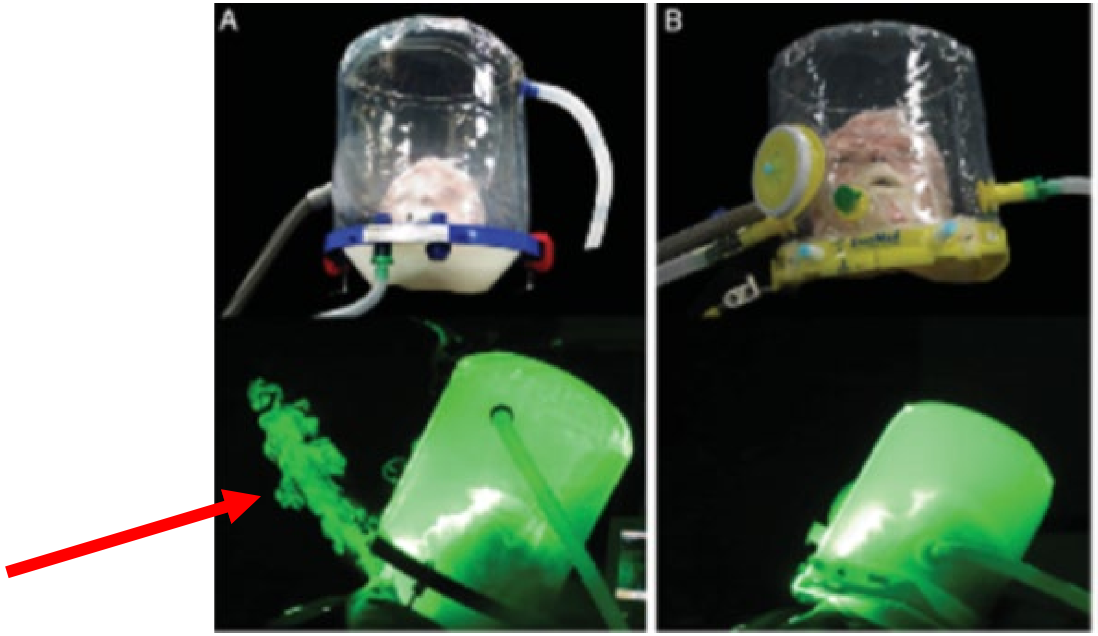


Non-invasive ventilation





Non-invasive ventilation



Hui et al. Chest 2015; 147: 1336-1343

Non-invasive ventilation

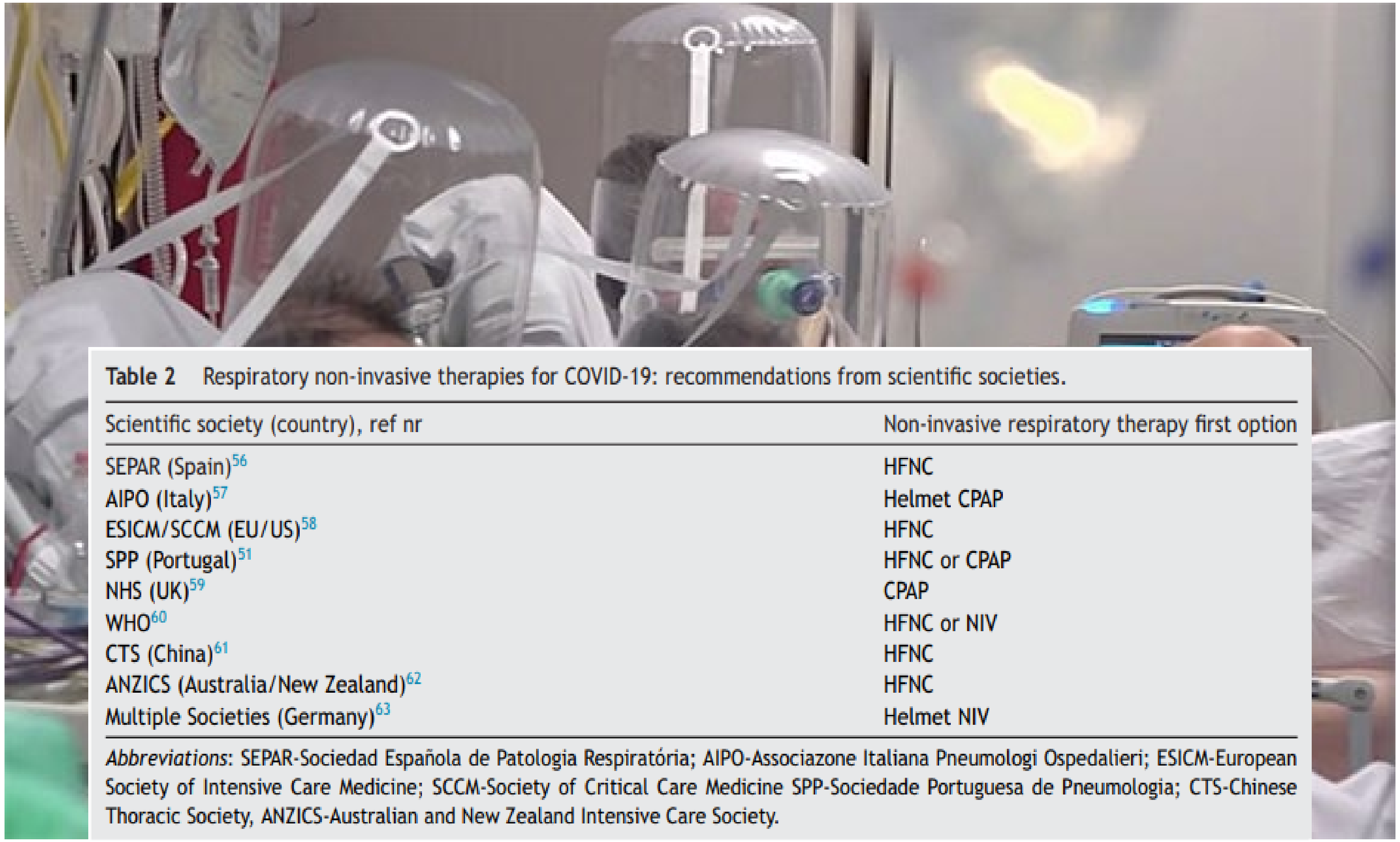


Table 2 Respiratory non-invasive therapies for COVID-19: recommendations from scientific societies.

Scientific society (country), ref nr	Non-invasive respiratory therapy first option
SEPAR (Spain)[56]	HFNC
AIPO (Italy)[57]	Helmet CPAP
ESICM/SCCM (EU/US)[58]	HFNC
SPP (Portugal)[51]	HFNC or CPAP
NHS (UK)[59]	CPAP
WHO[60]	HFNC or NIV
CTS (China)[61]	HFNC
ANZICS (Australia/New Zealand)[62]	HFNC
Multiple Societies (Germany)[63]	Helmet NIV

Abbreviations: SEPAR-Sociedad Española de Patologia Respiratória; AIPO-Associazone Italiana Pneumologi Ospedalieri; ESICM-European Society of Intensive Care Medicine; SCCM-Society of Critical Care Medicine SPP-Sociedade Portuguesa de Pneumologia; CTS-Chinese Thoracic Society, ANZICS-Australian and New Zealand Intensive Care Society.

Winck & Ambrosino. Pulmonology 2020; 26:213-220

Dispersion distance and device

TABLE 1

Maximum exhaled air dispersion distance *via* different oxygen administration and ventilatory support strategies

Method	Maximum exhaled air dispersion distance
Oxygen *via* nasal cannula 5 $L \cdot min^{-1}$	100 cm
Oxygen *via* oronasal mask 4 $L \cdot min^{-1}$	40 cm
Oxygen *via* Venturi mask F_{IO_2} 40%	33 cm
Oxygen *via* non-rebreathing mask 12 $L \cdot min^{-1}$	<10 cm
CPAP *via* oronasal mask 20 cmH_2O	Negligible air dispersion
CPAP *via* nasal pillows	33 cm
HFNC 60 $L \cdot min^{-1}$	17 cm (62 cm sideways leakage if not tightly fixed)
NIV *via* full face mask: IPAP 18 cmH_2O, EPAP 5 cmH_2O	92 cm
NIV *via* helmet without tight air cushion: IPAP 20 cmH_2O, EPAP 10 cmH_2O	27 cm
NIV *via* helmet with tight air cushion: IPAP 20 cmH_2O, EPAP 10 cmH_2O	Negligible air dispersion

Ferioli et al; Europ Respir Rev 2020; 29(155): 200068

AGMPs – Public Health Ontario

Aerosol Generating Medical Procedure

Procedures Considered AGMPs

- Intubation, extubation and related procedures e.g. manual ve
- Tracheotomy/tracheostomy procedures (insertion/open suct
- Bronchoscopy
- Surgeries*using high speed devices in the respiratory tract
- Post-mortem procedures involving high-speed devices
- Certain dental procedures e.g., high-speed drilling and ultraso
- Non-invasive ventilation (NIV) e.g. Bi-level Positive Airway Pre Positive Airway Pressure ventilation (CPAP)
- High-Frequency Oscillating Ventilation (HFOV)
- Induction of sputum with nebulized saline
- High flow nasal oxygen (high flow nasal cannula therapy)

*Specifically for acute respiratory infections this pertains to surgery in the respiratory tract.

Current List of Procedures that are not AGMPs

- Collection of nasopharyngeal or throat swab
- Ventilator circuit disconnect
- Chest compressions
- Chest tube removal or insertion (unless in setting of emergent insertion for ruptured lung/pneumothorax)
- Coughing, expectorated sputum
- Oral suctioning
- Oral hygiene
- Gastroscopy or colonoscopy
- Laparoscopy (gastrointestinal/pelvic)
- Endoscopic retrograde cholangiopancreatography
- Cardiac stress tests
- Caesarian section or vaginal delivery of baby done with regional anaesthesia
- Any procedure done with regional anaesthesia
- Electroconvulsive therapy
- Transesophageal echocardiogram
- Nasogastric/nasojejunal tube/gastrostomy/gastrojejunostomy/jejunostomy tube insertion
- Bronchial artery embolization
- Chest physiotherapy (outside of breath stacking)
- Oxygen delivered at less than or equal to 6 liters per minute by nasal prongs and less than or equal to 15 liters per minute by Venturi masks and non-rebreather masks
- Intranasal medication administration such as naloxone

Optimally in negative pressure room!

Individual risk assessment

Awake proning

- Technical feasible : self proning by the awake & alert patient
- Can be done with HFNO and with NIV
- May improve oxygenation, no data concerning longer term benefits
- A rapid systematic review: *Weatherald J, et al. J Crit Care, online Aug 27*
  - Small uncontrolled or retrospective cohort studies only
  - No standardization of duration of proning
  - Not tolerated by some patients

Awake proning

Data:

– ED study of 50 patients:
  - SpO_2 increased 84% to 94% after 5 minutes
  - 13 intubated within 24 hr

Caputo et al. Acad Emerg Med 2020; 27:375

– Study of 24 patients:
  - 63% tolerated 3 hrs
  - 25% had >20% increase in PaO_2
  - 25% intubated

Elharrar et al. JAMA 2020; 323:2336

– Ongoing RCTs underway: locally - “COVID-Prone”

Decision to intubate

- Early intubation was recommended following early experience in China:
  - due to severe hypoxemia
  - to avoid the transmission risk of emergent uncontrolled intubation
  - as HFNO and NIV were discouraged
  - RSI carries increased risk in markedly hypoxemic patient

The surest way to increase COVID-19 mortality is liberal use of intubation and mechanical ventilation

Tobin. Am J Respir Crit Care Med 201:1319–1336, Jun 1, 2020

Decision to intubate

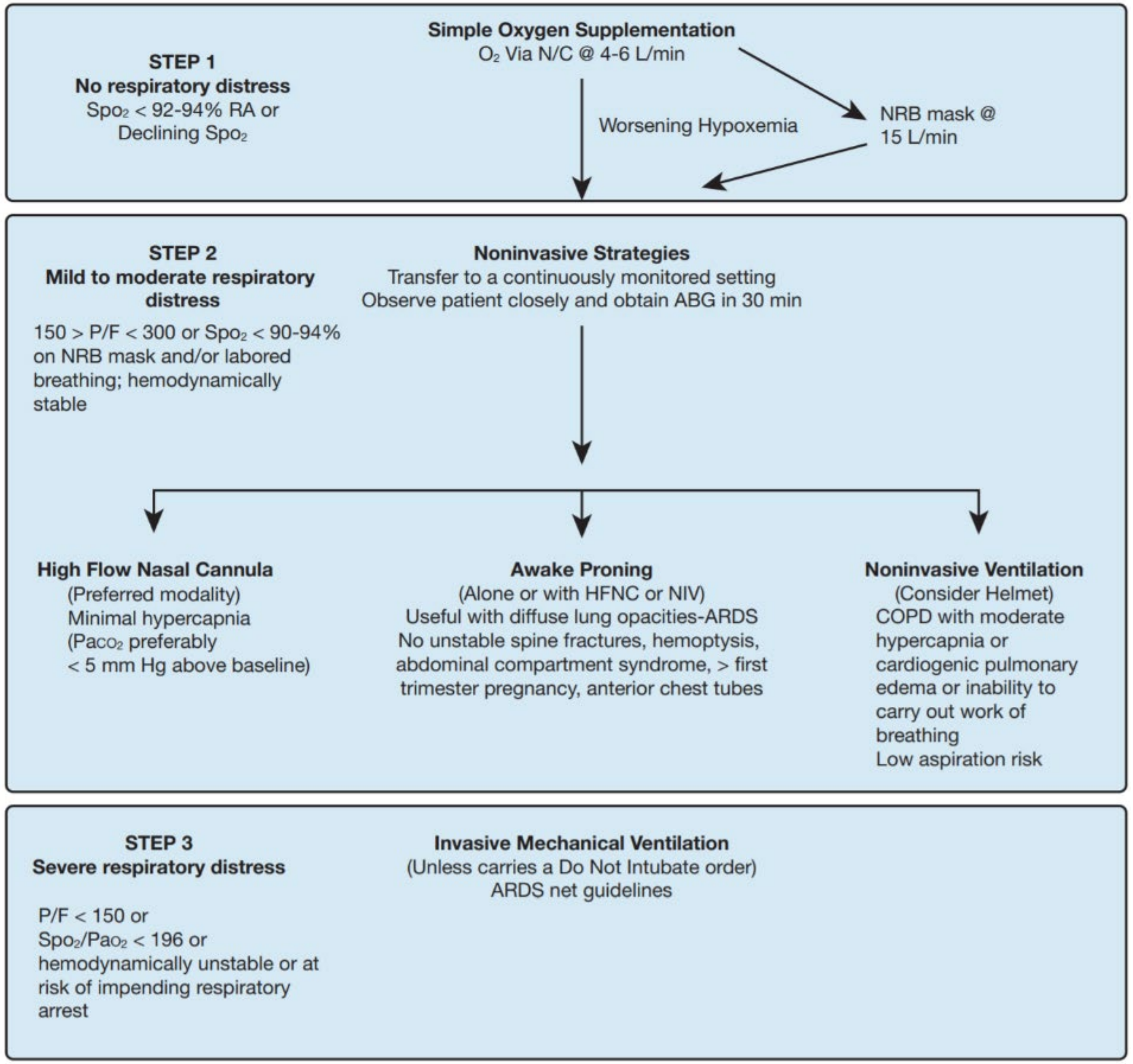
- Early intubation is no longer the recommendation, so when do we intubate?

Decision to intubate

- Indications for intubation: physician judgement

  - Clinical distress: accessory muscle use, diaphoresis & fatigue
  - Altered level of consciousness
  - Hypercapnic respiratory failure
  - Clinically significant hypoxemia:
    - Organ dysfunction
    - Lactic academia
    - Significant cardiovascular disease
    - Or trending in this direction
  - Early intubation to avoid emergency intervention, if the trend is deteriorating

NOT:
Just hypoxemia
Just tachypnea



Raoof et al. High-Flow, Noninvasive Ventilation and Awake (Nonintubation) Proning in Patients With Coronavirus Disease 2019 With Respiratory Failure Chest 2020; 158:1992-2002

Thank you

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Respiratory Management Post-Intubation - Dr. Eddy Fan

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Q&A with Dr. Stephen Lapinsky and Dr. Eddy Fan

Questions? **info@ccso.ca**

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