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
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?
Hypoxia – how low can you go?

Oxygen delivery =

Cardiac output

Hemoglobin

SaO₂
Hypoxia – how low can you go?

Oxygen delivery =

Cardiac output ×
Hemoglobin ×
SaO₂

Cardiovascular compensation
Hypoxia – how low can you go?

Oxygen delivery = Cardiac output \times Hemoglobin \times SaO_2
Hypoxia – how low can you go?

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

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”
“Aerosol generating procedures”

Aerosols:
These are respiratory droplets that are less than 100 micrometers in diameter that can remain suspended in the air for hours.

Droplets:
These are particles that are larger than 300 micrometers and, due to air currents, fall to the ground in seconds.

1,200 aerosols are released for each droplet.
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

**Aerosols, droplet and exhaled particles**

1. **LARGE INFECTIOUS DROPLETS**
   - Mucus/water **encased**. Viruses are aerosolized by the infector or by toilet water.
   - Quickly fall to the ground after traveling up to 1–3 ft.

2. **SMALL INFECTIOUS DROPLETS**
   - Mucus/water coating **starts to evaporate**.
   - Fall to ground after traveling 3–5 ft.
   - Can become droplet nuclei.

3. **INFECTIOUS DROPLET NUCLEI**
   - Droplet size has decreased to <3 microns.
   - Can float in the air for prolonged periods due to microscopic size.
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.

<table>
<thead>
<tr>
<th>ACH</th>
<th>90% Efficiency</th>
<th>99% Efficiency</th>
<th>99.9% Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>69</td>
<td>138</td>
<td>207</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
<td>69</td>
<td>104</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>46</td>
<td>69</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>35</td>
<td>52</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>28</td>
<td>41</td>
</tr>
</tbody>
</table>

Minimum > Preferred >

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

Modified from Table B.1, CDC Guidelines for Environmental Infection Control in Health-Care Facilities, 2003.
Aerosol generating procedures?

Main reason for defining AGMP: use of N95 respirator

*Rapid systematic review to identify evidence base & consensus:*

<table>
<thead>
<tr>
<th>ICU Procedures</th>
<th>% sources that classified this as AGMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubation/extubation</td>
<td>96</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>95</td>
</tr>
<tr>
<td>Manual ventilation</td>
<td>93</td>
</tr>
<tr>
<td>Airway suctioning</td>
<td>89</td>
</tr>
<tr>
<td>CPR</td>
<td>89</td>
</tr>
<tr>
<td>Noninvasive ventilation</td>
<td>88</td>
</tr>
<tr>
<td>HNFO</td>
<td>86</td>
</tr>
<tr>
<td>Nebulizer therapy</td>
<td>82</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aerosol generator</th>
<th>Applied physiology</th>
<th>Clinical evidence</th>
<th>Estimated risk of aerosol generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchoscopy</td>
<td>High airway pressures and distal airway collapse</td>
<td>Increased viral aerosols in H1N1 [33, 47]</td>
<td>High</td>
</tr>
<tr>
<td>Percutaneous tracheostomy with bronchoscopy</td>
<td>High airway pressures and distal airway collapse with tracheostomy patent for unfiltered aerosols</td>
<td>Limited</td>
<td>Extrem</td>
</tr>
<tr>
<td>Bag-valve mask ventilation</td>
<td>Aerosol generation with high pressures and airway collapse</td>
<td>Associated with HCW transmission of SARS-CoV-1 [2, 4]</td>
<td>Technique dependent</td>
</tr>
<tr>
<td>CPR</td>
<td>Airway collapse, shear forces from CPR, high airway pressures for ventilation</td>
<td>Strongly associated [6]</td>
<td>Extrem</td>
</tr>
<tr>
<td>Suctioning</td>
<td>Shear forces from significant negative pressure and flows. Causes coughing</td>
<td>Increased viral aerosols in H1N1 [47]</td>
<td>High</td>
</tr>
<tr>
<td>Frequent cough</td>
<td>Natural aerosol generator</td>
<td>Associated with HCW transmission of SARS-CoV-1 [1, 2, 4]</td>
<td>High</td>
</tr>
<tr>
<td>Dyspnæic spontaneous respiration</td>
<td>Likely natural aerosol generator</td>
<td>Association with HCW transmission of SARS-CoV-1 [1, 2, 4]</td>
<td>High</td>
</tr>
<tr>
<td>Extubation</td>
<td>High risk due to coughing and distal airway collapse</td>
<td>Not studied</td>
<td>High</td>
</tr>
<tr>
<td>Laryngoscopy</td>
<td>Unlikely to cause aerosols per se</td>
<td>None showing rise in viral aerosols. Associated with HCW transmission of SARS-CoV-1 [2, 4]</td>
<td>Depend on ventilation period</td>
</tr>
<tr>
<td>High-flow nasal cannula</td>
<td>Possibly reduce viral aerosols through decreased airway collapse and airway pressures.</td>
<td>Associated in limited quality studies. Used as part of Chinese COVID-19 protocol. Increased dispersal [53, 55, 56]</td>
<td>High – moderate</td>
</tr>
<tr>
<td>Non-invasive ventilation</td>
<td>Possibly reduce viral aerosols through decreased airway collapse and pressures.</td>
<td>Association in limited quality studies. Used safely in small study [13]. Increased dispersal [24].</td>
<td>High – Moderate</td>
</tr>
<tr>
<td>Nebulisers</td>
<td>Alter the composition of RTLF and viscosity. Subject-dependent effect [24]. Could reduce shear</td>
<td>Associated in low quality studies. Increased dispersal [24].</td>
<td>High – Moderate</td>
</tr>
</tbody>
</table>
Data versus dogma - intubation
Data versus dogma - intubation

BUT: patients with normal lungs!

Brown et al, Anaesthesia, Oct 6, 2020
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.
HCW and AGMP – the risk

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

\[
\text{HCW risk} \propto \text{Particle concentration} \times \text{HCW minute ventilation} \times \text{time exposed} \\
\text{Mask efficiency}
\]
Mitigation strategies

Hierarchy of Controls in a Pandemic

- **Elimination**: Physically remove the hazard
- **Engineering Controls**: Isolate people from the hazard
- **Administration Controls**: Change the way people work
- **PPE**: Protect the worker with Personal Protective Equipment

**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

Preferred PPE – Use N95 or Higher Respirator

- Face shield or goggles
- N95 or higher respirator
  When respirators are not available, use the best available alternative, like a facemask.
- One pair of clean, non-sterile gloves
- Isolation gown
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

<table>
<thead>
<tr>
<th>Device</th>
<th>Flow rate (litre/minute)</th>
<th>AGMP?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal prongs</td>
<td>1 – 10</td>
<td>&gt; 6 LPM?</td>
</tr>
<tr>
<td>Venturi mask</td>
<td>4-6</td>
<td>~50</td>
</tr>
<tr>
<td></td>
<td>10-12</td>
<td>~45</td>
</tr>
<tr>
<td></td>
<td>12-15</td>
<td>~30</td>
</tr>
<tr>
<td>Non-rebreather</td>
<td>10-15</td>
<td>~30</td>
</tr>
<tr>
<td>HFNO</td>
<td>20 - 60</td>
<td>~30</td>
</tr>
</tbody>
</table>

![Diagram showing flow rates and AGMP]
Flow rates

**Mechanisms:**
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<td>1 – 10</td>
<td>&gt; 6 LPM?</td>
</tr>
<tr>
<td>Venturi mask</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% O2</td>
<td>Wall flow</td>
<td>Total flow</td>
</tr>
<tr>
<td>28</td>
<td>4-6</td>
<td>~50</td>
</tr>
<tr>
<td>40</td>
<td>10-12</td>
<td>~45</td>
</tr>
<tr>
<td>60</td>
<td>12-15</td>
<td>~30</td>
</tr>
<tr>
<td>Non-rebreather</td>
<td>10-15</td>
<td>Yes</td>
</tr>
<tr>
<td>HFNO</td>
<td>20 - 60</td>
<td>Yes</td>
</tr>
</tbody>
</table>
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 CO₂
3. Positive pressure generated

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)

<table>
<thead>
<tr>
<th>Mode</th>
<th>intubation</th>
<th>90d mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Oxygen</td>
<td>47%</td>
<td>23%</td>
</tr>
<tr>
<td>NIV</td>
<td>50%</td>
<td>28%</td>
</tr>
<tr>
<td>HFNO</td>
<td>38%</td>
<td>12%</td>
</tr>
</tbody>
</table>

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

When should high flow nasal cannula (HFNC) be used in the clinical setting?

- Hypoxemic respiratory failure (moderate certainty)
- Following extubation (moderate certainty)
- Postoperative HFNC in high risk and/or obese patients following cardiac or thoracic surgery (moderate certainty)
- Per-intubation period (moderate certainty)

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>
<thead>
<tr>
<th>Oxygen device</th>
<th>Flow rate L·min$^{-1}$</th>
<th>Dispersion distance cm</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFNC</td>
<td>60</td>
<td>17.2±3.3</td>
<td>[6]</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>13.0±1.1</td>
<td>[6]</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>6.5±1.5</td>
<td>[6]</td>
</tr>
<tr>
<td>Simple mask</td>
<td>15</td>
<td>11.2±0.7</td>
<td>[7]</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9.5±0.6</td>
<td>[7]</td>
</tr>
<tr>
<td>Non-rebreathing mask</td>
<td>10</td>
<td>24.6±2.2</td>
<td>[7]</td>
</tr>
<tr>
<td>Venturi mask at $F_{O_2}$ 0.4</td>
<td>6</td>
<td>39.7±1.6</td>
<td>[7]</td>
</tr>
<tr>
<td>Venturi mask at $F_{O_2}$ 0.35</td>
<td>6</td>
<td>27.2±1.1</td>
<td>[7]</td>
</tr>
</tbody>
</table>

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; $F_{O_2}$: 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 $\text{PaCO}_2$


Without mask

With mask

Vapotherm website
High flow nasal oxygen

Can intubation be inappropriately delayed?

- Risk of progressive fatigue, despite good oxygenation
- ROX index = \((\text{SpO}_2/\text{FiO}_2)/\text{RR}\) to predict respiratory failure

\[
> 4.88 = \text{little risk of failure}
\]

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

+ usual clinical judgement

\[\text{Roca et al, AJRCCM 2019; 199:1368}\]
Non-invasive ventilation

- Major role is in COPD and cardiogenic pulmonary edema.
- May avoid intubation in hypoxemic respiratory failure
- 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 1

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

<table>
<thead>
<tr>
<th>Method</th>
<th>Maximum exhaled air dispersion distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen via nasal cannula 5 L·min⁻¹</td>
<td>100 cm</td>
</tr>
<tr>
<td>Oxygen via oronasal mask 4 L·min⁻¹</td>
<td>40 cm</td>
</tr>
<tr>
<td>Oxygen via Venturi mask FIO₂ 40%</td>
<td>33 cm</td>
</tr>
<tr>
<td>Oxygen via non-rebreathing mask 12 L·min⁻¹</td>
<td>&lt;10 cm</td>
</tr>
<tr>
<td>CPAP via oronasal mask 20 cmH₂O</td>
<td>Negligible air dispersion</td>
</tr>
<tr>
<td>CPAP via nasal pillows</td>
<td>33 cm</td>
</tr>
<tr>
<td>HFNC 60 L·min⁻¹</td>
<td>17 cm (62 cm sideways leakage if not tightly fixed)</td>
</tr>
<tr>
<td>NIV via full face mask: IPAP 18 cmH₂O, EPAP 5 cmH₂O</td>
<td>92 cm</td>
</tr>
<tr>
<td>NIV via helmet without tight air cushion: IPAP 20 cmH₂O, EPAP 10 cmH₂O</td>
<td>27 cm</td>
</tr>
<tr>
<td>NIV via helmet with tight air cushion: IPAP 20 cmH₂O, EPAP 10 cmH₂O</td>
<td>Negligible air dispersion</td>
</tr>
</tbody>
</table>

Ferioli et al; Europ Respir Rev 2020; 29(155): 200068
AGMPs – Public Health Ontario

Aerosol Generating Medical Procedures (AGMPs)

Procedures Considered AGMPs:
- Intubation, extubation and related procedures e.g. manual ventilation
- Tracheotomy/tracheostomy procedures (insertion/opening/closure)
- 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 ultrasonic
- Non-invasive ventilation (NIV) e.g. Bi-level Positive Airway Pressure (BiPAP)
- 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/nasojugal 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

publichealthontario.ca
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:
  - SpO₂ 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 PaO₂
  - 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
Thank you
Thank you for joining us today

Feedback?
Suggestions for the next topic?

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Eventbrite
Dec 10 2020 at 2pm
Respiratory Management Post-Intubation - Dr. Eddy Fan

Dec 22 2020 at 2pm
Q&A with Dr. Stephen Lapinsky and Dr. Eddy Fan

Questions?
info@ccso.ca

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