Physiologic challenges in COVID-19 airway management

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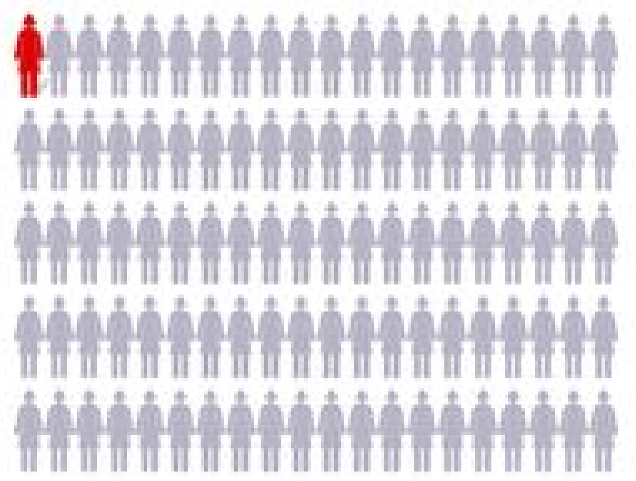
Objectives

- Review physiologic challenges in critically ill airway management
  - Hypoxemia
  - Hemodynamics
- Discuss how these physiologic challenges apply to COVID-19

Physiologic Challenges in Critically Ill Airway Management

ICU Intubations are Complicated

<u>OR Intubation</u>
Severe Complication Rate

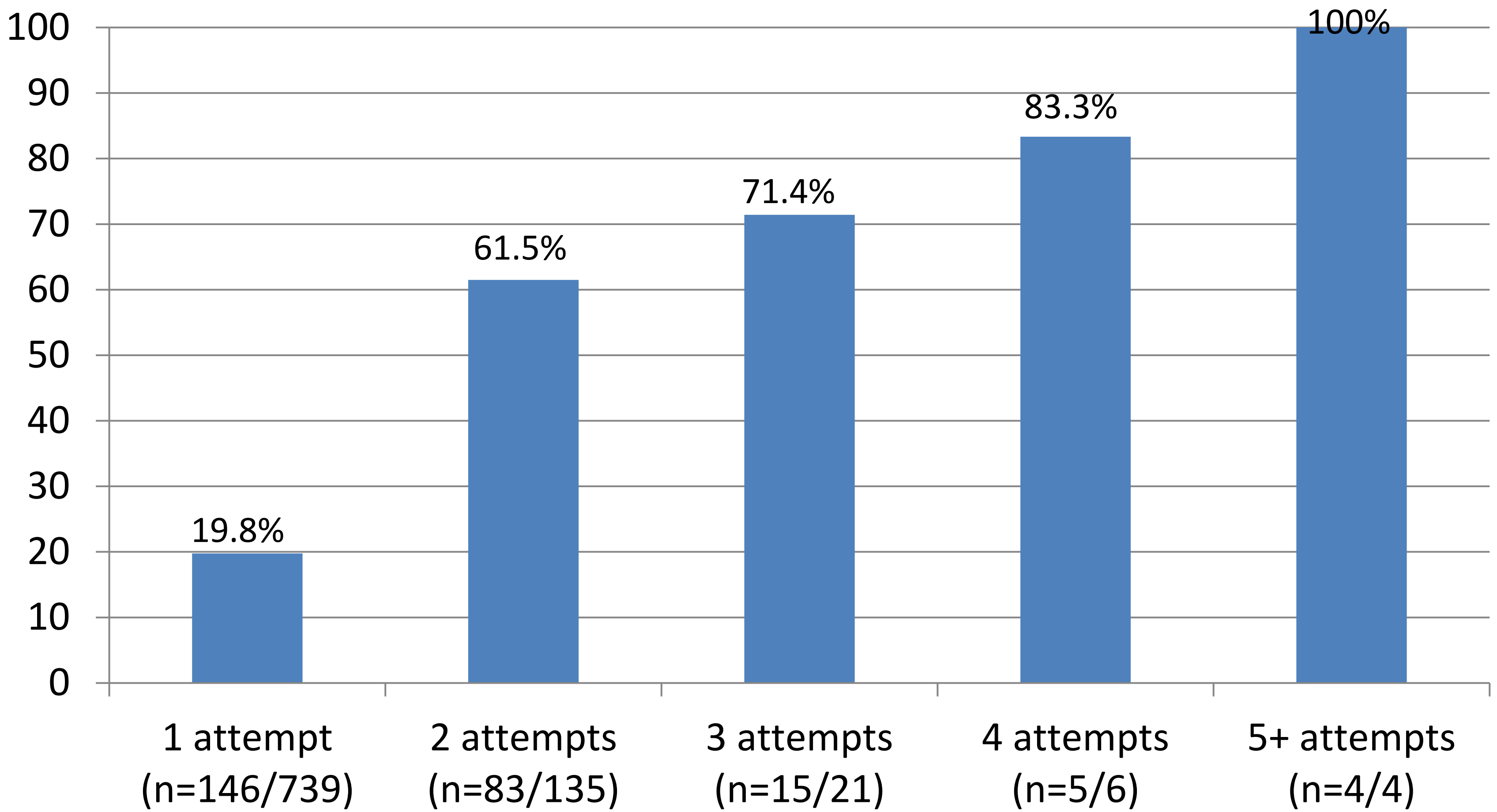


<u>ICU Intubation</u>
Severe Complication Rate

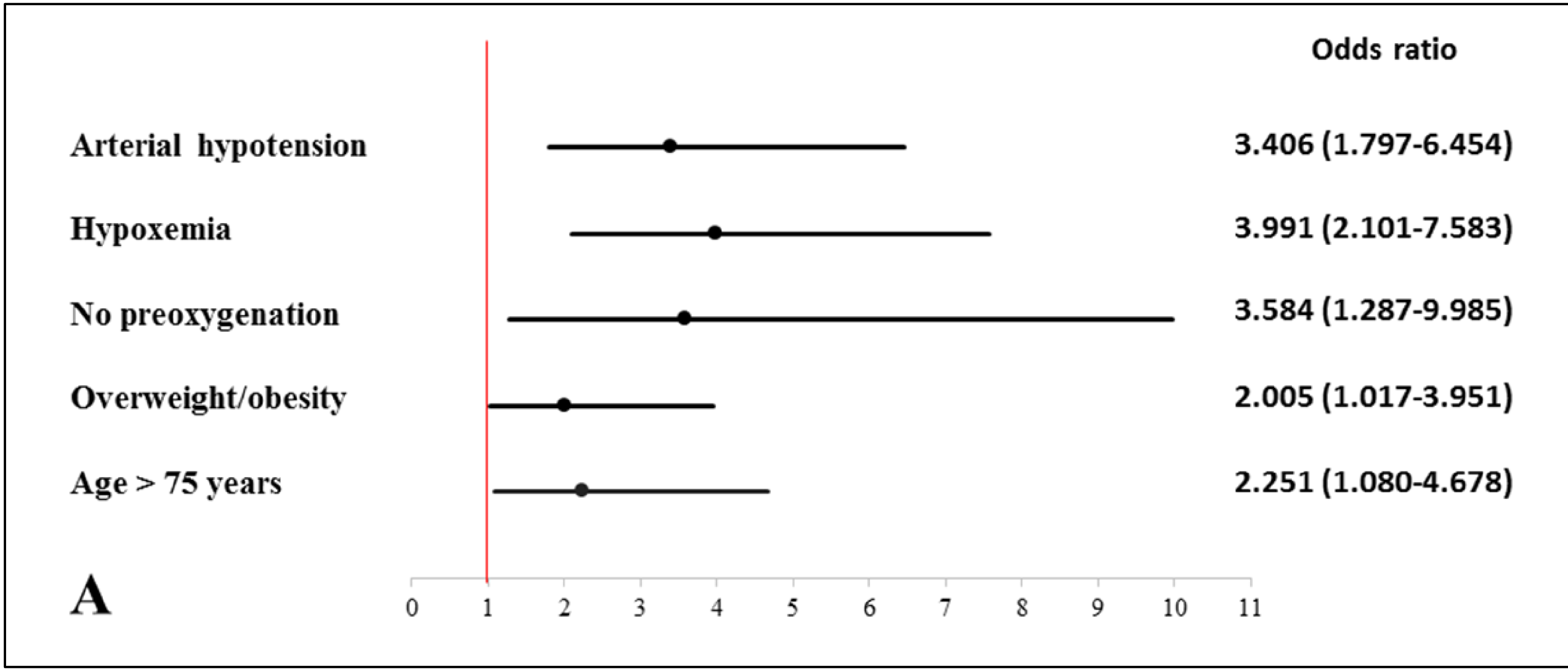
Severe Complications = cardiac arrest, death, new SBP <65, new hypoxemia <80%

Mort, TC, et al. J of Cli Anes, 2004
Jaber S, et al. Int Care Med, 2010
Cook TM, et al. BJA, 2011
De Jong et al,. Crit Care Med 2018
Heffner et al. Resuscitation 2013

Proportion of ≥ 1 Complication by Number of Attempts



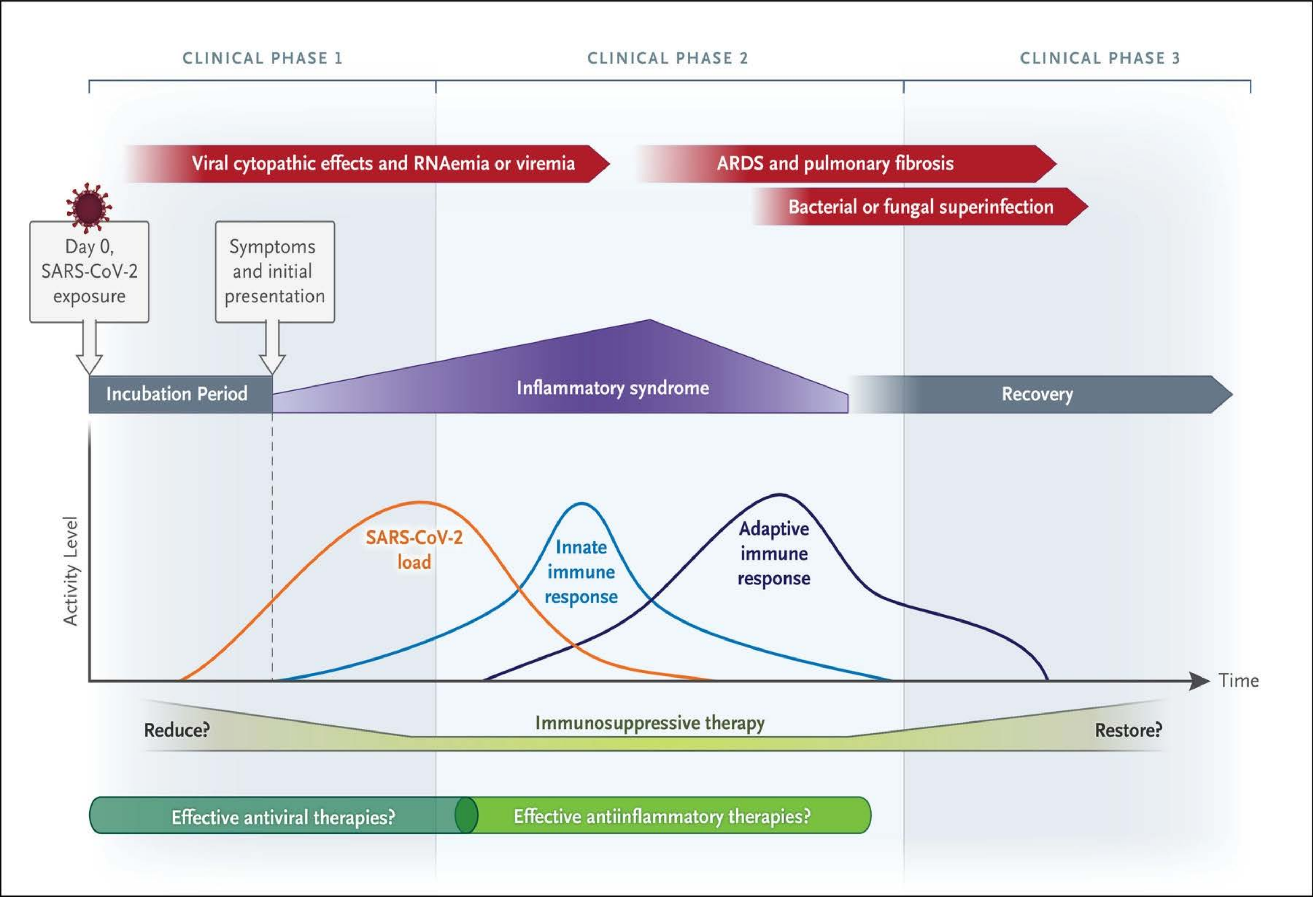
Hypes et al. Intern Emerg Med 2017



De Jong et al. Crit Care Med 2018

Many factors that contribute to difficulty:

- **Emergent, limited airway assessment**
- **Cardiopulmonary disease**
- **Hemodynamic instability**
- **Hypoxemia**
- **Full stomach**
- **Diverse clinical considerations**
  - **Increased ICP, myocardial ischemia**
  - **Obesity**
- **COVID-19**



CLINICAL PHASE 1
CLINICAL PHASE 2
CLINICAL PHASE 3
Viral cytopathic effects and RNAemia or viremia
ARDS and pulmonary fibrosis
Bacterial or fungal superinfection
Day 0, SARS-CoV-2 exposure
Symptoms and initial presentation
Incubation Period
Inflammatory syndrome
Recovery
Activity Level
SARS-CoV-2 load
Innate immune response
Adaptive immune response
Time
Reduce?
Immunosuppressive therapy
Restore?
Effective antiviral therapies?
Effective antiinflammatory therapies?

NEJM 2020

Physiologic challenges

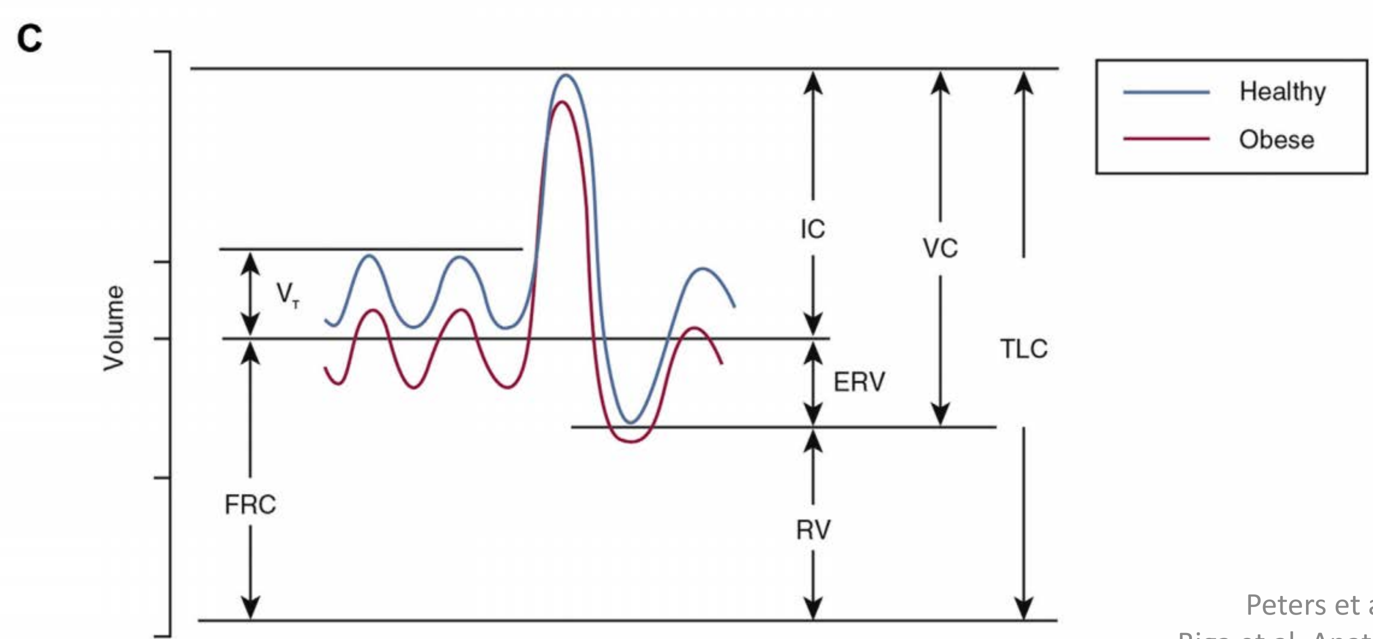
Factors	Consequence
Hypoxemia / shunt physiology	Rapid desaturation during intubation, which may result in hemodynamic instability, hypoxic brain injury and cardiopulmonary arrest
Hypotension (shock index > 0.8 predicts post-intubation hypotension)	Cardiopulmonary arrest (induction, positive pressure ventilation, loss of systemic vascular resistance, hypovolemia)
Severe metabolic acidosis	Brief apneic period can lead to precipitous drop in pH given loss of already inadequate respiratory compensation and hemodynamic deterioration
Right ventricular failure (worsened by any process that increases RV afterload)	RV dilation, retrograde flow, decreased coronary perfusion, hypotension, CV collapse, extremely sensitive to intrathoracic pressure changes and worsened with positive pressure

Mosier et al. West J Emerg Med 2015

Preoxygenation Goals

- Increase oxygen reservoir in FRC
- Denitrogenation
- Ultimately increase safe apnea time

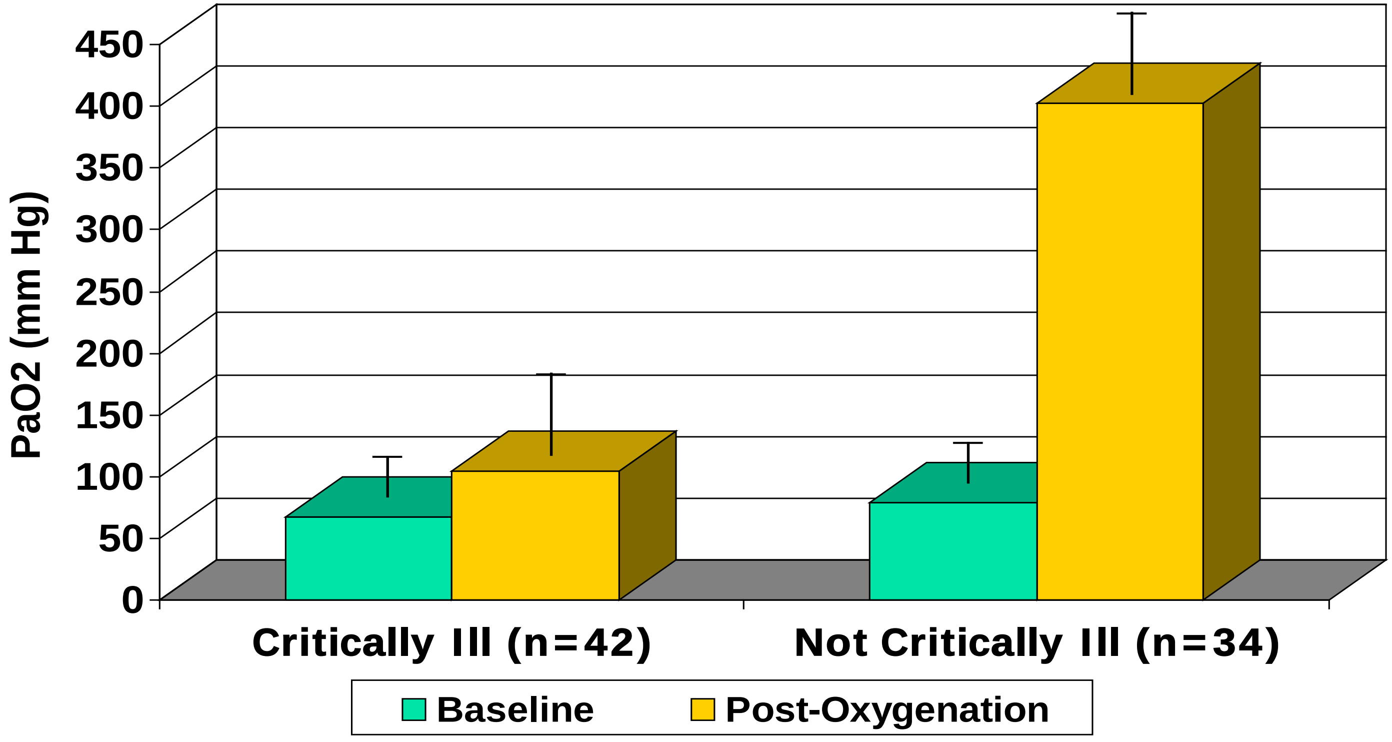
Composition and Partial Pressures of Alveolar Air (Table 22.3)		
Gas	**Percent of total composition**	**Partial pressure (mm Hg)**
Nitrogen (N_2)	74.9	569
Oxygen (O_2)	13.7	104
Water (H_2O)	6.2	40
Carbon dioxide (CO_2)	5.2	47
Total composition/total alveolar pressure	100%	760.0



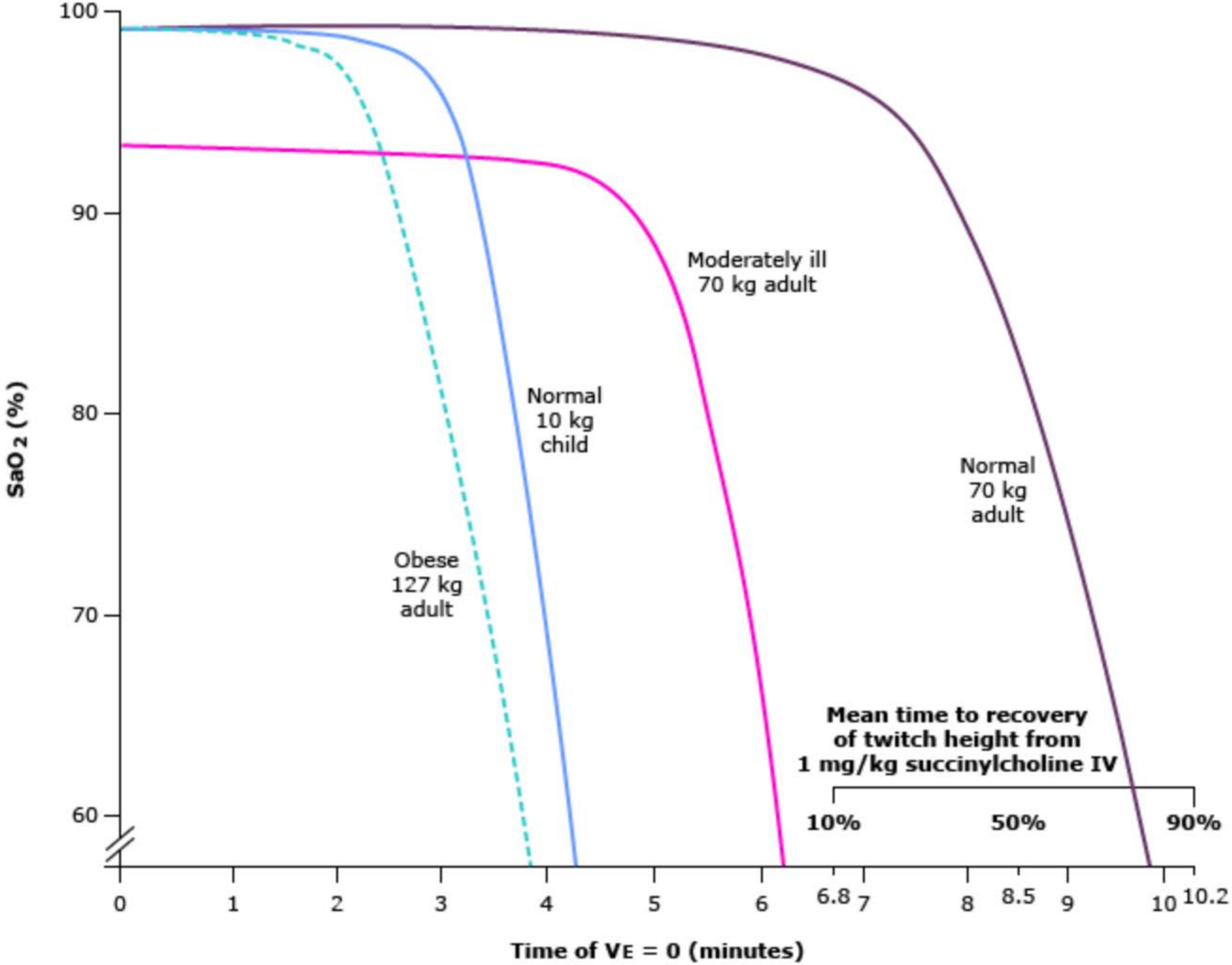
Peters et al. CHEST 2018
Biga et al. Anatomy and Physiology

Pre-Oxygenation in the Critically Ill

- Less time for intubation attempts



Mort TC. Crit Care Med 2005; 33:2672



Benumof. Anesthesia 1997

SAFE APNEA TIME

$$= \frac{\left(F_A O2_{\text{End preoxygenation}} - F_A O2_{\text{O2 saturation of 90\%}}\right) \times \text{FRC}}{\dot{V}O_2}$$

$$= \frac{\left(\left[F_A O2_{\text{End preoxygenation}} - F_A O2_{\text{O2 saturation of 90\%}}\right] \times \text{FRC}\right) \times \%\,\text{shunt}}{\dot{V}O_2}$$

Tanoubi et al. Can J Anesth 2009
Mosier . Brit J Anesth 2020

Hemodynamics

- Post intubation hypotension occurs in about ½ ICU intubations
- Cardiac arrest complicated about 4% of intubations
  - PEA most common presenting rhythm
  - 2/3 occurred within 10 minutes of pushing RSI drugs
- Increased odds of in hospital arrest (OR 14.8)

De Jong. CCM 2018
Green. J Crit Care 2015
Heffner. Resuscitation 2013

Shock Index

Shock Index = HR / SBP : Should be < 0.8

>= 0.9 Higher hospital mortality (Trivedi 2015)

>= 1 Predicted post intubation arrest (Wardi 2017)

Other outcome data, esp post intubation hypotension:
Smischney. J Crit Care 2018
Smischney. JICM 2017
Smischney. Med Sci Monit 2016
Courtesy of Viren Kaul, MD

HYpotension Prediction Score (HYPS) and (s)table HYpotension prediction score [(s)HYPS] and risk categorization

- Variables:
  - APACHE II score
  - Age, years
  - Sepsis diagnosis
  - Intubation setting (resp failure, MAP<65, cardiac arrest)
  - Diuretics in prior 24 hours
  - Catecholamine 60 minutes prior to intubation
  - Phenylephrine 60 minutes prior to intubation
  - Systolic blood pressure (mmHg)
  - Etomidate used for intubation

Smischney et al. PLoS ONE. 2020

Table 5. Risk categorization for full and stable HEMAIR cohorts.

			Immediate		
			Hypotension	Logistic regression	
Risk Score	**Expected Risk**	**N**	**# (%)**	**OR**	**(95% C.I.)**
HYPS-score (Full Cohort)*					
≤ 1.5	Low (≤ 19%)	101	12 (12%)	1.0	Reference
2 to 10.5	Moderate (20–39%)	526	140 (27%)	2.7	(1.4, 5.1)
11 to 18.5	High (40–59%)	211	123 (58%)	10.4	(5.3, 20.1)
≥ 19	Very High (≥ 60%)	96	69 (72%)	19.0	(9.0, 40.1)
(s) HYPS-score (Stable cohort)†					
≤ 1	Low (≤ 19%)	81	9 (11%)	1.0	Reference
1.5 to 11.5	Moderate (20–39%)	579	161 (28%)	3.1	(1.5, 6.3)
≥ 12	High (≥ 40%)	69	46 (67%)	16.0	(6.8, 37.6)

Effect of a fluid bolus on cardiovascular collapse among critically ill adults undergoing tracheal intubation (PrePARE): a randomised controlled trial

David R Janz, Jonathan D Casey, Matthew W Semler, Derek W Russell, James Dargin, Derek J Vonderhaar, Kevin M Dischert, Jason R West, Susan Stempek, Joanne Wozniak, Nicholas Caputo, Brent E Heideman, Aline N Zouk, Swati Gulati, William S Stigler, Itay Bentov, Aaron M Joffe, Todd W Rice, for the PrePARE Investigators and the Pragmatic Critical Care Research Group*

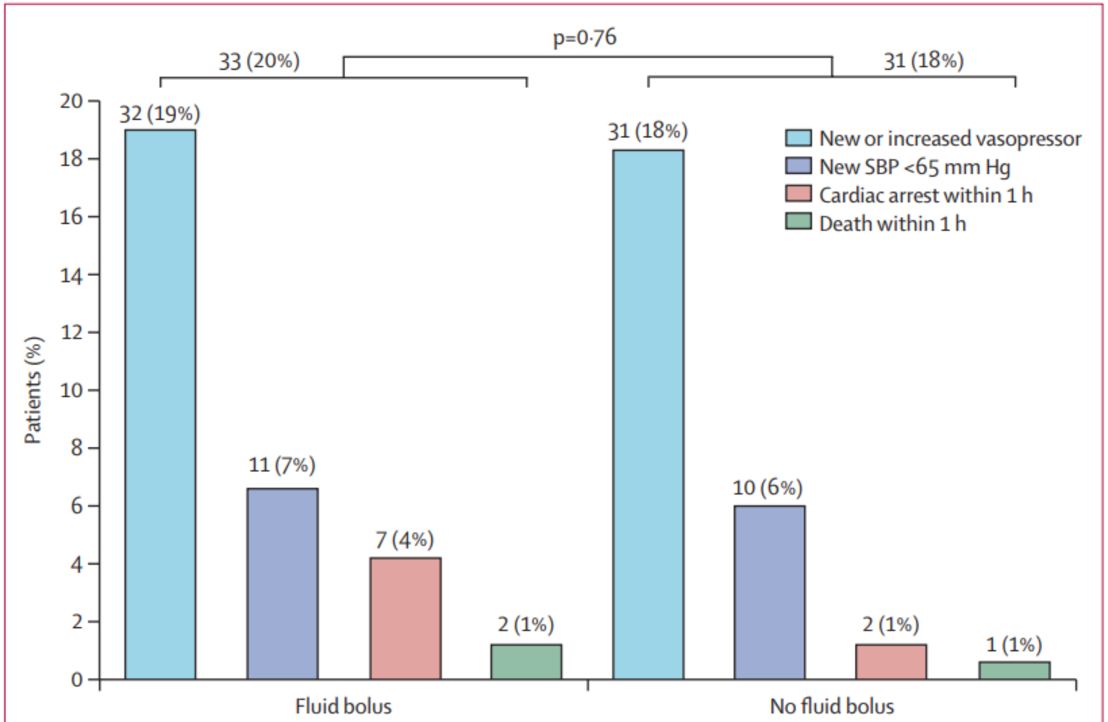


***Figure 2*: Cardiovascular collapse in the fluid bolus *vs* no fluid bolus groups**
Horizontal bars represent the overall incidence of the primary outcome in each group. The p value represents the test for a difference between groups in the overall incidence of the primary outcome. Number (%) of patients is given above each bar. SBP=systolic blood pressure.

	Low	High	Refractory
Preoxygenation	Typical Patient is intubated for airway protection without any airspace disease. Recommendations: 1. Flush flow oxygen 2. Upright positioning 3. Apneic oxygenation 4. Mask ventilation between induction and laryngoscopy	Typical Patient is intubated for respiratory failure in the presence of recruitable disease and minimal–moderate shunt. Recommendations: 1. NIPPV preoxygenation 2. HFNO preoxygenation and apenic oxygenation 2. Upright positioning 3. Apneic oxygenation 4. Mask ventilation between induction and laryngoscopy	Typical Patient is intubated for severe ARDS and refractory hypoxemia. PaO2 does not increase despite optimal preoxygenation. Recommendations: 1. Maintain spontaneous respiration 2. HFNO 2. Upright positioning 3. Consider inhaled vasodilators to improve ventilation:perfusion
Hemodynamics	Typical Patient is normotensive with a normal or elevated shock index. Recommendations: 1. Fluid bolus if likely to be volume responsive 2. Push-dose or continuous vasopressors immediately available	Typical Patient is hypotensive with elevated shock index. Recommendations: 1. Fluid resuscitation if likely to be volume responsive 2. Inline continuous vasopressor 3. Consider point-of-care ultrasound 4. Hemodynamically neutral sedative agent (consider a reduced dose)	Typical Patient is hypotensive with an etiology likely to worsen with intubation (e.g., pulmonary embolism, ARDS with RV failure, decompensated pulmonary hypertension). Recommendations: 1. Consider maintaining spontaneous respiration 2. HFNO 2. Point-of-care ultrasound to evaluate RV function 3. Vasopressors/fluids/inotropes based on ultrasound findings 4. Slow transition to positive pressure, maintain low mean airway pressure

Risk of Decompensation

Figure 2. Recommendations for reducing the risk of desaturation and cardiovascular collapse depending on preintubation risk. Future research is needed to characterize patients' risk on the basis of preintubation hemodynamics and gas exchange and evaluate the interventions within each risk category. ARDS = acute respiratory distress syndrome; HFNO = high-flow nasal oxygen; NIPPV = noninvasive positive pressure ventilation; RV = right ventricle.

TABLE 1 Key considerations for airway management outside of a negative pressure room

Airway management step	Recommendation[a]
Oxygenation	Avoid high-flow pre-oxygenation. Use NIPPV with a tight-fitted mask for escalating preoxygenation. Avoid nasal cannula for apneic oxygenation.
Intubation	Avoid "closely intubating" with direct laryngoscopy. Use VL for indirect tracheal tube placement. Use RSI with the highest recommended dose of an NMBA.
Rescue techniques	SGA placement attached to closed ventilator circuit for rescue oxygenation in lieu of manual bagging. Use HEPA filters whenever PPV is performed.
Personal protective equipment	PAPR use preferred over N95, if available consider plastic face tent or hood.

- ☐ Avoid aerosol-generating procedures, including high-flow nasal oxygen, non-invasive ventilation, bronchoscopy and tracheal suction without an in-line suction system in place.

Brown et al. JACEP 2020
Cook et al. Anesthesia 2020

Take Home Points

- Intubation of critically ill patients is high risk
- Key physiologic challenges include hypoxemia and hypotension, both of which can increase risk for cardiac arrest
- Preoxygenation is key to increase safe apnea time, which is dependent on size of FRC, denitrogenation of that FRC and oxygen consumption
- Adhere to core preexisting airway management principles with strict adherence to appropriate PPE in COVID-19 era