Penn Medicine

Pulmonary and Critical Care Medicine

Covid-19 Bootcamp #2

Jasleen Minhas, Katie Auriemma, Roger Kim

March 31, 2020

Presentation Slides and Tip sheets

V5 **COVID PPE Tip Sheet.pdf**
Tip Sheets · Updated Mar 25, 2020 by JEFF MIN

MK JM CC +3 ··· Open Download Sh

Penn Medicine Tip Sheet: Personal Protective Equipment

Updated 3/25/2020 – newest version here

DONNING PPE

HAND HYGIENE

N95/mask	PAPR
Put on mask & eye shield	Clip PAPR battery around waist
If N95, leak test	
Put on gown	
Feed power cord down back of gown	
Plug cord into battery, confirm operation	
Place PAPR on head	
Tie gown & don gloves	

HIGH-RISK PROCEDURES & ALTERNATIVES

Nebulized bronchodilators	MDI for COVID+ or PUI
Inhaled epoprostenol (Veletri)	Maximize all other ARDS adjuncts
BiPAP or HFNC	Intubate if impending respiratory failure Do not switch between modalities
Mask ventilation	Rapid seq. intubation
Ventilator disconnect **Open suctioning**	Minimize if possible

Also includes: **intubation, CPR, bronchoscopy**

PPE GUIDELINES

Workspaces		Droplet + Social Distancing
Non-PUI		Droplet
PUI	**PUI ED**	Droplet + Contact
	PUI Ward	Droplet + Contact
	PUI ICU	Airborne* + Contact
Confirmed COVID-19 + *Droplet if PPE/room unavailable		Airborne* + Contact
Aerosol Generating Procedures (PUI or COVID-19+)		Airborne + Contact + Eye Shield

RRT/CODE

Non-PUI	**RRT (respiratory)**	Droplet + Contact + Eye Shield
	Code and/or Intubation	Droplet + Contact + Eye Shield
PUI	**RRT (any)**	Droplet + Contact + Eye Shield
	Code and/or Intubation	Airborne + Contact + Eye Shield
Confirmed COVID-19 +	**RRT (any)**	Airborne + Contact + Eye Shield
	Code and/or Intubation	Airborne + Contact + Eye Shield

DOFFING PPE

SANITIZE GLOVES

N95/mask	PAPR
Remove gown & gloves	
HAND HYGIENE	
Exit room	
HAND HYGIENE	
Put on clean gloves	
Remove eye shield and sanitize	Remove PAPR: loosen ratchet then pull forward & over head
SANITIZE GLOVES	
Remove N95: tilt head forward, remove bottom strap then top strap	Disinfect PAPR & place equipment in designated area, charge battery
Remove gloves & HAND HYGIENE	

CONSERVING PPE

Relocate IV pumps & vent control outside room
Bundle invasive procedures
Consolidate lab draw & med admin times
Order imaging only if results will change care

CHECK SHAREPOINT FOR UPDATES

Penn Medicine | Intranet

HOME
Service Requests
SITE DIRECTORIES
What's Hot
COVID-19 UPDATES
COVID-19

A quick-reference guide created for the Division of Pulmonary and Critical Care Medicine. Contents may change as situation demands. Email Jeff Min & Jennifer Ginestra for corrections.

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Screening and Diagnosis

HUP COVID-19 Testing - Logistics

- Rapid Cartridge PCR with run time of < 45 minutes

- Specimens: obtained by MDs
  - Non intubated: NP or OP swab
  - Intubated: NP swab only

- Can be added on to RPP if sent in ED

- In house testing: currently only by approval from ID

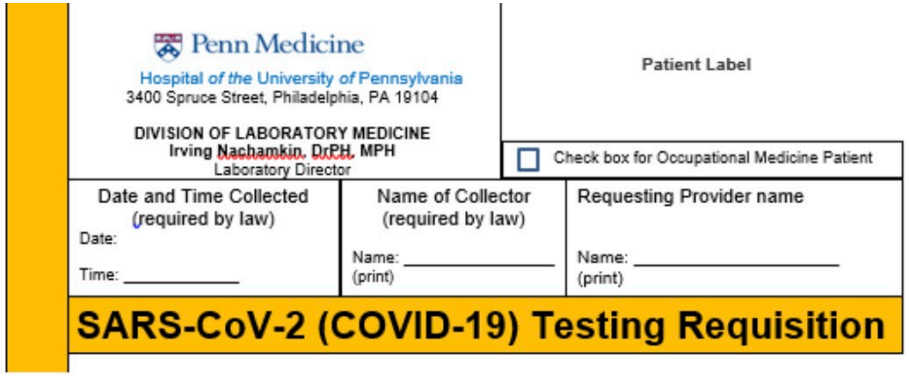
Key Contact Information

HUP ID APPROVAL PAGER: (215)-614-0895 → contact 24/7 for in-house test approval

HUP COVID-19 Testing - Logistics

	Daily Volume	Result time	Population targeted	Order
Urgent	120 tests/day	<4 hours	ED/Obs/Inpatients	Golden Ticket
Less Urgent	200 tests/day	4-12 hours	Occ Exposures	Blue Ticket

- As of 3/30 testing is being offered 24 hours a day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DIVISION OF LABORATORY MEDICINE
Irving Nachamkin, DrPH, MPH
Laboratory Director
Patient Label
Check box for Occupational Medicine Patient
Date and Time Collected (required by law)
Date:
Time: _____
Name of Collector (required by law)
Name: _____ (print)
Requesting Provider name
Name: _____ (print)
SARS-CoV-2 (COVID-19) Testing Requisition

HUP COVID19 – Inpatient Protocol

Has patient had a recent RPP or rapid flu/RSV sample that is still in HUP lab

YES

1. Call ID approval pager
2. Infection control completes COVID-19 Requisition form aka “Golden Ticket”. No order entry in EPIC
3. Deliver / tube form to Central Receiving (Founders 7)

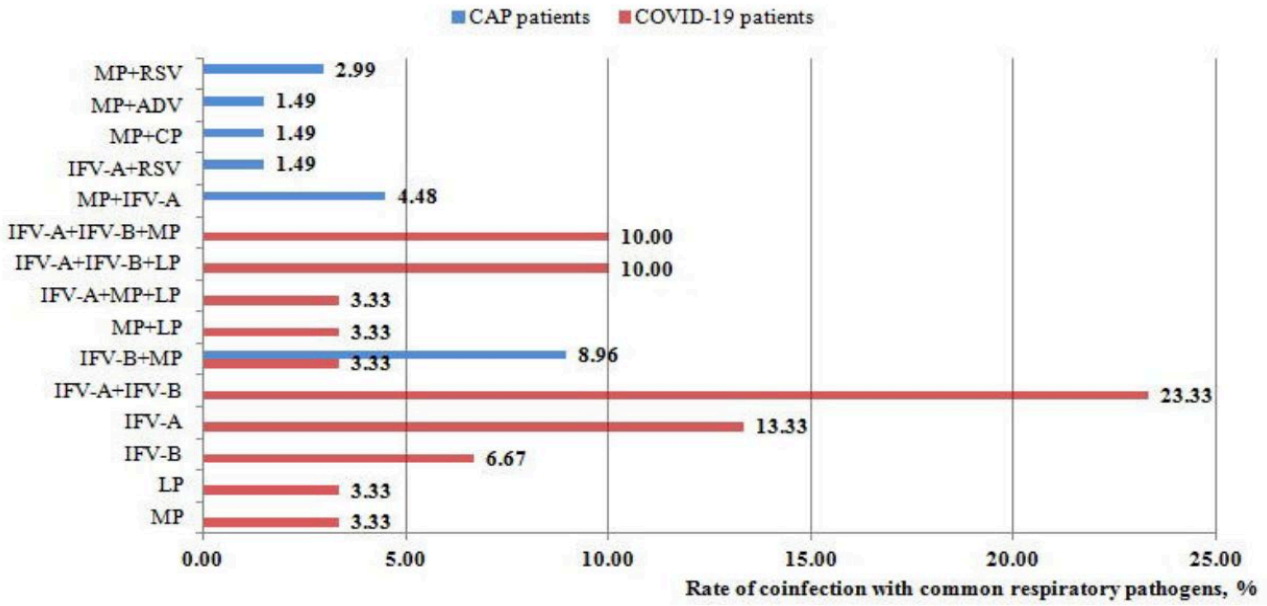
NO

1. Call ID approval pager
2. Infection control completes COVID-19 Requisition form aka “Golden Ticket” – form emailed/delivered in person
3. Collect Specimen
4. Deliver / tube form to Central Receiving (Founders 7)

Co-infections

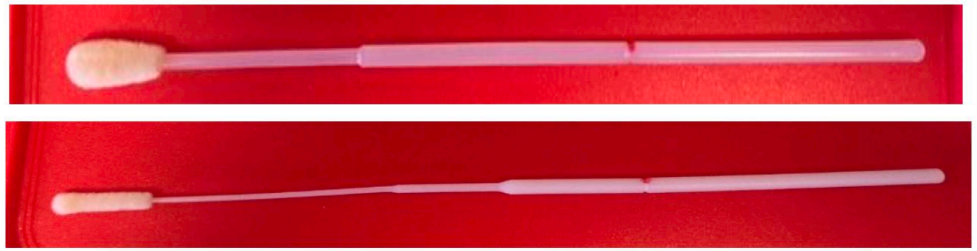
Table 4. Common respiratory pathogens detected in COVID-19 patients and healthy controls

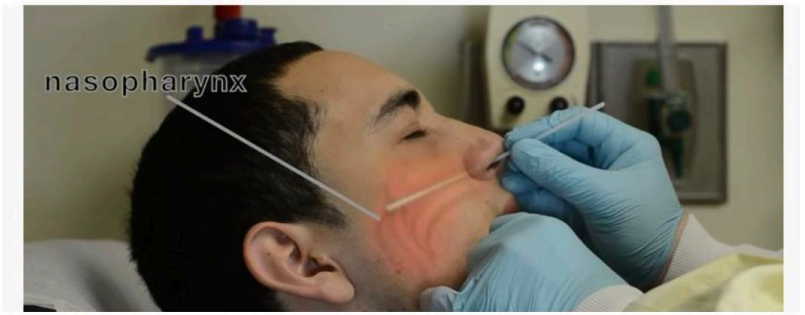
Pathogens detected	COVID-19 patients (n=30) No. (%)	Healthy controls (n=30) No. (%)	*P*-value
IFV-A	18 (60.00)	0 (0.00)	**<0.0001**
IFV-B	16 (53.33)	4 (13.33)	**0.0018**
MP	7 (23.33)	0 (0.00)	**0.0105**
LP	6 (20.00)	0 (0.00)	**0.0237**
RSV	0 (0.00)	0 (0.00)	NA



Nasopharyngeal Swabs

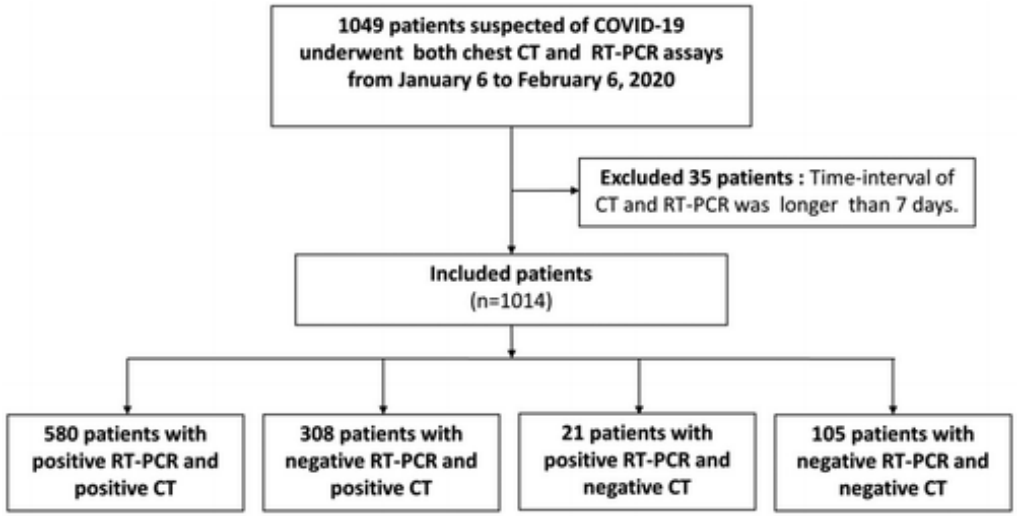
- PPE: surgical mask + eye protection + gown + gloves
- Procedure:
  - Tilt head back & insert swab parallel to palate
  - Stop when resistance met
  - Leave in place for 2 – 3 seconds
  - Rotate 10 – 15 sec
  - Repeat on other side

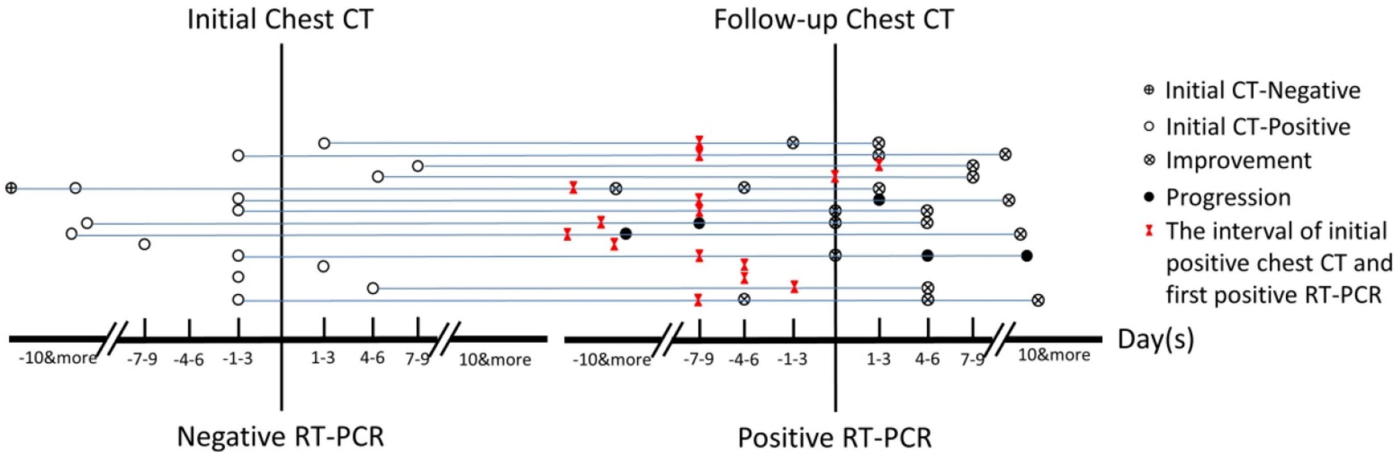




- OP swab: larger swab
- Immediately place both into sterile viral transport media vial
- Double bag specimen
- Include “golden ticket”
- Deliver to central receiving (Founders 7)

Correlation of Chest CT and RT-PCR





Tao et al Radiology 2020

Screening for COVID 19

- Logistics of screening
- Co-infections may occur with COVID 19
- Procedure of obtaining NP swab
- False negatives – more to come as we learn

Clinical Features and Course

Katie Auriemma

Actual Patients admitted in UPHS System

- 72M with confusion and a fever
- 80M with disequilibrium – activated for code stroke
- 68W with fever and SOB
- 72M with 1 week of diarrhea and emesis

All Covid-19 Positive

Early Reports of Epidemiology and Clinical Characteristics

Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study

Nanshan Chen, Min Zhou*, Xuan Dong*, Jieming Qu*, Fengyun Gong, Yang Han, Yang Qiu, Jingli Wang, Ying Liu, Yuan Wei, Jia'an Xia, Ting Yu, Xinxin Zhang, Li Zhang*

- Lancet, February 15, 2020
- Largest early cohort of hospitalized patients
- Fever, cough, shortness of breath

	Patients (n=99)
Signs and symptoms at admission	
Fever	82 (83%)
Cough	81 (82%)
Shortness of breath	31 (31%)
Muscle ache	11 (11%)
Confusion	9 (9%)
Headache	8 (8%)
Sore throat	5 (5%)
Rhinorrhoea	4 (4%)
Chest pain	2 (2%)
Diarrhoea	2 (2%)
Nausea and vomiting	1 (1%)
More than one sign or symptom	89 (90%)
Fever, cough, and shortness of breath	15 (15%)

Clinical Characteristics of Coronavirus Disease 2019 in China

W. Guan, Z. Ni, Yu Hu, W. Liang, C. Ou, J. He, L. Liu, H. Shan, C. Lei, D.S.C. Hui, B. Du, L. Li, G. Zeng, K.-Y. Yuen, R. Chen, C. Tang, T. Wang, P. Chen, J. Xiang,

- NEJM, February 28, 2020
- 1099 patients – 93.6% hospitalized
- Less than half of patients presented with fever
- Vast majority did develop fever during hospitalization
- Wide range of other reported symptoms
- Cough, sputum, and fatigue most common

Characteristic	All Patients (N = 1099)
Fever on admission	
Patients — no./total no. (%)	473/1081 (43.8)
Fever during hospitalization	
Patients — no./total no. (%)	975/1099 (88.7)
Symptoms — no. (%)	
Conjunctival congestion	9 (0.8)
Nasal congestion	53 (4.8)
Headache	150 (13.6)
Cough	745 (67.8)
Sore throat	153 (13.9)
Sputum production	370 (33.7)
Fatigue	419 (38.1)
Hemoptysis	10 (0.9)
Shortness of breath	205 (18.7)
Nausea or vomiting	55 (5.0)
Diarrhea	42 (3.8)
Myalgia or arthralgia	164 (14.9)
Chills	126 (11.5)

Guan W et al NEJM 2020

Clinical Characteristics of Coronavirus Disease 2019 in China

- 15.7% of 1099 patients had “severe disease”

Table 3. Complications, Treatments, and Clinical Outcomes.

Variable	All Patients (N = 1099)	Disease Severity	
		Nonsevere (N = 926)	Severe (N = 173)
Complications			
Septic shock — no. (%)	12 (1.1)	1 (0.1)	11 (6.4)
Acute respiratory distress syndrome — no. (%)	37 (3.4)	10 (1.1)	27 (15.6)
Acute kidney injury — no. (%)	6 (0.5)	1 (0.1)	5 (2.9)
Disseminated intravascular coagulation — no. (%)	1 (0.1)	0	1 (0.6)
Rhabdomyolysis — no. (%)	2 (0.2)	2 (0.2)	0
Physician-diagnosed pneumonia — no./total no. (%)	972/1067 (91.1)	800/894 (89.5)	172/173 (99.4)
Median time until development of pneumonia (IQR) — days*			
After initial Covid-19 diagnosis	0.0 (0.0–1.0)	0.0 (0.0–1.0)	0.0 (0.0–2.0)
After onset of Covid-19 symptoms	3.0 (1.0–6.0)	3.0 (1.0–6.0)	5.0 (2.0–7.0)

Guan W et al NEJM 2020

Clinical Characteristics of Coronavirus Disease 2019 in China

W. Guan, Z. Ni, Yu Hu, W. Liang, C. Ou, J. He, L. Liu, H. Shan, C. Lei, D.S.C. Hui, B. Du, L. Li, G. Zeng, K.-Y. Yuen, R. Chen, C. Tang, T. Wang, P. Chen, J. Xiang,

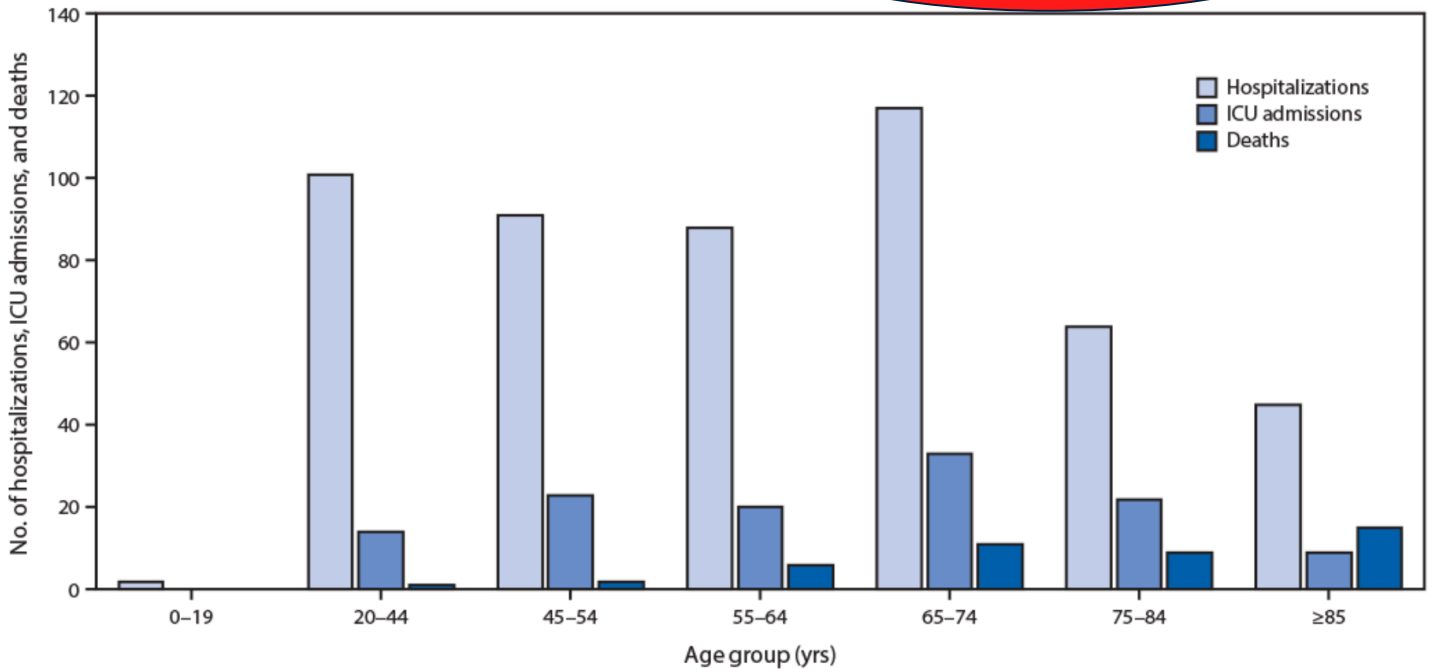
- 6.1% experienced the primary composite endpoint:
  - ICU admission - 5%
  - invasive MV - 2.3%
  - death - 1.4%
- Characteristics associated with worst outcomes
  - Older age
  - Comorbid illness

Characteristic	Presence of Primary Composite End Point†	
	Yes (N=67)	No (N=1032)
Age		
Median (IQR) — yr	63.0 (53.0–71.0)	46.0 (35.0–57.0)
Distribution — no./total no. (%)		
0–14 yr	0	9/946 (1.0)
15–49 yr	12/65 (18.5)	545/946 (57.6)
50–64 yr	21/65 (32.3)	271/946 (28.6)
≥65 yr	32/65 (49.2)	121/946 (12.8)
Coexisting disorder — no. (%)		
Any	39 (58.2)	222 (21.5)
Chronic obstructive pulmonary disease	7 (10.4)	5 (0.5)
Diabetes	18 (26.9)	63 (6.1)
Hypertension	24 (35.8)	141 (13.7)
Coronary heart disease	6 (9.0)	21 (2.0)
Cerebrovascular disease	4 (6.0)	11 (1.1)
Hepatitis B infection¶	1 (1.5)	22 (2.1)
Cancer‖	1 (1.5)	9 (0.9)
Chronic renal disease	2 (3.0)	6 (0.6)
Immunodeficiency	0	2 (0.2)

Guan W et al NEJM 2020

US Disease Outcomes – CDC.gov

FIGURE 2. Coronavirus disease 2019 (COVID-19) hospitalizations,* intensive care unit (ICU) admissions,† and deaths,§ by age group — United States, February 12– March 16, 2020



* Hospitalization status missing or unknown for 1,514 cases.

† ICU status missing or unknown for 2,253 cases.

§ Illness outcome or death missing or unknown for 2,001 cases.

- 4,226 total US cases at that time
- Highest fatality in age ≥ 85 (10-27%)
- Overall in US, persons age ≥ 65:
  - 31% of cases
  - 45% of hospitalizations
  - 53% of ICU admissions
  - 80% of deaths
- Of ICU admissions
  - 36% age 45-64
  - 12% age 20-44

NYC and Philadelphia

- In Philadelphia, half of cases <40 years
- In NYC, majority of cases <65 years

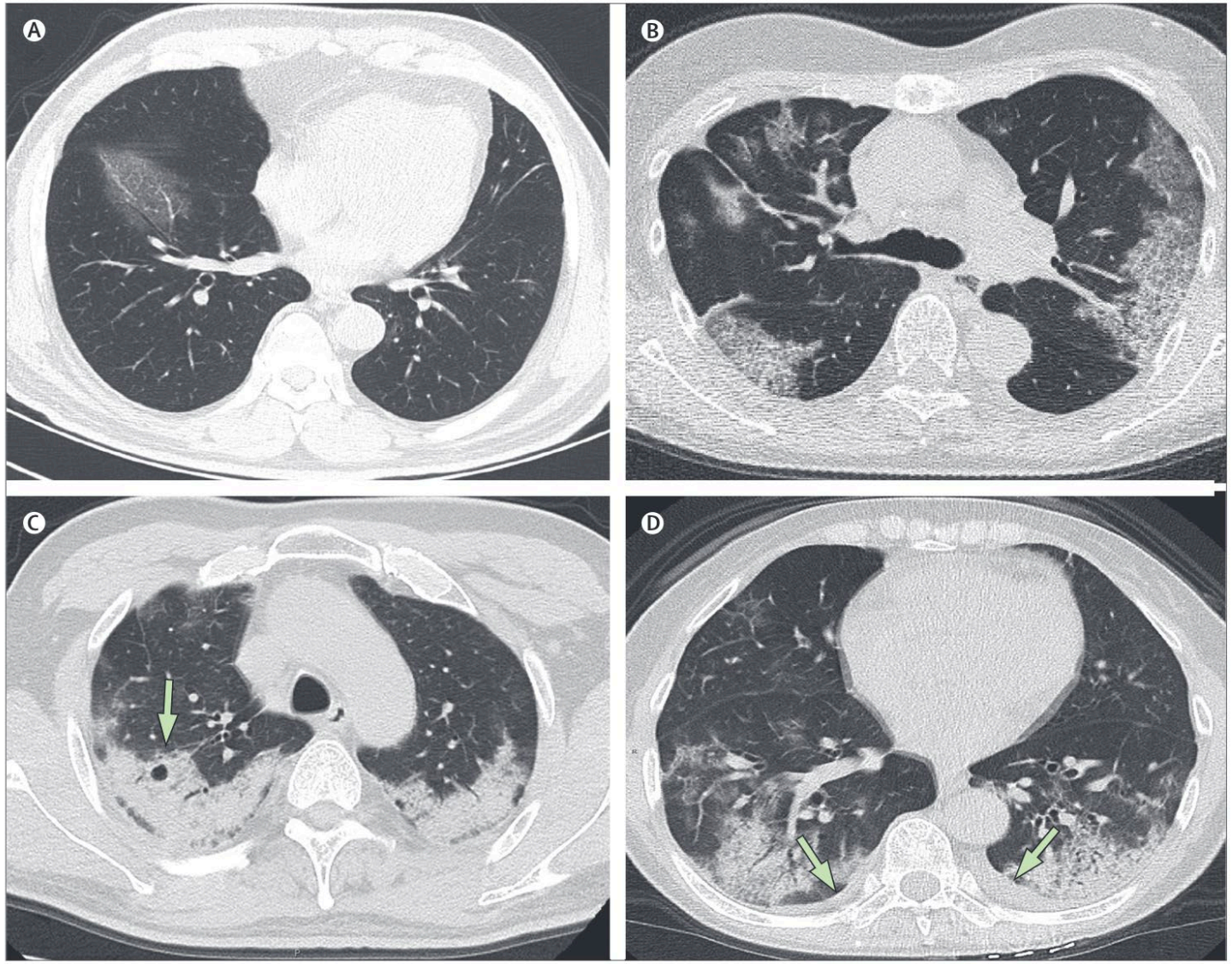
NYC COVID-19 Cases

	Total Cases
Total	32308
Median Age (Range)	48 (0-105)
Age Group	
- 0 to 17	611 (2%)
- 18 to 44	13794 (43%)
- 45 to 64	11146 (35%)
- 65 to 74	3790 (12%)
- 75 and over	2897 (9%)
- Unknown	70
Age 50 and over	
- Yes	15074 (47%)
- No	17164 (53%)
Sex	
- Female	14293 (44%)
- Male	17971 (56%)
- Unknown	44
Borough	
- Bronx	6145 (19%)
- Brooklyn	8451 (26%)
- Manhattan	5438 (17%)
- Queens	10373 (32%)
- Staten Island	1866 (6%)
- Unknown	35
Deaths	678

NYC.gov
Philadelphia.cbslocal.com

Imaging Findings

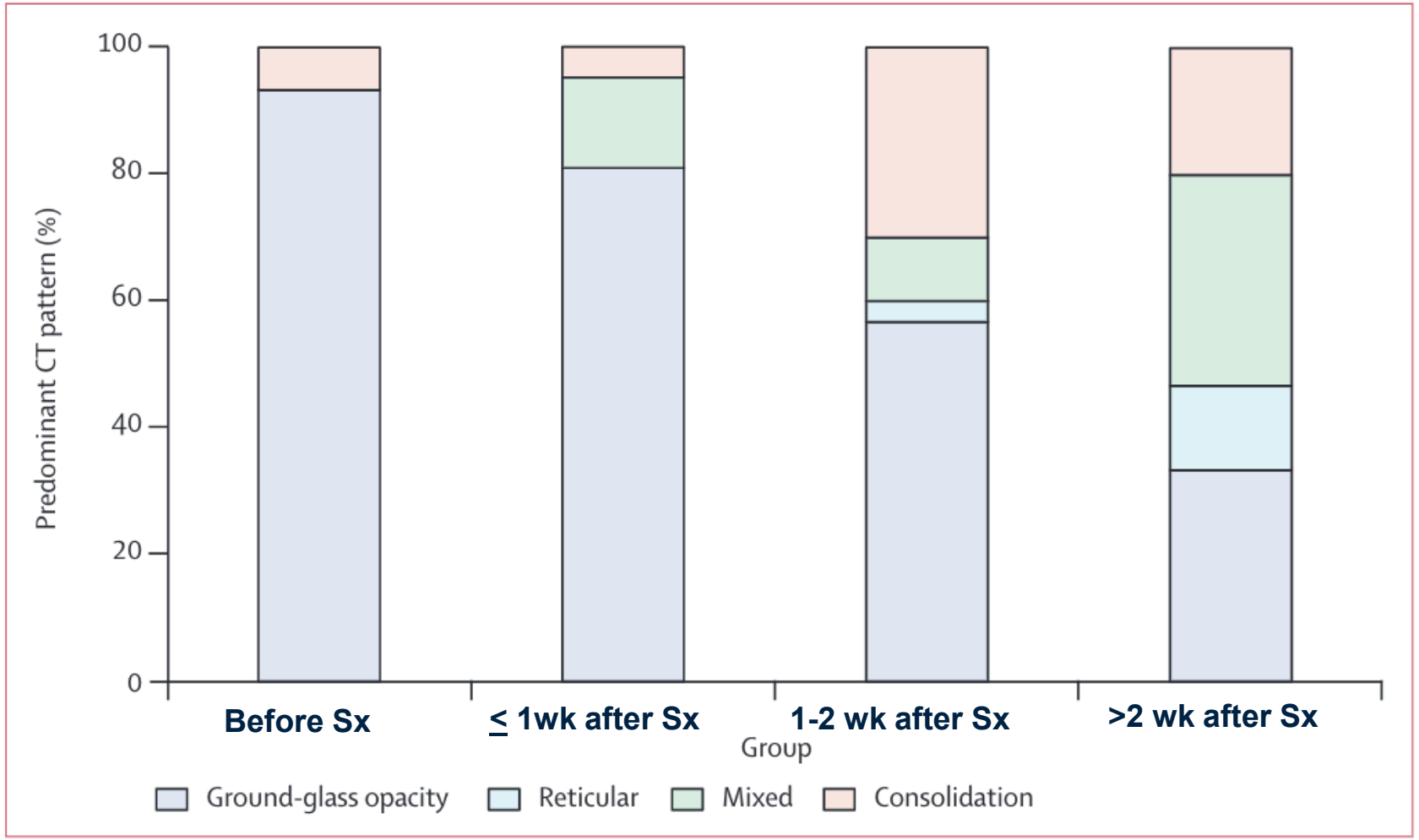
- A: 56M, d3 after Sx onset
- B: 74W, d10 after Sx onset
- C: 61W, d20 after Sx onset
- D: 63W, d17 after Sx onset



Shi H et al Lancet 2020

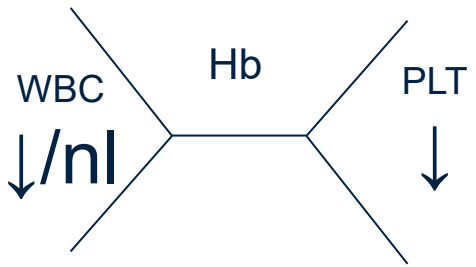
Imaging Findings

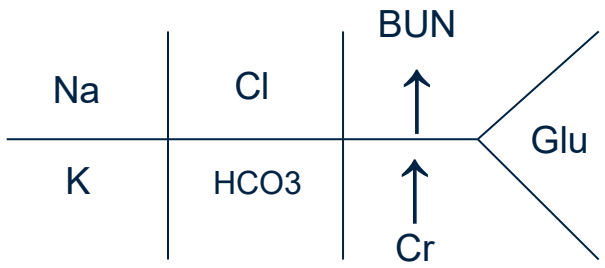
- Distribution CT patterns at various timepoints from symptom onset

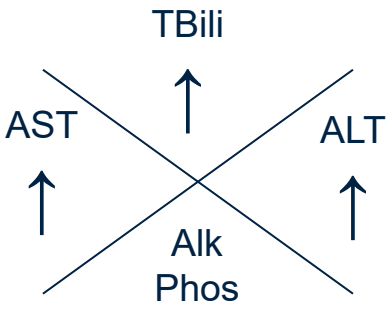


Shi H et al Lancet 2020

Laboratory Findings



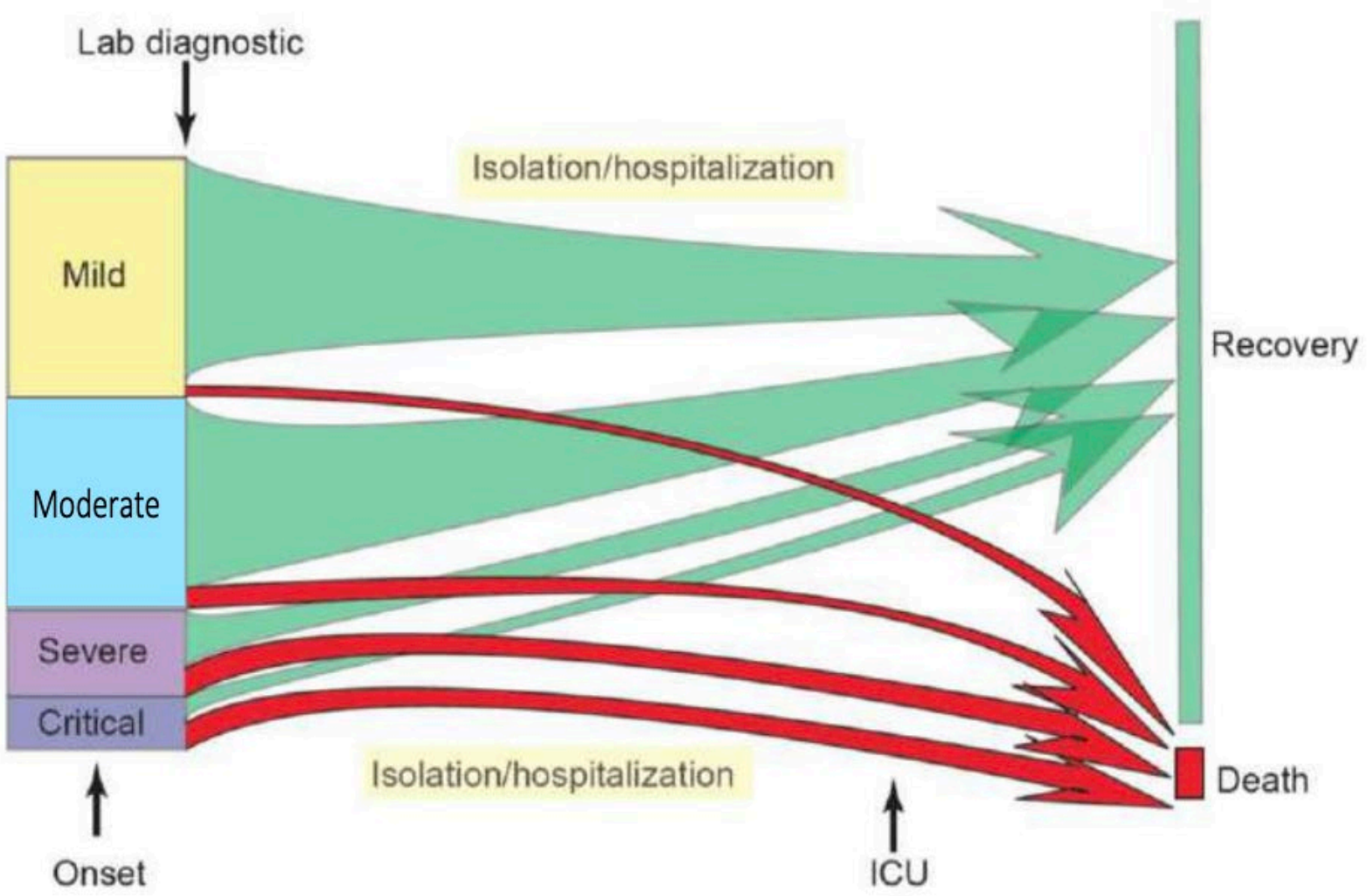




- Leukopenia and lymphopenia (80%+)
- IL-6, Ferritin elevated
- D-Dimer, CRP, LDH elevated
- Procalcitonin generally low → may be high with bacterial superinfection

Ruan Q et al ICM 2020

Disease Progression



Median time from onset to recovery:

- Mild: 2 weeks
- Severe: 3-6 weeks

Onset to development of severe disease:

- 1 week

Among those who have died, time of symptom onset to death:

- 2-8 weeks

WHO. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)

Decompensation – Mainly Anecdotal

- Respiratory Failure
  - Rapidly progressive from hospital admission (often 7-10d out from symptom onset)
- Shock
  - Onset described when respiratory failure seems to be resolving
  - Described as cold/clamped, POCUS demonstrating impaired cardiac function
- Cardiac Arrest
  - VT/VF
  - PEA

Washington ICU Outcomes

- Case series of 21 critically ill patients from Washington State
- Published 3/19/20

- Over half had severe ARDS
- 2/3 developed shock requiring vasopressors
- 19% AKI
- 1/3 developed a cardiomyopathy

Table 2. Clinical Measures During the Course of Illness and Outcomes of 21 Critically Ill Patients With Coronavirus Disease 2019

	No. (%) of patients[a]
Clinical measures	
Acute respiratory distress syndrome (ARDS)[b]	
None	1 (4.8)
Mild	2 (9.5)
Moderate	6 (28.6)
Severe	12 (57.1)
Required mechanical ventilation	15 (71.0)
Use of vasopressors	14 (67.0)
Acute kidney failure[d]	4 (19.1)
Cardiomyopathy[e]	7 (33.3)
Acute hepatic injury[f]	3 (14.3)
Seizures	1 (4.8)
Length of follow-up, mean (range), d	5.2 (1-10)
Outcomes	
Died	11 (52.4)
Survived to transfer out of ICU	2 (9.5)
Remains critically ill and requires mechanical ventilation	8 (38.1)
Length of follow-up for those who survived or remain critically ill, mean (range), d	7.5 (5-10)

Arentz M et al JAMA 2020

Critical Care Management

Roger Kim

Outline

- Respiratory failure
- Mechanical ventilation
- Hemodynamic management
- Novel strategies / future directions

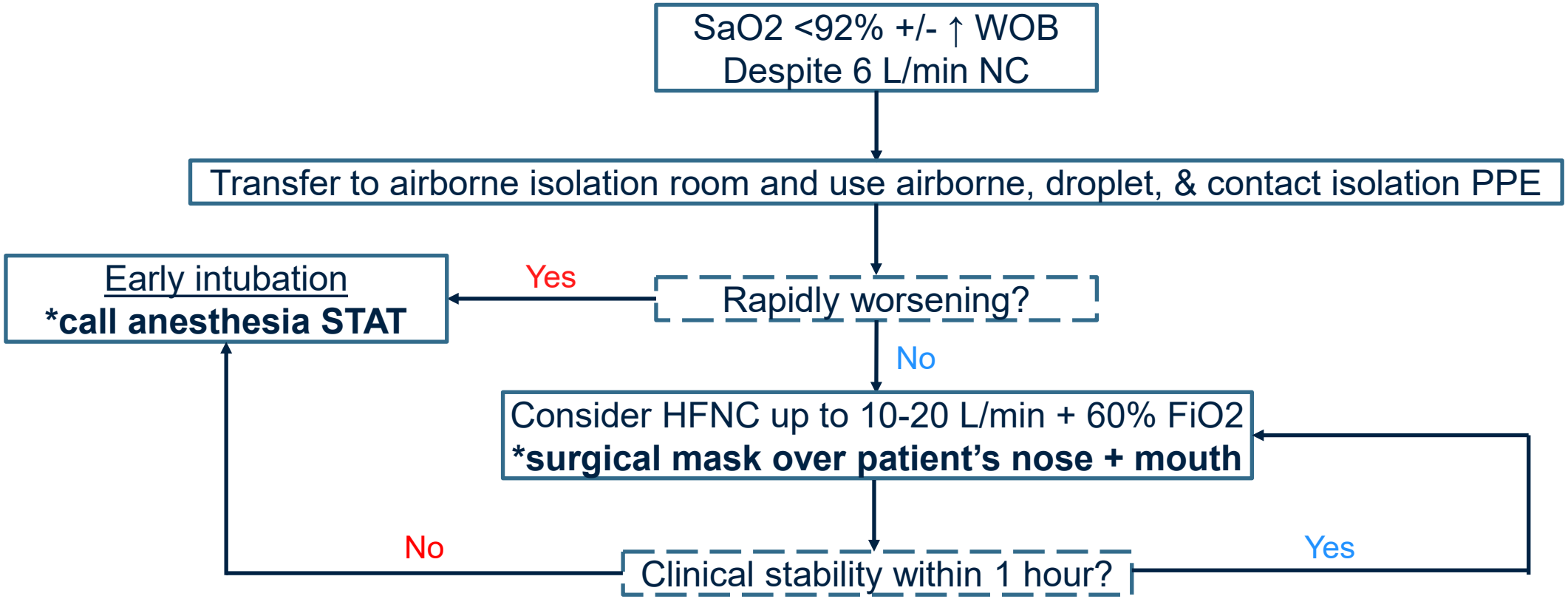
Respiratory failure algorithms

UPHS guidelines
March 27, 2020

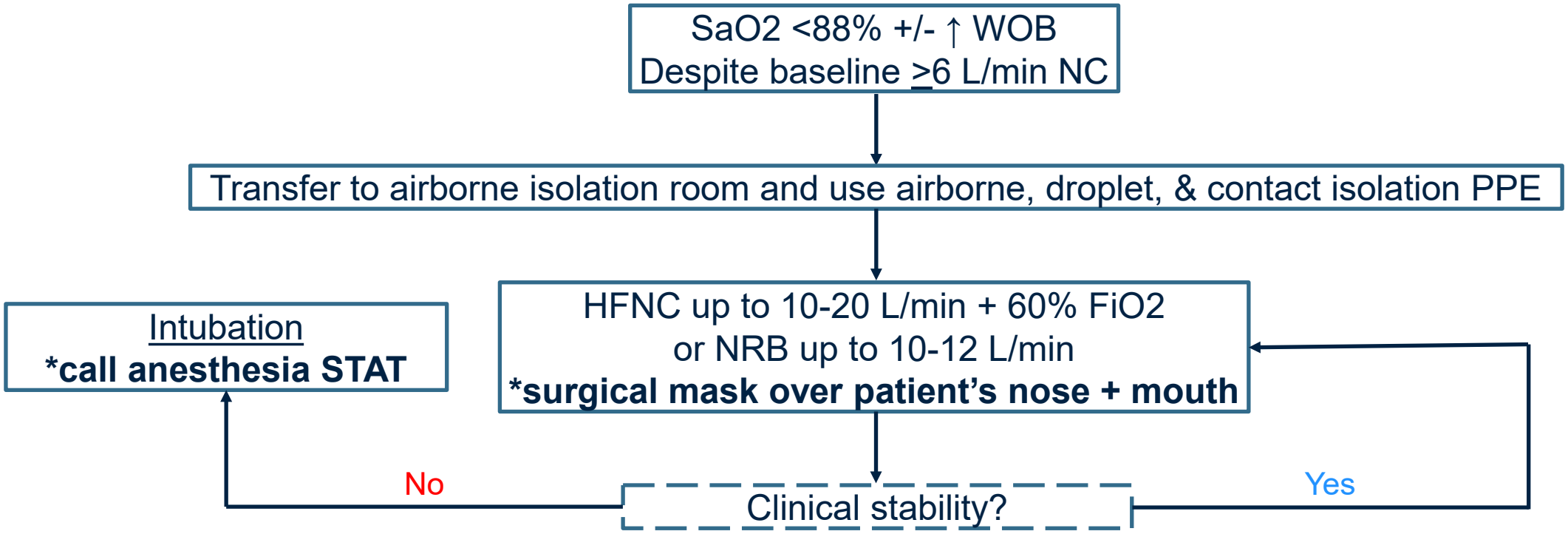
Respiratory support general principles

- Favor early intubation
- Avoid NIPPV (i.e. CPAP, BiPAP)
- Limit HFNC use to 10-20 L/min flow rate and 60% FiO2

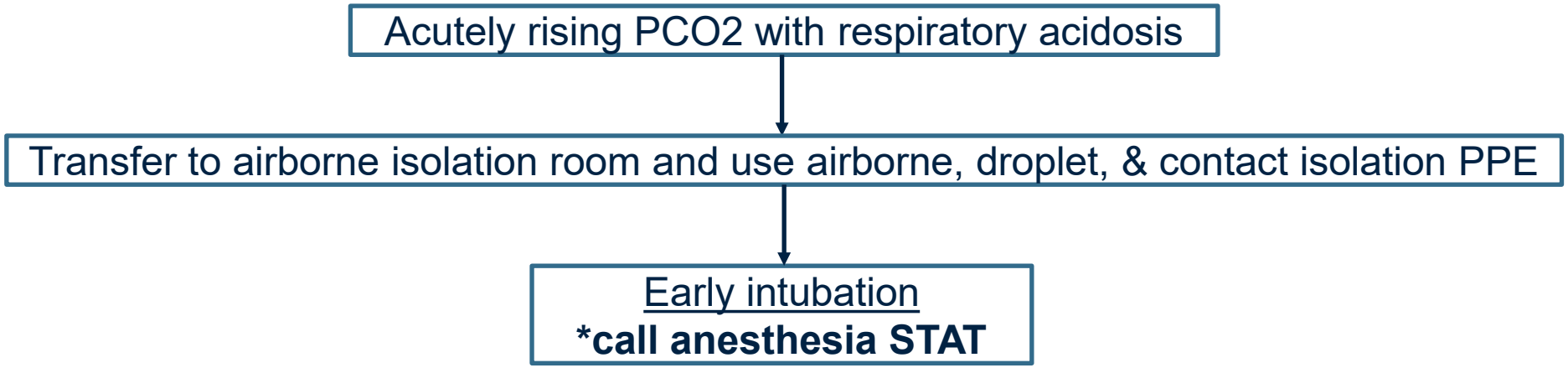
Acute hypoxic respiratory failure



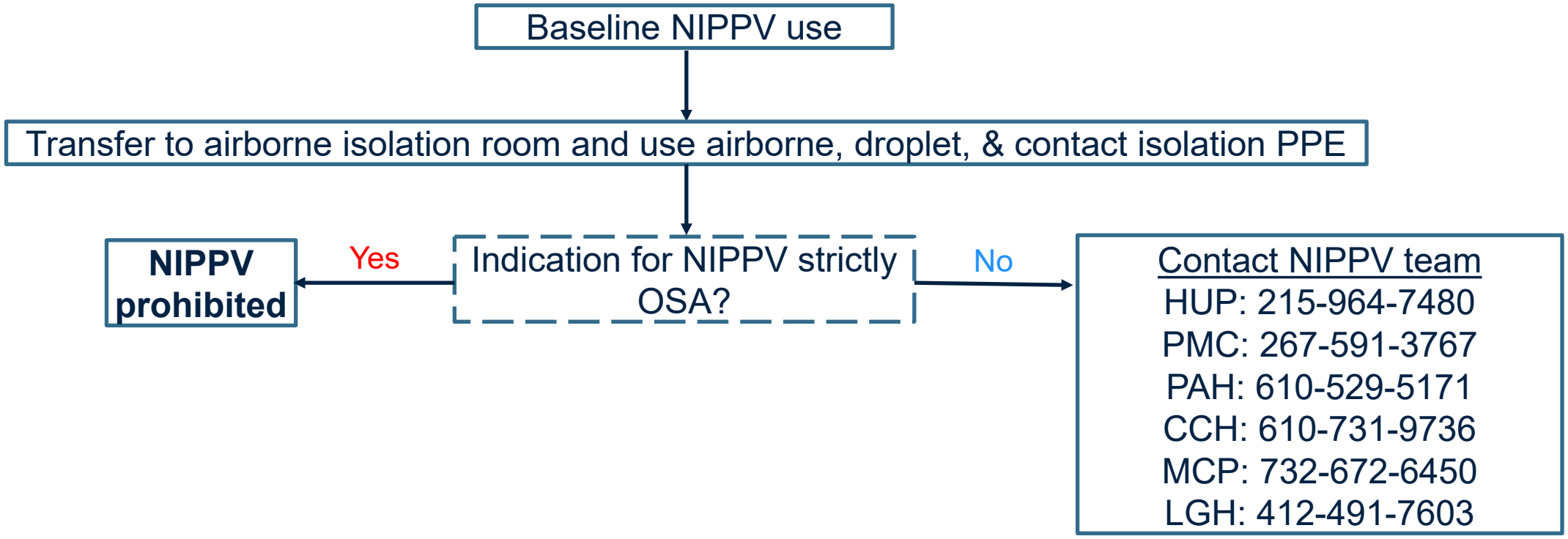
Acute on chronic hypoxic respiratory failure



Acute / acute on chronic hypercapnic respiratory failure



Stable chronic hypercapnic respiratory failure



ARDS mechanical ventilation strategies

UPHS guidelines
March 27, 2020

SCCM COVID-19 guidelines
March 2020

ARDS mechanical ventilation general principles

- Low-stretch (lung protective) ventilation
- High PEEP strategy
- Conservative fluid strategy
- Refractory hypoxemia
  - Neuromuscular blocking agents (NMBA)
  - Prone ventilation

JAMA, DOI: 10.1001/jama.2020.3633
SCCM COVID-19 guidelines

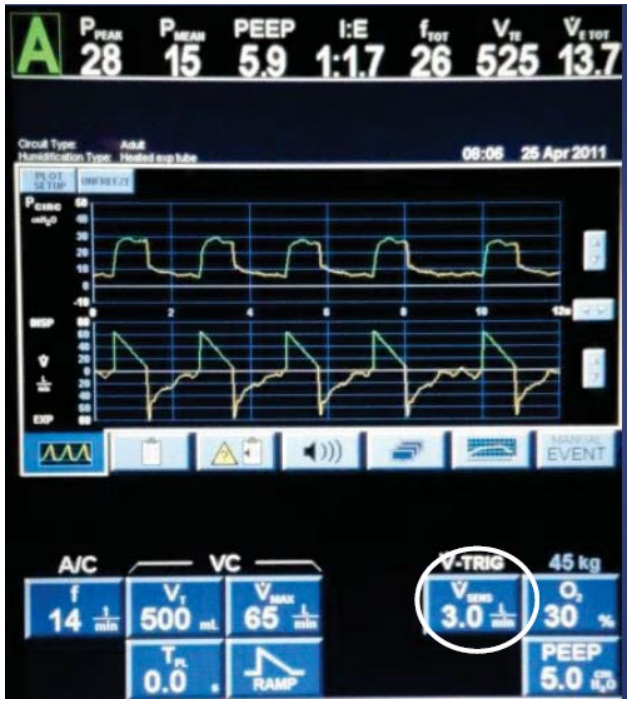
ARDS mechanical ventilation general principles

- **Low-stretch (lung protective) ventilation**
- High PEEP strategy
- Conservative fluid strategy
- Refractory hypoxemia
  - Neuromuscular blocking agents (NMBA)
  - Prone ventilation

JAMA, DOI: 10.1001/jama.2020.3633
SCCM COVID-19 guidelines

Low-stretch (lung protective) ventilation

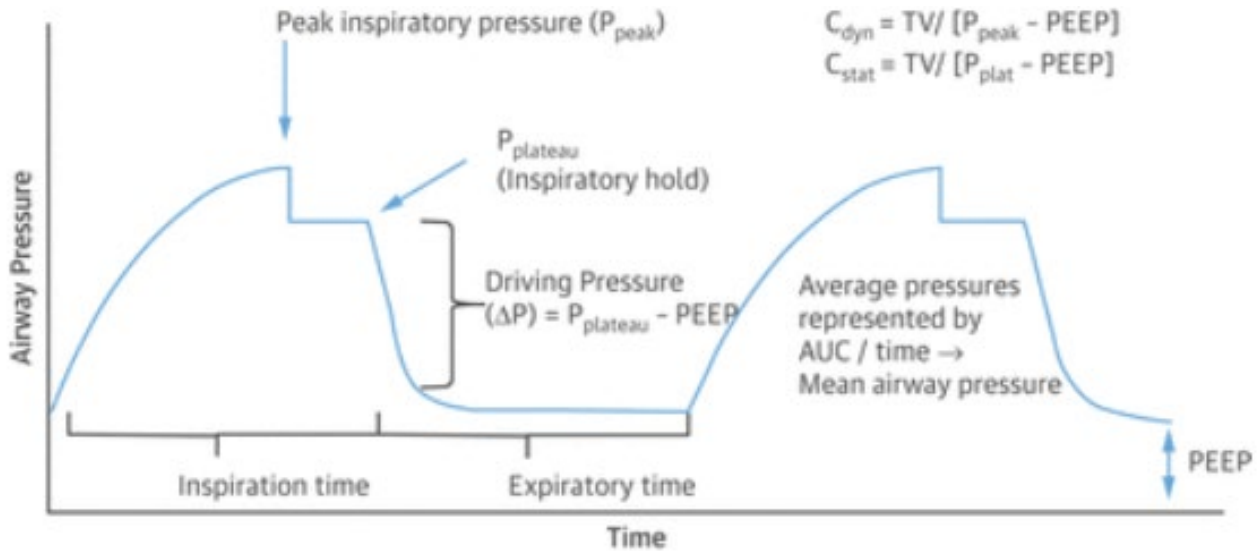
- Volume assist control (VAC) with low tidal volumes
  - Vt 4-8 mL/kg of predicted ideal body weight (start at 6 mL/kg)
- Target plateau pressure (P_{plat})<30 cm H_2O
- Goal pH: 7.30-7.45
- Goal SpO2: 92-96%
- Ventilator dyssynchrony is common
  - Adequate sedation is required
  - Consider RASS goal of -2 to -3



NEJM, DOI: 10.1056/NEJM200005043421801; *Ann Am Thorac Soc*, DOI: 10.1513/AnnalsATS.201704-337OT
BMJ Open, DOI: 10.1136/bmjopen-2016-015091; *NEJM*, DOI: 10.1056/NEJMoa1916431

High PEEP strategy

- PEEP-responsive ARDS with driving pressures <15 cm H_2O consistently reported
- Start with PEEP of ≥14-18 cm H_2O
- Risk of PTX and hemodynamic compromise

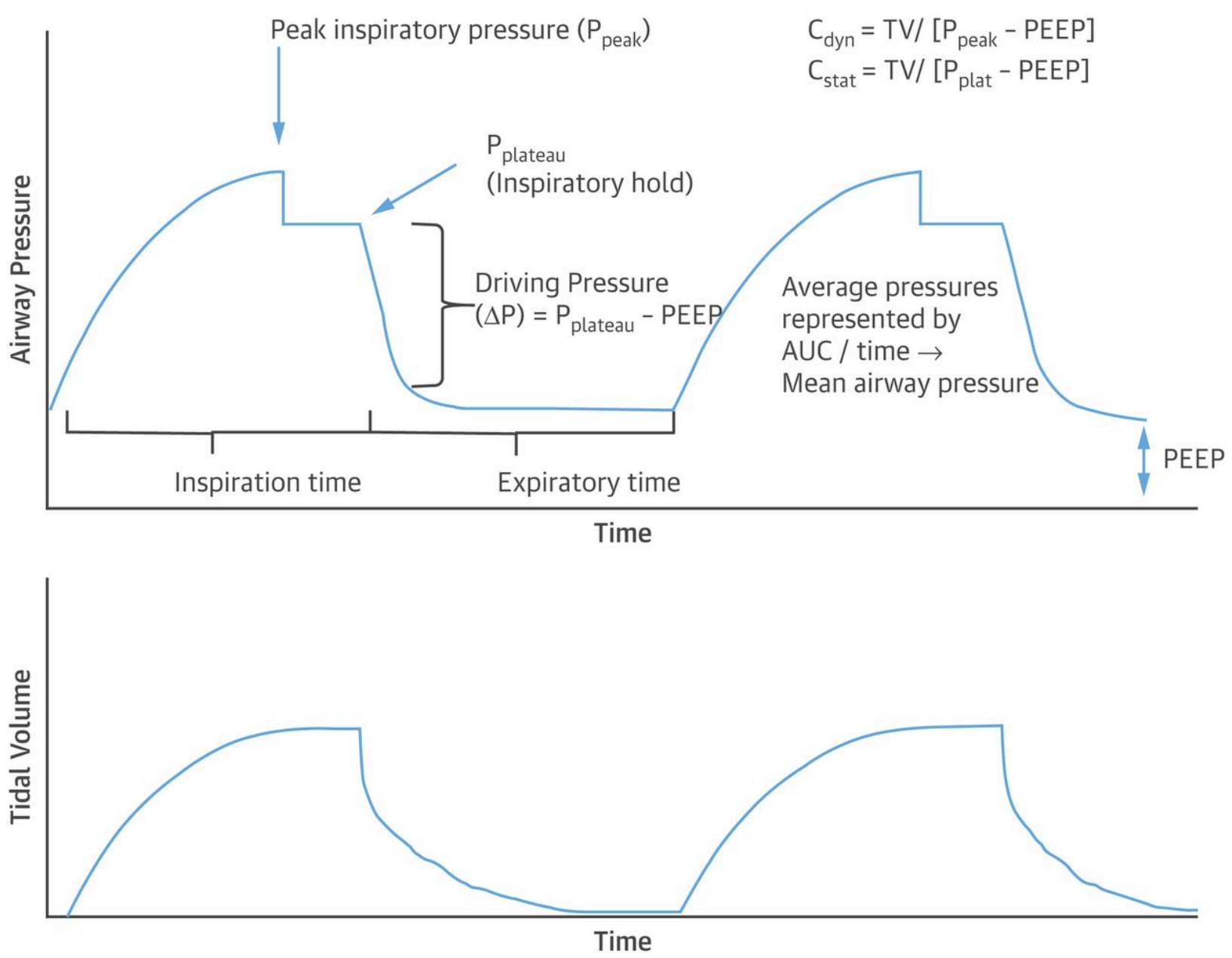


Higher PEEP/lower FiO2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

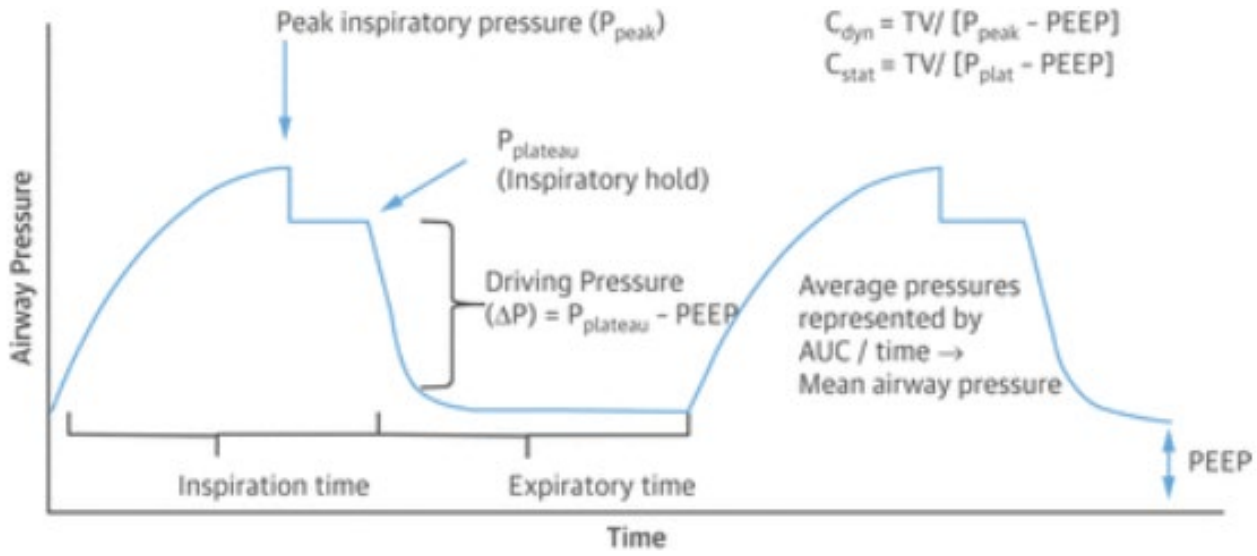
FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

JACC, DOI: 10.1016/j.jacc.2018.06.074; *NEJM*, DOI: 10.1056/NEJM200005043421801
NEJM, DOI: 10.1056/NEJMoa032193; *JAMA*, DOI: 10.1001/jama.2010.218


Peak inspiratory pressure (P_{peak})
$C_{dyn} = TV/ [P_{peak} - PEEP]$
$C_{stat} = TV/ [P_{plat} - PEEP]$
$P_{plateau}$
(Inspiratory hold)
Airway Pressure
Driving Pressure
(ΔP) = $P_{plateau}$ - PEEP
Average pressures
represented by
AUC / time →
Mean airway pressure
PEEP
Inspiration time
Expiratory time
Time
Tidal Volume
Time

High PEEP strategy

- PEEP-responsive ARDS with driving pressures <15 cm H_2O consistently reported
- Start with PEEP of ≥14-18 cm H_2O
- Risk of PTX and hemodynamic compromise



Higher PEEP/lower FiO2

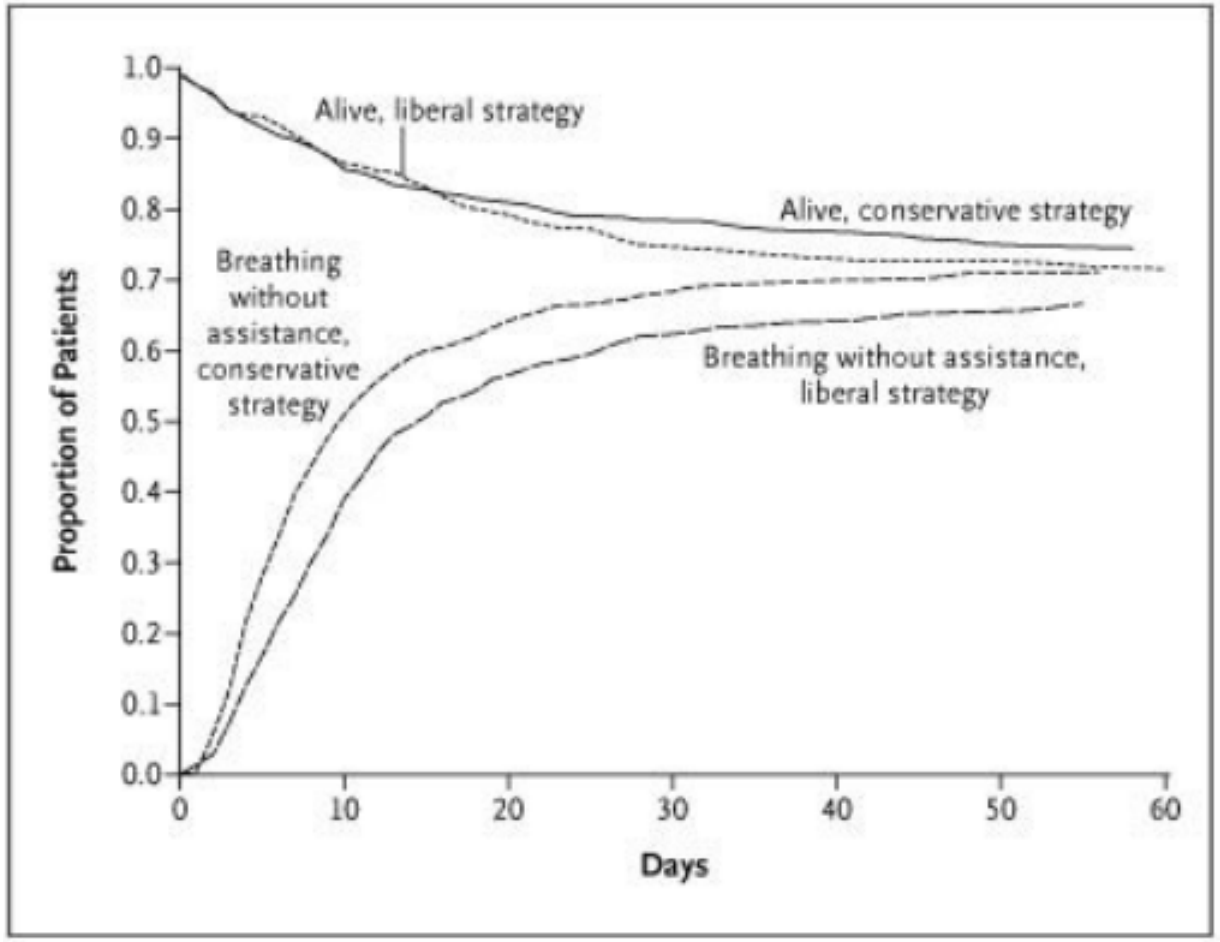
FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

JACC, DOI: 10.1016/j.jacc.2018.06.074; *NEJM*, DOI: 10.1056/NEJM200005043421801
NEJM, DOI: 10.1056/NEJMoa032193; *JAMA*, DOI: 10.1001/jama.2010.218

Conservative fluid strategy

- No consensus on definition
- Diurese to avoid obvious volume overload
- Diurese if SpO2 <92% despite optimization of ventilator mechanics
- Consider diuresis if on low-dose pressors with normal renal function



Intensive Care Med, DOI:10.1007/s00134-016-4573-3; *NEJM*, DOI: 10.1056/NEJMoa062200

Refractory hypoxemia – recommended strategies

Neuromuscular blocking agents (NMBA)

- Intermittent boluses to facilitate lung protective ventilation
- Continuous infusion ≤48 hrs for prone ventilation, persistent P_{plat} >30 cm H_2O, or persistent ventilator dyssynchrony

Prone ventilation

- Use if P:F ≤150, FiO2 ≥60%, and PEEP ≥5 cm H_2O after ≥ 12 hours of ventilator support
- Prone 16-18 hours per day
- Stop:
  - When P:F >150 with PEEP ≤10 cm H_2O and FiO2 ≤60% in supine position for ≥4 hours
  - If prone position decreases P:F by >20% compared to supine position

Crit Care, DOI: 10.1186/cc12557; *NEJM*, DOI: 10.1056/NEJMoa1901686
Lancet Infect Dis, DOI: 10.1016/S1473-3099(20)30086-4*; Ann Am Thorac Soc*, DOI: 10.1513/AnnalsATS.201704-343OT

Refractory hypoxemia – strategies to consider

Traditional recruitment maneuvers

- 30-40 cm H_2O for 30-40 s
- If oxygenation improves, use higher PEEP

Bronchoscopy

ONLY in following situations:

- Complete lung atelectasis from mucous plugging with worsening hypoxemia
- Massive hemoptysis with need to clear blood/clot and place bronchial blocker
- Unable to obtain tracheal aspirate for VAP workup

VV-ECMO

Consider if all other interventions exhausted AND any 1 of following:

- Injurious ventilator settings necessary to achieve adequate oxygenation
- Uncontrolled respiratory acidosis
- Right heart failure with persistent organ dysfunction despite lung protective ventilation
  - May need to switch to VA-ECMO if does not improve with VV-ECMO

Ann Am Thorac Soc, DOI: 10.1513/AnnalsATS.201704-340OT; *CHEST*, DOI: 10.1016/j.chest.2019.07.012
Lancet Respr Med, DOI: 10.1016/S2213-2600(18)30452-1; *J Thorac Dis*, DOI: 10.21037/jtd.2017.10.75

Refractory hypoxemia – **NOT** recommended strategies

Inhaled epoprostenol (i.e. Flolan, Veletri)

- No mortality benefit
- May clog vent filter and increase risk of aerosolization
- *Can consider a trial of inhaled nitric oxide after discussion with pharmacy*

Staircase (incremental PEEP) recruitment maneuvers

- Defined as incremental increases in PEEP from 25 to 35 to 45 cm H_2O for 1-2 min. each
- May be associated with increased mortality

Cochrane Database Syst Rev, DOI: 10.1002/14651858.CD002787.pub3
Ann Am Thorac Soc, DOI: 10.1513/AnnalsATS.201704-340OT

Hemodynamic management

UPHS guidelines
March 27, 2020

SCCM COVID-19 guidelines
March 2020

Septic shock management

- Empiric antibiotics in mechanically ventilated patients
- Conservative isotonic crystalloid fluids (LR > NS) for acute resuscitation
  - Preferred over hydroxyethyl starches, dextrans, gelatins, or albumin
- Norepinephrine = preferred 1st line vasoactive agent
  - If not available, consider vasopressin or epinephrine
  - Preferred over dopamine
- Vasopressin = preferred 2nd line vasoactive agent
  - If not available, consider epinephrine
- MAP goal: 60-65 mmHg
- Consider “stress-dose” steroids (hydrocortisone 200 mg/d) for refractory shock

NEJM, DOI: 10.1056/NEJMoa1711584; *NEJM*, DOI: 10.1056/NEJMoa0907118; *NEJM*, DOI: 10.1056/NEJMoa067373
JAMA, DOI: 10.1001/jama.2020.0930; *Intensive Care Med*, DOI: 10.1007/s00134-018-5197-6

COVID-19 hemodynamic considerations

- Start norepinephrine at 0.05-0.1 mcg/kg/min immediately after intubation and titrate accordingly

- Presumed viral myocarditis → cardiac dysfunction / fluid overload
  - Favor negative fluid balance without causing organ hypoperfusion
  - Consider diuresis if POCUS reveals non-collapsible IVC
  - Dynamic hemodynamic reassessment with POCUS TTE
  - Consider VA-ECMO for severe myocarditis causing cardiogenic shock

- Ensure adequate preload in setting of high PEEP ventilatory strategy
  - Consider careful IVF boluses if PEEP >15cm H_2O

Novel strategies / future directions

Helmet NIPPV

JAMA, DOI: 10.1001/jama.2016.6338

Awake prone ventilation

- Floor patients with hypoxic respiratory failure on supplemental O2 (including HFNC)

- NOT recommended in patients with:
  - Chronic lung disease
  - Chest tubes
  - Spinal instability
  - Cardiogenic pulmonary edema
  - GCS <15
  - PaCO2 >45 mmHg

- Prone for ≥2-4 hours bid as tolerated

Critical Care, DOI: 10.1186/s13054-020-2738-5

BMI-based PEEP ventilatory strategy

BMI	Starting PEEP
<35	10
35-50	12
>50	15

Future directions

- Define PEEP weaning and prolonged SBT protocol
- Standardize approach to cardiac monitoring
  - Daily EKG not recommended
  - Early POCUS vs. TTE?
- Standardize sedation protocol
  - Concerns about propofol (↑TG's & LFT's)
  - Cisatracurium shortage
- Standardize laboratory testing frequency
  - D-dimer, procalcitonin, LFT's, LDH, ferritin, WBC w/ diff, CRP, IL-6, coags


Penn Medicine

Supplemental slides / figures

Penn Medicine Tip Sheet: Escalation of Care for Respiratory Failure

Updated 3/28/2020 – newest version here

ACUTE RESPIRATORY FAILURE

Are O_2 requirements or work of breathing rapidly escalating?

NO

COVID-19 STATUS

Non-COVID / Non-PUI	COVID-19 PUI	COVID-19 Confirmed
Upgrade to **droplet + contact isolation** Close door, minimize entry	Upgrade to **airborne + contact isolation** Move to negative pressure room if possible	
Call ID for testing (hypercapnia only)	Call lab to expedite results	

HYPOXEMIA
(↑WOB or SaO_2 <92% on ≥6L LPM)

Normal management	Trial HFNC Flow: 10-20 LPM; FiO2: up to 60% Place surgical ask over patient's nose/mouth	
	Only if chronic baseline O_2 ≥6 LPM -or- Trial NRB Flow: 10-12 LPM	
	REASSESS at 1 HR	

HYPERCAPNIA

Start NPPV Non-vented mask Active ventilation circuit w/ exhalation filter **Healthcare workers to wear N95 until COVID testing is negative**	Consider Early Intubation if high risk for COVID-19 or impending respiratory failure -or- Trial NPPV Non-vented mask Active ventilation circuit w/ exhalation filter	**EARLY INTUBATION** Risk of rapid progression of respiratory failure requiring mechanical ventilation
REASSESS → usual management	REASSESS at 1 HR	

YES

EARLY INTUBATION

All intubations, including ICU intubations should be called **overhead STAT**

Ward (neg pressure):
intubate in room prior to ICU transfer

Ward (regular):
transfer to ICU with mask on patient, then intubate

For most patients, use
Low Stretch Protocol for ARDS

EARLY INTUBATION

SaO_2 < 92% or pH < 7.3
despite maximal interventions

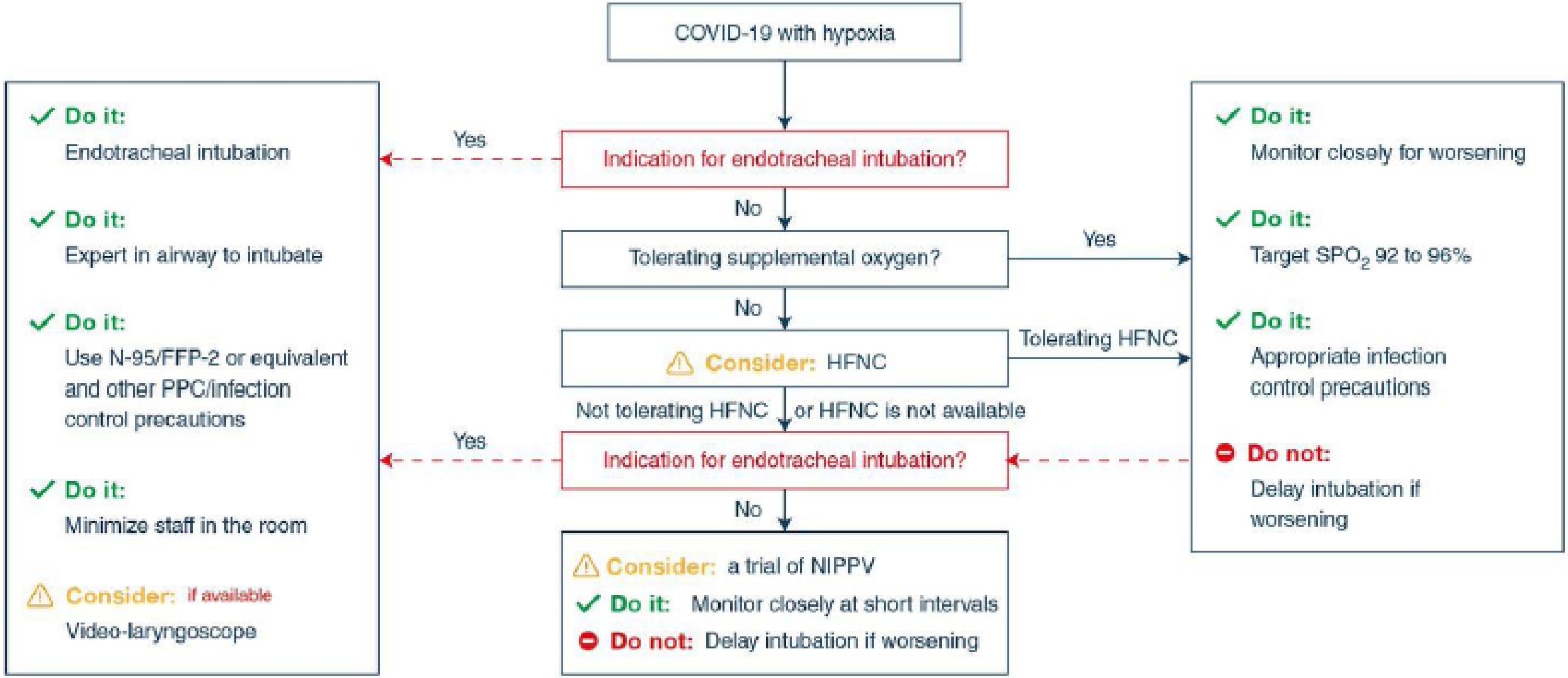
Stable Chronic Hypercapnia

Upgrade isolation by COVID-19 status as per acute respiratory failure algorithm.

OSA: No NPPV allowed
COPD, OHS, NMD: contact hospital NIV team

HUP: 215-964-7480	CCH: 610-731-9736
PMC: 267-591-3767	MCP: 732-672-6450
PAH: 610-529-5171 chronic 215-498-6357 acute	LGH: 412-491-7603

Adapted from the UPHS Critical Care Clinical Operations COVID-19 guidelines. UPHS CCC guidelines are rapidly evolving - check Penn SharePoint for most updated information. Email Jeff Min & Jennifer Ginestra for corrections.



SCCM COVID-19 guidelines, March 2020

Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

	Acute Respiratory Distress Syndrome
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging[a]	Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mm Hg < Pao_2/Fio_2 ≤ 300 mm Hg with PEEP or CPAP ≥5 cm H_2O[c]
Moderate	100 mm Hg < Pao_2/Fio_2 ≤ 200 mm Hg with PEEP ≥5 cm H_2O
Severe	Pao_2/Fio_2 ≤ 100 mm Hg with PEEP ≥5 cm H_2O

Abbreviations: CPAP, continuous positive airway pressure; Fio_2, fraction of inspired oxygen; Pao_2, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.

[a] Chest radiograph or computed tomography scan.

[b] If altitude is higher than 1000 m, the correction factor should be calculated as follows: [Pao_2/Fio_2 × (barometric pressure/760)].

[c] This may be delivered noninvasively in the mild acute respiratory distress syndrome group.

NIH PREDICTED BODY WEIGHT (PBW) / TIDAL VOLUME CHART

MALES

HEIGHT		PBW	4	5	6	7	8
Feet	Inches	Male	ml/kg	ml/kg	ml/kg	ml/kg	ml/kg
4' 10"	58	45.4	180	230	270	320	360
4' 11"	59	47.7	190	240	290	330	380
5' 0"	60	50	200	250	300	350	400
5' 1"	61	52.3	210	260	310	370	420
5' 2"	62	54.6	220	270	330	380	440
5' 3"	63	56.9	230	280	340	400	460
5' 4"	64	59.2	240	300	360	410	470
5' 5"	65	61.5	250	310	370	430	490
5' 6"	66	63.8	260	320	380	450	510
5' 7"	67	66.1	260	330	400	460	530
5' 8"	68	68.4	270	340	410	480	550
5' 9"	69	70.7	280	350	420	490	570
5' 10"	70	73	290	370	440	510	580
5' 11"	71	75.3	300	380	450	530	600
6' 0"	72	77.6	310	390	470	540	620
6' 1"	73	79.9	320	400	480	560	640
6' 2"	74	82.2	330	410	490	580	660
6' 3"	75	84.5	340	420	510	590	680
6' 4"	76	86.8	350	430	520	610	690
6' 5"	77	89.1	360	450	530	620	710
6' 6"	78	91.4	370	460	550	640	730

FEMALES

HEIGHT		PBW	4	5	6	7	8
Feet	Inches	Female	ml/kg	ml/kg	ml/kg	ml/kg	ml/kg
4' 7"	55	34	140	170	200	240	270
4' 8"	56	36.3	150	180	220	250	290
4' 9"	57	38.6	150	190	230	270	310
4' 10"	58	40.9	160	200	250	290	330
4' 11"	59	43.2	170	220	260	300	350
5' 0"	60	45.5	180	230	270	320	360
5' 1"	61	47.8	190	240	290	330	380
5' 2"	62	50.1	200	250	300	350	400
5' 3"	63	52.4	210	260	310	370	420
5' 4"	64	54.7	220	270	330	380	440
5' 5"	65	57	230	290	340	400	460
5' 6"	66	59.3	240	300	360	420	470
5' 7"	67	61.6	250	310	370	430	490
5' 8"	68	63.9	260	320	380	450	510
5' 9"	69	66.2	260	330	400	460	530
5' 10"	70	68.5	270	340	410	480	550
5' 11"	71	70.8	280	350	420	500	570
6' 0"	72	73.1	290	370	440	510	580
6' 1"	73	75.4	300	380	450	530	600
6' 2"	74	77.7	310	390	470	540	620
6' 3"	75	80	320	400	480	560	640

NIH NHLBI ARDS Clinical Network
Mechanical Ventilation Protocol Summary

INCLUSION CRITERIA: Acute onset of

1. $PaO_2/FiO_2 \leq 300$ (corrected for altitude)
2. Bilateral (patchy, diffuse, or homogeneous) infiltrates consistent with pulmonary edema
3. No clinical evidence of left atrial hypertension

PART I: VENTILATOR SETUP AND ADJUSTMENT

1. Calculate predicted body weight (PBW)
   Males = 50 + 2.3 [height (inches) - 60]
   Females = 45.5 + 2.3 [height (inches) -60]
2. Select any ventilator mode
3. Set ventilator settings to achieve initial V_T = 8 ml/kg PBW
4. Reduce V_T by 1 ml/kg at intervals ≤ 2 hours until V_T = 6ml/kg PBW.
5. Set initial rate to approximate baseline minute ventilation (not > 35 bpm).
6. Adjust V_T and RR to achieve pH and plateau pressure goals below.

OXYGENATION GOAL: PaO_2 55-80 mmHg or SpO_2 88-95%
Use a minimum PEEP of 5 cm H_2O. Consider use of incremental FiO_2/PEEP combinations such as shown below (not required) to achieve goal.

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

PLATEAU PRESSURE GOAL: ≤ 30 cm H_2O
Check Pplat (0.5 second inspiratory pause), at least q 4h and after each change in PEEP or V_T.
If Pplat > 30 cm H_2O: decrease V_T by 1ml/kg steps (minimum = 4 ml/kg).
If Pplat < 25 cm H_2O and V_T< 6 ml/kg, increase V_T by 1 ml/kg until Pplat > 25 cm H_2O or V_T = 6 ml/kg.
If Pplat < 30 and breath stacking or dys-synchrony occurs: may increase V_T in 1ml/kg increments to 7 or 8 ml/kg if Pplat remains ≤ 30 cm H_2O.

pH GOAL: 7.30-7.45

Acidosis Management: (pH < 7.30)

If pH 7.15-7.30: Increase RR until pH > 7.30 or $PaCO_2$ < 25 (Maximum set RR = 35).

.

If pH < 7.15: Increase RR to 35.

If pH remains < 7.15, V_T may be increased in 1 ml/kg steps until pH > 7.15 (Pplat target of 30 may be exceeded).

May give $NaHCO_3$

Alkalosis Management: (pH > 7.45) Decrease vent rate if possible.

I: E RATIO GOAL: Recommend that duration of inspiration be ≤ duration of expiration.

PART II: WEANING

A. Conduct a SPONTANEOUS BREATHING TRIAL daily when:

1. $FiO_2 \leq 0.40$ and PEEP ≤ 8 OR $FiO_2 \leq 0.50$ and PEEP ≤ 5.
2. PEEP and FiO_2 ≤ values of previous day.
3. Patient has acceptable spontaneous breathing efforts. (May decrease vent rate by 50% for 5 minutes to detect effort.)
4. Systolic BP ≥ 90 mmHg without vasopressor support.
5. No neuromuscular blocking agents or blockade.

B. SPONTANEOUS BREATHING TRIAL (SBT):

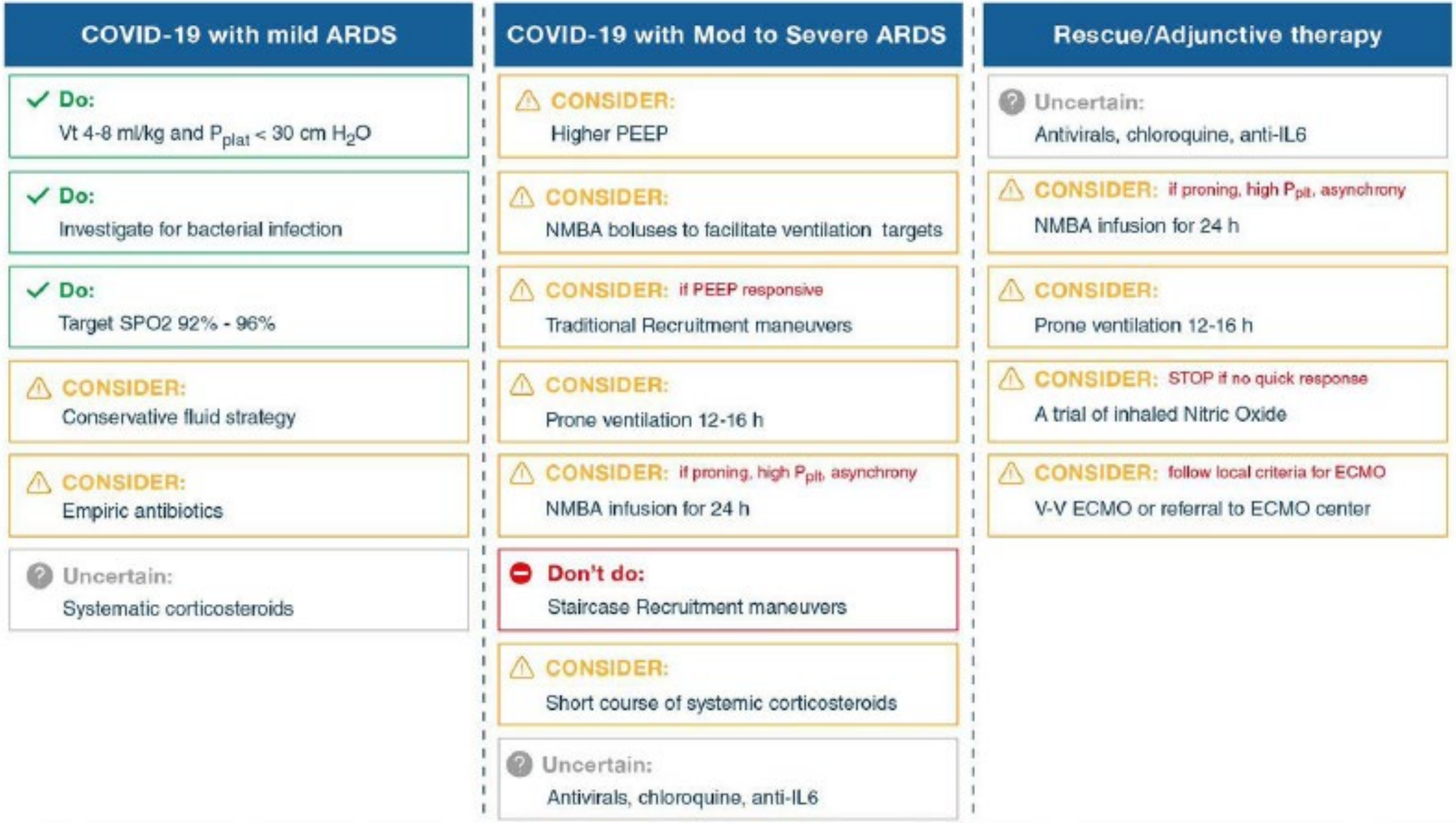
If all above criteria are met and subject has been in the study for at least 12 hours, initiate a trial of UP TO 120 minutes of spontaneous breathing with FiO2 ≤ 0.5 and PEEP ≤ 5:

1. Place on T-piece, trach collar, or CPAP ≤ 5 cm H_2O with PS ≤ 5
2. Assess for tolerance as below for up to two hours.
   a. $SpO_2 \geq 90$: and/or $PaO_2 \geq 60$ mmHg
   b. Spontaneous $V_T \geq 4$ ml/kg PBW
   c. RR ≤ 35/min
   d. pH ≥ 7.3
   e. No respiratory distress (distress= 2 or more)
      - HR > 120% of baseline
      - Marked accessory muscle use
      - Abdominal paradox
      - Diaphoresis
      - Marked dyspnea
3. If tolerated for at least 30 minutes, consider extubation.
4. If not tolerated resume pre-weaning settings.

Definition of UNASSISTED BREATHING

(Different from the spontaneous breathing criteria as PS is not allowed)

1. Extubated with face mask, nasal prong oxygen, or room air, OR
2. T-tube breathing, OR
3. Tracheostomy mask breathing, OR
4. CPAP less than or equal to 5 cm H_20 **without pressure support or IMV assistance.**



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