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Severe ARDS in COVID-19-infected pregnancy: obstetric and intensive care considerations

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Condensation: A review of the clinical findings, algorithmic approach, and clinical considerations for the management of COVID-19 related ARDS in pregnancy

Keywords: COVID-19, SARS-CoV-2, pregnancy, ARDS, coronavirus, pneumonia, acute respiratory distress syndrome

Abstract

Since the emergence of a novel coronavirus (SARS-CoV-2) in Wuhan, China, at the end of December 2019, its infection – COVID-19 – has been associated with severe morbidity and mortality and has left world governments, healthcare systems and providers caring for vulnerable populations, such as pregnant women, wrestling with the optimal management strategy. Unique physiologic and ethical considerations negate a one-size-fits-all approach to the care of critically ill pregnant women with COVID-19, and few resources exist to guide the multi-disciplinary team through decisions regarding optimal maternal-fetal surveillance, intensive care procedures, and delivery timing. We present a case of rapid clinical decompensation and development of severe Acute Respiratory Distress Syndrome (ARDS) in a woman at 31 weeks' gestation to highlight these unique considerations and present an algorithmic approach to the disease's diagnosis and management.

Introduction

As of April 3, 2020, the COVID-19 global pandemic totaled 972,303 cases with 50,322 deaths (5.2% mortality rate) worldwide, and it is spreading rapidly with a basic reproduction number (R0) of 2-2.5 suggesting that 2-3 people will become infected from an index patient [1,2]. Although the United States now leads the world in total cases (239,279), the U.S. mortality rate is less than half that seen worldwide at 2.3% (5,443 confirmed deaths), and the hospitalization rate remains low at 24.1 per 100,000 population [3]. Such statistics may embolden skeptics eager to challenge the severity of this public health crisis. However, the rates of critical illness and mortality associated with COVID-19 infection among pregnant women - a potentially highly vulnerable population, remain unclear [4-7].

We present the clinical challenges and potential strategies for optimal maternal-fetal surveillance, intensive care procedures, and delivery timing posed by a case of a pregnant woman at 31 weeks' gestation who presented to a tertiary care hospital in Cincinnati, Ohio, with COVID-19 symptoms, laboratory abnormalities, and chest-imaging findings immediately prior to the development of rapid clinical decompensation and severe Acute Respiratory Distress Syndrome (ARDS) requiring prolonged mechanical ventilation and ultimately indicated preterm delivery.

Case:

A 39-year-old Caucasian G6 P2031 with a 31.0-week live singleton intrauterine gestation conceived via in-vitro fertilization required admission on 3/24/2020 from the

emergency department of a tertiary care center in Cincinnati, Ohio, due to complaints of 5 days of worsening non-productive cough, shortness of breath, fever, and malaise. Four days prior (3/20/2020 – COVID disease day #1 in Figure 1), she had been discharged from the emergency department following work-up for a milder presentation of these symptoms that included normal findings on chest x-ray, normal vital sign assessment, and normal results of a respiratory viral pathogen laboratory analysis including influenza A and B rapid screening. Of note, a nasopharyngeal swab for COVID-19 reverse-transcriptase polymerase chain reaction (RT-PCR) was sent to the Ohio Department of Health at that time, but results did not return for 8 days and were still pending when she re-presented on 3/24/2020 (COVID disease day #5). She had previously established early and complete prenatal care through the Maternal-Fetal Medicine service due to underlying mild myotonic dystrophy (without cardiomyopathy), bicuspid aortic valve (without aortic dilation, stenosis or regurgitation), history of two prior low-transverse cesarean deliveries, and history of a prior mild cerebrovascular accident while on combined oral contraceptives. Her pre-gravid body mass index (BMI) was 24.7, and she denied any tobacco or illicit substance abuse. Serial surveillance with obstetric ultrasound imaging and maternal echocardiography suggested that her pregnancy had thus far been without complication, and she had been compliant with prescribed daily prophylactic low-molecular weight heparin.

Upon re-presentation to the emergency department (3/24/2020, COVID disease day #5), her symptoms had progressed to include fever to 101°F, worsening shortness of breath prohibiting the ability to complete full sentences, and persistent non-productive cough (Figure 1). Initial vital sign assessment identified significant tachypnea

(respiratory rate of 32 breaths per minute), mild tachycardia (heart rate in the low 100's beats per minute), low normal blood pressure (mean arterial pressure in the low 70's mmHg), and mild hypoxia (SpO_2 93%) despite 4 liters of oxygen via nasal cannula. Physical examination was notable for rhonchi and egophony throughout all lung fields. A chest X-ray, CT pulmonary angiogram, and lung ultrasound assessment were performed with the findings demonstrated in Figure 2. The attending emergency department provider ordered the CT angiogram of the chest to investigate the potential for pulmonary embolism, and the lung ultrasound imaging was performed bedside by the attending MFM physician to further investigate the potential for COVID-19 pneumonia. Specifically, her chest X-ray identified bilateral diffuse pulmonary infiltrates, and her chest CT scan identified bilateral airspace disease characterized by ground-glass appearance with peripheral consolidations compatible with viral pneumonia. Her lung ultrasound demonstrated bilateral pleural thickening and nodularity of the visceral pleura (Figure 2). Horizontal A-lines representing normal aerated lung were absent and replaced by multiple B-lines, pleural nodularity and thickening, and an overall "white lung" appearance with focal areas of consolidation.

Laboratory analysis identified a normal PaO_2:FiO_2 ratio > 300 (suggesting no evidence of ARDS) but definite leukopenia (7,700/mcL), lymphopenia (800/mcL), thrombocytopenia (114,000/mcL), elevated transaminases (AST 65 IU/L), and a mildly elevated procalcitonin (0.33 ng/ml). Although the results from her prior COVID-19 RT-PCR were pending, her clinical presentation supported the diagnosis of COVID-19 infection with pneumonia and the potential for development of Acute Respiratory

Distress Syndrome (ARDS). The emergency department physician felt that her SpO_2 of 93% on 4 liters/minute (L/min) nasal cannula oxygen and PaO_2:FiO_2 ratio > 300 was appropriate for admission to the hospital's lower-acuity COVID floor, and her disposition was planned to that unit. However, the staff Maternal-Fetal Medicine physician recognized her SpO_2 as abnormal for pregnancy and re-directed her care to the intensive care unit (ICU). The degree of her probable COVID-19 infection at this point was severe [8].

Upon arrival to a negative pressure room in the ICU, she was placed in strict isolation with airborne precautions. Reassessment of her SpO_2 revealed worsening hypoxia (78%) despite 4 L/min oxygen via nasal cannula. A non-re-breather mask was applied, and the inhaled oxygen rate was increased to 15 L/min. Her SpO_2 increased to 82%, but she complained of feeling exhausted with inspiration and the decision was made to proceed with rapid sequence intubation with planned mechanical ventilation for respiratory failure and critical illness severity (approximately 9.5 hours after presentation to the emergency department). Continuous electronic fetal monitoring was initiated and demonstrated a 3-minute prolonged fetal heart rate deceleration to the 80 beat-per-minute range that spontaneously resolved following intubation. During this brief period, the consideration for emergent delivery was entertained. Maximal ventilatory assistance was applied, however, and both the maternal and fetal status improved - prompting initiation of both antenatal corticosteroid administration and magnesium sulfate for the dual benefit of fetal neuroprotection and control of maternal bronchospasm (6-gram bolus over 20 minutes intravenously followed by 2 grams per hour IV). She required

large dosages of intravenous benzodiazepines and narcotics for sedation, and her mean arterial blood pressures (MAPs) dropped below 65 mmHg requiring continuous infusion of norepinephrine.

Over the next 8 hours, the ventilator settings were increased to 100% FiO_2 and PEEP (positive end-expiratory pressure) of 10 cm H_20, without complete resolution of her hypoxia (SpO_2 ~ 90-93%). A volume control ventilation modality with automatic pressure augmentation (VC+) was employed to minimize volu- and baro-trauma with the following settings: respiratory rate of 20 breaths per minute, tidal volume of 6 ml/kg, FiO_2 of 100%, inspiratory-to-expiratory time of 1:1.3, and PEEP of 10 cm H_20. The PaO_2:FiO_2 ratio remained below 150 signifying severe ARDS per American-European Consensus Conference criteria [9]. Surprisingly, the fetal heart rate remained reassuring and signified a certain degree of maternal stability. Per recommendations by the infectious disease specialist, the following medications were initiated: ceftriaxone, azithromycin, oseltamivir, and hydroxychloroquine. Marked improvement in her oxygenation was not witnessed until the team manually placed her in a prone position per the PROSEVA study protocol [9]. The initial plan included utilization of a mechanical rotating bed designed for prone ventilation, but manual prone positioning was preferred due to the ability to more quickly return her to supine positioning for performance of CPR or emergent delivery. Manual pronation required a collaborative effort involving the intensive care and obstetric team members to establish invasive hemodynamic monitoring (central venous access and arterial line access), secure her airway, cushion and support her gravid abdomen, and maintain continuous tocodynamometry and

electronic fetal heart rate monitoring (Figure 3). This allowed for gradual diminishment of the FiO_2 and PEEP requirements.

Her care throughout the following week involved twice daily multi-disciplinary "huddles" to elicit input from the Infectious Disease specialists, Pulmonology and Critical care teams, Maternal-Fetal Medicine teams, Anesthesia Critical Care specialists, Cardiology, CardioThoracic surgeons, Neonatology, and Obstetric nursing teams. Plans were established regarding staff exposure mitigation, emergency preparedness, delivery timing, neonatal resuscitation, nutritional support (oral gavage feedings), venous thromboembolism prophylaxis (subcutaneous heparin twice daily), and adjunctive measures including the potential for inhaled pulmonary vasodilators (epoprostenol) and extracorporeal membrane oxygenation (ECMO). Her COVID-19 RT-PCR result returned positive on hospital day 4 (COVID disease day #8), and strict isolation with airborne droplet precautions was maintained. Consent and regulatory permission was obtained to allow for initiation of a 10 day course of remdesivir – a promising antiviral agent targeting a wide array of RNA viruses including SARS/MERS-CoV [7]. Daily lung ultrasound assessments revealed a lack of visual improvement to her sonographic findings. She was rotated between the prone and left lateral decubitus positions each day with a gradual tolerance toward longer durations out of the prone position on hospital days 6 and 7. This tolerance combined with a gradual reduction in FiO_2 and PEEP requirements negated the need to move forward with delivery or to institute inhaled pulmonary vasodilators or ECMO.

On hospital day 8 / COVID disease day #13 (32.0 weeks' gestation), the continuous tocodynamometry and fetal heart rate tracing began to demonstrate regular uterine contractions with persistent late decelerations. This prompted a "huddle" and mobilization of all teams to prepare for urgent but non-emergent delivery via repeat cesarean section. Her ICU ventilator circuit was maintained and transported with her to the operating suite to minimize exposure during transport. Bedside echocardiography was utilized to monitor her intravascular volume status to help guide fluid resuscitation. Repeat laboratory assessment revealed a mild coagulopathy (elevated INR 1.7, PT 20.2 sec, aPTT 35.1 sec), and preparations were made for prevention of massive hemorrhage including procurement of blood products and uterotonics (oxytocin and misoprostol) in the operating room. A vertical midline skin incision was made to optimize exposure and minimize vascular injury in case hemorrhage was encountered. Delayed cord clamping was intentionally not employed, and the neonatology team utilized an adjacent operating room for neonatal resuscitation to minimize staff and newborn exposure to the mother. The patient tolerated the repeat low-transverse cesarean delivery quite well without postpartum hemorrhage or respiratory compromise. She returned to the ICU where her status continued to improve over the next several days. A "de-brief" was held among all team members to review opportunities for improvement. Umbilical cord blood gas analysis revealed a normal pH (7.2), PCO2 (63 mmHg), PaO2 (21 mmHg), base deficit of 3, and the male newborn transitioned to extra-uterine life without complication and was extubated on day of life (DOL) 3. His amniotic fluid and nasopharyngeal swabs were sent for COVID-19 RT-PCR analysis on DOL 1 and 2 (24 hours apart), and both results returned negative. The need to maintain strict isolation

and airborne droplet precautions prohibited the patient's husband from visiting either his wife or his newborn son for a total of 14 days. Currently (hospital day 17 / COVID disease day #22), she is improving but continues on synchronized intermittent mandatory ventilation (SIMV) with an FiO2 of 35%, no PEEP requirement, and daily attempts of spontaneous breathing trials.

Discussion:

This case highlights the rapidity of COVID-19 infection in pregnancy with development of severe COVID-19 ARDS within 10 hours of admission, and the importance of considering physiologic maternal adaptations in delineating an algorithmic approach. The maternal physiologic adaptations to pregnancy not only leave the woman more vulnerable to cell-mediated viral infections such as COVID-19 but also more susceptible to rapid cardio-pulmonary decompensation due to the reduced cardiac and pulmonary reserves. Such considerations may not be forefront in the minds of the intensive care team members, and these physiologic alterations must be emphasized by the obstetric providers as they assist in serving in a "quarter-back" role leading the implementation of the algorithmic approach. Such approach must entail input from multiple disciplines and establish a framework for optimal team dynamics utilizing daily "huddles" or other open means of direct communication. This planning should occur prior to any patient's arrival where the myriad of team members establish a consensus regarding the optimal imaging investigations, laboratory studies, COVID testing, fetal assessment, and

admission locations for these women. The team's safety must also remain a priority ensuring appropriate personal protective equipment, staffing (nurse-to-patient ratio), facilities equipped to minimize exposure, and mobile or hand-held equipment with easy cleaning / disinfecting. An example of our management algorithm is included for reference but should be individualized to one's own institution (Figure 4).

One of the most difficult yet crucial aspects of the management approach is the determination of delivery timing. The physiologic adaptations to labor, delivery, and the immediate postpartum period include maximization of the maternal cardiac output, auto-transfusion of up to 500 mL of blood volume back into the intravascular compartment, a catecholaminergic surge, release of inflammatory mediators within the endothelium, and considerable fluid shifts between the interstitial, intracellular, and intravascular compartments. In the setting of severe systemic infection, these physiologic changes can serve to exacerbate the dysregulated inflammatory cascade leading to a higher potential for endothelial dysfunction, pulmonary edema, myocardial edema and cardiac dysfunction [11]. Thus, the decision to proceed toward delivery should be deferred in the setting of severe and critical maternal COVID-19 infection until maternal cardio-pulmonary stability can be achieved unless the pregnancy has reached full term, fetal status is non-reassuring, or the maternal status is so dire that evacuation of the uterus is likely to facilitate improvement in cardio-pulmonary function [4]. Consideration for administration of antenatal corticosteroids prior to anticipated preterm birth is controversial in the setting of severe maternal COVID-19 infection. Evidence from treatment studies for SARS suggested that high dosages of corticosteroids posed a risk

for severe side effects that drastically affected prognosis, but shorter courses of low-to-moderate dosages may be considered in the care for the critically ill COVID-19 patient [12]. The decision regarding administration of magnesium sulfate for fetal neuroprotection prior to 32 weeks' gestation should proceed per standard indications in that this agent may provide an additional benefit of bronchodilation in the setting of bronchospasm following intubation. Caution is advised to minimize fluid overload with the administration of magnesium sulfate due to the potential for development of additional pulmonary edema, and we recommend restricting the total volume of infused intravenous fluids to 125 ml/hour or less. Delayed cord clamping and immediate skin-to-skin maternal contact should be avoided [4]. Table 1 represents our approach to delivery considerations including timing, location, and medications.

When attempting to defer delivery and achieve resolution of the acute maternal illness with supportive care, several adjunctive therapies should be considered. Emerging evidence suggests that antiviral agents including hydroxychloroquine and remdesivir may demonstrate efficacy in treating the SARS-CoV-2 virus, but neuraminidase inhibitors such as oseltamivir have no proven benefit [10,13]. Although the safety of these agents in pregnancy has not been definitely determined and their efficacy remains controversial, the pharmacokinetic properties and mechanisms of action may support their judicious use while we await further clinical trials. Non-invasive modes of ventilation such as "CPAP" or "BiPAP" are not recommended for managing acute hypoxemic respiratory failure due to their increased likelihood of failure with need for more urgent transition to invasive ventilation [14]. Rapid sequence endotracheal

intubation should be performed per routine but with consideration for a slightly smaller endotracheal tube size due to the potentially edematous and narrowed airway calibers in pregnancy. Oxygenation and ventilatory goals include consideration for the physiologic mild respiratory alkalosis of pregnancy, the diminished functional residual volume, a higher PEEP requirement, and potential for less lung compliance with higher innate plateau pressures due to diaphragmatic compression by the gravid uterus and chest wall compression by enlarged breast tissue. Physiologic tidal volumes in pregnancy are greater than the target value of 6ml/kg ideal body weight utilized in the ARDS Network study [15]. This coupled with the decreased chest wall / diaphragmatic compliance present a challenge to the "lung protective" strategy for mechanical ventilation in pregnant patients. Our clinical observation suggests a 5 cm H_20 difference in plateau pressures prior to and immediately following evacuation of the gravid uterus. Therefore, it seems reasonable to increase tidal volume and/or PEEP to meet goal $PaCO_2$ and oxygenation targets remaining mindful not to allow alveolar plateau pressures to exceed 35 cm H_20.

The prone position can help overcome some of these issues. Prone ventilation has been found to significantly improve oxygenation in the setting of ARDS, and its feasibility and safety in pregnancy have been documented [16,17]. Lastly, veno-venous ECMO is a proven life-saving salvage therapy for severe, reversible respiratory failure, and its benefit among critically ill pregnant women has been reported [18]. Consideration for ECMO cannulation should be entertained among a multi-disciplinary team of experienced providers in situations where the patient's oxygenation is so

severely compromised as to require maximal ventilatory support early in the disease process (less than 7 days of mechanical ventilatory support). Often therapeutic anticoagulation is required, and the postpartum period appears to be a potentially tenuous timepoint for initiation of ECMO with 100% maternal mortality in a recent case series [18].

In summary, this case of rapid clinical decompensation and development of severe (PaO2:FiO2 < 150) COVID-19 related ARDS in a woman at 31 weeks' gestation highlights many of the physiologic and management considerations for the care of critically ill pregnant women with COVID-19. Few contemporary resources exist to guide the multi-disciplinary team through decisions regarding optimal maternal-fetal surveillance, intensive care procedures, and delivery timing. This detailed case reviews the thought process, team-based strategy, and algorithmic approach to this emerging disease's diagnosis and management.

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Figure Legend

Figure 1. Clinical course, major symptoms, and outcomes from illness onset in this patient with COVID-19 related critical illness and severe ARDS (acute respiratory distress syndrome.

Figure 2. Patient's chest imaging including chest CT (A) with ground glass opacities and peripheral consolidation bilaterally (arrows), chest X-ray (B) demonstrating bilateral diffuse pulmonary infiltrates (arrow), normal (different healthy patient) lung ultrasound (C) with characteristic normal A-lines (arrow), and the patient's abnormal lung ultrasound images (D, E, F) demonstrating abnormal B-lines (arrow, D), pleural thickening and nodularity (arrow, E), and focal sub-pleural consolidation (arrow, F) with underlying "white lung" (arrow, F). G represents a schematic demonstrating the 12 anatomic locations to thoroughly evaluate the lung with sonography.

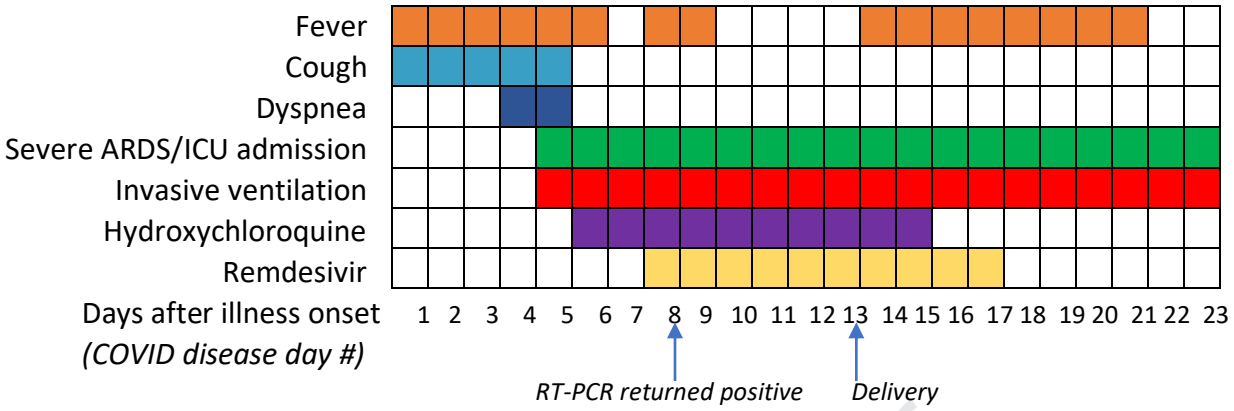
Figure 3. A depiction of pad placement and body positioning to achieve manual prone ventilation in a pregnant woman with severe COVID-19 related ARDS. When the patient is supine, six to eight standard hospital bed pillows are placed across the patient's face, upper chest and arms, lateral abdomen on each side, pelvis, and upper legs. A bedsheet is draped over these pillows and then rolled together with the bedsheet beneath the patient's back on each side to create a "sandwich". The rolled sheets on each side are grasped by the team members and used to roll the patient onto her side and then prone such that the pillows remain in position as shown.

Figures 4A, 4B, and 4C. Example management algorithm for the pregnant patient with COVID-19.

Delivery Considerations		
GA < 24 weeks	Non-Critically ill	• If previable PTL – can deliver in COVID unit or LDR
GA < 24 weeks	Critically ill	• Avoid delivery in an UNSTABLE mother • If previable PTL – deliver in ICU, main OR if D&C required
GA 24-34 weeks	Severe but Non-Critically ill	• Attempt to delay delivery and stabilize/ treat mother • Betamethasone if imminent delivery within a week • MgSO4 for fetal neuroprotection if GA < 32 weeks (if benefits outweigh risk of pulmonary edema) • Consider delivery for NRFHTs (category 3 or persistent category 2 fetal tracing) if stable mother • Imminent need for SVD – move to LDR • Imminent need for C/section – move to L&D OR
GA 24-34 weeks	Critically ill	• Avoid delivery in UNSTABLE mother • Attempt to delay delivery & stabilize / treat mother • Case by case determination of delivery for maternal or fetal benefit if stable mother • Betamethasone ONLY if HIGH risk for imminent delivery within a week • MgSO4 for fetal neuroprotection if GA < 32 weeks (if benefits outweigh risk of pulmonary edema) • Imminent need for SVD – deliver in ICU • Imminent need for C/section – move to Main OR • Perimortem c/section – proceed in ICU
GA ≥ 34 weeks	Severe but Non-Critically ill	• Attempt to delay delivery and stabilize / treat mother • Case by case determination of delivery for maternal or fetal benefit if stable mother • Consider delivery for NRFHTs if stable mother • Avoid late preterm betamethasone • Imminent need for SVD – move to LDR • Imminent need for C/section – move to L&D OR
GA ≥ 34 weeks	Critically ill	• Avoid delivery in UNSTABLE mother • Case by case determination of delivery for maternal or fetal benefit if stable mother • Avoid late preterm betamethasone • Imminent need for SVD – deliver in ICU • Imminent need for C/section – move to Main OR

		• Perimortem c/section – proceed in ICU

Critical Care Goals		
MAP	> 65 mmHg	• First assess if fluid responsive with passive leg raise or bolus LR 500 mL to see if MAP raises > 65 mmHg • Start norepinephrine @ 5 mcg/min (up-titrate to 10 mcg/min) for MAP < 65 mmHg • Ensure CEFM if GA > 24 weeks
SpO_2	> 94%	• Increase PEEP to 10-24 cm H_20 • Consider VC+ modality • Consider prone positioning • Ensure finger is warm or place monitor on forehead
PaO_2	> 80 mmHg	• Increase PEEP to 10-24 cm H_2O • Increase I:E ratio • Consider prone positioning
$PaCo_2$	< 40 mmHg	• Increase ventilatory / respiratory rate to 20-25 bpm • Consider higher tidal volume than 6 ml/kg ideal body weight • Ensure no “auto-PEEP” – keep plateau pressure < 35 cmH_20
pH	7.3-7.5	• First assess if acidemic or alkalemic • Then assess which is more out-of-range (PO_2 or PCO_2) • If metabolic acidosis, assess anion gap & ensure appropriate ventilatory compensation (Bicarb x 1.5) + 8 = PCO_2
Bicarb	16-22 mmHg	• Consider addition of IV bicarb if low AND pH is < 7.1
Anion Gap	6-15	• Correct for hypoalbuminemia (add 2.5 to gap for every 1 g/dl albumin below level of 2.5 g/dl)
PiP	< 35 mmHg	• Check peak inspiratory pressure on vent & ensure < 40 cm H_20 • Consider VC+ modality
UOP	> 20 ml/kg/hr	• Place foley and ensure strict Is/Os + daily weights
Skin	No break-down	• Evaluate skin front & back daily (esp under fetal monitors)
VTE	prophylaxis	• Consider institution of Heparin 7,500 U BID in 2^{nd} trimester & 10,000 U BID in 3^{rd} trimester if delivery is not imminent
Peptic Ulcer	prophylaxis	• Consider H2 blockade
CEFM	Category 1-2	• Delivery for category 3 if GA > 28 weeks • Worsening category 2 may signal worsening maternal status
Sedation	Lowest achievable	• Goal is to achieve RASS of 0 (alert & calm) while on mechanical ventilation • May need to increase sedation with propofol, fentanyl, & midazolam • May need paralytic (cisatracurium) esp when proning

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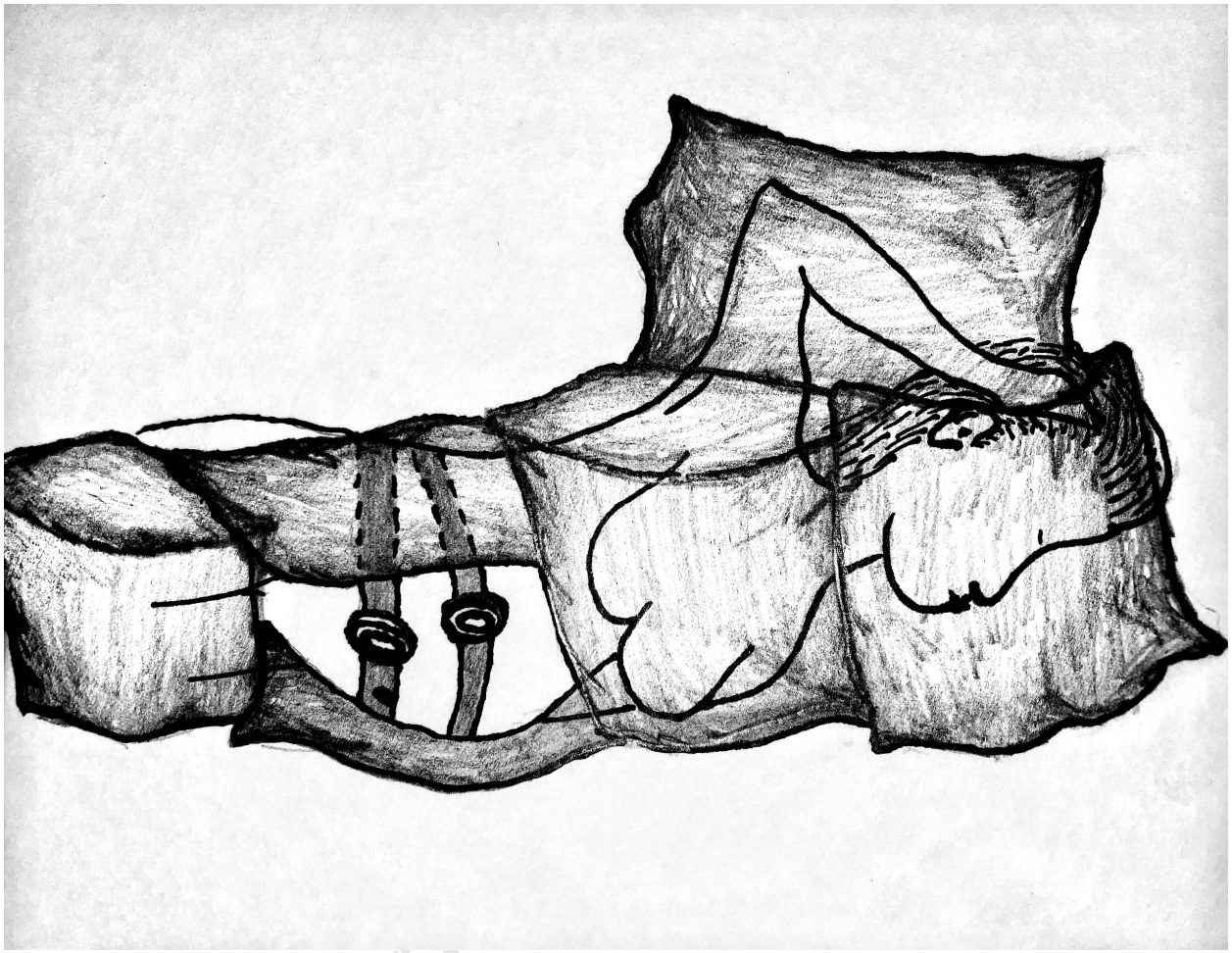
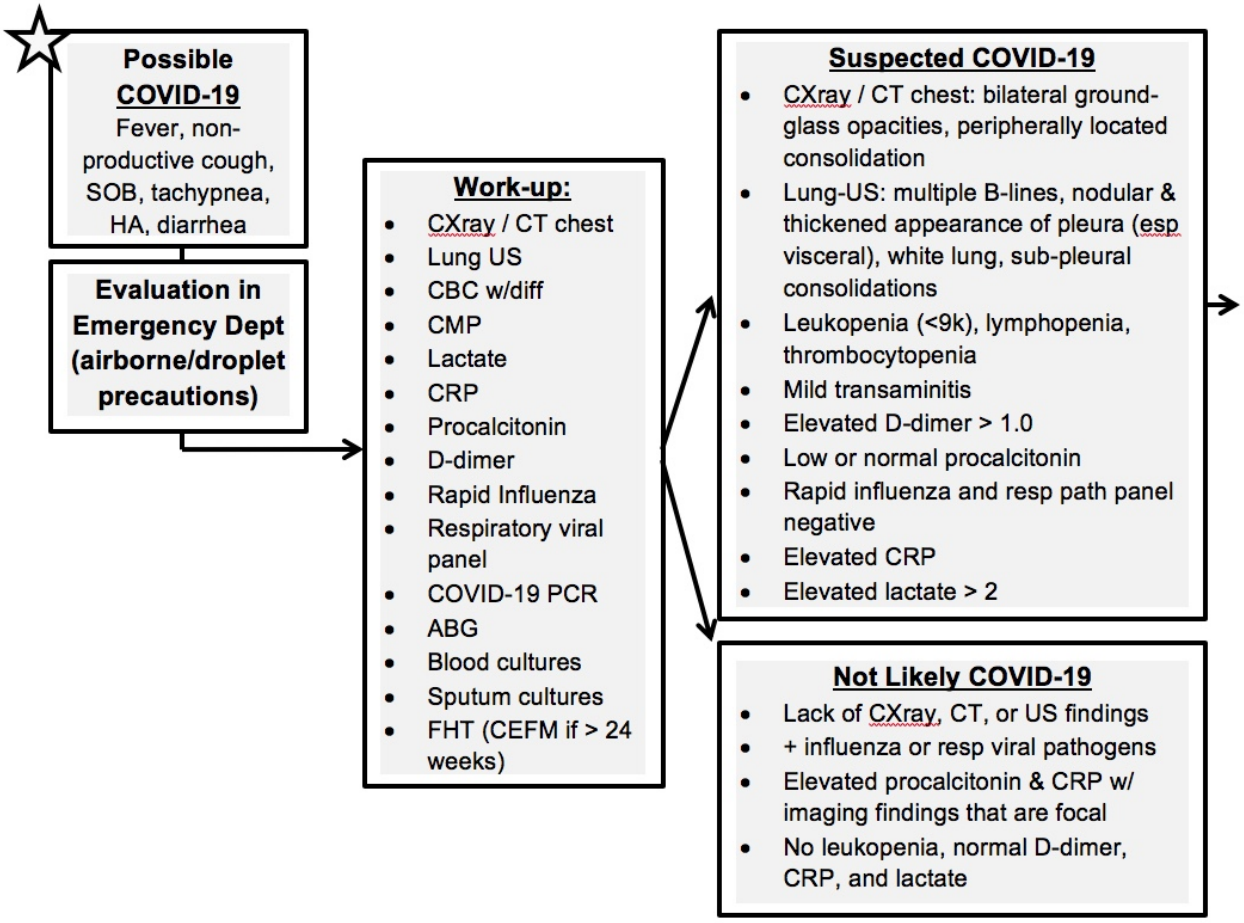


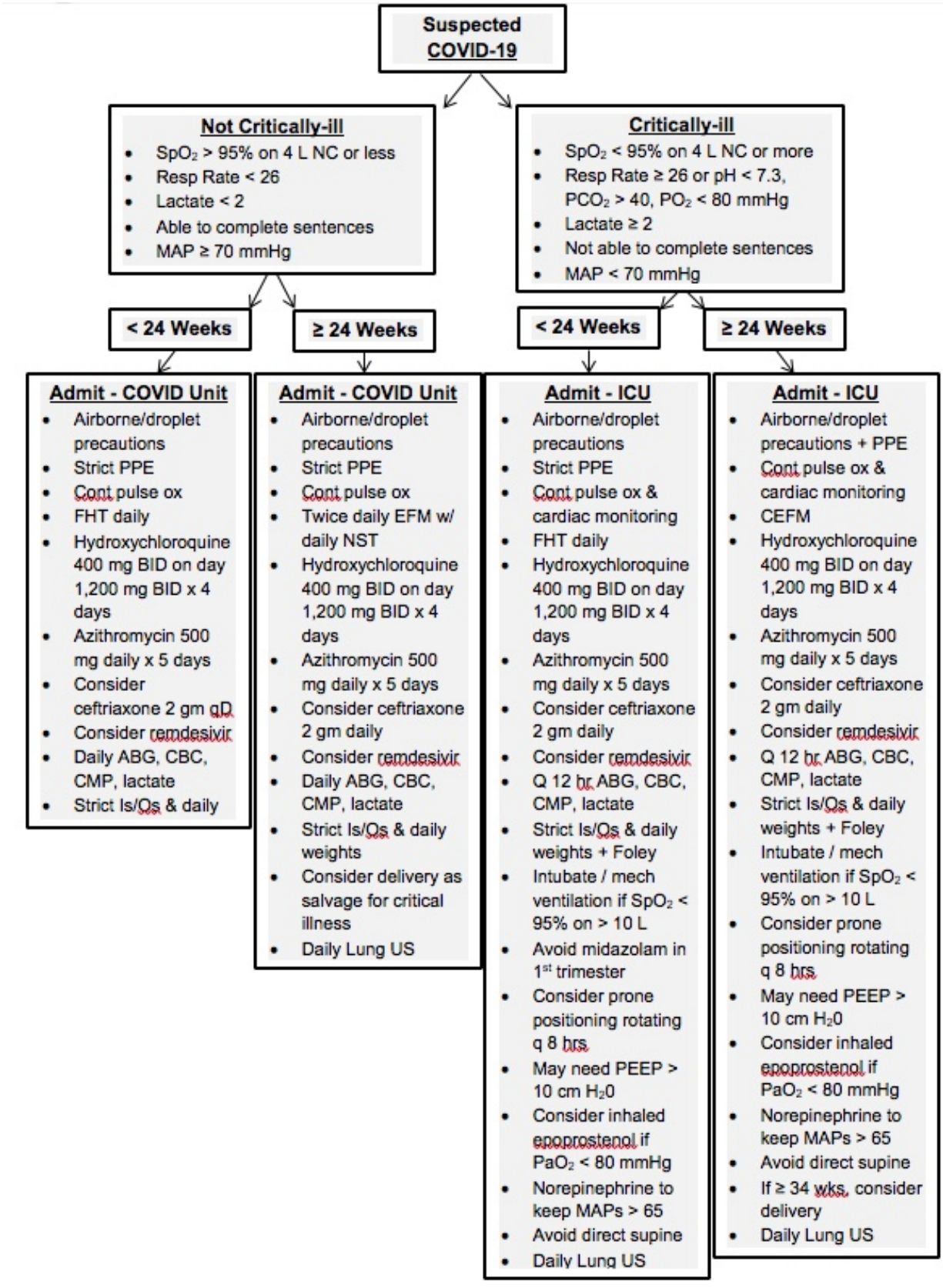
READINESS	RECOGNITION	RESPONSE	REPORTING

• Pre-Hospital
  • Awareness
  • Testing
  • Transport
  • Therapies
	• **Presentation**
	  • Signs Symptoms
	  • Physiologic considerations
		• Bed Placement
		  • Nurse : patient
		  • Capabilities
		  • Isolation
			• Internal
			  • Debrief
			  • Iris reporting
			  • QA

• Hospital
  • Staffing
  • Bed space
  • Equipment
  • PPE
  • Preparedness / simulation
	• **Work-up**
	  • Labs
	  • Imaging
	  • Ancillary teams
	  • Point people / champions
		• Multi-disciplinary
		  • Communication
		  • Huddles
		  • Assign "Captain"
		  • Delivery preparedness & decision tree
			• External
			  • Regional HD
			  • State ODH
			  • National - CDC, SMFM registry

	• **Logistics**
	  • Timely triage
	  • Timely dispo
	  • Communication
	  • Minimizing exposure
		• Treatment
		  • Medications
		  • Ventilation/Oxy
		  • Positioning
		  • Surveillance
		  • Family / support
		  • Care for self	


Possible COVID-19
Fever, non-productive cough, SOB, tachypnea, HA, diarrhea
Evaluation in Emergency Dept (airborne/droplet precautions)
Work-up:
CXray / CT chest
Lung US
CBC w/diff
CMP
Lactate
CRP
Procalcitonin
D-dimer
Rapid Influenza
Respiratory viral panel
COVID-19 PCR
ABG
Blood cultures
Sputum cultures
FHT (CEFM if > 24 weeks)
Suspected COVID-19
CXray / CT chest: bilateral ground-glass opacities, peripherally located consolidation
Lung-US: multiple B-lines, nodular & thickened appearance of pleura (esp visceral), white lung, sub-pleural consolidations
Leukopenia (<9k), lymphopenia, thrombocytopenia
Mild transaminitis
Elevated D-dimer > 1.0
Low or normal procalcitonin
Rapid influenza and resp path panel negative
Elevated CRP
Elevated lactate > 2
Not Likely COVID-19
Lack of CXray, CT, or US findings
+ influenza or resp viral pathogens
Elevated procalcitonin & CRP w/ imaging findings that are focal
No leukopenia, normal D-dimer, CRP, and lactate


Suspected COVID-19
Not Critically-ill
SpO2 > 95% on 4 L NC or less
Resp Rate < 26
Lactate < 2
Able to complete sentences
MAP ≥ 70 mmHg
Critically-ill
SpO2 < 95% on 4 L NC or more
Resp Rate ≥ 26 or pH < 7.3, PCO2 > 40, PO2 < 80 mmHg
Lactate ≥ 2
Not able to complete sentences
MAP < 70 mmHg
< 24 Weeks
≥ 24 Weeks
< 24 Weeks
≥ 24 Weeks
Admit - COVID Unit
Airborne/droplet precautions
Strict PPE
Cont pulse ox
FHT daily
Hydroxychloroquine 400 mg BID on day 1,200 mg BID x 4 days
Azithromycin 500 mg daily x 5 days
Consider ceftriaxone 2 gm qD
Consider remdesivir
Daily ABG, CBC, CMP, lactate
Strict Is/Os & daily
Admit - COVID Unit
Airborne/droplet precautions
Strict PPE
Cont pulse ox
Twice daily EFM w/ daily NST
Hydroxychloroquine 400 mg BID on day 1,200 mg BID x 4 days
Azithromycin 500 mg daily x 5 days
Consider ceftriaxone 2 gm daily
Consider remdesivir
Daily ABG, CBC, CMP, lactate
Strict Is/Os & daily weights
Consider delivery as salvage for critical illness
Daily Lung US
Admit - ICU
Airborne/droplet precautions
Strict PPE
Cont pulse ox & cardiac monitoring
FHT daily
Hydroxychloroquine 400 mg BID on day 1,200 mg BID x 4 days
Azithromycin 500 mg daily x 5 days
Consider ceftriaxone 2 gm daily
Consider remdesivir
Q 12 hr ABG, CBC, CMP, lactate
Strict Is/Os & daily weights + Foley
Intubate / mech ventilation if SpO2 < 95% on > 10 L
Avoid midazolam in 1st trimester
Consider prone positioning rotating q 8 hrs
May need PEEP > 10 cm H20
Consider inhaled epoprostenol if PaO2 < 80 mmHg
Norepinephrine to keep MAPs > 65
Avoid direct supine
Daily Lung US
Admit - ICU
Airborne/droplet precautions + PPE
Cont pulse ox & cardiac monitoring
CEFM
Hydroxychloroquine 400 mg BID on day 1,200 mg BID x 4 days
Azithromycin 500 mg daily x 5 days
Consider ceftriaxone 2 gm daily
Consider remdesivir
Q 12 hr ABG, CBC, CMP, lactate
Strict Is/Os & daily weights + Foley
Intubate / mech ventilation if SpO2 < 95% on > 10 L
Consider prone positioning rotating q 8 hrs
May need PEEP > 10 cm H20
Consider inhaled epoprostenol if PaO2 < 80 mmHg
Norepinephrine to keep MAPs > 65
Avoid direct supine
If ≥ 34 wks, consider delivery
Daily Lung US

CRediT Author Statement

William Schnettler: Conceptualization, Writing – Original Draft, Visualization, Supervision.
Yousef Al Ahwel: Writing – Review & Editing, Resources, Methodology
Anju Suhag: Conceptualization, Writing – Review & Editing, Validation, Resources, Methodology, Supervision