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Introduction

- The reported prevalence of COVID-19 among parturients in the United States was 10-15% in 2020-2021.¹
- COVID-19 confers an increased risk of intensive care unit (ICU) admission (~5 fold) , invasive ventilation (~2 fold), and extra-corporeal membrane oxygenation (ECMO) (~2 fold) in peri-partum patients compared with non-pregnant peers, with an overall mortality of 0.02-1.6%.¹⁻³
- Multi-center retrospective analysis of 201 pregnant COVID-19 positive patients revealed decompensation from hypoxemia in 58%, an ICU admission rate of 11%, and a 11% endotracheal intubation rate.³
- COVID-19 ARDS is associated with an increased likelihood of cesarean delivery (CD); 72-84% deliver surgically.^{1,3}
- These cases are more likely to be conducted under general anesthesia due to maternal respiratory failure.⁴

Primary objective: *To describe the general anesthetic technique for CD and postoperative outcomes of three parturients who were critically ill with COVID-19 during their hospitalization to Mount Sinai Hospital, Toronto, one of the largest tertiary care obstetric centers in Canada.*

Written informed consent for publication was obtained from all patients.

Case 1

Patient Profile: 33-year-old, G1P0, 36+2 weeks gestation

COVID-19 Species: SARS-CoV-2 N501Y S Gene Mutation (Beta variant)

Indication(s) for Emergency CD: Maternal respiratory failure (SpO₂ 67% on room air), fetal tachycardia, coincidental breech presentation

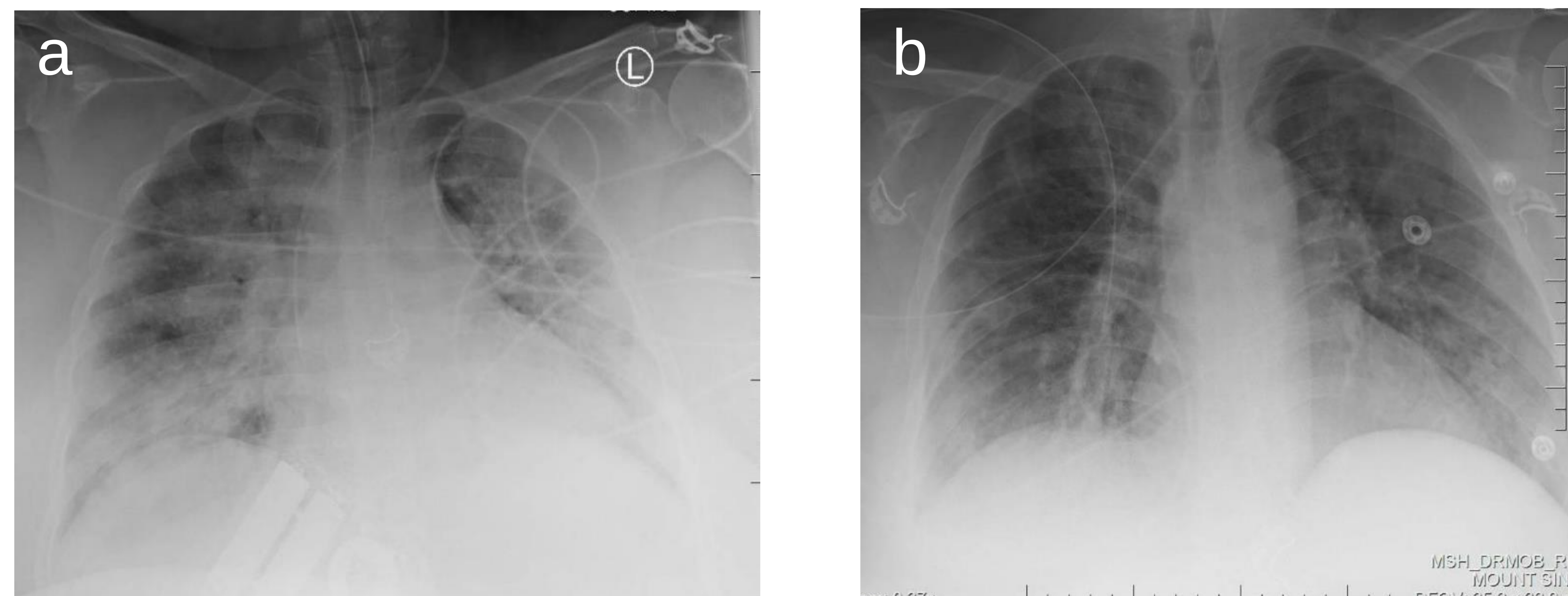
Anesthetic Technique (Table 1):

- Initial oxygenation was provided by HFNC (60 L/min, FiO₂ 100%); her SpO₂ improved to 80% (Fig 1a).
- *Induction:* Ketamine 120 mg, propofol 40 mg, succinylcholine 200 mg. Intubation with Glidescope™. Hemodynamics were supported with boluses of norepinephrine and epinephrine to MAP 65mmHg.
- *Ventilation:* Manual hand ventilation at a rate of 30-40 breaths/min; manual ventilation was chosen to match pre-operative respiratory rate. Intra-operative SpO₂ was 74% at its nadir.
- *Maintenance:* Sevoflurane (MAC of 0.8-1.0), with BIS ranging from 45-60.

Post-operative course:

- Transferred to ICU intubated.
- Ventilation and oxygenation were difficult to maintain; volume control ventilation (VCV) targeted to achieve VT of 250-350 ml required P_{peak} 38 cmH₂O, PEEP 18 cmH₂O.
- Transferred to a tertiary center for consideration of ECMO.
- Responded to a combination of proning and iNO 20 ppm, without receiving ECMO.
- Over the course of 5 days, respiratory and ventilatory parameters improved; extubated on IV dexmedetomidine infusion to HFNC (Fig 1b).
- Acute kidney injury early into admission resolved without renal replacement therapy.
- Rapid improvement with de-escalation of cardiovascular and respiratory support; discharged 16 days after admission.

Figure 1: (a) Diffuse bilateral pulmonary opacification with some sparing of the peripheral right upper lung, consistent with known history of COVID-19. **(b)** Day 9. Post-extubation chest x-ray. Improvement of diffuse bilateral pulmonary opacification.



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Case 2

Patient Profile: 31-year-old, G3P2, 26+0 weeks gestation

COVID-19 Species: SARS-CoV-2 N501Y S Gene Mutation (Beta variant) and E484K Gene Mutation (B1.1.7 variant)

Indication(s) for Emergency CD: Pre-terminal fetal status on ultrasound (US) at day 20 of admission to ICU.

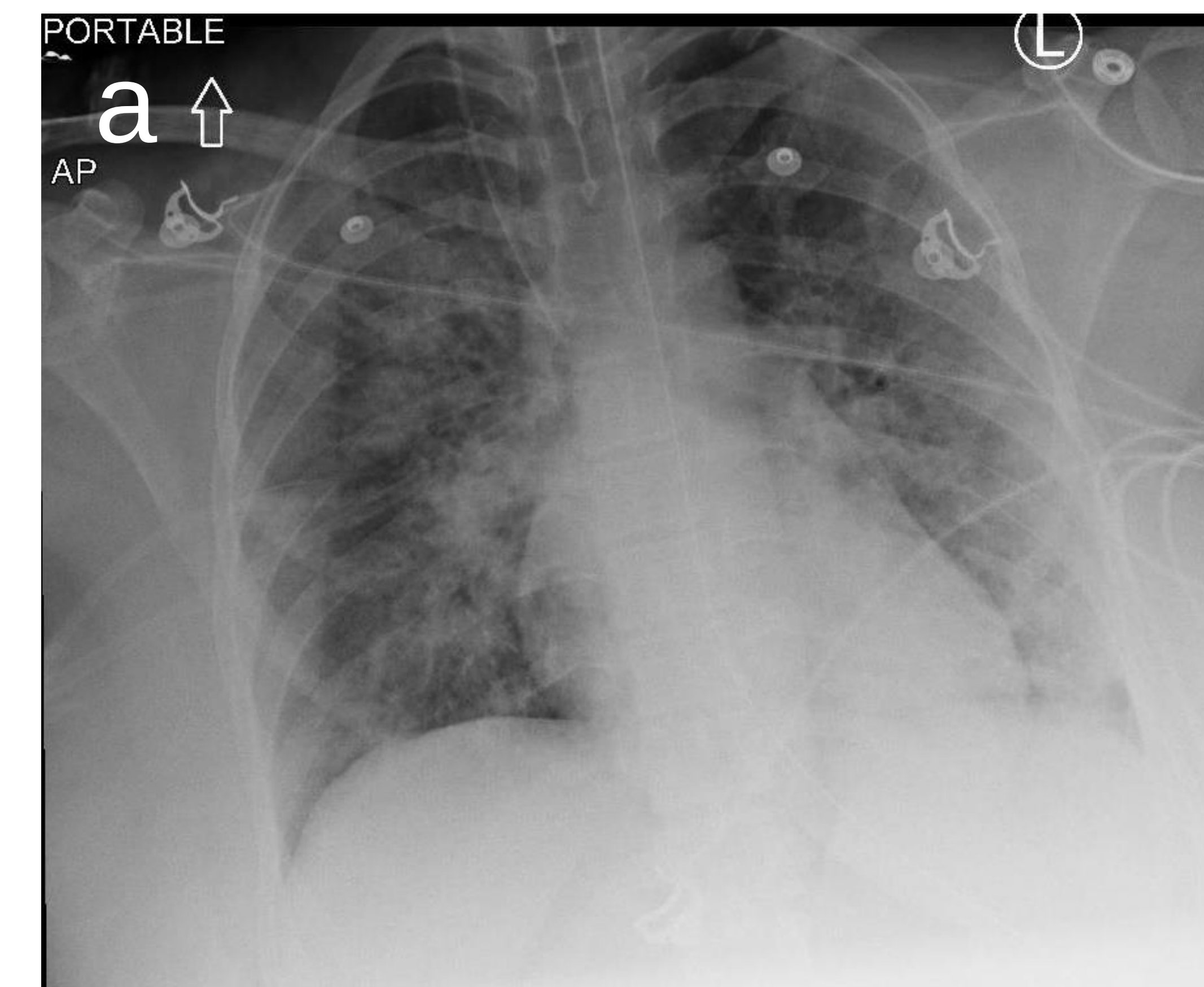
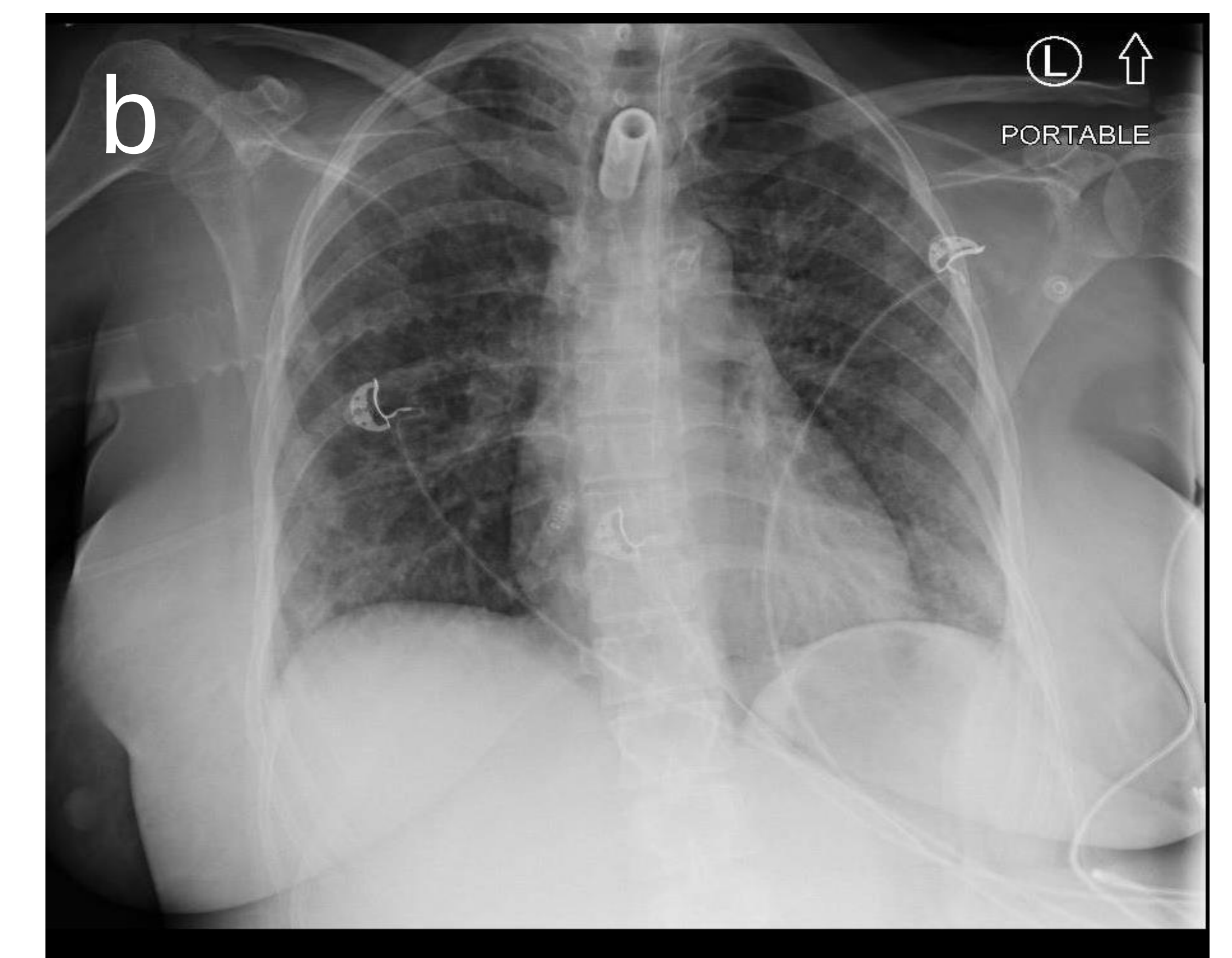
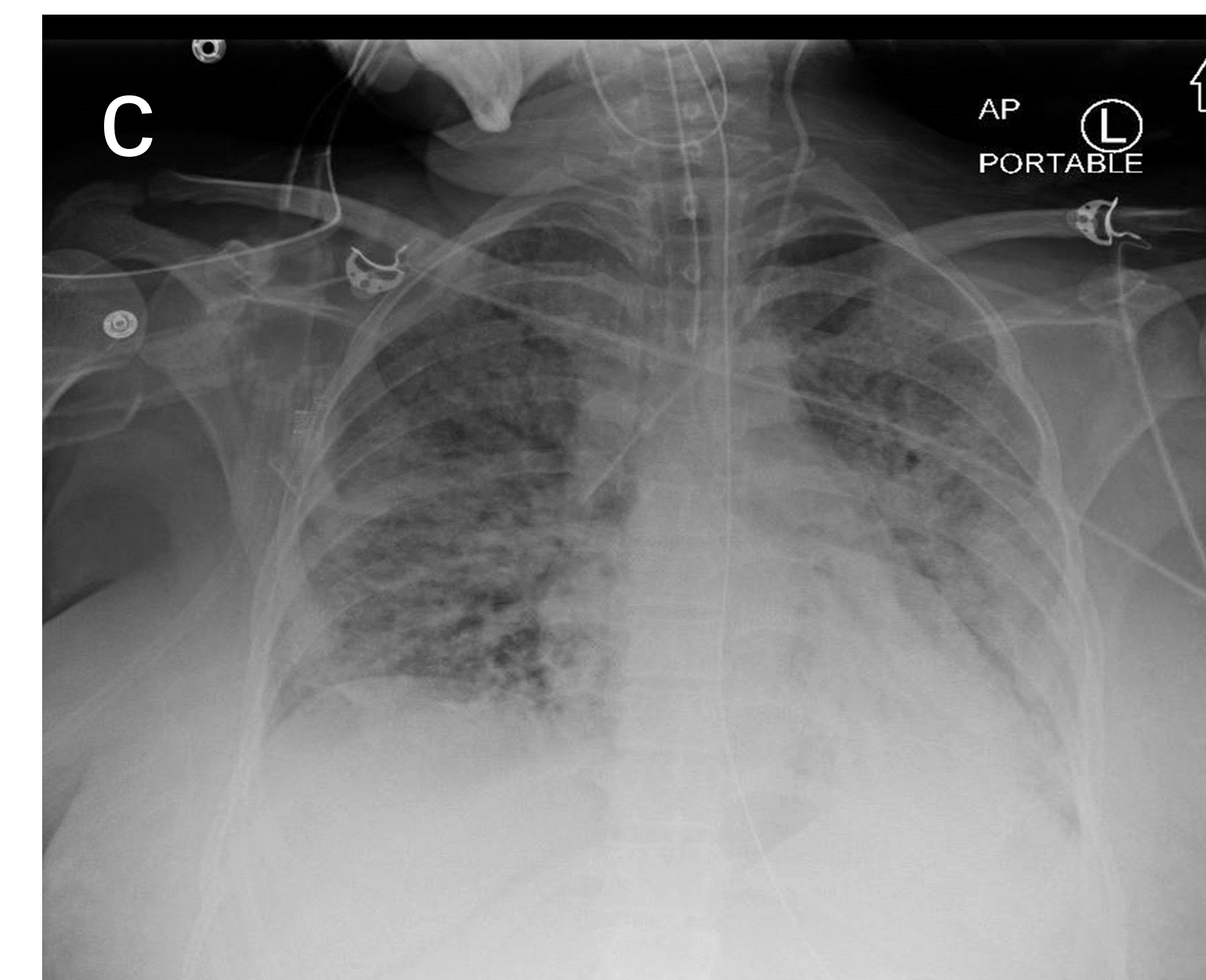
Anesthetic Technique (Table 1):

- Presented with pyrexia and respiratory distress (Fig 2a). Intubated at hospital admission and transferred to ICU. Deteriorated on day 10 of admission with ventilator-associated pneumonia (VAP), septic shock, and AKI (Fig 2b)
- Fetal US- Reversed end-diastolic flow in umbilical artery, reversed flow in ductus venosus on day 13.
- CD at 28+6 weeks gestation.
- Induction:* Maintained on ICU sedation and paralyzed with 50mg IV rocuronium. Hemodynamics were supported with norepinephrine and vasopressin infusions to MAP 65mmHg.
- Ventilation:* Volume-controlled ventilation; FiO₂ 1.0.
- Maintenance:* Propofol 60mcg/kg/min, fentanyl 250mcg/hr, midazolam 10mg/hr.
- Intra-operative blood loss was 1500ml, with starting hemoglobin of 78g/L. She required 3u pRBC in addition to 2L of IV crystalloid. Additional measures included: oxytocin IV boluses and infusion, ergometrine, hemabate, and calcium chloride. Tranexamic acid 1g was administered intra-operatively and immediately post-operatively.

Post-operative course:

- Respiratory status remained critical in the post-natal period; driving pressures >20cmH₂O were required to achieve VT of 250-350ml.
- Intermittent proning, paralysis and escalation of antimicrobial therapy for VAP did not result in improvement.
- Tried high frequency oscillatory ventilation with no improvement in oxygenation
- Transferred to tertiary center for ECMO and tracheostomy on post-operative day 3 (day 16 of admission). She was decannulated after 10 days.
- Slow weaning of respiratory support administered via tracheostomy. Discharged from ICU on post-operative day 26 (Fig 2c). Prolonged inpatient rehabilitation course thereafter.

Figure 2: **(a)** Day 1. Significant bilateral pulmonary opacification.. **(b)** Day 13. Pre-cesarean delivery chest x-ray. Increasing bilateral opacities associated with presumptive VAP superimposed on ARDS. **(c)** Day 38.. Interval improvement of bilateral chest opacities following decannulation from ECMO





General Anesthesia for Cesarean Delivery in Two Critically Ill Parturients with COVID-19



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Summary

Table 1: Overview of patient characteristics including COVID-19/ ARDS management and intra-operative management.

Demographics	Comorbidities	COVID Subtype	Medical Management	Anesthetic Management	Neonatal outcome	Timeline/ Complications
Case 1: Age: 33 years G1 P0 Gestational age at delivery: 36 ⁺⁴ weeks	Morbid obesity (BMI 62 kg/m ²)	SARS-CoV-2 N501Y S Gene Mutation (Beta variant - B.1.351)	Dexamethasone 6 mg IV x10 days; Tocilizumab 8 mg/kg IV x1 dose, Ceftriaxone 1 g; Enoxaparin 40 mg sc	GA maintenance: MAC (Sevoflurane)= 0.8-1.0 Ventilation: PCV switched to manual ventilation, FiO ₂ 1.0 Hemodynamic Support: Ephedrine 10 mg IV, Epinephrine 20 mcg IV, Norepinephrine 6 mcg IV x 9 doses EBL= 800 ml PPH Management: Ergometrine 250 mcg IM x 2 doses, Oxytocin (20U/L) 125ml/h IV infusion, pRBC x1 unit	Weight: 2.58 kg APGAR scores: 5, 9 and 9 at 1, 5, and 10 min	Symptom day at CD: 4 ICU LOS: 9 days (8 days intubated) Total LOS: 16 days Complications: cardiomyopathy, AKI
Case 2: Age: 31 years G3 P2 Gestational age at delivery: 28 ⁺⁶ weeks	N/A	SARS-CoV-2 N501Y S Gene Mutation (Beta variant - B.1.351) & E484K Gene Mutation (B1.1.7 variant)	Dexamethasone 6 mg IV x 2 days - switched to Methylprednisolone 40 mg IV x 8 days; Tocilizumab 8 mg/kg IV x1 dose; Ceftriaxone 1 g; Piperacillin-Tazobactam; Meropenem; Caspofungin; Heparin 5000 IU sc	GA maintenance: Propofol 60 mcg/kg/min, Fentanyl 250 mcg/hr, Midazolam 10 mg/hr Ventilation: VCV, FiO ₂ 1.0 Hemodynamic Support: Norepinephrine (0.02 mcg/kg/min) IV infusion, Vasopressin (0.04 IU/min) IV infusion EBL= 1500 ml PPH Management: Oxytocin infusion 5U IV bolus x4, Oxytocin (40U/L) 125 ml/hr infusion, Ergometrine 250 mcg IM x2 doses, Hemabate 250 mcg IMM, Tranexamic acid 1g IV x 2 doses, pRBC x3 units.	Weight: 1.49 kg born apneic with flaccid tone. APGAR scores: 2, 5 and 8 at 1, 5, and 10 min	Symptom day at CD: 28 ICU LOS: >30 days Total LOS: >30 days Complications: VAP, AKI

Discussion

- Parturients with COVID-19 ARDS are a challenge; combine considerations for ARDS, multi-system critical illness, and concurrent pregnancy.
- Severe hypoxemia and precipitous clinical decline served as the basis for managing these cases under general anesthesia.
- Lung protective ventilation improves outcomes in patients with ARDS.⁵ Plateau pressures < 30 cmH2O and driving pressure < 15 cmH2O were targeted. High PEEP (≥15 cmH2O) was employed for hypoxemia. Alveolar recruitment and improved oxygenation with higher PEEP should be weighed against the hemodynamic consequences of reduced cardiac preload.
- We support the use of norepinephrine as the first-line agent in the treatment of hypotension for critically ill obstetric patients, with phenylephrine, ephedrine, and vasopressin constituting second-line options.
- Fluid and blood product administration can contribute to lung edema and increased patient mortality in ARDS; this is exacerbated by auto-transfusion after delivery. May have contributed to patient 2’s worsening respiratory status post-CD. Restrictive fluid strategy and blood transfusion target of >7 g/dL may be optimal.⁶
- Uterotonic agents should be used with caution due to direct hemodynamic effects. Hemabate has been reported to cause bronchospasm in COVID-19 parturients, which may impair ventilation and oxygenation.⁷
- Post-operative ICU admission is necessary for COVID-19 parturients with ARDS. An intra- and post-operative decline in respiratory status should be anticipated. CD did not improve respiratory status in our patients.

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