

COMMENTARY

ADULT COVID-19 PATIENTS CARED FOR IN A PEDIATRIC ICU EMBEDDED IN A REGIONAL BIOTHREAT CENTER: DISEASE SEVERITY AND OUTCOMES

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The objective of this study was to describe the clinical characteristics and outcomes of adult coronavirus disease 2019 (COVID-19) patients admitted to a pediatric intensive care unit (PICU), with assessment of respiratory clinical severity and outcomes when cared for by pediatric intensivists utilizing specific care processes. We conducted a retrospective cohort study of adult patients admitted to the 14-bed PICU of a quaternary referral center during the COVID-19 surge in Boston between April and June 2020. A total of 37 adults were admitted: 28 tested COVID-19 positive and 9 tested COVID-19 negative. Of the COVID-19-positive patients, 21 (75%), were male and 12 (60.7%) identified as Hispanic/Latino. Comorbidities in the patients included diabetes mellitus (39.3%), hyperlipidemia (39.3%), and hypertension (32.1%). Twenty-four (85.7%) required mechanical ventilation, in whom the lowest median ratio of arterial oxygen partial pressure to fractional inspired pressure was 161.5 (141.0 to 184.5), the median peak positive end-expiratory pressure (PEEP) was 14 (12.0 to 15.8) cmH₂O and 15 (62.5%) underwent an optimal PEEP maneuver. Twelve (50%) patients were prone for a median of 3.0 (3.0 to 4.8) days. Of the 15 patients who were extubated, 3 (20%) required reintubation. Tracheostomy was performed in 10 patients: 3 after extubation failure and 7 for prolonged mechanical ventilation and weakness. Renal replacement therapy was required by 4 (14.3%) patients. There were 2 (7.1%) mortalities. We report detailed clinical outcomes of adult patients when cared for by intact pediatric critical care teams during the COVID-19 pandemic. Good clinical outcomes, when supported by adult critical care colleagues and dedicated operational processes are possible.

Keywords: COVID-19, Epidemic management/response, Pediatric critical care, Medical management/response, Infectious diseases, Biothreats

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INTRODUCTION

THE WORLDWIDE PANDEMIC OF coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in an overwhelming demand for intensive care.¹⁻⁵ Healthcare systems throughout the globe have worked to expand their intensive care capacity by employing alternative approaches to triage and care delivery. With the surge of adult COVID-19 patients requiring intensive care unit (ICU)-level care in our hospital beginning late March 2020, our 14-bed pediatric intensive care unit (PICU) fully transitioned to an adult ICU.⁶ Initial concerns centered on delivering competent care to adult patients with comorbidities rarely seen in the PICU population.² To address these concerns, specialized committees and teams were formed to determine appropriate admission criteria, triage in real-time, and augment adult care delivery.

Specialized operational processes used to care for critically ill adults with COVID-19 by pediatric care givers have been described by dual-trained and pediatric intensivists.^{2,3,5,6} However, the real-world implementation of these recommendations with patient-specific data and clinical outcomes, serving as a reflection of their efficacy, have yet to be reported. Our objective is to describe the characteristics and outcomes of adult COVID-19 patients cared for in this pandemic-specific ICU-level care model, lending clinical credibility to recently published process descriptions, reflections, and recommendations.^{2,3,6}

MATERIALS AND METHODS

This retrospective study was deemed exempt by the hospital Institutional Review Board and includes all adult patients admitted to the PICU between April 1, 2020 and June 30, 2020. The 14-bed PICU is embedded in a 999-bed mixed adult and pediatric academic quaternary referral hospital. Data were reviewed, entered into REDCap and analyzed using IBM SPSS Statistics for Windows version 24.0 (IBM Corp, Armonk, NY, USA). Categorical variables are described using frequencies and percentages; continuous variables are reported using median and interquartile range (IQR) values.

RESULTS

The initial process for COVID-19 critically ill patients was admission to the medical ICU, stabilization, and subsequent lateral transfer to surge ICUs, including the PICU. As patient numbers increased, the PICU transitioned to direct admissions from the emergency department and wards. Thirty-seven adults were admitted, including 28 who tested COVID-19 positive. Table 1 includes

Table 1. Demographics and Clinical Course of Patients Admitted to the PICU

<i>Demographics and Clinical Course</i>	<i>Data Value</i>
Male, n (%)	21 (75)
Weight (kgs), median (IQR)	80.35 (73.1-90.1)
Age (years), median (IQR)	54 (43.5-63.8)
Body Mass Index, median (IQR)	28.58 (25.6-33.0)
Mortality, n (%)	2 (7.1)
Ethnicity, n (%)	
Non-Hispanic/Latino	8 (28.6)
Hispanic/Latino	17 (60.7)
Not specified	3 (10.7)
Comorbidities, n (%)	
Diabetes mellitus	11 (39.3)
Hyperlipidemia	11 (39.3)
Hypertension	9 (32.1)
Neurological/seizures/stroke/psych	6 (21.4)
Cardiovascular system	5 (17.9)
Cancer	3 (10.7)
Immunocompromised condition	3 (10.7)
Pulmonary system	3 (10.7)
Gastrointestinal reflux	3 (10.7)
Tobacco user	3 (10.7)
Obstructive sleep apnea	2 (7.1)
Prediabetes	2 (7.1)
Renal disease	1 (3.6)
Alcohol use	1 (3.6)
None	4 (14.3)
Respiratory support	
Number intubated, n (%)	24 (85.7)
Time to intubation (days), median (IQR)	0 (0-1)
Duration of mechanical ventilation (days), median (IQR)	18 (14-21)
Time to tracheostomy (days), median (IQR)	23 (20.3-27.3)
Lowest PaO ₂ /FiO ₂ ratio while in PICU, median (IQR)	161.5 (141-184.5)
Number prone while in the PICU, n (%)	12 (50)
Prone duration while intubated in the PICU (days), median (IQR)	3 (3-4.8)
Best PEEP trial completed in the PICU, n (%)	15 (62.5)
Peak PEEP utilized while in PICU (cm H ₂ O), median (IQR)	14 (12-15.8)
COVID-19-specific therapies n (%)	
Atorvastatin	21 (75)
Azithromycin	19 (67.9)
Hydroxychloroquine	16 (57.1)
Nitric oxide	7 (25)
Tocilizumab	2 (7.1)
Remdesivir	5 (17.9)

(continued)

Table 1. (Continued)

<i>Demographics and Clinical Course</i>	<i>Data Value</i>
Outcomes	
PICU length of stay (days), median (IQR)	11 (4.3-18.8)
Hospital length of stay (days), median (IQR)	34 (19.5-45.5)
Mortality, n (%)	2 (7.1)

Abbreviations: IQR, interquartile range; PaO₂/FiO₂, ratio of arterial oxygen partial pressure to fractional inspired pressure; PEEP, positive end-expiratory pressure; PICU, pediatric intensive care unit; psych, psychiatric.

demographics and clinical course of the COVID-19-positive patients, with the majority, male, and Hispanic/Latino. Presenting symptoms included cough (85.7%), shortness of breath (85.7%), fever (75%), and myalgias (57.1%); comorbidities included diabetes mellitus (39.3%), hyperlipidemia (39.3%), and hypertension (32.1%); and median body mass index was 28.6 (25.6 to 33.0).

Twenty-four (85.7%) patients required intubation and mechanical ventilation, including 4 who were intubated after admission. Of those requiring mechanical ventilation, the lowest median ratio of arterial oxygen partial pressure to fractional inspired pressure (PaO₂/FiO₂) was 161.5 (141.0

to 184.5). Fifteen patients underwent an optimal positive end-expiratory pressure (PEEP) maneuver, with median peak PEEP requiring 14 (12.0 to 15.8) cmH₂O. Twelve intubated patients were prone—precisely turning a patient onto their stomach/abdomen—for a median of 3.0 (3.0 to 4.8) days, assisted by a specialized “proning team.” For mechanical ventilation outcomes, 15 patients were extubated and 3 required reintubation. Ten (41.7%) patients received tracheostomies: 3 after extubation failure and 7 for weakness due to prolonged mechanical ventilation. Twenty-six (92.9%) patients required central venous access, 23 (82.1%) arterial lines, and 20 (71.4%) vasopressors. Renal replacement therapy was required by 4 (14.3%) patients. Vascular access procedures were performed by a specialized procedure team in 17 (60.7%) patients. Sedation was needed in 26 (92.9%) patients and antibiotics were administered to 27 (96.4%). Anticoagulation was provided in 26 patients, with 11 (42.31%) receiving therapeutic anticoagulation during their hospitalization. Pertinent lab values for the patients while in the PICU, median nadir (lowest point) or peak (IQR), are listed in Table 2.

Disposition included the ward (64.3%), the respiratory acute care unit (17.9%), and the medical ICU (10.7%).

Table 2. Median Laboratory Values^a of Adult Patients While Admitted to the PICU

	<i>n (%)</i>	<i>Median (Interquartile Range)</i>
Lactate (mmol/L)	23 (82)	1.5 (1.1 to 2.2)
White blood cell count (K/uL)	28 (100)	14.59 (12.03 to 17.38)
White blood cell count (K/uL) [nadir]	28 (100)	7.5 (5.51 to 9.79)
Absolute neutrophil count (K/uL)	28 (100)	10.11 (8.3 to 13.46)
Absolute lymphocyte count (K/uL) [nadir]	28 (100)	0.69 (0.38 to 1.06)
Platelet (K/uL) [nadir]	28 (100)	268.5 (153.3 to 384.3)
C-reactive protein (mg/L)	25 (89)	229.3 (124.6 to 313.3)
D-dimer (ng/mL)	28 (100)	3985.5 (2324 to 6542)
Aspartate aminotransferase (U/L)	28 (100)	95.5 (70.3 to 144.5)
Alanine Aminotransferase (U/L)	28 (100)	91.5 (55.3 to 197.5)
Procalcitonin (ng/mL)	16 (57)	0.63 (0.32 to 1.11)
Ferritin (ug/L)	26 (93)	1344.5 (693 to 2828.3)
Interleukin-6 (pg/mL)	11 (39)	52.6 (48.5 to 107)
Troponin T (ng/L) ^b	23 (82)	31 (15 to 102)
NT-proBNP (pg/mL) ^c	13 (46)	551 (261.5 to 3220.5)
Fibrinogen (mg/dL)	21 (75)	841 (678.5 to 920.5)
Lactate dehydrogenase (U/L)	28 (100)	384.5 (304.8 to 530)
Creatinine kinase (U/L)	27 (96)	680 (198 to 1731)
Creatinine (mg/dL)	28 (100)	1.4 (0.82 to 1.94)

^aAll values are peak, unless otherwise noted to be nadir.

^bHigh-sensitivity Troponin T.

^cN-terminal pro b-type natriuretic peptide.

Three patients who possibly needed extracorporeal membrane oxygenation (ECMO) were transferred to the medical ICU, where ECMO delivery was consolidated to optimize utilization of limited human and equipment resources. Two (7.1%) patients died, 1 with multiorgan failure and the other with a limited trial of antibiotics and vasopressors, but otherwise limited code status.

DISCUSSION

Previous reports describe the operational challenges of converting a PICU into an adult ICU,^{1-4,6} a children's hospital into a COVID-19 hospital,⁷ and a neurocritical care unit into a respiratory ICU.¹ To our knowledge, this is the first detailed clinical description of critically ill adult COVID-19 patients cared for by pediatric intensivists, highlighting the severity of illness, clinical course, respiratory interventions, and outcomes, using recommended processes to deliver competent care.

In anticipation of a surge in adult COVID-19 patients, our hospital, identified as 1 of 9 regional treatment centers for emerging special pathogens by the US Department of Health and Human Services in 2015, initiated a series of operational procedures to increase capacity and safely and competently care for COVID-19 patients.⁸ Elective surgeries and admissions were halted, and our 14-bed PICU discharged and/or transferred our remaining pediatric patients.⁶ We admitted our first 3 adult COVID-19 patients on April 2, 2020, and within a span of 4 days, the unit reached capacity. The overall symptomatology, severity of illness, laboratory values, and critical care needs of our cohort are commensurate with those described elsewhere,⁹ and specifically, patients demonstrated PaO₂/FiO₂ ratios similar to adult patients admitted to adult ICUs in our institution.¹⁰

In addition to previous reports describing a similar transition, there are a few unique institutional processes to highlight. First, we made the decision to remain intact as a PICU nurse-physician team rather than be deployed to other units. Second, hospital leadership expanded emergency credentialing for pediatric providers to care for adults. Given the anticipated knowledge and skills gaps related to delivering adult critical care, adult medicine consultative and collaborative processes at the nurse, resident, and attending physician levels were utilized. The assistance by adult medicine provided a reframing of our mental model of disease severity, which, for example, helped us gauge the severity of tachypnea (rapid breathing) and tachycardia (rapid heartbeat) manifesting in adult patients.

Third, the initial triage was selective to ramp up expertise and comfort, and an incident command team triaged patient placement across the ICUs to minimize placement of unstable patients and those with comorbidities, including liver failure and severe cardiac disease, outside the adult

legacy ICUs. Thus, our outcomes may reflect our level of selectivity when admitting adult patients, as fewer patients had renal failure requiring renal replacement therapy or cardiovascular comorbidities compared to others.^{9,10} Fourth, with increased confidence, established collaboration, and robust support from centralized intubation, vascular access, and proning teams, a successful transition to direct admission of unstable adults from the wards and emergency department was accomplished.

Lastly, given the hospital's designation 5 years prior as a regional treatment center for emerging special pathogens, PICU nurses and physicians had extensive experience garnered from our center's biothreat training exercises and preparations. These activities included personal protective equipment donning and doffing, real-world simulations, and participation in conferences with other regional centers to share lessons learned and collaborate on best practices. These everyday skills enhanced our ability to rapidly identify and address our needs, and safely care for critically ill adults with an infectious disease of high consequence. We attribute our PICU's overall successful pivot to caring for adult COVID-19 acute respiratory distress syndrome patients to these 5 essential factors and wonder whether our outcomes would have suffered had any one of them been omitted.

Our experience with critically ill COVID-19 adults highlights the respiratory pathophysiology typically manifest in these patients, while underscoring the successful processes implemented to ensure delivery of competent care in a crisis. Our description provides credibility to recently published insights and recommendations made by dual-trained and pediatric intensivists^{2,3,6} and understanding the achievable clinical outcomes with nontraditional teams managing adults can inform the ongoing global response.

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