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Outcomes in Temporary ICUs Versus Conventional ICUs: An Observational Cohort of Mechanically Ventilated Patients With COVID-19–Induced Acute Respiratory Distress Syndrome

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IMPORTANCE: Throughout the COVID-19 pandemic, thousands of temporary ICUs have been established worldwide. The outcomes and management of mechanically ventilated patients in these areas remain unknown.

OBJECTIVES: To investigate mortality and management of mechanically ventilated patients in temporary ICUs.

DESIGN, SETTING, AND PARTICIPANTS: Observational cohort study in a single-institution academic center. We included all adult patients with severe COVID-19 hospitalized in temporary and conventional ICUs for invasive mechanical ventilation due to acute respiratory distress syndrome from March 23, 2020, to April 5, 2021.

MAIN OUTCOMES AND MEASURES: To determine if management in temporary ICUs increased 30-day in-hospital mortality compared with conventional ICUs. Ventilator-free days, ICU-free days (both at 28 d), hospital length of stay, and ICU readmission were also assessed.

RESULTS: We included 776 patients (326 conventional and 450 temporary ICUs). Thirty-day in-hospital unadjusted mortality (28.8% conventional vs 36.0% temporary, log-rank test $p = 0.023$) was higher in temporary ICUs. After controlling for potential confounders, hospitalization in temporary ICUs was an independent risk factor associated with mortality (hazard ratio, 1.4; CI, 1.06–1.83; $p = 0.016$).There were no differences in ICU-free days at 28 days (6; IQR, 0–16 vs 2; IQR, 0–15; $p = 0.5$) or ventilator-free days at 28 days (8; IQR, 0–16 vs 5; IQR, 0–15; $p = 0.6$). We observed higher reintubation (18% vs 12%; $p = 0.029$) and readmission (5% vs 1.6%; $p = 0.004$) rates in conventional ICUs despite higher use of postextubation noninvasive mechanical ventilation (13% vs 8%; $p = 0.025$). Use of lung-protective ventilation (87% vs 85%; $p = 0.5$), prone positioning (76% vs 79%; $p = 0.4$), neuromuscular blockade (96% vs 98%; $p = 0.4$), and COVID-19 pharmacologic treatment was similar.

CONCLUSIONS AND RELEVANCE: We observed a higher 30-day in-hospital mortality in temporary ICUs. Although both areas had high adherence to evidence-based management, hospitalization in temporary ICUs was an independent risk factor associated with mortality.

KEY WORDS: acute lung injury; acute respiratory distress syndrome; COVID-19; intensive care unit; mechanical ventilation; mortality

As the COVID-19 pandemic reached unprecedented dimensions, it forced healthcare systems to adapt to the care of critically ill patients. This adaptation was particularly troublesome in middle- and low-income countries, which were already strained regarding ICU bed availability (1).

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In the initial phase of the pandemic, expert panels issued guidelines for resource allocation (2, 3). They recommended redeploying healthcare workers and trainees to care for critically ill patients, regardless of background training (3). They advised converting emergency departments (EDs), operating rooms, and other areas into temporary ICUs (T-ICUs) (4–7). T-ICUs were physically separated from conventional ICUs (C-ICUs) and operated by a multidisciplinary team managed by nonspecialized personnel under intensive care staff guidance (8).

Little is known regarding mortality and quality of care-related outcomes in T-ICUs. Data from small cohorts studying patients with moderate COVID-19–induced acute respiratory distress syndrome (ARDS) managed in T-ICU reported similar mortality rates compared with their C-ICU (9, 10). However, these units were functional for brief periods, and the studies were merely descriptive.

According to public data from the Mexican Ministry of Health, the number of ICU beds increased from 2,446 to 11,634 during the initial 10 months of the pandemic. Up to 70% of the patients who required invasive mechanical ventilation (IMV) were managed outside the ICU and had a case fatality rate of 84% (23,823/28,209) in general wards and 74% (8,433/11,639) in C-ICU (11). Taccone et al (12) analyzed Belgium's nationwide ICUs database and reported that the creation of new ICU beds was independently and linearly associated with increased mortality.

While thousands of T-ICUs have been established worldwide (13–19), a direct comparison between T-ICUs and C-ICUs has not been described. Prepandemic data suggest that managing critically ill patients outside the ICU significantly increases mortality (20, 21). Therefore, we hypothesize that management of COVID-19 ARDS in T-ICUs conveys an increased risk for mortality compared with management in C-ICUs. This study aims to determine whether management in T-ICUs increased 30-day in-hospital mortality compared with C-ICUs.

METHODS

Study Design and Setting

We conducted a retrospective observational cohort study in mechanically ventilated patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)–induced ARDS admitted to either C-ICUs or T-ICUs at a COVID-19 center in Mexico City. We included data of patients hospitalized from March 2020 to April 2021. During the first wave of the COVID-19 pandemic, the predominant SARS-CoV-2 variants circulating in Mexico City were B.1, B.1.1, and B.1609, followed by an increase in the B.1.1.222, B.1.189, and B.1.241 (22). From January 2021 onward, variant 1.1.519 became dominant (23).

Although there is no standard definition of a C-ICU, the World Federation of Societies of Intensive and Critical Care Medicine suggested a framework based on personnel background training (24). In this study, we defined a C-ICU based on the personnel managing the area. C-ICUs were those with more than half of the physician/nursing personnel trained in the care of critically ill patients. In contrast, the T-ICUs had less than 50% of their personnel with specialized training.

This center was converted from a 211-bed tertiary care center to a COVID-19 center on March 16, 2020. By redeploying ICU personnel to the intermediate care unit, C-ICU beds increased from 14 (pre pandemic) to 28. The ICU nurse-to-patient and intensivist-to-patient ratios did not differ in these 28 C-ICU beds (1:4 and 1:6, respectively).

ED and postsurgical/procedural beds were converted into 28 new T-ICU beds. Personnel from the critical care service and internal medicine/subspecialties services were redeployed to these areas. The ICU nurse-to-patient and intensivist-to-patient ratios were lower than in C-ICU beds (1:13 and 1:10 respectively) (see resource allocation and **Fig. 1**). This resulted in 56 ICU beds (28 C-ICUs and 28 T-ICUs). The number of ICU beds available ranged from 36 to 56 depending on the number of patients with ICU requirements and the closure of beds due to nosocomial infection surges (similar in both areas).

Informed Consent and Ethics Committee Approval

The Institutional Review Board (Comité de Investigación and Comité de Ética en Investigación, reference number 3333) approved this study and waived the informed consent requirement due to the minimal risk of an observational study. All the patients admitted during the pandemic agreed with releasing their medical data via standardized consent and had the option to opt-out.

Resource Allocation and ICU Logistics

Before the pandemic, C-ICU areas had a 1:1 to 1:2 critical care trained nurse-to-patient ratio and a 1:4 to 1:5

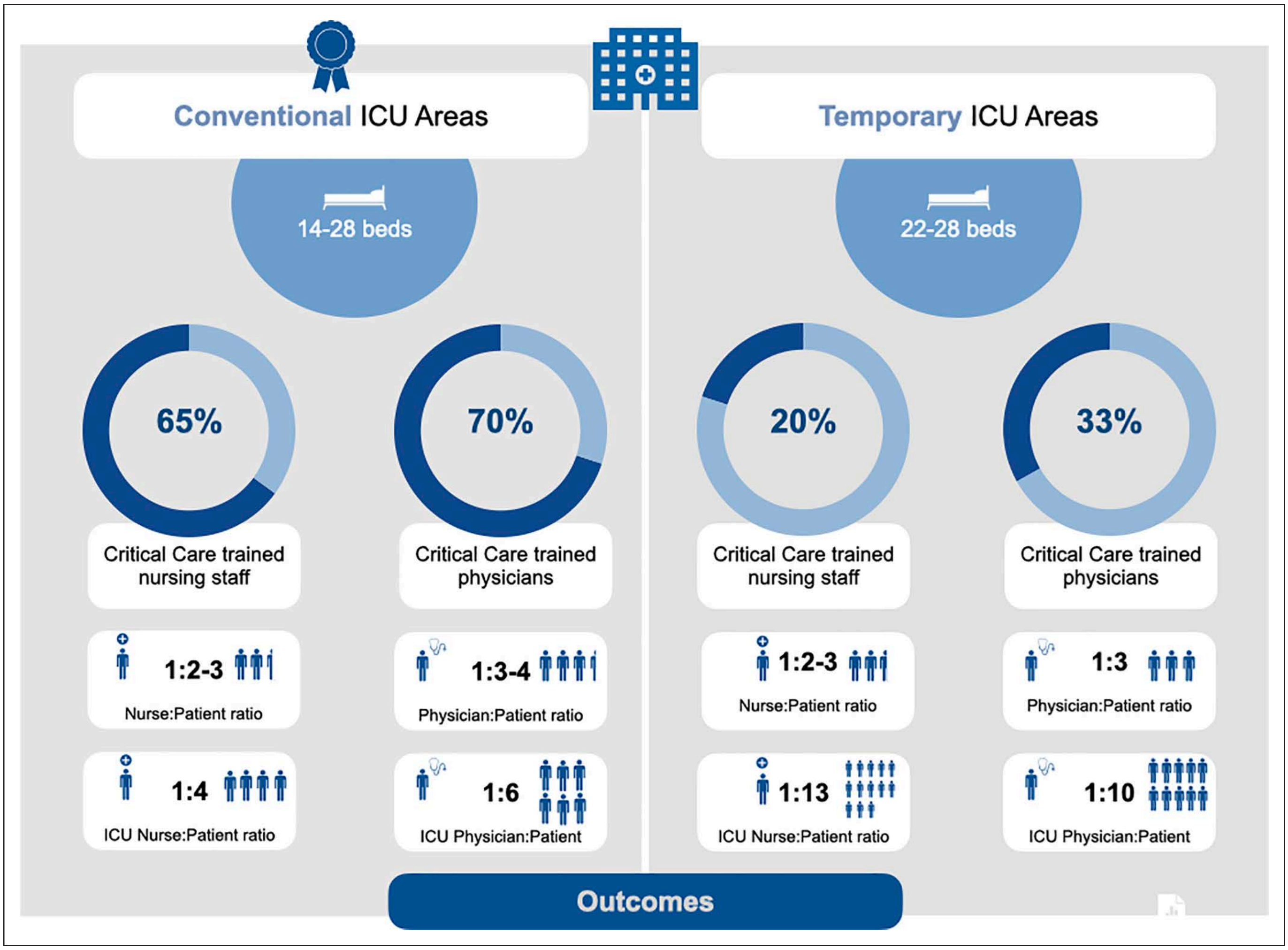

Figure 1. Resource and personnel allocation. Conventional (*left panel*) and temporary (*right panel*) ICU total bed capacity and percent of personnel trained in critical care medicine. ICU-trained and non-ICU–trained nurse/physician:patient ratio.

intensivist-to-patient ratio. After the pandemic onset, 30–35% of the critical care–trained personell was partially redeployed to T-ICUs. Personell without certified critical care training were redeployed to C-ICUs and T-ICUs (predominantly T-ICU) (Fig. 1). This personell consisted in general nurses, internal medicine residents/attendings, and subspecialty fellows (gastroenterology, endocrinology, nephrology, hematology-oncology, dermatology, and rheumatology) (**Fig. S1**, Supplemental Digital Content, http://links.lww.com/CCX/A956). Nursing and medical personnel without critical care training were enrolled in continuous medical education programs focusing on IMV, hemodynamic monitoring, and the general management of critically ill patients (**Supplemental Digital Content**, http://links.lww.com/CCX/A956).

The treating team performed IMV initiation, titration, and weaning. The respiratory therapy service was available for equipment installation and technical support in T-ICUs and C-ICUs. Both areas had access to the same pool of mechanical ventilators and followed ARDS Network protocol (25) for positive end-expiratory pressure (PEEP) and FIO_2 titration. In addition, PEEP titration was targeted to the lower driving pressure possible (ideally ≤ 13 cm H_2O_2). The treating team decided on prone positioning (PP) initiation and termination as per the Effect of Prone Positioning on Mortality in Patients With Severe and Persistent Acute Respiratory Distress Syndrome trial protocol (26). To cope with the increasing load of patients and due to its efficacy and safety, continuous PP was used (27, 28). Esophageal pressure monitorization, extracorporeal membrane oxygenation, inhaled nitric oxide, and high-frequency oscillatory ventilation were unavailable in both areas. In both areas, nursing and medical teams followed protocolized assess, prevent, and manage pain, spontaneous awakening and spontaneous breathing trials, choice of analgesia and sedation, delirium bundle assessment (29). Both areas had invasive hemodynamic monitoring, ultrasound devices, hemodialysis, and subspecialty services consultation.

See Supplemental Digital Content for protocol description (http://links.lww.com/CCX/A956).

Data Collection

We conducted this study from March 23, 2020, to April 5, 2021. We retrospectively collected demographics, clinical variables, and ICU-related outcomes from ICU report sheets available through the electronic medical record. A standardized format for reporting ICU-related data was updated daily through the electronic medical record (EMR). The format sheet included ventilator variables, lung mechanics, hemodynamic variables, and the use/duration of vasoactive, sedatives, and neuromuscular blockade (NMB). We followed up on patients until in-hospital death or discharged from the hospital.

Eligibility Criteria

We included patients 18 years old or older admitted to C-ICUs or T-ICUs for IMV due to suspected COVID-19 ARDS. Due to bed overflow, T-ICUS and C-ICUS were designated exclusively for patients requiring IMV. In regular wards, internal medicine teams managed patients requiring non-IMV (NIV) and high-flow nasal cannula (HFNC).

We confirmed COVID-19 with a positive SARS-CoV-2 polymerase chain reaction (30) or a highly suggestive CT scan and consistent epidemiologic/clinical data. We excluded patients who were initially considered to have SARS-CoV-2 pneumonia but were later given an alternative diagnosis or did not receive IMV. The decision of hospitalizing a patient to either T-ICU or C-ICUs was based on bed availability. Hospital overcrowding precluded patient allocation based on severity (31).

Exposure, Outcomes, and Definitions

The exposure variable was the type of ICU where the patient was managed (either T-ICU or C-ICU). The primary outcome was 30-day in-hospital mortality. Secondary outcomes included ventilator-free days (VFDs), ICU-free days (both at 28 d), as well as hospital length of stay and ICU readmission. We analyzed the need for renal replacement therapy (RRT), use of vasopressors/inotropes, duration (and type) of sedation, lung-protective ventilation (LPV), and NMB. We explored the occurrence of delirium, pulmonary embolism (PE), IMV related complications, and hospital-acquired infections. We provide a complete description of the definitions used in this study in the Supplemental Digital Content (http://links.lww.com/CCX/A956).

Statistical Analysis

We presented baseline characteristics in means/SD geometric means/SD (32), or medians/interquartile ranges (IQRs) if numerical and in frequencies/percentages if categorical.

We estimated the unadjusted 30-day in-hospital mortality for subjects treated at T-ICUs and C-ICUs using the Kaplan-Meier method and compared it with the log-rank test. We estimated hazard ratios (HRs) for dying hospitalized within 30-days from admission between subjects treated at T-ICUs and C-ICUs using a Cox regression model stratifying for age and admission date. We adjusted for potential confounders, which were selected a priori based on biologic plausibility (gender, comorbidities, body mass index, PaO_2/FIO_2 ratio, disease severity, and use of LPV). We assessed the proportional hazard assumption via the scaled Schoenfeld residuals. We compared VFDs and ICU-free days at 28 days between subjects treated at T-ICUs and C-ICUs using a zero-inflated negative binomial regression model adjusting for the same confounders for both models (count and zero-inflated models). This way, we accounted for overdispersed count data with excess zero counts. We compared the rest of the binary secondary variables during follow-up using a chi-square test for independence. We performed the statistical analysis with R version 4.1.0 (R Foundation for Statistical Computing). We considered a confidence level of 95% at two tails.

RESULTS

Overall Cohort Characteristics

A total of 818 patients with a presumed diagnosis of COVID-19–induced ARDS were admitted to either T-ICUS or C-ICUS, of whom we excluded 42.

We analyzed 776 mechanically ventilated patients (**Fig. S2**, Supplemental Digital Content, http://links.lww.com/CCX/A956). There were no patient transfers in-between areas. After personnel redeployment, T-ICUs had 20% of their nursing staff trained in intensive care nursing compared with 65% in C-ICUs (24/121 vs 45/69). Critical care physicians composed 33% of the medical staff in T-ICUs compared with

TABLE 1.
Baseline Patients Characteristics

Characteristics	Conventional ICU (*N* = 326)	Temporary ICU (*N* = 450)
Age (yr), mean (SD)	53 (13)	53 (13)
Male, *n* (%)	232 (70)	319 (70)
Weight (kg), geometrical mean (geometrical SD)	83 (1.2)	82 (1.2)
Height (cm), mean (SD)	165 (10)	164 (9)
Body mass index (kg/m^2), geometrical mean (geometrical SD)	30.9 (1.2)	30.6 (1.2)
Comorbidities, *n* (%)		
Obesity	177 (54)	227 (50)
Overweight	109 (34)	176 (39)
Diabetes mellitus	102 (31)	113 (25)
Hypertension	103 (32)	129 (29)
Cardiovascular	16 (4.9)	20 (4.5)
Immunosuppression	17 (5.3)	18 (4)
HIV	1 (0.3)	6 (1.3)
Chronic kidney disease	7 (2.2)	13 (2.9)
Chronic obstructive pulmonary disease	2 (0.6)	5 (1.1)
Asthma	7 (2.1)	6 (1.3)
Cirrhosis	4 (1.2)	2 (0.4)
Tobacco use	55 (17)	63 (14)
Sequential Organ Failure Assessment at hospital admission, median (IQR)	2 (2–3)	2 (2–3)
Cardiovascular > 0, *n* (%)	8 (2.5)	12 (2.7)
Respiratory > 0, *n* (%)	326 (100)	450 (100)
Renal > 0, *n* (%)	75 (23)	127 (28)
Hepatic, *n* (%)	16 (4.9)	38 (8.4)
Hematologic > 0, *n* (%)	26 (8)	31 (6.9)
Acute Physiology and Chronic Health Evaluation II at ICU admission, median (IQR)	9 (7–12)	9 (6–12)
Noninvasive mechanical ventilation pre-ICU admission, *n* (%)	25 (7.9)	27 (6.3)
Pao_2/Fio_2 ratio prior to intubation, median (IQR)	95 (80–110)	92 (77–110)
Severity of acute respiratory distress syndrome, *n* (%)		
Mild	10 (3)	6 (1.3)
Moderate	131 (40)	162 (36)
Severe	185 (57)	279 (62)
Days from symptom onset to admission, median (IQR)	8 (6–10)	8 (6–11)

IQR = interquartile range.

Missing data: Comorbidities missing for three patients (0.4%), noninvasive mechanical ventilation pre-ICU admission status missing in 29 patients (3.7%), pre-intubation Pao_2/Fio_2 ratio missing for six patients (0.8%) (no preintubation arterial gases to determine Pao_2).

70% in C-ICUs (11/33 vs 7/23). We summarize the characteristics of the cohort in **Table 1**. Both groups had similar demographic characteristics, comorbidities, and disease severity. The median preintubation PaO_2/FIO_2 ratio was 95 (IQR, 80–110) in C-ICUs and 92 (IQR, 77–110) in T-ICUs.

Mortality and Major ICU Outcomes

Thirty-day unadjusted in-hospital mortality was higher in T-ICUs (28.8% vs 36%; log-rank test, $p = 0.023$) (**Figs. 2** and **3**). After we controlled for potential confounders, management in a T-ICU was an independent risk factor associated with mortality (HR, 1.4; CI, 1.06–1.83; $p = 0.016$).

The duration of IMV (13 vs 12 d; $p = 0.1$) and VFD at 28 days (8 vs 5 d; $p = 0.6$) was not statistically significant among areas. Patients in C-ICUs had longer ICU stays (14 vs 13 d; $p = 0.049$), an effect that we no longer observed when we considered ICU-free days at 28 days (6 vs 2 d; $p = 0.5$). However, they had longer hospital stays (23 vs 21 d; 0.033) and higher readmissions (5% vs 1.6%; $p = 0.004$) (**Table 2**). Of the 776 patients included, 84 of them required RRT with higher use of continuous RRT (5% vs 0.9%; $p \leq 0.001$) in C-ICUs, the use of intermittent RRT was similar (8% vs 9%; $p = 0.9$) (**Table 3**).

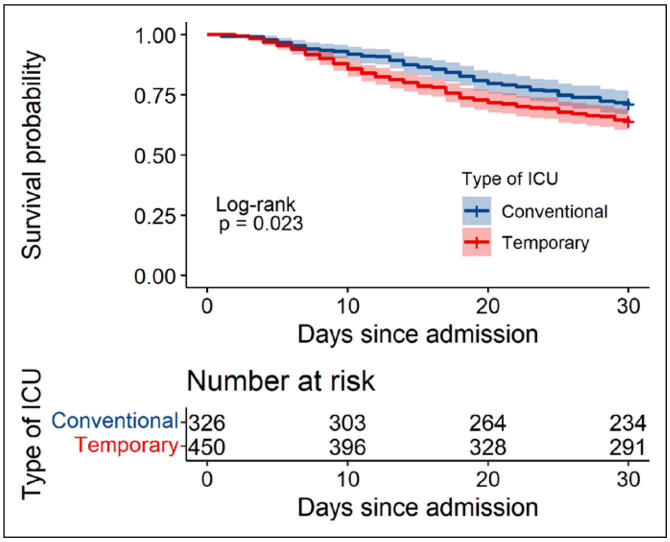

Figure 2. Kaplan-Meier curves. Thirty-day in-hospital mortality in conventional and temporary ICU areas. ICU survival at 30 d according to the area of hospitalization. *p* value was obtained with a Cox regression model stratifying for age and admission date and adjusting for potential confounders (gender, metabolic conditions, and ventilatory variables at ICU admission). The Kaplan-Meier analysis was unadjusted.

ICU Management and Complications

We did not note differences in the use of LPV (at 0, 4, and 8 d), PP, early NMB, recruitment maneuvers, or vasopressors/inotropes (Table 2). The frequency of tracheostomy and ease to wean from IMV were similar among areas. However, patients in C-ICUs had higher extubation failure rates (18% vs 12%; $p = 0.029$) despite more frequent use of postextubation NIMV (13 vs 8; $p = 0.029$). The reported occurrence of delirium was higher in C-ICUs (36% vs 27%; $p = 0.009$) despite a higher benzodiazepine use in T-ICUs (98% vs 95%; $p = 0.007$). Propofol and dexmedetomidine use were similar. We did not observe differences in COVID-19 pharmacologic therapies or anticoagulation doses (**Table S2**, Supplemental Digital Content, http://links.lww.com/CCX/A956).

We observed a similar occurrence of unplanned extubation, barotrauma, pneumothorax, PE, clinically significant bleeding, and transfusion requirement between areas (Table 3). Despite a high occurrence of ventilator-associated pneumonia (VAP) (63% in C-ICUs and 67% in T-ICUs; $p = 0.2$), we observed a similar occurrence of ICU-acquired infections.

Mechanical Ventilation

IMV was delivered primarily through volume control continuous mandatory ventilation (96.8% vs 98.2%; $p = 0.6$) during the first 24 hours. We found mean tidal volume (6.1 vs 6.1 mL/kg predicted body weight; $p = 0.4$), plateau pressure (25 vs 25 cm/H_2O; $p = 0.061$), driving pressure (12 vs 12 cm/H_2O; $p = 0.2$), PaO_2/FIO_2 ratio (134 vs 125; $p = 0.2$), and respiratory system compliance (31 vs 30 mL/cm H_2O; $p = 0.055$) were similar. Respiratory system compliance was low and had wide variability in both groups. We noted higher plateau pressures, respiratory rates, and PCO_2 among nonsurvivors. **Figure S3** (Supplemental Digital Content, http://links.lww.com/CCX/A956) and **Figure S4** (Supplemental Digital Content, http://links.lww.com/CCX/A956).

Hospitalization and management in T-ICUs (HR, 1.4; CI, 1.06–1.83; $p = 0.016$), male sex (HR, 1.48; CI, 1.08–2.2; $p = 0.015$), and higher Acute Physiology and Chronic Health Evaluation II scores (1.07; CI, 1.03–1.1 for every score point $p \leq 0.001$) were associated with increased mortality. LPV was associated with a decreased risk of death (HR, 0.54; CI, 0.39–0.74)

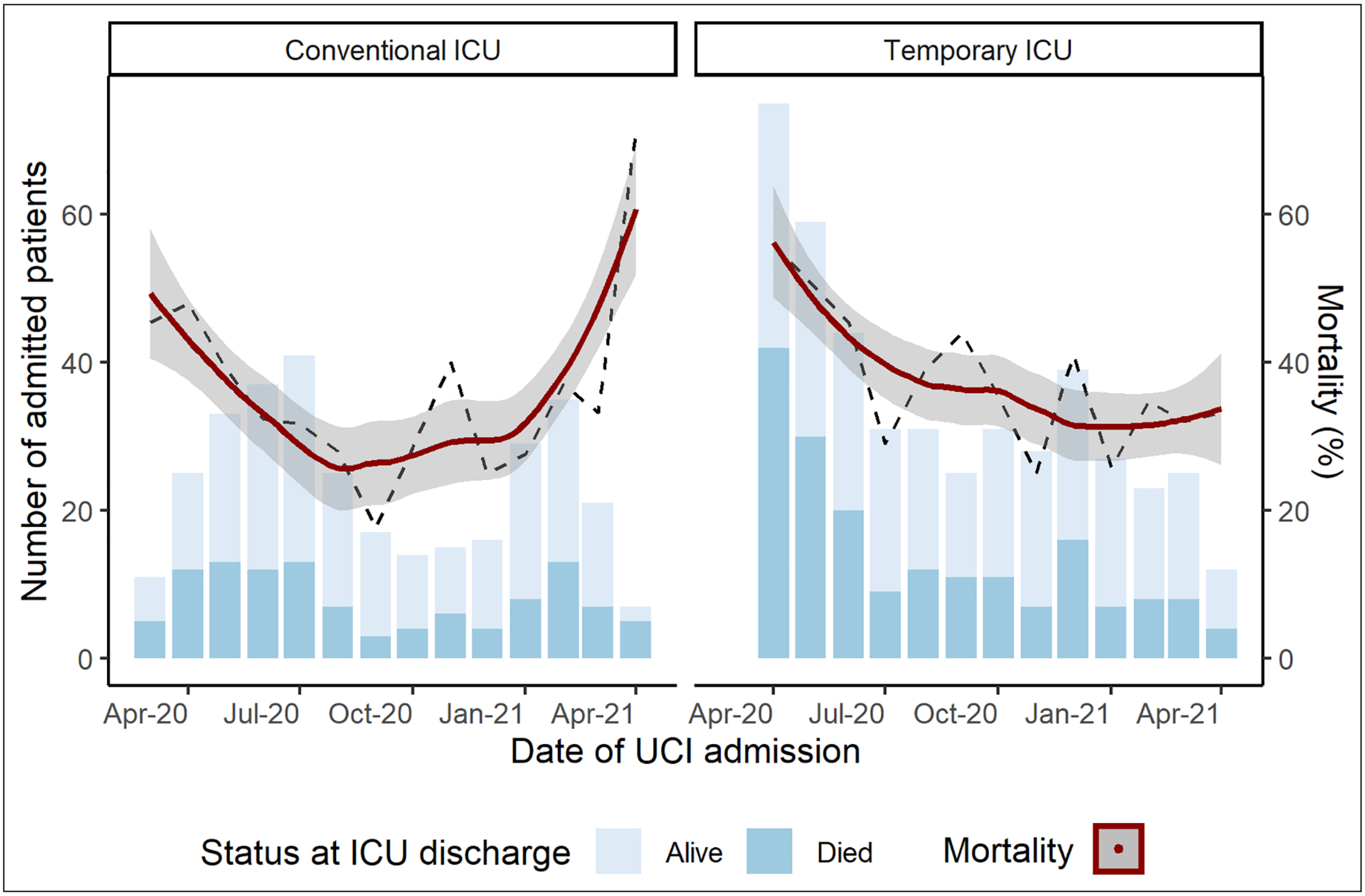

Figure 3. Mortality through time in conventional and temporary. Thirty-day in-hospital mortality according to the month of hospital admission. *Blue bars* represent the total of patients who were either alive (soft *blue*) or dead (dark *blue*) per month. The *red line* depicts the monthly mortality rate's mean (and *gray* shadow the CI) (conventional or temporary ICU areas). *Solid lines* represent survival and shaded areas at the 95% CI.

(**Table S4**, Supplemental Digital Content, http://links.lww.com/CCX/A956).

DISCUSSION

In this study, we explored and compared the management and outcomes of intubated patients with COVID-19 induced ARDS in T-ICUs versus C-ICUs. Although both areas had mortality rates similar to other cohorts (45–57%) (33–38), those managed in T-ICUs had decreased survival. Baseline demographics and disease severity were similar in both areas. After adjusting for potential cofounders, management in T-ICUs was independently associated with increased mortality.

Prepandemic studies from regions where physicians and nurses routinely manage critically ill patients outside the ICU have similar observations (20, 21, 39, 40). In a multicenter study from Israel, Simchen et al (20) reported that among 736 patients meeting ICU criteria, 27% were managed in C-ICUs, 24% in special care units, and 49% in regular wards. After the authors adjusted for cofounders, those admitted to the ICU had early survival benefits (20, 41, 42). Similarly, using Japan's nationwide database, Ohbe et al (21) studied 14,859 mechanically ventilated patients with pneumonia of which 49% were managed outside the ICU. The authors used propensity score matching to demonstrate lower 30-day in-hospital mortality in those managed in the ICU.

Subsequent studies have provided insights into why delivering care in an ICU provides a survival benefit. Iwashita et al (43) reported lower use of invasive monitoring, vasopressors, RRT, and NMB among mechanically ventilated patients managed outside the C-ICU. Similarly, Owyang et al (44) reported low use of LPV in patients managed in EDs. Additionally, Hersch et al (42) observed that nonprotocolized weaning strategies, frequent endotracheal tube-related complications,

TABLE 2.
Major ICU Outcomes

Characteristics	Conventional ICU ($N = 326$)	Temporary ICU ($N = 450$)	p
30-d mortality, *n* (%)	94 (29)	162 (36)	**0.036**
Days on invasive mechanical ventilation, geometrical mean (geometrical SD)	13 (2)	12 (2)	0.1
Ventilator-free days, median (IQR)	8 (0–17)	5 (0–16)	0.6
ICU length of stay (d), geometrical mean (geometrical SD)	14 (2)	13 (2)	**0.049**
ICU-free days, median (IQR)	6 (0–16)	2 (0–15)	0.5
Hospital length of stay (d), geometrical mean (geometrical SD)	23 (2)	21 (2)	**0.033**
ICU readmission, *n* (%)	17 (5)	7 (1.6)	**0.004**
Lung-protective ventilation, *n* (%)[a]			
Day 0	278 (87)	375 (85)	0.5
Day 4	244 (88)	343 (89)	0.6
Day 8	145 (86)	186 (85)	0.8
Prone position, *n* (%)	248 (76)	355 (79)	0.4
Duration prone position, median (IQR)	7 (4–10)	7 (4–11)	0.7
Recruitment maneuvers, *n* (%)	205 (63)	3)	$>$ 0.9
Extubation failure, *n* (%)	59 (18)	56 (12)	**0.029**
Type weaning, *n* (%)			0.5
Simple	145 (44)	192 (43)	
Difficult	37 (11)	42 (9)	
Prolonged	33 (10)	40 (9)	
Postextubation noninvasive mechanical ventilation, *n* (%)	43 (13)	37 (8)	**0.029**
Type			0.1
High-flow nasal cannula	26 (8)	21 (5)	
Bilevel/continuous positive airway pressure	17 (5)	16 (4)	
Tracheostomy, *n* (%)	30 (9)	39 (9)	0.2
Percutaneous tracheostomy	18 (5)	17 (4)	
Surgical tracheostomy	12 (4)	22 (5)	

IQR = interquartile range.

[a]Defined as ALL of the following: plateau pressure < 30 cm/H_2O + driving pressure < 15 cm/H2O + tidal volume < 8 mL/kg predicted body weight.

Missing data: respiratory system compliance, Pplat, peak pressure, and DP; therefore, lung-protective ventilation at day 0 missing for 14 patients (1.8%), at day 4 missing for 33 of intubated and alive patients (4.4%), and at day 8, missing for 214 of intubated and alive patients (33%). Recruitment maneuver intervention missing for two patients (0.2%). Bold values denote statistical significance.

and delays in extubation occurred more frequently in patients managed outside the C-ICU.

However, our findings showed similar management and complications, not accounting for the observed survival differences. It is essential to consider that although we observed a high adherence to evidence-based interventions in both areas, their success relies on their timely application and proper patient selection (NMB and PP). We did not design our study to obtain such a dynamic evaluation.

A plausible explanation for the survival differences might lie in the allocation of specialized personnel among areas. The recommended nurse-to-patient ratio for an intubated patient ranges between 1:1 and 1:2 (45, 46) since low nurse-to-patient ratios and high workload are associated with increased mortality (47–49). Neuraz et al

TABLE 3.
ICU Complications

Characteristics	Conventional ICU (*N* = 326)	Temporary ICU (*N* = 450)	*p*
Unplanned extubation, *n* (%)	31 (9)	43 (9)	> 0.9
Barotrauma, *n* (%)	19 (6)	30 (7)	0.7
Pneumothorax, *n* (%)	29 (9)	45 (10)	0.6
Cause			
Barotrauma	19 (63)	30 (67)	0.8
Periprocedural	4 (14)	8 (18)	0.7
Spontaneous	4 (14)	4 (9)	0.5
Other	1 (4)	(4)	> 0.9
Pleural catheter required, *n* (%)	17 (5)	25 (6)	0.8
Continuous renal replacement therapy, *n* (%)	15 (5)	4 (0.9)	**< 0.001**
Intermittent hemodialysis, *n* (%)	26 (8)	39 (9)	0.7
Pulmonary embolism, *n* (%)	44 (13)	60 (13)	> 0.9
Diagnosed after ICU admission, *n* (%)	34 (79)	44 (73)	0.5
Clinically significant bleed, *n* (%)	44 (13)	48 (11)	0.2
RBC transfusion	39 (12)	38 (8.4)	0.11
Fresh frozen plasma transfusion	8 (2.4)	3 (0.7)	0.06
Platelets transfusion	4 (1.2)	0 (0)	0.03
Cryoprecipitate transfusion	1 (0.3)	0 (0)	0.4
Ventilator-associated pneumonia, *n* (%)	204 (63)	301 (67)	0.2
Intravascular catheter-related infection, *n* (%)	21 (6.4)	23 (5)	0.4
Bacteremia, *n* (%)	36 (11)	48 (11)	0.8
Urinary tract infection, *n* (%)	22 (6.8)	25 (5.6)	0.5
Fungal infection, *n* (%)	38 (12)	51 (11)	0.8
Antibiotic use, *n* (%)	304 (93)	416 (93)	0.8

Bold values denote statistical significance. Missing data: hospital-acquired infections data missing for 11 patients (1.4%).

(50) found that an increase of over 2.5 patients per nurse was associated with a 3.5-fold increase in mortality. In contrast with cohorts by Simchen et al (20) and Ohbe et al (21), which reported a 1:4.5 ratio in non-ICU areas (vs 1:2 in the ICU) ; in our study, both T-ICUs and C-ICUs had a 1:2.5 ratio. However, when considering specialized training, a factor associated with improved survival (51), T-ICU had greater than three times lower ICU-trained nurses (1:4 vs 1:13). McHugh et al (52) reported that decreasing as few as one patient per nurse was associated with improved outcomes. Presumably, the high workload of ICU nurses could have impacted events not assessed by our study (time to antibiotic initiation, detection of clinical deterioration, or endotracheal tube dislodgement/clogging, etc.).

Intensivists are considered essential for achieving favorable outcomes in the critically ill (53). Gershengorn et al (54) analyzed the impact of the patient-to-intensivist ratio in 94 ICUs in the United Kingdom, finding an "optimal" ratio of 7.5, above which mortality increased. Considering its relevance in high acuity settings (55), the higher ratio in T-ICUs (10 vs 6) might have influenced patient care. For example, the discordance between a higher usage of benzodiazepines in T-ICUs (56, 57) and a lower occurrence in delirium might reflect pitfalls in identification (58, 59). In addition, detecting and responding appropriately to clinical deterioration (influenced by expertise and degree of training) (60) is essential for patient survival, particularly during the initial stabilization phase. Simchen et al (20) demonstrated that the beneficial impact of ICU management occurred within the initial 3 days of deterioration (41). Finally, ICU-acquired infections, particularly VAP, are associated with a worse prognosis (61, 62). Although the occurrence was similar among areas, we did not assess antibiotic adequacy, delayed initiation, or appropriate escalation/deescalation. All of which portends a poor prognosis and have been commonly observed in critically ill patients managed outside the ICU (63).

Besides the expected limitations of a retrospective study, we must acknowledge several others: 1) we conducted this study in an academic center with standardized protocols and continuous medical education programs, which have been shown to impact outcomes (64). We cannot generalize our findings to nonacademic centers. 2) C-ICU areas redeployed part of their ICU-trained personnel to T-ICUs and filled those positions with non-ICU–trained personnel; therefore, the comparison between areas considers a C-ICU which was not on prepandemic status. 3) We did not collect data to evaluate ICU strain and overflow indicators, which could have confounded our findings. Similarly, although we hypothesize that staffing could have accounted for the observed difference in the primary outcome, we did not analyze the association of workload or staffing in mortality (the data necessary for such analysis were not readily available). 4) Factors such as the decision to limit care based on the futility and delay in ICU admission were not routinely reported in the EMR; therefore, we did not include them in this study. 5) Certain secondary outcomes paradoxically favored T-ICUs; we observed that despite a higher use of postextubation NIV/HFNC, extubation failure rates were higher in C-ICU (although this did not impact VAP occurrence). We acknowledge we do not have data regarding the timing (early vs late reintubation, with the latter having a higher impact on mortality), cause (transient upper airway obstruction vs other causes, the former not being associated with higher mortality), or the appropriateness of reintubation/postextubation NIV/HFNC use, all of which influence the association of extubation failure and mortality (65). Similarly, the higher occurrence of readmissions observed in C-ICU must be interpreted with caution. At our institution (particularly during the first pandemic wave), 45% percent of the patients who did not survive and were eligible for ICU admission (or readmission) did not receive such care due to ICU saturation (31). Therefore, the readmission rates reported in our study do not represent readmission criteria, which could have differed substantially and cofound such observation. 6) We did not assess outcomes beyond 30 days. Therefore, the potential implications of management in a T-ICU in the occurrence of persistent critical illness and post-ICU syndrome remain unexplored. 7) We did not assess vaccination status, which could have cofounded our study, particularly during January to April 2021 (vaccination in Mexico City started January 2021).

CONCLUSIONS

We report the first cohort to explore and compare major outcomes in T-ICUs caring for mechanically ventilated patients. In this study, we found an increase in 30-day in-hospital mortality in patients managed in T-ICUs despite having similar therapeutic strategies and complications to C-ICUs. Although residual cofounders could have played a role in our observations, we hypothesize that the inexperience (low ICU nurse/intensivist staffing) and high workload (low ICU-nurse/intensivist-to-patient ratio) intrinsic to the definition of an T-ICU played an important role. This report underscores the importance of specialized care of the critically ill by intensive care–trained personnel.

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