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System-Wide Strategies Were Associated With Improved Outcome in Critically Ill Patients With Coronavirus Disease 2019 Experience From a Large Health-Care Network

To the Editor:

The coronavirus disease 2019 (COVID-19)-associated critical illness poses an unprecedented challenge to ICU capacity and resources\(^1\),\(^2\) with an estimated mortality rate of 41.6% and a long ICU stay.\(^3\) Initial data have linked multiple patient-level risk factors with worse clinical outcomes\(^4\),\(^5\) and include older age, preexisting conditions (diabetes mellitus, hypertension, and obesity), initial illness severity, acute inflammation markers, and coagulation.\(^4\),\(^5\) However, few studies reported the impact of hospital-level factors on ICU outcome. Furthermore, no report has compared clinical outcomes between patients with COVID-19 and non-COVID-19-related critical illness during the pandemic’s initial phase. We described the temporal trend of outcomes in ICU patients with and without COVID-19 across nine hospitals within a large regional health-care system in Northeastern Ohio.

Methods

Between March 1, 2020 and June 30, 2020, all adult patients who were admitted to ICUs in nine hospitals across the Cleveland Clinic health-care system were included. Patients who remained hospitalized on June 30, 2020, were excluded from the analysis (<5%). Deidentified individual demographics, Acute Physiology and Chronic Health Evaluation (APACHE) III score\(^6\) on day 1 of ICU admission, laboratory-confirmed COVID-19 status (positive vs negative), and key treatment information were obtained. We evaluated outcomes that included ICU and hospital mortality rates, ICU and hospital length of stay, and duration of mechanical ventilation. During the study period, several system-wide COVID-19-specific strategies were devised and implemented: (1) establishment of cohort COVID-19 ICU in the major health system hubs; (2) continuous monitoring of ICU occupancy, with predetermined plan of staffing adjustment, patient triage thresholds, and caseload redistribution; (3) webinars on COVID-19 clinical care that targeted all ICU providers; (4) protocolized management to ensure standardization of ICU care; and (5) multidisciplinary collaboration that involved critical care, infectious disease, nephrology, and palliative care. Chi square test was used to compare mortality rates between patients with and without COVID-19.

Results

A total of 5,460 patients were included in the study, which included 582 patients (10.7%) with COVID-19. On review of monthly temporal trends, there was a steady improvement in ICU outcomes in patients with COVID-19 with no significant change in APACHE III scores (Table 1). Compared with patients without COVID-19, ICU and hospital mortality rates were significantly higher in patients with COVID-19 in March (both \(P < .001\)), but not statistically different in June (both \(P = .16\)). Similar trends were observed for hospital deaths, ICU length of stay, hospital length of stay, and mechanical ventilation duration in COVID-19 group (Figure 1). There was no significant difference in the number of mechanically ventilated patients or in the use of prone position ventilation. Therapeutic interventions that included the use of hydroxychloroquine, remdesivir, and steroids were variable and were consistent with the emerging literature. ICU outcomes for non-COVID-19 group remained relatively unchanged across the study period.

Discussion

This is the first large case series, to our knowledge, from a major health-care system, that showed continuous improvement in clinical outcomes in patients with COVID-19-related critical illness. Additionally, our study showed that, in well-prepared health-care systems with sufficient ICU capacity and resources, these outcomes become comparable with those of non-COVID-related critical illness and compared favorably to recently published data from the United States and worldwide.\(^3\),\(^2\) These intriguing observations suggest the potential benefits to the adoption of system-wide strategies.
| Variable | March | April | May | June |
|----------|-------|-------|-----|------|
|          | Non-COVID-19 (n=1,418) | COVID-19 (n=87) | Non-COVID-19 (n=996) | COVID-19 (n=192) | Non-COVID-19 (n=1,147) | COVID-19 (n=197) | Non-COVID-19 (n=1,317) | COVID-19 (n=106) |
| Patient characteristics | | | | | | | | |
| Age, median [interquartile range], y | 68 [60-78] | 66 [53-75] | 65 [53-75] | 66 [51-77] | 65 [54-79] | 67 [51-78] | 65 [56-80] | 67 [55-79] |
| Male sex, No. (%) | 680 (48.0) | 52 (59.8) | 512 (51.4) | 110 (57.3) | 597 (52.0) | 114 (57.9) | 696 (52.8) | 58 (54.7) |
| APACHE III, median [interquartile range], points | 54 [42-80] | 58 [46-92] | 55 [40-78] | 55 [48-88] | 55 [41-87] | 57 [42-88] | 54 [41-78] | 53 [38-84] |
| Treatments, a No. (%) | | | | | | | | |
| Mechanical ventilation | 475 (33.5) | 40 (46.0) | 348 (34.9) | 85 (44.3) | 390 (34.0) | 77 (39.1) | 394 (29.9) | 42 (39.6) |
| Prone position ventilation | N/A | 9 (10.3) | N/A | 12 (6.3) | N/A | 14 (7.1) | N/A | 7 (6.6) |
| Neuromuscular blocker b | N/A | 19 (21.8) | N/A | 38 (19.9) | N/A | 28 (14.4) | N/A | 10 (9.7) |
| Glucocorticoids c | N/A | 36 (41.4) | N/A | 89 (46.6) | N/A | 58 (29.7) | N/A | 40 (38.8) |
| Remdesivir | N/A | 0 (0.0) | N/A | 0 (0.0) | N/A | 52 (26.7) | N/A | 43 (41.7) |
| Hydroxychloroquine | N/A | 81 (93.1) | N/A | 106 (55.5) | N/A | 14 (7.2) | N/A | 1 (1.0) |
| Lopinavir/ritonavir | N/A | 6 (6.9) | N/A | 0 (0.0) | N/A | 0 (0.0) | N/A | 0 (0.0) |
| Azithromycin | N/A | 74 (85.1) | N/A | 91 (47.6) | N/A | 58 (29.7) | N/A | 23 (22.3) |
| Outcomes | | | | | | | | |
| Duration of mechanical ventilation, median [interquartile range], d | 4 [1-8] | 13 [6-18] | 4 [2-7] | 10 [6-14] | 4 [2-9] | 11 [6-13] | 4 [2-7] | 7 [4-10] |
| ICU length of stay, median [interquartile range], d | 3 [2-7] | 11 [2-19] | 3 [2-6] | 8 [2-16] | 3 [2-7] | 7 [2-12] | 3 [1-7] | 5 [2-10] |
| Hospital length of stay, median [interquartile range], d | 7 [4-16] | 16 [6-28] | 7 [6-14] | 14 [5-23] | 7 [7-18] | 13 [6-23] | 7 [6-16] | 7 [6-20] |
| ICU deaths, No. (%) | 94 (6.6) | 21 (24.1) | 72 (7.2) | 35 (18.2) | 92 (8.0) | 35 (17.8) | 74 (5.6) | 10 (9.4) |
| Hospital deaths, No. (%) | 106 (7.5) | 23 (26.4) | 85 (8.5) | 42 (21.9) | 108 (9.4) | 34 (17.3) | 85 (6.5) | 11 (10.4) |

APACHE III = Acute Physiology and Chronic Health Evaluation III; COVID-19 = coronavirus disease 2019; N/A = not available.

aNumber of patients with available data on each treatment: mechanical ventilation and prone position ventilation (data available for all patients); medications that included neuromuscular blocker, glucocorticoids, remdesivir, hydroxychloroquine, lopinavir/ritonavir, azithromycin (March, 87; April, 191; May, 195; June, 103.

bDefined as using a continuous IV drip of atracurium.

cDefined as patients received more than two doses of IV or po prednisone, dexamethasone, hydrocortisone, or methylprednisolone.
COVID-19-specific strategies in managing a large pandemic surge. A key benefit was the standardization of ICU care and reduction of therapy variability that was evidenced by modification of clinical treatment practice in response to emerging evidence. Recent studies reported wide variability in the adoption and implementation of different therapies for patients with COVID-19 across hospitals the United States with a subsequent wide range in 28-day in-hospital mortality rates (6.6% to 80.8%). Conversely, our system-wide strategies maximized the ability to provide optimal and standardized ICU care to all patients and resulted in better clinical outcomes.

A health-care system’s early preparation and planning is critical during pandemic outbreak. Facing patient surge, systems must assess capacity and capability early and begin to implement structures and processes
for navigating through the surge. In the United States, up to 32% of hospitalized patients with COVID-19 can require ICU admission,7 and the caseload is distributed unevenly, even among hospitals within a network. Health-care systems preemptively can optimize interhospital workflow to redistribute patients so that no one hospital or ICU has disproportionate disease burden. Before the patient surge occurred in Northeastern Ohio, our critical care incident command team and individual hospitals jointly created comprehensive multidepartment action plans. These action plans included the redeployment of personnel based on needs across ICUs, the identification of space for additional ICU capacity, and the early dissemination of clinical knowledge on COVID-19 with participation and “buy-in” across stakeholders from the different ICUs.

This is the first study to compare outcomes associated with COVID-19 with other ICU admissions in the United States. Using well-validated APACHE III scoring system, we reported a large cohort of ICU patients across nine hospitals with high critical illness severity. As a result, our study has good generalizability, and our data are an accurate representation of the mortality rate of critically ill patients with COVID-19 in a controlled surge situation after care standardization. We acknowledge that this study does not address potential confounders that are associated with the possible temporal changes in patient demographics and disease characteristics. To mitigate the risk of bias, we compared all the outcomes of interest in nonpatients with COVID-19 as a general representation of our ICU population. While acknowledging the changes in the utilization of certain therapies that included remdesivir and the potential effect on patients’ clinical outcomes, we believe that the temporal improvement in mortality rates in our cohort cannot be explained solely by these therapies, especially given the results of recent randomized controlled trials.8,9

This study is a snapshot of patients with COVID-19-associated critical illness across a large regional health-care system in the initial phase of the pandemic. We show that ICU outcomes have improved significantly in patients with COVID-19 and were comparable with outcomes in non-COVID-19 ICU-related admissions. Furthermore, we believe that development and implementation of system-wide COVID-19-specific strategies can have a significant impact. Facing a pandemic such as COVID-19, health-care systems should consider similar measures to promote optimal resource allocation and standardization of care.

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