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ABSTRACT

Background: COVID-19 is a novel disease caused by SARS-CoV-2.

Methods: We conducted a retrospective evaluation of patients admitted with COVID-19 to one site in March 2020. Patients were stratified into 3 groups: survivors who did not receive mechanical ventilation (MV), survivors who received MV, and those who received MV and died during hospitalization.

Results: There were 140 hospitalizations; 22 deaths (mortality rate 15.7%), 83 (59%) survived and did not receive MV, 35 (25%) received MV and survived; 18 (12.9%) received MV and died. The mean age of each group was 57.8, 55.8 and 72.7 years, respectively (P = .0001). Of those who received MV and died, 61% were male (P = .01). More than half the patients (n = 90, 64%) were African American. First measured d-dimer >575.5 ng/mL, procalcitonin >0.24 ng/mL, lactate dehydrogenase >445.6 units/L, and brain natriuretic peptide (BNP) >104.75 pg/mL had odds ratios of 10.5, 5, 4.5 and 2.9, respectively for MV (P < .05 for all). Peak BNP >167.5 pg/mL had an odds ratio of 6.7 for inpatient mortality when mechanically ventilated (P = .02).

Conclusions: Age and gender may impact outcomes in COVID-19. D-dimer, procalcitonin, lactate dehydrogenase and BNP may serve as early indicators of disease trajectory.
METHODS

The protocol was reviewed by the local Institutional Review Board and deemed exempt.

The study was conducted at a large, academic, Midwestern institution which serves as a referral center for the State of Indiana. Surge planning allowed our institution to accommodate up to 278 patients with COVID-19 who may require intensive care and up to 400 patients who may require medical-surgical or progressive levels of care. The first patient with testing confirmed COVID-19 was admitted to our hospital on March 11, 2020.

Initially, polymerase chain reaction based testing was available through coordination with the State Department of Health for all patients. Polymerase chain reaction testing became available within the institution on March 18, 2020. A list of all patients who present to the hospital and have testing performed is maintained by our Infection Preventionist (I.K.K.). We used this list to identify all patients admitted to the hospital between March 1 and March 31, 2020 whose test results indicated infection by the novel coronavirus.

A data collection form was created in REDCap, a secure web-based tool to facilitate research (data collection form available as supplementary material). Items included demographics, comorbid conditions, clinical presentations, time stamped laboratory values, and hospital course. Data collection was discussed and operationalized between 3 authors who reviewed the electronic medical record of each patient (W.G., E.C., A.K.). The form was pilot tested and edited to enhance ease of use and consistency. Each patient’s admission history and physical was reviewed and corroborating diagnostic information was retrieved when relevant (eg. hemoglobin A1c for patients with diabetes mellitus). Presenting symptoms were categorized as (1) respiratory complaints (cough, shortness of breath, and chest pain), (2) gastrointestinal (GI) complaints (nausea, vomiting, diarrhea, and abdominal pain), (3) fever, (4) syncope and altered mental status and, (5) constitutional symptoms (myalgias, anosmia, dysgeusia, anorexia, night sweats, fatigue, and weakness). The first recorded set of vital signs, imaging and laboratory data was captured. Vital signs and respiratory care notes were reviewed to assess the timing and magnitude of increasing oxygen needs. Laboratory data was reviewed for the entire hospital stay. The timing and values of first drawn possible prognosticators were recorded and peak values and timing were captured when these laboratories were checked more than once. Medications prior to admission were determined by reviewing the pharmacist’s admission medication history. The medication administration record was accessed to confirm the receipt of COVID-19 specific therapies, steroids and vasopressors. The discharge summary was reviewed for complications. All patients admitted for confirmed or suspected COVID-19 during the study period at our institution had a complete blood count (CBC) and basic chemistries drawn on admission. Timing of prognostic laboratories and clinical trajectories were reported relative to the timing of this admission CBC. Data were collected for all patients until June 5, 2020.

Data were then downloaded from REDCap and described using descriptive statistics. We stratified the sample into three distinct groups of worsening severity based on outcomes: patients who did not receive mechanical ventilation (MV) and survived, those who received MV and survived, and those who received MV and died during the hospitalization.

Laboratory values that may serve as markers of disease severity were compared among these three groups. Based on prior research, laboratory values that were tracked included alanine transaminase, brain natriuretic peptide (BNP), creatine kinase (CK), c-reactive protein (CRP), d-dimer, ferritin, lactate dehydrogenase (LDH), procalcitonin and troponin. First and peak recorded values were retrieved and compared using analysis of variance testing. If testing revealed statistically significant differences in values between groups at $P < .05$, odds ratios were then calculated. At the time of presentation, concerns about the trajectory of patients with COVID-19 often revolve around whether the patient will require MV; and shift towards survival once MV is necessary. To parallel these clinical questions, the first measured values were used to calculate the odds of receiving MV, while peak values were used to calculate the odds of inpatient mortality in those who received MV. The 75th percentile value in the group that did not receive MV and survived was used as the cut-off to calculate the odds of receiving MV, while the 75th percentile value in those who received MV and survived was used as the cut-off to calculate the odds of mortality in those who received MV. The timing of both the first and peak prognostic laboratory values relative to the admission CBC time were also compared between the three groups.

Data was analyzed using the pandas package for Python, with Fisher exact testing used for categorical variables and contingency tables. Analysis of variance testing was performed for continuous variables, using the Scipy STATS package. Characteristics of the sample were compared between the 3 outcome groups.

RESULTS

Between March 1 and March 31, 2020, there were 140 admissions to the hospital with testing confirmed COVID-19. More than half (59.3%) of the sample did not receive MV.

There were a total of 22 deaths (15.7% mortality rate) however, 4 patients had goals of care that were focused on comfort and did not receive MV. Of those who received MV, 35 (66%) survived.

Demographics and comorbidities

Overall the sample had roughly equal numbers of males and females; however, 68% of those who received MV were male. The mean age of those who received MV and died was 73 years while the mean age of those who received MV and survived was 55.8 years. More than half the sample (64%) was African American and 67% of those who did not survive MV were African American. Gender and age distribution were statistically significantly different between the three outcome groups (Table 1).

Hypertension and diabetes mellitus were the most frequently noted comorbidities with the overall sample having a mean of 2.9 comorbidities per patient. The mean number of outpatient medications at the time of admission per patient was 7.6. Patients had few inpatient stays in our hospital system before the current encounter with a mean of 0.4 hospitalizations per patient over the prior 12 months.

The group that received MV and survived had the highest mean body mass index (BMI) (36) and the lowest proportion of individuals with normal BMIs. The mean BMI for those who received MV and did not survive was 27.2 which was lower than the mean BMI for the group who did not receive MV (32.3) ($P < .05$ for all pair-wise comparisons of BMI).

Presenting symptoms and initial evaluation

Most patients presented with multiple symptoms, however patients who received MV and died reported fewer symptoms on presentation. Symptoms related to the respiratory system were the most frequent (93.6%) followed by reports of fever (65%) and GI complaints (51%). Fewer patients who received MV and died reported fever on admission and reported shorter duration of symptoms at the time of presentation (Table 2).

While fever was a common complaint, the first mean recorded temperature for all groups was <38°C. More than half the sample (52%) met systemic inflammatory response (SIRS) criteria on
admission; however, the distribution of the mean quick sequential organ failure assessment (Q SOFA) score differed between the three groups with the highest mean score noted in those who received MV and died.8

Initial chest X-ray imaging was normal in 13.6% of presentations and bilateral infiltrates were the most commonly noted abnormality (69%). Bilateral infiltrates were less frequently observed in those who did not receive MV and survived.

| Table 1 | Demographics and medical comorbidities: adult admissions for COVID-19 between March 1-March 31, 2020 at an academic health center |
|---------|----------------------------------------------------------------------------------------------------------------------------|
| Total number | Did not receive mechanical ventilation - survived | Received mechanical ventilation - survived | Received mechanical ventilation - died | P-value* |
| 140 | 83 (59.3%) | 35 (25.0%) | 18 (12.9%) |  |
| Gender | | | |  |
| Female | 68 (48.6%) | 48 (57.8%) | 10 (28.6%) | 7 (38.9%) | .01 |
| Male | 72 (51.4%) | 35 (42.2%) | 25 (71.4%) | 11 (61.1%) |  |
| Mean age (years) | 60 | 57.8 | 55.8 | 72.7 | .0001 |
| IQR | 48-72 | 45-69 | 42-65 | 67-81 |  |
| Race and ethnicity | | | |  |
| African American | 90 (64.3%) | 60 (72.3%) | 17 (48.6%) | 12 (66.7%) | .07 |
| White | 37 (26.4%) | 16 (19.3%) | 13 (37.1%) | 5 (27.8%) |  |
| Asian | 5 (3.6%) | 2 (2.4%) | 5 (14.3%) | 2 (11.1%) | .3 |
| Hispanic | 7 (5.0%) | 5 (6.0%) | 2 (5.7%) | 0 (0.0%) |  |
| Not recorded | 1 (0.7%) | 0 (0.0%) | 1 (2.9%) | 0 (0.0%) |  |
| Health care worker | 11 (7.9%) | 10 (12.0%) | 2 (5.7%) | 0 (0.0%) | .1 |
| Presented from Group living | 5 (3.6%) | 5 (6.0%) | 0 (0.0%) | 0 (0.0%) | .3 |
| Mean number of comorbid conditions per patient | 2.9 | 2.7 | 2.9 | 3.2 | .4 |
| | | | |  |
| Initial chest X-ray imaging |  |  |  |  |
| Normal | 13.6% |  |  |  |
| Bilateral infiltrates | 69% |  |  |  |
| Bilateral infiltrates |  | 61% |  |  |
| Mean hemoglobin A1c in the last 6 months | 8.3 | 8.5 | 8.7 | 7.0 | .5 |
| IQR | 6-7 | 4-10 | 2-10 | 6-12 |  |
| Hypertension | 96 (68.6%) | 53 (63.9%) | 25 (71.4%) | 14 (77.8%) | .4 |
| Diabetes mellitus | 51 (36.4%) | 24 (29.8%) | 17 (48.6%) | 7 (38.9%) | .1 |
| Mean Hemoglobin A1c in the last 6 months |  |  |  |  |
| Normal | 8.3 | 8.5 | 8.7 | 7.0 | .5 |
| IQR | 6-7 | 4-10 | 2-10 | 6-12 |  |
| BMI, body mass index; HIV, human immunodeficiency virus; IQR, interquartile range; SD, standard deviation; TIA, transient ischemic attack. |  |  |  |  |
| *P-values comparing the three outcome groups. Total column includes 4 patients whose goals of care focused on comfort. |  |  |  |  |
| yChronic lung disease = COPD, sarcoidosis, interstitial lung disease, pulmonary hypertension, cystic fibrosis, restrictive lung disease. |  |  |  |  |
| zImmune suppressed = chronic steroid use, biologic agents for rheumatologic disorders or inflammatory bowel disease, recent chemotherapy, hematologic malignancy, history of bone marrow or solid organ transplant. |  |  |  |  |
| xSite of malignancy = lung (1), breast (2), colon (1), head and neck (1), renal (1), melanoma (1), prostate (4), hematologic (1) one patient had both prostate and colon cancer. |  |  |  |  |
| *2 lung transplant, 2 kidney transplant recipients. |  |  |  |  |
Mean presenting white counts, absolute neutrophil counts and blood urea nitrogen values were noted to be highest amongst those who received MV and died.

Only 3% of patients had a coinfection detected by respiratory viral panel testing.

Clinical trajectory

Upon initial presentation, 79 patients (56%) did not receive supplemental oxygen while 26 (18.6%) did not receive any supplemental oxygen throughout the stay.

In patients who did not receive MV support and survived, the mean peak oxygen requirement by nasal cannula was 5.1 L. If needs were not met by nasal cannula, the mean peak FiO2 was 42.5%. These peak needs were reached in a mean of 32.4 hours following admission.

Patients who received MV and survived had a mean peak preintubation requirement of 12.1 liters by nasal cannula or mean FiO2 80% when nasal cannula did not suffice, reaching this peak in a mean of 35.9 hours following admission. In those who received MV and died, mean peak preintubation requirements by nasal cannula were 10.25 liters or FiO2 72.5%. These peak needs were reached in a mean of 36.1 hours following admission (Supplementary Table 1).

The mean time to MV from admission in those who survived was 30 hours and for those who died was 52.5 hours ($P = .1$).

Laboratory values and prognostication

Laboratory values that showed differences in distribution between groups with $P$-value < .05 in the first reported values included BNP, d-dimer, LDH, and procalcitonin. Odds ratio using the specified cut-offs for receiving MV were statistically significant for each of these laboratory values with the highest odds ratio (10.5) for
receiving MV noted for d-dimer values elevated above 575.5 ng/mL (Tables 3 and 4).

Alanine transaminase, BNP, CK, CRP, d-dimer IL-6, and LDH values were statistically different between the groups at peak and were used to calculate the odds for mortality in patients receiving MV. At the thresholds used, only peak BNP achieved statistical significance with levels elevated above 167.5 pg/mL associated with a 6.8-fold increased risk for mortality in patients receiving MV (Tables 3 and 4).

Ferritin and troponin did not achieve statistically significant differences between groups at either first or peak measured values.

The timing of first reported laboratory values relative to admission CBC were similar between the 3 groups, however there were statistically significant differences in when peak values of CK, CRP, ferritin, procalcitonin, and troponin were achieved between the groups (Table 3).

Outcomes and complications

The mean length of stay was 6.5 days for patients who did not receive MV and 21.3 days for those who received MV and survived (P < .00001).

Shock requiring vasopressors was noted in 54.3% of those who survived MV and in 77.8% of those who received MV and died. Secondary bacterial infection which included pneumonia and bacteremia was common amongst those who received MV (noted in 42.9% of survivors who received MV and in 44.4% of those who received MV and died). Venous thromboembolism occurred in 3.6% of patients who did not receive MV and survived, in 20% of those who received MV and survived and in 27.8% of those who received MV and died. The 14-day readmission rate was 8.4% for those who did not receive MV and 11.4% for those who did. Renal failure necessitating the initiation of renal replacement therapy was noted in a third of those who received MV and died (Table 5).

DISCUSSION

We present in rich detail the clinical characteristics, laboratory evaluation, trajectories, and outcomes of all patients admitted with COVID-19 to our institution in March 2020 and explore prognostic implications of certain clinical and laboratory markers.

Our data corroborates the increased risk of severe disease and mortality in COVID-19 conferred by increasing age and male gender noted in previous studies. An early US report found a mortality rate of 67% in patients admitted to the intensive care unit where the mean age of the population was 70 years, and more serious illnesses in the US have been noted in older adults.6,10 In our sample, while more males received ventilatory support than females, these differences were less marked than the initial data from China where 85% of those who required ICU care were male.4 Data from hospitalized patients in the New York City area also noted worse outcomes in older and male patients.11 Strategies to protect vulnerable, older adults should continue to be prioritized and further data adjusted for potential confounders will be needed to explore gender related disparities in COVID-19 outcomes.

We also note racial differences in the epidemiology of COVID-19. African Americans represented 64% of all hospitalized COVID-19 patients in our sample. To place this in perspective, in the five months preceding March 2020, the proportion of patients admitted to our facility who were African American was 21%. Our work does not allow us to explain the root causes of these differences however urgent attention is needed to understand and mitigate this trend.

Diabetes mellitus was the most frequently reported comorbid condition in patients hospitalized with COVID-19 in China.2,4 However, both our sample and a large series from New York City found hypertension to be the most frequent comorbidity noted in patients hospitalized with COVID-19.2,11 Interestingly, patients admitted for COVID-19 in our sample did not appear to be high utilizers of health care with few prior hospitalizations within our system.

There is data emerging linking obesity and increased disease severity in COVID-19.12 We found similar higher mean BMIs in patients who received MV compared to those who did not. However, in those who received MV but died, mean BMIs fell in the overweight category with more than a third of those who died having normal BMIs. The interaction between weight, need for MV and outcomes when ventilated requires further exploration.

In terms of presenting symptoms, half the patients in our sample had GI complaints, higher than reports from China where GI symptoms were recorded for only 13% of patients.13 Fewer patients who received MV and died reported fever as a presenting complaint and presented with a shorter duration of symptoms. These findings may offer clues to the differences in presentation that may signal different trajectories.

Presenting vital signs between patients in the 3 outcome groups appeared comparable and the high prevalence of meeting SIRS criteria on admission limits its utility as a predictor of clinical trajectory. However, q SOFA scoring on admission may prove to be a useful prognosticator on admission. Imaging and laboratory evaluations may also be helpful in guiding initial clinical concern as the presence of bilateral infiltrates, higher white counts, higher absolute neutrophil and blood urea nitrogen values on admission were noted more frequently in those who received MV and died.

Patients appear to “declare” themselves in the first 48 hours of admission with the mean time to reaching maximum oxygen requirements ranging from 32 to 36 hours following admission. Statistically nonsignificant differences were noted in the times to receiving MV. While the time from admission to MV in those who subsequently survived appears to be shorter than the time from admission to MV in those who died, we cannot determine whether this observation represents a difference in the rate of decline (with slower rates of decline portending worse prognosis), an impact on outcomes by early versus late MV or whether the decision to intubate was impacted by the team’s awareness of prognosis.

Several laboratory values are being investigated as prognostic markers for severe disease. We analyzed the predictive ability of laboratory evaluations in two critical clinical periods posing two different decisions. We used the first measured values to predict the need for mechanical ventilation and the peak values to predict inpatient mortality in those who were mechanically ventilated. Multiple studies and our own data have demonstrated the marked derangements seen in patients with COVID-19.14 Accordingly, we used cutoff values derived from the distribution of our own data set rather than reference ranges as thresholds to calculate odds ratios to present more meaningful and discriminatory interpretations for clinicians. D-dimer values have been reported to be abnormal in more than a third of patients presenting in China and with values >1,000 ng/mL associated with mortality.13 Our findings indicate that initial d-dimer values may also be used to predict the need for mechanical ventilation with values >575.5 ng/mL conferring a 10.5-fold increase in risk. Increasing procalcitonin and LDH values have also been associated with increased odds of mortality in COVID-19.4,15 Our findings indicate that their first reported values may also predict the need for
| Laboratory | Total | Did not receive mechanical ventilation - survived | Received Mechanical Ventilation - survived | Received Mechanical Ventilation – died | P-value* |
|------------|-------|---------------------------------|---------------------------------|---------------------------------|----------|
| First measured ALT | Mean value (units/L) 32.9 | 32.1 | 35.7 | 33.9 | 0.8 |
| | IQR | 16-37 | 14-34 | 21-41 | 18-47 |
| | Mean time to first measured value (hours) 8.8 | 6.9 | 7.8 | 7.8 | 0.5 |
| Peak measured ALT | Mean value (units/L) 140 | 45.2 | 135.9 | 445.1 | 0.0001 |
| | IQR | 25-111 | 16-60 | 66-160 | 57-748 |
| | Mean time to peak value (hours) 152.7 | 101.7 | 182.9 | 152.4 | 1.0 |
| First measured BNP | Mean value (pg/mL) 259.6 | 167.1 | 144.1 | 587.4 | 0.04 |
| | IQR | 35-120 | 39-105 | 26-101 | 80-342 |
| | Mean time to first measured value (hours) 1158.5 | 2450.12 | 58.2 | 46 | 0.5 |
| Peak measured BNP | Mean value (pg/mL) 434.8 | 154 | 116.4 | 1276.3 | 0.001 |
| | IQR | 66-423 | 42-221 | 56-168 | 514-1636 |
| | Mean time to peak value (hours) 103.9 | 78 | 124.3 | 103.8 | 0.3 |
| First measured CK | Mean value (units/L) 742.1 | 463.6 | 859.9 | 1820 | 0.1 |
| | IQR | 76-325 | 78-230 | 47-273 | 248-2279 |
| | Mean time to first measured value (hours) 42.1 | 32 | 66.5 | 46.7 | 0.3 |
| Peak measured CK | Mean value (units/L) 1174.1 | 594.6 | 1634.9 | 3130.7 | 0.03 |
| | IQR | 106-1126 | 100-340 | 126-1762 | 1474-2905 |
| | Mean time to peak value (hours) 149.1 | 84.7 | 257 | 153.3 | <.00001 |
| First measured CRP | Mean value (mg/dL) 13.3 | 11 | 18.7 | 123 | 0.1 |
| | IQR | 5-15 | 3-12 | 10-27 | 8-14 |
| | Mean time to first measured value (hours) 730.3 | 1239 | 32.1 | 15.2 | 0.7 |
| Peak measured CRP | Mean value (mg/dL) 19.9 | 12.3 | 27.6 | 28.7 | <.00001 |
| | IQR | 10-28 | 7-16 | 23-33 | 18-41 |
| | Mean time to peak value (hours) 116.2 | 70.1 | 147.6 | 162.9 | 0.01 |
| First measured D-dimer | Mean value (ng/mL) 1874.9 | 550.1 | 846.9 | 6743.2 | 0.001 |
| | IQR | 291-984 | 234-576 | 397-886 | 886-4478 |
| | Mean time to first measured value (hours) 1112.3 | 33.7 | 47.4 | 5534.6 | 0.1 |
| Peak measured D-dimer | Mean value (ng/mL) 5857.5 | 1605.6 | 4598.7 | 13354.7 | 0.008 |
| | IQR | 683-4206 | 383-1039 | 930-4056 | 2528-12396 |
| | Mean time to peak value (hours) 5.6 | 2.4 | 14 | 1.4 | 0.2 |
| First measured ferritin | Mean value (ng/mL) 1211.4 | 1356.9 | 1165.2 | 723.8 | 0.6 |
| | IQR | 275-1044 | 191-969 | 379-1324 | 240-838 |
| | Mean time to first measured value 855.8 | 1555.1 | 44.6 | 48.4 | 0.6 |
| Peak measured ferritin | Mean value (ng/mL) 2740.1 | 2519.1 | 1677.7 | 5477.7 | 0.1 |
| | IQR | 348-2157 | 289-1325 | 788-2187 | 271-3074 |
| | Mean time to peak value (hours) 16.2 | 0 | 21.8 | 7.3 | <.00001 |
| First measured IL-6 | Mean value (pg/mL) 33.5 | 12 | 42.5 | 35.8 | 0.08 |
| | IQR | 5-38 | 2-12 | 8-54 | 10-30 |
| | Mean time to first measured value (hours) 1398.2 | 4640.5 | 59 | 60.4 | 0.3 |
| Peak measured IL-6 | Mean value (pg/mL) 130.4 | 0 | 119.9 | 144.8 | <.00001 |
| | IQR | 41-170 | 0-0 | 34-170 | 46-100 |
| | Mean time to peak value (hours) 953.7 | 1803.4 | 110.3 | 164.6 | 0.6 |
| First measured LDH | Mean value (units/L) 432.2 | 360.9 | 489.4 | 562.9 | 0.002 |
| | IQR | 305-519 | 280-446 | 358-579 | 342-736 |
| | Mean time to first measured value (hours) 24.4 | 20.7 | 28.6 | 30.9 | 0.5 |
| Peak measured LDH | Mean value (units/L) 772.9 | 448 | 631.7 | 1716.2 | 0.001 |
| | IQR | 368-719 | 318-519 | 504-696 | 524-1224 |
| | Mean time to peak value (hours) 63.1 | 44.6 | 99.2 | 86.4 | 0.2 |
| First measured procalcitonin | Mean value (ng/mL) 1.4 | 0.3 | 1.8 | 4.7 | 0.007 |
| | IQR | 0-1 | 0-0 | 0-1 | 0-3 |
| | Mean time to first measured value (hours) 733.9 | 11.8 | 2622.8 | 14.6 | 0.2 |
| Peak measured procalcitonin | Mean value (ng/mL) 3.2 | 1.8 | 2.7 | 5.6 | 0.2 |
| | IQR | 0-2 | 0-1 | 0-2 | 1-4 |

(continued)
mechanical ventilation. We additionally identified the potential of first and peak BNP values to predict the need for mechanical ventilation and mortality respectively. Previous reports have found ferritin and troponin values to be predictive of mortality.5,16 In our sample, however, these values were not statistically significantly different between groups at either first or peak measurement. Our findings may form the basis of future work to create scoring systems to improve our ability to predict the trajectory of patients presenting with COVID-19, stratify risk and guide subsequent management. The differences in the timing of peak values noted for certain laboratory

| Laboratory | Total | Did not receive Mechanical Ventilation - survived | Received Mechanical Ventilation - survived | Received Mechanical Ventilation – died | P-value* |
|------------|-------|-----------------------------------------------|---------------------------------------------|----------------------------------------|---------|
| Mean time to peak value (hours) | 166.1 | 0 | 160.8 | 173.5 | <.00001 |
| First measured troponin | 0.3 | 0 | 0.8 | 0.2 | .3 |
| Mean value (ng/mL) | 0-0 | 0-0 | 0-0 | 0-0 | .1 |
| Mean time to first measured value (hours) | 0.6 | 0 | 1.8 | 0.8 | |
| Peak measured troponin | 0.6 | 0 | 1.8 | 0.8 | 0.1 |
| Mean value (ng/mL) | 0-0 | 0-0 | 0-0 | 0-0 | 0.04 |
| Mean time to peak value (hours) | 111.6 | 37.9 | 133.4 | 146.2 | |

IQR, interquartile range; ALT, alanine transaminase; BNP, B type natriuretic peptide; CK, creatine kinase; CRP, C-reactive protein; LDH, lactate dehydrogenase.

**Reference ranges:** ALT = 7-52, BNP = 0-100, CK = 30-223, CRP = <1, D-dimer = <292, ferritin = 15-400, LDH-140-271, procalcitonin = <0.5 low risk for sepsis, >2 high risk for sepsis, troponin <0.03.

*P-values comparing the three outcome groups. Total column includes 4 patients whose goals of care focused on comfort.

Table 4
Unadjusted odds ratios for receiving mechanical ventilation and mortality if mechanically ventilated based on laboratory evaluation

| Laboratory type | Laboratory value | Cut-off threshold | Outcome | Odds Ratio | P-value* |
|-----------------|------------------|-------------------|---------|------------|---------|
| First measured value | D-Dimer (ng/mL) | 575.5 | Receive mechanical ventilation | 10.5 | <.00001 |
| Procalcitonin (ng/mL) | 0.24 | Receive mechanical ventilation | 5.06 | .00004 |
| LDH (units/L) | 445.5 | Receive mechanical ventilation | 4.46 | .0003 |
| BNP (pg/mL) | 104.75 | Receive mechanical ventilation | 2.95 | .03 |
| Peak value | BNP (pg/mL) | 167.5 | Inpatient mortality if mechanically ventilated | 6.79 | .02 |
| D-Dimer(ng/mL) | 4055.5 | Inpatient mortality if mechanically ventilated | 2.15 | .3 |
| LDH (units/L) | 695.75 | Inpatient mortality if mechanically ventilated | 2.15 | .3 |
| CRP (mg/dL) | 33.47 | Inpatient mortality if mechanically ventilated | 1.69 | .5 |
| ALT (units/L) | 159.75 | Inpatient mortality if mechanically ventilated | 1.3 | .7 |
| CK (units/L) | 1762 | Inpatient mortality if mechanically ventilated | 3.05 | .2 |
| IL-6 (pg/mL) | 170 | Inpatient mortality if mechanically ventilated | 2.06 | .6 |

ALT, alanine transaminase; BNP, brain natriuretic peptide; CK, creatine kinase; CRP, c-reactive protein; IL-6, interleukin 6; LDH, lactate dehydrogenase.

Table 5
Outcomes and complications for adult patients admitted with COVID-19 between March 1- March 31, 2020 at an academic health center

| Total | Did not receive Mechanical Ventilation- survived | Received Mechanical Ventilation - survived | Received Mechanical Ventilation – died | P-value* |
|-------|-----------------------------------------------|---------------------------------------------|----------------------------------------|---------|
| Total | 140 | 83 | 35 | 18 | .00001 |
| Mean length of stay (days) | 10.7 | 6.5 | 21.3 | 12.8 | .00004 |
| IQR | 4-15 | 3-8 | 12-25 | 8-16 | |
| Mean days on ventilator | 10.9 | NA | 11.1 | 10.6 | .03 |
| IQR | 6-14 | 6-14 | 6-13 | |
| Readmitted within 14 days | 11 (7.9%) | 7 (8.4%) | 4 (11.4%) | NA | .7 |
| Shock requiring vasopressors | 33 (23.6%) | 0 (0%) | 19 (54.3%) | 14 (77.8%) | 1.0 |
| Secondary infection | 27 (19.3%) | 3 (3.6%) | 15 (42.9%) | 8 (44.4%) | 2.0 |
| Adult respiratory distress syndrome | 19 (13.6%) | 0 (0%) | 13 (37.1%) | 6 (33.3%) | 2.0 |
| Acute kidney injury | 41 (29.3%) | 14 (16.9%) | 12 (34.3%) | 12 (66.7%) | .00006 |
| Venous thromboembolism | 15 (10.7%) | 3 (3.6%) | 7 (20.0%) | 5 (27.8%) | .0007 |
| New need for renal replacement therapy | 10 (7.9%) | 0 (0%) | 4 (11.4%) | 6 (33.3%) | .000004 |
| Amyrthias | 21 (15.0%) | 8 (9.6%) | 8 (22.9%) | 5 (27.8%) | .04 |
| Other complications*** | 37 (26.4%) | 13 (15.7%) | 14 (40.0%) | 9 (50.0%) | .001 |
| New O2 requirement upon discharge | 3 (2.1%) | 2 (2.4%) | 1 (2.9%) | NA | .9 |
| Discharge disposition not home | 16 (11.4%) | 6 (7.2%) | 10 (28.6%) | NA | .005 |

Notes:
***Other complications included diabetic ketoacidosis (2), prolonged encephalopathy/ delirium (6) thrombocytopenia (2) stridor following extubation (3).
IQR, interquartile range; NA, not applicable; O2, oxygen.

*P-values comparing the three outcome groups. Total column includes 4 patients whose goals of care focused on comfort.
values (CK, CRP, ferritin, procalcitonin, and troponin) raise additional areas for future research.

The medical management of these patients appears to be complex and resource intensive with multiple complications, long lengths of stay and need for placement upon discharge. In addition to shock, venous thromboembolism and secondary bacterial infections, we also noted patients with prolonged encephalopathy and sequelae of prolonged intubation. Long-term monitoring is needed to identify delayed or prolonged deficits arising from the initial illness.

Our study has limitations. It is a single center’s experience with a novel illness over the first month of its appearance at our institution. We relied on discharge summary documentation of complications with targeted review of corroborating diagnostics and may therefore be under reporting adverse outcomes. While our health system shares an electronic medical record platform across all 18 hospitals, we did not access city wide data to confirm readmissions or prior hospitalizations. Importantly, we present unadjusted odds ratios and analysis of differences between the three outcome groups. The differences found should be considered exploratory and hypothesis generating requiring confirmation in larger, multivariate analysis.

As the burden of this novel disease grows, sharing clinical information about patients will help us generate hypotheses and adapt our management and prevention strategies. Continued research on presentations, outcomes and complications in different settings and over longer periods will help improve the care we provide our patients.

Acknowledgments

IU Health Academic Health Center Hospital Medicine Covid-19 Response Team: Chad Trambaugh, Tony Ren, Josef Streepey, Mary Eckerle, Matthew George, Jason Russ, Simran Singh, Fnu Sanna, Mark Kandary, Tasneem Siddiqua, Sukhwinder Singh, Jane Turner, Nicholas Newsom, Fnu Jaydev, Sydney Wilson, John Botkin, Neshah Wijeyakuhana, Vinod Kumar, Amy Mattingly, Kavitha Subramoney, Neetu Mahendraker, Khristian Sunga, Santi Gottumukkala, Anil Achaen, Arefin Chowdhury, Faiza Amin, Jeffrey Nace, Sachin Shah, Asim Mohamed, Opeyemi Awe, Atif Zafar, Jeffrey Kons, Karan Mathur, Vijay Are, Sarah Jones, Devon Blackburn, William Thompson, Pamela Dam, Nyuka Lamey, Phyllicia Richardson, Nadia Gonzalez, Haleigh Hanson, Kate Tenbarge, Alaina McSherry, Shaina Boone, Jeremiah Lewis, James Millward, Jeanna Francis, Melissa Craig, Amy Lawrence, Kelly Robertson, Melissa Davis and Brad Sutter.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2020.07.005.

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