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Remote Biometric Monitoring of Patients With COVID-19 With Exertional Hypoxia Treated With Supplemental Oxygen

To the Editor:

Hospitalizations to treat patients infected with COVID-19 have strained health systems worldwide. Monitored outpatient treatment of select low-risk patients with COVID-19 could help preserve hospital resources and reduce costs while aiming to maintain a high standard of care. However, criteria to identify patients appropriate for outpatient monitoring do not exist. Isolated exertional hypoxia may be an early predictor of moderate-to-severe COVID-19 and could be an indication for remote monitoring or inpatient admission; however, data to support its use are limited.[1-3] Our institution implemented a standardized ED triage process that included exertional hypoxia and the COVID-19-associated hyperinflammation (cHIS) score.[4] The cHIS scoring includes fever, degree of cytopenia, hyperferritinemia, D-dimer, markers of hepatic injury (lactate dehydrogenase or aspartate aminotransferase), and markers of cytokinemia (c-reactive protein, IL-6, or hypertriglyceridemia) and is associated with progression to mechanical ventilation and death. This triage process identified patients who were considered to be at an acceptable morbidity and mortality risk for discharge to home on low-flow home oxygen with remote SpO_2 and vital sign monitoring. In this retrospective cohort analysis, we report the safety and effectiveness of the COVID-19 remote patient monitoring with home oxygen (cRPM-O_2) program as a strategy to reduce hospitalization days and preserve resource utilization.

Patients and Methods

The cRPM-O2 algorithm was implemented across 23 of Intermountain Healthcare's integrated hospitals from November 2020 to April 2021, during the COVID-19 alpha variant surge. Included patients had an ED encounter within 14 days after a confirmed COVID-19 positive test, received a COVID exercise tolerance test (cETT) to assess exertional hypoxia per protocol, and had a cHIS <2 by laboratory results that were obtained during the index ED encounter. cETT consisted of either briskly walking for 1 min or sit-to-stand for 1 min. Any SpO_2 result <90% or severe dyspnea that prevented completion of the test was considered a positive cETT. The clinical criteria for cRPM-O_2 inclusion and triage process are presented in Figure 1. Patients who met the criteria for cRPM-O_2 participation from the ED, but with an inpatient admission, constituted the control arm. The primary outcome was inpatient hospital days associated with the first admission within 14 days after the index ED encounter modeled by ordinary least squares regression (covariates are listed in Table 1). Secondary outcomes were ICU length of stay and combined ICU admission or all-cause death within 28 days. ICU length of stay was modeled in the same fashion as the primary outcome. Death was identified by state death database review to ascertain any death that occurs outside of our system. The composite binary outcome of ICU admission or death was modeled with the use of a logistic regression. Patient COVID-19 vaccination status was not available. The Intermountain Healthcare Institutional Review Board approved the analysis.

Patients who enrolled in cRPM-O_2 received a Bluetooth-enabled pulse oximeter paired to their smart phone via an application downloaded and confirmed by the ED nurse or technician prior to ED discharge. Patients were asked to record SpO_2/heart rate biometrics at least twice daily, or as often as they preferred, for 14 days. Submitted biometric data from enrolled patients were monitored 24 hours per day, 7 days per week. Patients without transmitted vital signs for >18 hours or with SpO_2 <88% and/or pulse rate >120 beats/min were contacted by a monitoring technician. If new hypoxemia was identified despite supplemental oxygen, the patient was instructed to return to the ED. Patients with concerns about their symptoms or the device could contact a monitoring technician via the application at any point, and concerns could be escalated to the monitoring center critical care nurse or nurse practitioner. The application included built-in text and video visit functionality to facilitate remote patient assessment. The pulse oximeter device, application, and monitoring service were offered to patients without out-of-pocket charges.

Results

Of the 755 patients identified in the study cohort, 522 patients comprised the control group, and 233 patients were in the cRPM-O_2 group. The cRPM-O_2 group was younger and had fewer comorbidities (Table 1). After adjustment for age, sex, ethnicity/race identifiers, insurance provider, Charlson Comorbidity Index, and lowest recorded oxygen saturation during index ED visit, cRPM-O_2 participation was associated with a reduction of 2.27 hospital days per patient (95% CI, 1.53 to 3.01;

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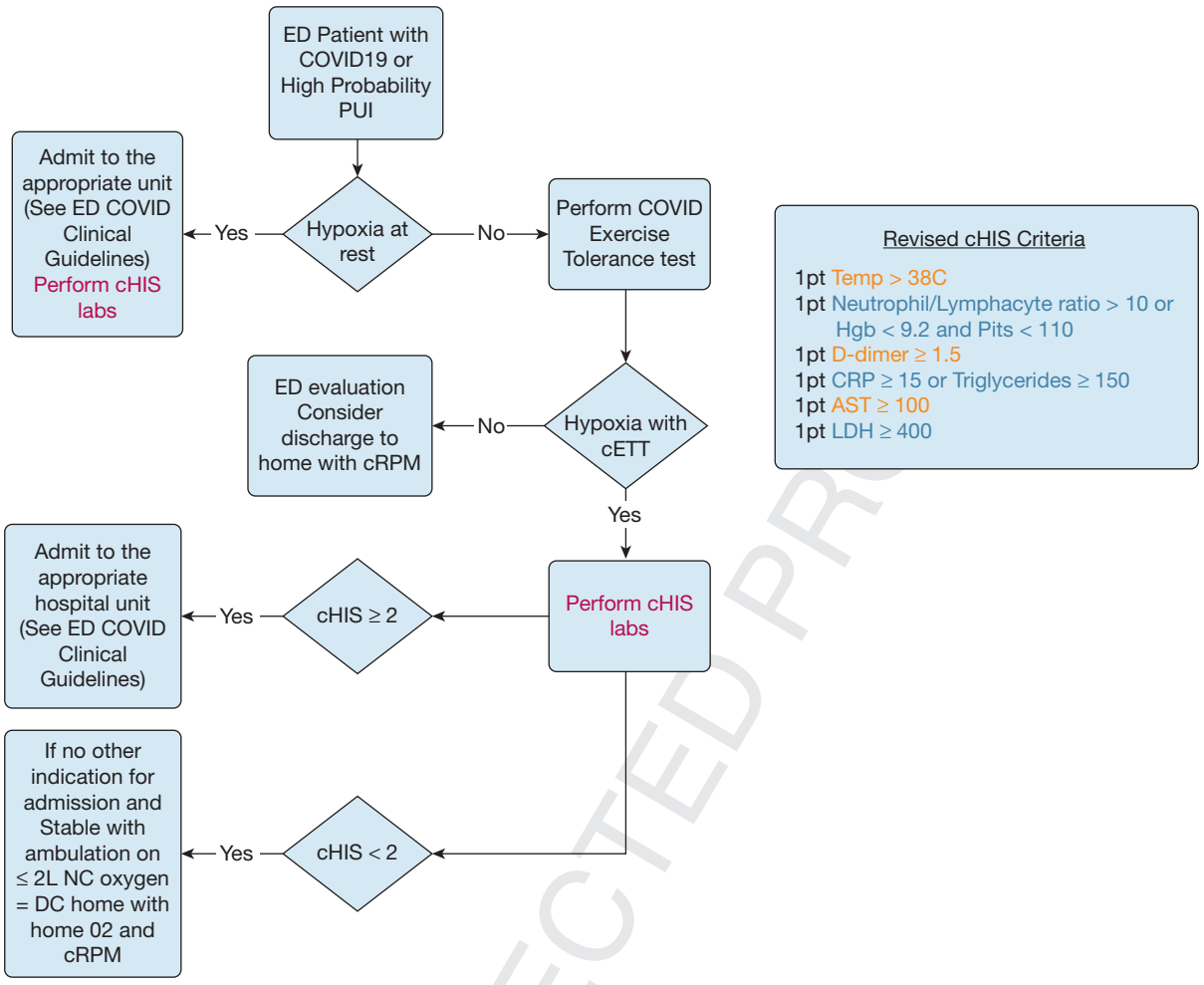

Figure 1 – *COVID-19-Associated Hyperinflammation Score Assessment Flow Diagram. AST = aspartate aminotransferase; cETT = COVID exercise tolerance test; cHIS = COVID-19-associated hyperinflammation score; cRPM = COVID remote patient monitoring; Hgb = hemoglobin; LDH = lactate dehydrogenase.*

$P < .001$). Of the 233 patients who received cRPM-O_2, 39 patients (16.7%) subsequently were admitted with a median of 4 days (interquartile range, 2 to 6) from ED visit to admission. cRPM-O_2 participation was associated with a numeric increase in combined ICU admission and deaths (OR, 1.93; $P = .07$; 95% CI, 0.94 to 3.95); ICU days were significantly increased in cRPM-O_2 participants (0.33 days; 95% CI, 0.00 to 0.65; $P = .05$). In the preplanned subgroup analysis that was limited to patients ≥70 years old, hospital length of stay did not differ with cRPM-O_2 participation (-0.50 days; 95% CI, -3.44 to 2.44; $P = .74$) and participation in cRPM-O_2 was associated with increased ICU length of stay (1.05 days; 95% CI, 0.07 to 2.0; $P = .04$) and a numerically increased odds of ICU admission or death (OR, 5.44; 95% CI, 0.93 to 31.75; $P = .06$). In this subgroup, there were four deaths in the control group and no deaths in the cRPM-O_2 group. In contrast, cRPM-O_2 for patients <70 years of age was associated with hospital length of stay reduction of 2.56 days (95% CI, 1.84 to 3.30; $P < .001$), no change in ICU length of stay (+0.18 days; 95% CI, -0.16 to 0.53; $P = .296$), and no difference in the odds of combined ICU admission or death (OR, 1.40; 95% CI, 0.63 to 3.14; $P = .410$).

Discussion

This ED program to triage low-risk patients with COVID-19 with exertional hypoxia to treatment at home with remote monitoring and low-level supplemental oxygen was associated with fewer hospital days but with an increase in ICU days and trend toward an increase in the composite outcome of

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TABLE 1] Baseline Characteristics of Patients and Outcomes

Model Input and Patient Characteristics[a]	ED Admission to Floor (n = 522)	COVID Remote Patient Monitoring With Home Oxygen (n = 233)	*P* value
Age, mean (SD), y	61.5 (47.5-71.5)	55.1 (43.6-64.9)	<.001
Sex, No. (%)			.82
Male	251 (48.1)	110 (47.2)	
Female	271 (51.9)	123 (52.8)	
Insurance, No. (%)			<.001
Private or commercial	253 (48.5)	167 (71.7)	
Medicaid	46 (8.8)	11 (4.7)	
Medicare	204 (39.1)	45 (19.3)	
Other	19 (3.6)	10 (4.3)	
Collapsed race/ethnicity, No. (%)			.28
White, not Hispanic	370 (70.9)	174 (74.7)	
Hispanic or other	152 (29.1)	59 (25.3)	
Charlson Comorbidity Index	1.6 (2.7)	0.8 (2.0)	<.0001
Lowest oxygen saturation during ED visit	87.6 (4.4)	87.3 (3.2)	.38
Unadjusted patient outcomes[b]			
Inpatient hospital days, No. (%)	4.0 (3.2)	1.5 (4.7)	<.001
ICU length of stay, d (%)	0.2 (1.8)	0.5 (2.1)	.079
ICU level care or death, No. (%)	22 (4.2)	15 (6.4)	.19
28-Day all-cause deaths, No. (%)	5 (1.0)	2 (0.9)	.90
cRPM-O2 adjusted outcomes[c]	Coefficient/OR	95% CI	
Hospital days (coefficient)	-2.27	-3.01 to -1.53	<.001
<70 Years old	-2.57	-3.30 to -1.84	<.001
≥70 Years old	-0.05	-3.44 to 2.44	.74
ICU days (coefficient)	0.33	0.00 - 0.65	.048
<70 Years old	0.18	-0.16 - 0.53	.30
≥70 Years old	1.05	0.07 - 2.031	.04
ICU admission of death (OR)	1.93	0.94 - 3.95	.074
<70 Years old	1.40	0.63 - 3.14	.41
≥70 Years old	5.44	0.93 - 31.75	.06

[a]Covariates adjusted for in our model for all 3 outcomes.
[b]Unadjusted outcome measures.
[c]Adjusted outcomes (ordinary least squares and logistic regression).

death or ICU for patients triaged to home with cRPM-O_2, driven by events that occurred among patients ≥70 years old. In total, 83.3% of patients with cRPM-O_2 were treated safely without hospitalization; however, only 67% in those patients aged ≥70 years. Inclusion in cRPM-O_2 significantly increased ICU days, but by a clinically insignificant 0.33 days in our main analysis. When assessing only those patients admitted to the ICU in each group, we observed the adjusted ICU length of stay is not statistically different, which suggests that trends toward increased risk of ICU admission between groups accounts for some of the increased ICU length of stay finding. When assessing only patients who were admitted from the cRPM-O_2 , we found that patients who required hospitalization are more likely to be older and male and to have more comorbidities than those patients who remain at home. Inpatient interventions such as Remdesivir and steroids are considered confounders that may have influenced the differences in outcomes between groups in addition to expected confounders of a retrospective analysis. Additionally, this implementation from a single integrated health care system may not be generalizable externally.

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ED triage of select patients with COVID-19 with isolated exertional hypoxia to home with low-flow supplemental oxygen plus remote monitoring is associated with fewer hospital days, and a net clinical benefit especially may be realized among patients <70 years old. Appropriate risk assessment and treatment with cRPM-O_2 may be a strategy to improve hospital capacity safely. Future study of subgroups is warranted to ensure the safety of this approach.

Harris L. Carmichael
Murray, UT
Ithan D. Peltan
Kerry Palakanis
Andrew Davis
Joe Dalto
Jason R. Jacobs
Rachelle Rhodes
Mark Shah
Brandon Webb
Salt Lake City, UT
Scott C. Woller
Murry, UT
Joseph R. Bledsoe
Salt Lake City, UT

AFFILIATIONS: From the Department of Medicine (H. L. C. and S. C. W.), Intermountain Medical Center; the Department of Medicine (H. L. C.), Stanford Medicine, Stanford, CA; the Department of Medicine (I. D. P. and J. R. J.), Division of Pulmonary and Critical Care Medicine, Intermountain Medical Center; the Department of Medicine (I. D. P.), Division of Pulmonary and Critical Care Medicine, University of Utah School of Medicine; Intermountain Healthcare Telehealth and Outreach (K. P. and A. D.); Intermountain Healthcare Enterprise Analytics (J. D. and J. R. J.); Intermountain Healthcare Emergency Medicine and Trauma Operations (R. R., M. S., J. R. B.); the Division of Infectious Diseases and Clinical Epidemiology (B. W.), Intermountain Healthcare; the Division of Infectious Diseases and Geographic Medicine (B. W.), Stanford Medicine, Palo Alto, CA; the Department of Emergency Medicine (J. R. B.), Stanford Medicine, Stanford, CA; and the Department of Internal Medicine (S. C. W.), University of Utah School of Medicine.

CORRESPONDENCE TO: Joseph R. Bledsoe, MD; email: Joseph.Bledsoe@imail.org

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