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Christina Creel-Bulos, *Emory University*
Maxwell Hockstein, *Emory University*
Neha Amin, *Emory University*
Samer Melhem, *Emory University*
[Alexander Truong](#), *Emory University*
Milad Sharifpour, *Emory University*

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CORRESPONDENCE

COVID-19 CASES

To rapidly communicate information on the global clinical effort against Covid-19, the Journal has initiated a series of case reports that offer important teaching points or novel findings. The case reports should be viewed as observations rather than as recommendations for evaluation or treatment. In the interest of timeliness, these reports are evaluated by in-house editors, with peer review reserved for key points as needed.

Acute Cor Pulmonale in Critically Ill Patients with Covid-19

We describe five patients in our intensive care units (ICUs) who had confirmed Covid-19. All five patients presented to the ICUs between March 23 and April 4, 2020. Four of the five patients had profound hemodynamic instability and cardiac arrest with acute right ventricular failure, and one had severe hemodynamic instability without cardiac arrest. The clinical scenario and echocardiographic findings in one representative patient are provided (see the Video, available with the full text of this case at NEJM.org).

A 42-year-old man with a body-mass index (the weight in kilograms divided by the square of the height in meters) of 34 and a history of asthma presented to the hospital with hypoxemic respiratory failure and was admitted to the ICU for invasive mechanical ventilation. Testing to detect SARS-CoV-2 infection was positive. Other laboratory values on admission of this patient (Patient 1) are summarized in Table 1; these values were notable for normal levels of B-type natriuretic peptide, troponin, and D-dimer. The patient did not have a personal or family history of hypercoagulability and had received enoxaparin for prophylaxis against venous thromboembolism. Previous outpatient echocardiographic findings showed a normal biventricular size and function.

On ICU day 8, the patient became acutely hypotensive and had rapid progression to cardiac arrest with pulseless electrical activity. He received cardiopulmonary resuscitation with administration of epinephrine and intravenous thrombolytics,

and spontaneous circulation returned. Echocardiography showed acute right ventricular dilatation with impaired systolic function (see Video), and subsequent computed tomography confirmed the presence of thromboembolism obstructing the left pulmonary artery.

Over a 48-hour period, five patients who were admitted to ICUs within our hospital system had profound hemodynamic instability due to the development of acute cor pulmonale (clinical details are summarized in Table 1). Cardiac arrest with pulseless electrical activity occurred in four patients, and three of these patients had died as of May 1. In one patient, acute cor pulmonale developed without cardiac arrest; this patient's condition improved with thrombolytic therapy. At the time of hemodynamic instability, one patient was receiving therapeutic anticoagulation with intravenous heparin according to a non-citrate-based anticoagulation protocol, and the remaining patients were receiving prophylactic anticoagulation.

Myocardial dysfunction and hypercoagulability have been reported in patients with Covid-19; however, the true incidence and clinical implications of these events remain unclear.¹⁻³ Although acute pulmonary thromboembolism was the most likely cause of right ventricular failure in these patients, this was not definitively confirmed in all cases. Acute cor pulmonale causing obstructive shock should be included in the differential diagnosis in critically ill patients with Covid-19.^{4,5} The role of thrombolytics and advanced manage-



A video showing echocardiographic findings is available at NEJM.org

Table 1. Demographic, Clinical, and Laboratory Data for Five Patients with Covid-19 and Acute Cor Pulmonale.*

Variable	Reference Value or Range	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age (yr)		42	51	63	76	53
Sex		Male	Female	Female	Male	Male
BMI†		34	33	NA	22	38
Smoker		No	No	No	No	No
Medical history						
Conditions		Asthma	Diabetes, hypertension, hyperlipidemia	Hypertension, Sjögren's syndrome	Diabetes, hypertension, chronic kidney disease	Hyperlipidemia
Medications		Budesonide	Hydrochlorothiazide, losartan, glipizide, simvastatin	Hydrochlorothiazide, meloxicam	Aspirin, NPH insulin, simvastatin, hydralazine	Naproxen
Immobile before admission		No	No	No	Yes	No
Personal or family history of coagulopathy		No	No	No	No	No
Anticoagulation		Enoxaparin prophylaxis	Therapeutic heparin (non-citrate-based renal replacement therapy protocol)	Enoxaparin prophylaxis	Enoxaparin prophylaxis	Heparin prophylaxis
Duration of ICU stay before right ventricular collapse (days)		8	5	2	5	9
Values on admission to ICU						
Creatinine (mg/dl)	0.60–1.20	1.12	3.70	0.92	1.12	1.10
Troponin (ng/ml)	<0.04	0.03	0.03	0.04	0.05	0.03
B-type natriuretic peptide (pg/ml)	<99	29	66	30	130	16
White-cell count (per mm ³)	4000–10,000	96,000	13,000	172,000	18,000	44,000
C-reactive protein (mg/liter)	<10	174	254	255	NA	NA
D-dimer (ng/ml)	<574	304	41,900	11,700	18,900	3450
Platelet count (per mm ³)	150,000–400,000	134,000	252,000	131,000	373,000	93,000
International normalized ratio	≤1.10	1.35	1.10	1.26	1.57	1.18

Trans thoracic echocardiographic findings on admission	Preserved EF; normal right ventricular size and function; tricuspid annular plane systolic excursion, 2.9 cm	Not performed	Grade I diastolic dysfunction; normal right ventricular cavity size and global systolic function	Preserved EF; normal right ventricular size and function	Not performed
Values on day of right ventricular collapse					
Creatinine (mg/dl)	0.60–1.20	1.70	3.35	0.95	1.75
Troponin (ng/ml)	<0.04	0.04	0.27	0.27	0.16
B-type natriuretic peptide (pg/ml)	<99	184	NA	NA	184
White-cell count (per mm ³)	4000–10,000	13,000	178,000	217,000	154,000
C-reactive protein (mg/liter)	<10	310	386	NA	348
D-dimer (ng/ml)	<574	3350	53,000	32,700	32,500
Platelet count (per mm ³)	150,000–400,000	144,000	24,000	144,000	141,000
International normalized ratio	≤1.10	1.73	1.23	1.28	1.26
Trans thoracic echocardiographic findings					
Right ventricular dilatation during systole	Yes	Yes	Yes	Yes	Yes
Right ventricular hypokinesis	Yes	Yes	Yes	Yes	Yes
Pulmonary-valve insufficiency	NA	No	No	No	NA
Tricuspid-valve regurgitation	NA	Yes	Yes	No	Yes
Abnormal tricuspid annular plane systolic exertion	NA	Yes	Yes	Yes	NA
Septal deviation	Yes	Yes	Yes	Yes	Yes
Intracardiac thrombus	No	Yes	No	Yes	No
Cardiac arrest with pulseless electrical activity	Yes	Yes	Yes	No	Yes
Use of thrombolytics	Yes	No	No	Yes	Yes
Survived	Yes	No	No	Yes	No

* EF denotes ejection fraction, NA not available, and NPH neutral protamine Hagedorn.

† Body-mass index (BMI) is the weight in kilograms divided by the square of the height in meters.

ment options such as extracorporeal life support for hemodynamic instability or cardiac arrest requires further investigation.

Christina Creel-Bulos, M.D.
Maxwell Hockstein, M.D.
Neha Amin, M.D.
Samer Melhem, M.D.
Alexander Truong, M.D., M.P.H.
Milad Sharifpour, M.D.

Emory University
Atlanta, GA
milad.sharifpour@emoryhealthcare.org

Disclosure forms provided by the authors are available with the full text of this case at NEJM.org.

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