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CASE REPORT

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COVID-19 complicating perioperative management of LVAD implantation: A case report and systematic review

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Abstract

The coronavirus 2019 disease (COVID-19) affected 125 million people worldwide and caused 2.7 million deaths. Some comorbidities are associated with worse prognosis and left ventricular assist device (LVAD) recipients are probably part of this high-risk population. We report a 31-year-old male patient who developed COVID-19 during LVAD implantation. His postoperative period was complicated by severe pneumonia and mechanical ventilation (MV) leading to right ventricular failure (RVF) and inotrope necessity. He experienced multiple complications, but eventually recovered. We present a systematic review of LVAD recipients and COVID-19. Among 14 patients, the mean age was 62.7 years, 78.5% were male. A total of 5 patients (35.7%) required MV and 3 patients (21.4%) died. A total of 2 patients (14.2%) had thromboembolic events. This case and systematic review suggest LVAD recipients are at particular risk of unfavorable outcomes and they may be more susceptible to RVF in the setting of COVID-19, particularly during perioperative period.

KEYWORDS

acute respiratory distress syndrome, COVID-19, LVAD, right ventricular dysfunction

1 | INTRODUCTION

The coronavirus 2019 disease (COVID-19) affected 125 million people worldwide and caused 2.7 million deaths so far.[1] Some conditions such as diabetes, hypertension, heart failure and coronary artery disease are associated with worse prognosis.[2] Left ventricular assist device (LVAD) recipients are probably part of this high-risk population since they usually have multiple comorbidities and live in a functionally immunocompromised state.[3]

There are few data on LVAD recipients and COVID-19, and most cases occurred months or years after LVAD implantation.[4–11] We present a case of a patient who presented fever during LVAD implantation as the first manifestation of COVID-19 who developed critical disease.

2 | CASE REPORT

A 31-year-old male patient without comorbidities was admitted due to dyspnea, cough, fever, and hypotension 9 days before hospitalization. Initial workup revealed bacterial pneumonia (Figure 1A) on thoracic computed tomography scan (CT scan) and severe left ventricular dysfunction (ejection fraction 24%) and moderate right ventricular dysfunction (RVD) on echocardiogram. Troponin was negative and brain natriuretic peptide was elevated. Multiple negative severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) reverse transcription polymerase chain reaction (RT-PCR) were performed on admission, 2nd, 3rd, and 4th days of hospitalization. An immunoglobulin M and

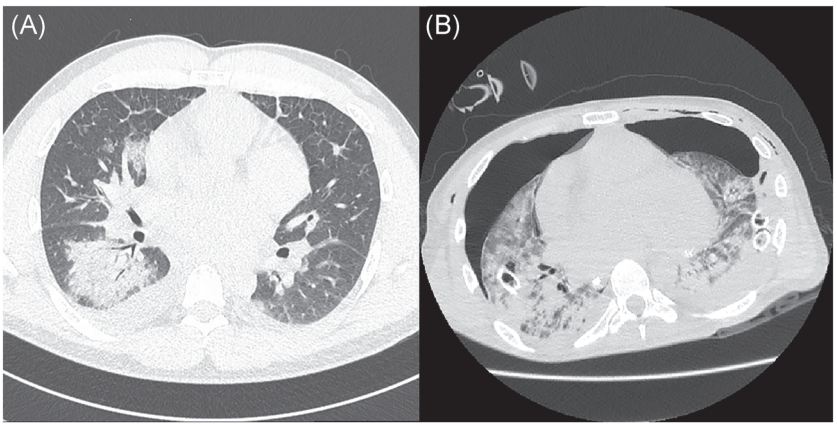

FIGURE 1 (A) Thoracic computed tomography (CT) scan on admission revealing consolidation on right lung. (B) Thoracic CT scan on postoperative Day 34 revealing multiple ground glass opacities, diffuse consolidations and moderate bilateral pneumothorax

immunoglobulin G SARS-CoV-2 test was also negative after 23 days of symptoms.

On the 2nd hospitalization day, he presented cardiogenic shock requiring orotracheal intubation, dobutamine and norepinephrine. On the 8th hospitalization day, he worsened hemodynamics, requiring intra-aortic balloon pump (IABP) and extracorporeal membrane oxygenation (ECMO). The presumed etiology of heart failure was dilated cardiomyopathy, since endomyocardial biopsy revealed diffuse hypertrophy and mild fibrosis and cardiac magnetic resonance revealed no late gadolinium enhancement. Coronary evaluation was not performed due to absence of fibrosis, negative troponin and no risk factors for atherosclerosis.

After initial support and antibiotics, the patient was extubated and ECMO was weaned off after 9 days. However, he persisted dependent on dobutamine and IABP, and LVAD implantation was planned as a bridge to transplant. Right heart catheterization revealed no pulmonary hypertension (Table 1).

A Heart Mate 3 was successfully implanted on-pump lately on 83rd day of hospitalization. However, the patient presented fever in the operating room and for the next 3 days. He was extubated on 2nd postoperative day (POD) and was weaned off vasopressors without RVD on echocardiogram. He also presented lymphopenia and C-reactive protein elevation (Table 2). Nasopharyngeal SARS-CoV-2 RT-PCR returned positive, probably due to nosocomial transmission before LVAD implantation.

On 5th POD, the patient became hypoxemic requiring high flow nasal cannula (chest X-ray in Figure 2). He was on intravenous heparin since 2nd POD and antibiotics and corticosteroids were prescribed. No other specific treatment, like antiviral therapy, was performed. Blood and tracheal secretion urine cultures returned negative. Echocardiogram revealed severe RVD. Hypotension and a drop on central venous saturation (Table 2) led to milrinone 0.75 mcg/kg/min and dobutamine 20 mcg/kg/min requirement.

On 10th POD endotracheal intubation was required. The patient experienced severe acute respiratory distress syndrome (ARDS) and multiple complications: shock requiring vasopressors, secondary bacterial pneumonia, hemothorax, catheter-related bloodstream infection and pneumothorax due to barotrauma. A CT scan performed on 34th POD revealed bilateral ground glass opacities, bilateral pneumothorax and consolidation (Figure 1B). He had no thromboembolic events (TEE).

After 48 days of LVAD implantation, he was free from mechanical ventilation (MV) and inotropes. He was discharged from the intensive care unit after 51 days and from the hospital after 199 days of hospitalization. After discharge, left ventricular dysfunction persisted but RV function improved. He is now in rehabilitation and in evaluation for heart transplantation.

3 | DISCUSSION

We present a case of a previously healthy young man who presented with cardiogenic shock and pneumonia. He required LVAD implantation, and postoperative period was complicated by nosocomial COVID-19. To the best of our knowledge this is the first case report of COVID-19 in the immediate postoperative period of LVAD implantation, which was complicated by right ventricular failure (RVF) in the setting of ARDS.

The new coronavirus could be associated with RVF by multiple mechanisms. First, the severe form of the disease may cause ARDS,

TABLE 1 Preoperative right heart catheterization

RAP	6 mmHg	CO	5.1 L/min
MPAP	29 mmHg	CI	2.67 L/min/m²
SPAP	34 mmHg	PVR	1.37 wood
DPAP	24 mmHg	SBP	108 mmHg
CPWP	22 mmHg	DBP	72 mmHg
HR	106	MBP	87 mmHg

Note: Patient in use of dobutamine 6.8 mcg/kg/min and nitroprusside 0.93 mcg/kg/min.

Abbreviations: CI, cardiac index; CO, cardiac output; CPWP, capillary pulmonary wedge pressure; DBP, diastolic blood pressure; DPAP, diastolic pulmonary artery pressure; HR, heart rate; MBP, mean blood pressure; MPAP, mean pulmonary artery pressure; PVR, pulmonary vascular resistance; RAP, right atrial pressure; SBP, systolic blood pressure; SPAP, systolic pulmonary artery pressure.

TABLE 2 Laboratory tests after LVAD implantation

Laboratory test	RV	POD 1	POD 2	POD 3	POD 4	POD 5	POD 6	POD 7
Hemoglobin, g/L	12–15	11.8	8.6	7.8	7.5	7.5	8.1	8.1
Leukocytes, $\times 10^3$ per mm^3	3.5–10.5	15620	16050	15390	14920	12610	10940	11250
Lymphocytes, $\times 10^3$ per mm^3	0.9–2.9	781	1284	1231	1190	1135	875	563
Platelets, $\times 10^3$ per mm^3	150–450	122	89	116	132	180	210	200
Creatinine, mg/dl	0.55–1.02	2.43	1.72	1.42	1.1	1.0	1.0	1.05
BUN, mg/dL	7–18.2	30.3	28.4	31.7	22.9	18.6	19.6	20.5
Troponin I—hs, ng/dl	<58	15528	12200	6366	–	1965	1794	1354
LDH, U/L	85–227	347	430	411	386	441	617	566
C-reactive protein, mg/L	<5.0	–	190	245	179	113	83.4	59
D-dimer, ng/ml	<500	–	452	471	1386	–	6630	6869
Ferritin, ng/ml	22–322	–	–	–	847	939	1639	1427
Central venous saturation, %	65–75	66.8	59.1	50.9	61.2	28.1	53.4	61.8
Lactate, mg/dl	4–14	28	10	9	11	33	12	10
BNP, pg/ml	<100	–	–	266	347	443	503	316

Abbreviations: BNP, brain natriuretic peptide; BUN, blood urea nitrogen; LDH, lactate dehydrogenase; LVAD, left ventricular assist device; POD, postoperative day; RV, reference value.

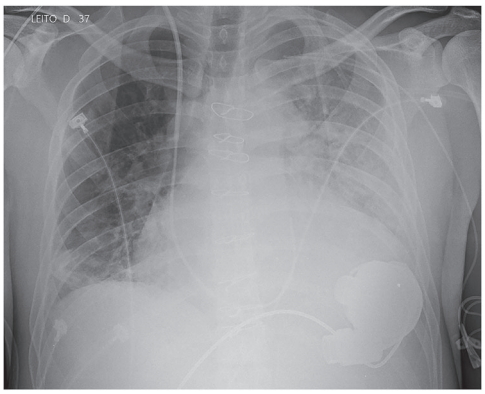

FIGURE 2 Chest radiography on postoperative Day 5 revealing multiple bilateral opacities

which in 10%–25% of cases may lead to RVF.[12] The pathophysiology is multifactorial: hypoxia, vascular alterations, MV and hypercapnia may lead to pulmonary hypertension and RVF.[12] Second, the new coronavirus also contributes to pulmonary hypertension and RVF causing microthrombi in pulmonary vasculature due to a prothrombotic state.[13] Finally, the virus can also cause direct cardiovascular conditions such as arrhythmias, acute coronary syndrome and acute myocardial injury, worsening biventricular function and leading to higher mortality.[14]

Right ventricular failure can be a consequence of LVAD implantation in 4%–50% of cases.[15] However, our patient did not present clinical or echocardiographic signs of RVF until he required noninvasive MV. Therefore, COVID-19 probably had a main contribution to RVF in this case.

A systematic review was performed searching PubMed and MEDLINE and using the keywords "LVAD" and "COVID-19" for comparison with this case. The selection criteria were case reports or case series of LVAD recipients and positive SARS-CoV-2 RT-PCR. Prespecified demographic and prognostic data was collected. A total of 157 publications were found, and 8 publications met the selection criteria.

A total of 14 patients are described (Table 3). The mean age was 62.7 years and 78.5% were male. The time since LVAD implant varied from 0.03 months to 6.8 years, and none of them happened in the immediate postoperative period. A total of 6 patients (42.8%) had mild symptoms, and three were followed as outpatients. As expected, LVAD patients with COVID-19 had higher mortality than general population. Data from China shows a mortality rate of 2.3%,[2] while in this systematic review LVAD recipients had a fatality rate of 21.4%, probably because they have multiple comorbidities and live in a functionally immunocompromised state.[3] In contrast, our patient recovered despite multiple complications, probably because of young age and lack of other comorbidities.

TABLE 3 Characteristics of LVAD recipients and COVID-19

Reference	Age	Sex	Tipe of LVAD	Time post-LVAD	Mechanical ventilation	Death	TEE	RVF
(4)	70	M	HM3	4 years	Yes	Yes	No	No
(5)	76	M	HMII	5.4 years	Yes	Yes	No	No
(5)	74	M	HVAD	6.8 years	No	No	No	No
(5)	79	M	HM3	10.8 months	No	No	No	No
(5)	30	F	HM3	0.03 months	Yes	Yes	Yes	No
(5)	74	M	HMII	5.9 years	No	No	No	No
(5)	75	F	HM3	12 months	No	No	No	No
(6)	61	M	HM3	2 months	No	No	No	Yes
(6)	72	M	Jarvik 2000	4 years	No	No	No	No
(7)	55	M	HVAD	4 years	No	No	No	No
(8)	44	M	HM3	1 year	Yes	No	Yes	No
(9)	48	F	HMII	–	No	No	No	No
(10)	66	M	HMII	–	Yes	No	No	No
(11)	54	M	HM3	2 years	No	No	No	No

Abbreviations: COVID-19, coronavirus 2019 disease; HMII, heartmate II; HVAD, HeartWare; LVAD, left ventricular assist device; RVF, right ventricular failure; TEE, thromboembolic events.

MV was required in 35.7% of patients, while in general population only 14% present pneumonia and 5% require MV.[2] Despite frequent need for MV in LVAD patients and the concern about RVF in this population, in this systematic review only one patient presented RVF requiring inotropes.[6]

The new coronavirus is also associated with high thromboembolic rates, and studies reported thromboembolism incidence of 25% in critical patients.[13] LVAD recipients in parallel are in intrinsic risk of pump thrombosis. This may raise a concern about TEE in this population. However, chronic anticoagulation may play a protective role since so far only 14.2% had TEE while infected.[5,8]

This study has limitations. All publications are case reports or case series. There is clinical heterogeneity between patients regarding age, type of LVAD and time since LVAD implantation. Mild cases of COVID-19 might be underrepresented. Despite these limitations, this is the first systematic review of LVAD and COVID-19. Also, the present case report illustrates the vulnerability of LVAD recipients regarding RVF in the perioperative setting. More study is needed to better understand COVID-19 in LVAD recipients.

CONFLICT OF INTERESTS

Dr. Ferreira has received personal fees and nonfinancial support from Abbott. The other authors have no conflict of interests.

CONSENT STATEMENT

The patient gave his consent for clinical information relating to his case to be reported in a medical publication.

REFERENCES

1. Organization WH. WHO Coronavirus Disease (COVID-19) Dashboard. Accessed 27/03/2021, https://covid19.who.int/
2. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *JAMA. Feb.* 2020;323:1239. https://doi.org/10.1001/jama.2020.2648
3. Ankersmit HJ, Edwards NM, Schuster M, et al. Quantitative changes in T-cell populations after left ventricular assist device implantation: relationship to T-cell apoptosis and soluble CD95. *Circulation.* 100, 1999: 19 Suppl, Ii211-Ii215. https://doi.org/10.1161/01.cir.100.suppl_2.ii-211
4. Chau VQ, Oliveros E, Mahmood K, et al. The imperfect cytokine storm: severe COVID-19 with ARDS in a patient on durable LVAD Support. *JACC: Case Reports.* 2020;2(9):1315-1320. https://doi.org/10.1016/j.jaccas.2020.04.001
5. Sobol I, Yuzefpolskaya M, Roth Z, et al. Characteristics and outcomes of patients with a left ventricular assist device with coronavirus disease-19. *J Card Fail.* 2020;26(10):895-897. https://doi.org/10.1016/j.cardfail.2020.09.011
6. Piperata A, Bottio T, Gerosa G. COVID-19 infection in left ventricular assist device patients. *J Card Surg.* 2020;35:2056-2058. https://doi.org/10.1111/jocs.14969
7. Loforte A, Gliozzi G, Martin Suarez S, Pacini D. Contributory role of positron emission tomography in a left ventricular assist device recipient at the time of COVID-19 pandemic. *ASAIO J.* 2020;66(6): 599-602. https://doi.org/10.1097/MAT.0000000000001176
8. Hodges K, Mubashir M, Insler J, et al. Successful management of COVID-19 and associated coagulopathy in a patient with durable left ventricular assist device. *J Card Surg.* 2020;35:3202-3204. https://doi.org/10.1111/jocs.14937
9. Korada SKC, Mann JA, Hasan AK, et al. Management of COVID-19 in a durable left ventricular assist device recipient: a continuity of care perspective. *Heart Lung.* 2020;49(6):688-691. https://doi.org/10.1016/j.hrtlng.2020.08.012

10. Singh R, Domenico C, Rao SD, et al. Novel coronavirus disease 2019 in a patient on durable left ventricular assist device support. *J Card Fail*. 2020;26(5):438-439. https://doi.org/10.1016/j.cardfail.2020.04.007
11. Mahmood K, Rashed ER, Oliveros E, et al. Predisposition or Protection?: COVID-19 in a patient on LVAD support with HIV/AIDS. *JACC Case Rep*. 2020;9:1337-1341.
12. Bunge JJH, Caliskan K, Gommers D, Reis Miranda D. Right ventricular dysfunction during acute respiratory distress syndrome and veno-venous extracorporeal membrane oxygenation. *J Thorac Dis*. 2018;10(Suppl 5):S674-S682. https://doi.org/10.21037/jtd.2017.10.75
13. Al-Ani F, Chehade S, Lazo-Langner A. Thrombosis risk associated with COVID-19 infection. A scoping review. *Thromb Res*. 2020;192:152-160. https://doi.org/10.1016/j.thromres.2020.05.039
14. Shi S, Qin M, Shen B, et al. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. *JAMA Cardiol*. 2020;5(7):802-810. https://doi.org/10.1001/jamacardio.2020.0950
15. Soliman OII, Akin S, Muslem R, et al. Derivation and validation of a novel right-sided heart failure model after implantation of continuous flow left ventricular assist devices: The EUROMACS (European Registry for Patients with Mechanical Circulatory Support) Right-Sided Heart Failure Risk Score. *Circulation*. 2018;137(9):891-906. https://doi.org/10.1161/CIRCULATIONAHA.117.030543

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