Impact of COVID-19 on Patients Supported with a Left Ventricular Assist Device

Jack Zakrzewski,* Laura Coyle,† Tracy Aicher,† Krystina Chickerillo,† Colleen Gallagher,† Katelyn Kuper,† Chris Sciamanna,† Vinh Q. Chau,† and Antone Tatooles†

Abstract: Patients on left ventricular assist device (LVAD) support may be susceptible to severe disease and complications from coronavirus disease-19 (COVID-19). The purpose of this study was to describe the clinical course of COVID-19 in LVAD patients. A retrospective review was performed at our center; 28 LVAD patients who developed COVID-19 between March 2020 and March 2021, and six patients with a prior COVID-19 infection who underwent LVAD implantation, were identified and examined. Of the 28 patients, nine (32%) died during the study period, five (18%) during their index hospitalization for COVID-19. Two patients (7%) presented with suspected pump thrombosis. In a nonadjusted binary regression logistic analysis, admission to the intensive care unit (unadjusted odds ratio, 7.6 [CI, 1.2–48], *P* = 0.03), and the need for mechanical ventilation (unadjusted odds ratio 14 [CI, 1.3–159], *P* = 0.03) were associated with mortality. The six patients who previously had COVID-19 and subsequently received a LVAD were on intra-aortic balloon pump and inotropic support at time of surgery. All six experienced a complicated and prolonged postoperative course. Three patients (50%) suffered from ischemic stroke, and there was one (17%) 30 day mortality. We observed an increased risk of morbidity and mortality in LVAD patients with COVID-19. *ASAIO Journal* 2021; 67;1189–1195

Key Words: COVID-19, left ventricular assist device, heart failure

Coronavirus disease 2019 (COVID-19) is a systemic illness caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2; formerly named 2019-nCoV), first identified in Wuhan, China, in December 2019. The first cases in North America were reported in the United States in January 2020, and COVID-19 was recognized by the World Health Organization as a pandemic in March 2020.[1] Older patients with comorbidities are thought to be at a higher risk for severe disease and death, with the immunologic response of the host playing a crucial role in the severity of illness.[2]

Patients with end-stage heart failure on left ventricular assist device (LVAD) support are susceptible to severe disease and complications from COVID-19 due to multiple comorbidities, a relatively immunocompromised state, and elevated inflammatory profiles.[3–5] The differences in cardiovascular physiology for patients with a LVAD and the exposure of blood to artificial surfaces may place them at an even higher risk for cardiac arrhythmias and thromboembolic events such as stroke and pump thrombosis. Clinical effects and treatment modalities utilized in patients on LVAD support who develop COVID-19 has not been fully described.

The characteristics of LVAD patients with COVID-19 and data evaluating outcomes are limited.[6–8] In this study, we describe the clinical characteristics, course, and outcomes of COVID-19 in the largest single-center experience of patients on LVAD support. We also report the characteristics and outcomes of six patients with a prior COVID-19 infection who subsequently underwent LVAD implantation.

Materials and Methods

A retrospective review was performed between March 2020 and March 2021 on all adult LVAD patients at our center. Only patients diagnosed with COVID-19 by SARS-CoV-2 PCR were included in the study. Patient demographics, clinical characteristics, laboratory, echocardiographic, management, and outcomes were extracted using electronic medical records. Follow-up data were collected through March 12, 2021.

Categorical variables were presented as counts with percentages. Continuous variables were presented as medians with interquartile ranges (IQRs). Because of the small sample size, a nonadjusted binary regression logistic analysis was performed to obtain the odds ratio for risk factors for mortality. Two-sided significance levels of 0.05 were used in all analyses. Data were analyzed using SPSS Software version 25. This study was approved by the Institutional Review Board at Advocate-Aurora Christ Medical Center.

All SARS-CoV-2 tests were reverse transcriptase polymerase chain reaction (rt-PCR) assays after specimen collection *via* nasopharyngeal swab. A mild to moderate COVID-19 infection was defined as symptomatic disease with normal oxygen saturation on room air, whereas a severe COVID-19 infection was defined as peripheral oxygen saturation <94% on room air with evidence of pulmonary infiltrates. Critically ill COVID-19 patients were described as having a severe COVID-19 infection with evidence of respiratory failure, septic shock, or

From the *Department of Surgery, University of Colorado Anschutz Medical Campus, Aurora, Colorado; and †Advocate Heart Institute, Advocate Christ Medical Center, Oak Lawn, Illinois.

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J.Z. and L.C. have equal contributions as first authors.

Correspondence: Antone Tatooles, Advocate Heart Institute, Advocate Christ Medical Center, 4400 West 95th Street, OPP, 6th Floor, Oak Lawn, IL 60453. E-mail: ajtatooles@ctvsurgeons.com.

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multisystem organ failure.[3] Administration of glucocorticoids and other COVID-19 directed therapies were based on the discretion of the treating healthcare practitioners. Hospitalized patients were maintained on their home anticoagulation regimen; however, patients that did not maintain therapeutic international normalized ratios (INRs) were started on systemic heparin. All echocardiograms were reviewed retrospectively by a single cardiologist to limit interinterpreter variation.

Results

Characteristics and Management in Established LVAD Patients with COVID-19

Among the 266 LVAD patients followed at our center, 28 (11%) established patients implanted between May 2014 and October 2020 contracted COVID-19 during the study period. Of the 28 patients, 23 (82%) were destination therapy, 22 (79%) male, and 17 (61%) were Black or Hispanic. The median age was 65 years (IQR, 57–70 years) with a median body mass index of 27 kg/m^2 (IQR, 25–32 kg/m^2). There were six (21%) HeartMate 2 (HM2), 10 (36%) HeartWare HVAD (HVAD), and 12 (43%) HeartMate 3 (HM3). The median time from LVAD implantation to COVID-19 diagnosis was 2.4 years (IQR, 0.9–3.4 years). The most common comorbidities included a history of hypertension (93%), diabetes mellitus (43%), smoking (43%), and lung disease (36%). Most patients were on chronic anticoagulation therapy with warfarin (96%) and antiplatelet therapy (68%) except those patients with a prior history of significant gastrointestinal bleeding. One patient was on dipyridamole due to an increased risk of hemolysis. At time of COVID-19 diagnosis, 32% of patients were on an ACEi or ARB. Baseline characteristics are detailed in Table 1.

Of the 28 LVAD patients who contracted COVID-19, 17 (61%) were diagnosed as being mild to moderately ill, six (21%) were severe, and five (18%) defined as critically ill. The most common presenting signs and symptoms upon diagnosis included respiratory (86%), fever (43%), and interstitial infiltrates on chest x-ray (36%). Fourteen patients had a D-dimer value greater than 2.0 mg/L (median peak value 3.6 mg/L [IQR, 1.8–8.49 mg/L]), 7 had a troponin level greater than 0.04 ng/mL (median peak value 0.05 ng/mL [IQR, 0.03–0.1 ng/mL]), and 7 had a ferritin level >1,000 ng/mL (median peak value 769 ng/mL [IQR, 320–1,632 ng/mL]). Thirteen patients had a peak INR greater than 3 during their hospitalization (median peak INR 3.5 [IQR, 2.6–4.5]). Clinical presentation and laboratory results are presented in Table 2. Anticoagulation with systemic heparin was administered in 50% of hospitalized patients. The most common medications used to manage COVID-19 were Remdesivir (39%) and systemic steroids (32%) as shown in Table 3.

Outcomes in Established LVAD Patients with COVID-19 Requiring Hospitalization

Twenty-four of the 28 patients (86%) were hospitalized for COVID-19 related symptoms, and 13 (46%) were monitored in an intensive care unit (ICU). Eleven patients (39%) required supplemental oxygen, including five (18%) that required mechanical ventilation for respiratory failure. Two patients (7%) required continuous renal replacement therapy (CRRT).

Table 1. Baseline Characteristics of LVAD Patients Who Developed COVID-19

Characteristic	
Total, n	Number (%)
Demographics	28
Age, years, median (IQR)	65 (57–70)
Age ≥60 years	18 (64)
Male	22 (79)
BMI (kg/m^2), median (IQR)	27 (25–32)
BMI ≥35 kg/m^2	3 (11)
Race	
White	11 (39)
Black	9 (32)
Hispanic (non-White)	8 (29)
Blood group	
O	13 (46)
A	9 (32)
B	3 (11)
AB	3 (11)
Duration on LVAD support, median (IQR) (years)	2.4 (0.9–3.4)
Device type	
HM3	12 (43)
HVAD	10 (36)
HM2	6 (21)
Destination therapy	23 (82)
Bridge to transplant	5 (18)
Comorbidities	
Hypertension	26 (93)
Diabetes mellitus	12 (43)
Smoking history	12 (43)
Chronic kidney disease	12 (43)
Lung disease	10 (36)
Prior stroke or TIA	9 (32)
Medications	
Warfarin	27 (96)
ASA or P2Y12 Inhibitor	19 (68)
ACEi/ARBs	9 (32)

ACEi, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ASA, Aspirin; BMI, body mass index; IQR, interquartile range; LVAD, left ventricular assist device; TIA, transient ischemic attack.

The most common complications were ventricular arrhythmia (29%), gastrointestinal bleeding requiring blood product transfusion (18%), and cardiac arrest (18%). Two patients, one supported with a HM2 and one with a HVAD, presented with classic signs and symptoms of suspected pump thrombosis. One patient was medically managed successfully with systemic heparin and intravenous fluid, and the other resulted in multisystem organ failure and died within 48 hours of presentation, respectively. There were no notable differences seen on echocardiogram at time of COVID-19 diagnosis and upon discharge as shown in Table, Supplemental Digital Content 1, http://links.lww.com/ASAIO/A715. The median length of hospital stay was 8 days (IQR, 4–13 days). Of the 24 patients hospitalized, 19 (79%) patients were discharged: 14 to home, 3 to a subacute rehabilitation facility, and 2 to acute inpatient rehabilitation. Six patients (25%) were readmitted within 30 days; four of these patients were readmitted with ventricular arrhythmias. Clinical outcomes are shown in Table 3.

Overall Mortality in Established LVAD Patients with COVID-19

At the end of follow up, nine (32%) LVAD patients who had COVID-19 expired. Five patients (18%) expired from complications of COVID-19 during their index hospitalization after a median of 5 days (range, 2–13 days). The other four patients

Table 2. Clinical Presentation and Laboratory Data of LVAD Patients Who Developed COVID-19

	Admission	Peak
Signs and symptoms, n (%)	n = 28	
Respiratory symptoms*	24 (86)	–
Fever	12 (43)	–
Interstitial pattern on chest radiograph	10 (36)	–
GI symptoms†	7 (25)	–
Confusion	3 (11)	–
Loss of smell/taste	3 (11)	–
Laboratory data, median (IQR)		
WBC (K/μL)	5.5 (4.4–6.4)	9.7 (5.0–15.0)
Absolute lymphocyte count (K/μL)	0.7 (0.6–1.0)	1.1 (0.9–1.4)
Platelet count (K/μL)	148 (114–191)	116 (83–157)
CRP (mg/mL)	5.0 (1.7–9.7)	11.2 (2.8–16)
D-dimer (mg/L)	2.30 (1.34–6.68)	3.6 (1.8–8.49)
D-dimer >2.0, n (%)	11 (55)‡	14 (67) ‡
Ferritin (ng/mL)	641 (280–988)	769 (320–1,632)
Ferritin >1,000, n (%)	4 (25) ‡	7 (39) ‡
LDH (Units/L)	309 (254–518)	481 (301–628)
INR	1.85 (1.5–3.3)	3.5 (2.6–4.5)
INR <2.0, n (%)	13 (54) ‡	–
INR >3.0, n (%)	8 (33) ‡	13 (57) ‡
NT-proBNP (pg/mL)	3,987 (1,335–7,854)	3,676 (966–13,802)
Troponin I (ng/mL)	0.04 (0.01–0.07)	0.05 (0.03–0.1)
Creatinine (mg/dL)	1.27 (0.92–1.85)	1.4 (0.95–2.15)

*Respiratory symptoms = cough, dyspnea, sore throat.
†GI symptoms = nausea, vomiting, or diarrhea.
‡Laboratory values were not available for all 28 patients
CRP, C-reactive protein; INR, international normalized ratio; IQR, interquartile range; LDH, lactate dehydrogenase; LVAD, left ventricular assist device; NT-proBNP, N-terminal pro hormone b-type natriuretic peptide; WBC, white blood cell count.

Table 3. Management and Outcomes of LVAD Patients Who Developed COVID-19

	Number (%) n = 28
Total hospitalized, n	24 (86)
Supplemental oxygen	11 (39)
Maximum amount of respiratory support	
Nasal cannula	4 (14)
High-flow nasal cannula, NIPPV, or nonrebreather	2 (7)
Mechanical ventilation	5 (18)
Vasopressor support	4 (14)
Renal replacement therapy*	2 (7)
Complications	
Ventricular arrhythmia	8 (29)
GI bleeding requiring blood transfusion	5 (18)
Cardiac arrest	5 (18)
Pump hemolysis	2 (7)
New stroke	0
COVID-19-specific therapies	
Treatment dose anticoagulation	14 (50)
Remdesevir	11 (39)
Systemic glucocorticosteroid	9 (32)
Natural supplements†	6 (21)
Azithromycin	3 (11)
Tocilizumab	2 (7)
Convalescent plasma	1 (4)
Outcomes	
Total, n	28
Outpatient management	4 (14)
Overall hospitalized	24 (86)
ICU admission	13 (46)
Hospital length of stay in days, median (IQR)	8 (4-13)
Overall discharged (n = 24)	19 (79)
Readmission within 30 days	6 (25)
Overall survival (at end of follow up)	19 (68)
Survival in hospitalized patients (n = 24)	19 (79)
Survival in ICU patients (n = 13)	6 (46)

*Not including long-term dialysis.
†Natural supplements include vitamins B12, C, D, and zinc.
ICU, intensive care unit; NIPPV, noninvasive positive pressure ventilation.

(14%) died after a median duration of 80 days (range, 22–190 days) from time of COVID-19 diagnosis: two were found unresponsive at home, one from respiratory failure, and one as a result of multisystem organ failure. Of the 13 patients (46%) admitted to the ICU, 7 had expired at study endpoint. Age, male sex, blood group A, pre-existing lung disease, duration of LVAD support, inflammatory markers, and troponin were not associated with mortality in unadjusted regression analysis. Risk analysis did not show an association between patients that received systemic anticoagulation or Remdesevir and improved mortality outcome. Further analysis can be seen in Table 4.

There was an association with ICU admission and mortality (unadjusted odds ratio 7.6 [CI, 1.2–48], $P = 0.03$), likely driven by the need for mechanical ventilation (unadjusted odds ratio 14 [CI, 1.3–159], $P = 0.03$). The use of systemic glucocorticosteroids was also associated with mortality (unadjusted odds ratio 10 [CI, 1.7–68], $P = 0.01$). Time from admission to initiation of glucocorticosteroids was a median of 2 days (IQR, 1–5 days).

Characteristics and Outcomes Following LVAD Implantation in Patients with Prior COVID-19

From July 1, 2020, to January 27, 2021, we performed LVAD implantation in six patients who previously had COVID-19 (Figure 1, Table 5). The median time from COVID-19 diagnosis to LVAD surgery ranged from 7 days to 6 months (median 40 days; IQR, 12–114 days). Five patients had been hospitalized for their COVID-19 infection. Of these five patients, two received Remdesivir and one patient required supplemental oxygen with continuous positive airway pressure. No patients required mechanical ventilation as part of their COVID-19 treatment strategy. Three (50%) patients received their LVAD during their index hospitalization for COVID-19 infection. At the time of LVAD implant, all patients were supported with an intra-aortic balloon pump and high-dose inotropes. One patient

Table 4. Risk Factor Analysis for Mortality in LVAD Patients Who Developed COVID-19

Characteristics	Alive (N = 19)	Death (N = 9)	Odd Ratio (CI)	*p*
Age ≥60 years old, n (%)	13 (68)	6 (67)	0.92 (0.2–5.0)	0.92
Male, n (%)	15 (79)	7 (78)	1.07 (0.16–7.3)	0.94
BMI, median (IQR) (kg/m^2)	27 (25–31)	29 (23–32)	1.01 (0.88–1.1)	0.83
A blood group, n (%)	7 (37)	2 (22)	0.49 (0.08–3.0)	0.44
Diabetes mellitus, n (%)	10 (52)	2 (22)	0.26 (0.04–1.6)	0.14
CKD stage ≥3, n (%)	8 (42)	4 (44)	1.1 (0.22–5.4)	0.91
Lung disease, n (%)	7 (37)	3 (33)	0.86 (0.16–4.5)	0.86
Smoking history, n (%)	7 (37)	5 (56)	2.1 (0.43–10.7)	0.35
Duration on LVAD support in days, median (IQR)	866 (330–1469)	777 (484–1,110)	1.0 (0.99–1.0)	0.52
ICU admission, n (%)	6 (32)	7 (78)	7.6 (1.2–48)	**0.03**
HFNC, NIPPV, or mechanical ventilation, n (%)	2 (11)	3 (33)	6.7 (1.1–40)	**0.04**
Mechanical ventilation, n (%)	2 (11)	3 (33)	14 (1.3–159)	**0.03**
Vasopressor support, n (%)	0	2 (22)	–	>0.99
Renal replacement therapy*, n (%)	0	2 (22)	–	>0.99
Severe RV dysfunction, n (%)	3 (16)	1 (11)	0.7 (0.6 – 7.4)	0.74
Peak lactate dehydrogenase	381 (298–581)	568 (524–935)	1.0 (0.99–1.0)	0.06
Peak troponin I (ng/mL)	0.04 (0.02–0.04)	0.09 (0.04–0.12)	–	0.54
Peak D-dimer (mg/L)	2.21 (1.73–3.64)	6.5 (4.7–9.0)	1.07 (0.93–1.2)	0.33
Peak ferritin (ng/mL)	496 (333–1,079)	784 (316–2,819)	1.0 (1.0–1.0)	0.26
Peak CRP (mg/mL)	8.1 (2.6–14.0)	14 (4.7–16)	1.09 (0.96–1.2)	0.18
Remdesevir, n (%)	7 (37)	4 (44)	1.4 (0.27–6.8)	0.70
Systemic glucocorticosteroid, n (%)	3 (16)	6 (67)	10 (1.7–68)	**0.01**
Treatment dose anticoagulation, n (%)	9 (47)	5 (56)	1.4 (0.28–6.8)	0.69

Bold values: $p < 0.05$ considered statistically significant.
KD, chronic kidney disease; HFNC, high-flow nasal cannula; RV, right ventricular.

(17%) had recently required mechanical ventilation secondary to cardiopulmonary arrest following a myocardial infarction. At the time of LVAD implantation, none of the patients were exhibiting signs or symptoms of active COVID-19, and no patients were on dialysis or an extracorporeal membrane oxygenator.

All patients with a history of COVID-19 who underwent LVAD implant received a HM3 for destination therapy. Most patients had a dilated cardiomyopathy (83%), were male (83%), and Black (67%). The median age was 60 years (IQR, 57–61 years) and body mass index 30 kg/m^2 (IQR 24–31 kg/m^2). All six patients had a history of hypertension (100%), smoking (67%), diabetes (50%), and one patient had a prior stroke (17%).

Patients were followed for a median of 163 days from implantation to study conclusion. Following LVAD implantation, five patients (83%) had prolonged respiratory failure greater than 7 days on ventilatory support, two (33%) required tracheostomy, and two (33%) were reintubated before successful extubation. Two patients (33%) developed severe right ventricular failure requiring temporary right ventricular assist device support with a CentriMag, and four patients (67%) developed renal insufficiency requiring CRRT. Three patients (50%) suffered ischemic strokes: two patients experienced embolic events on postoperative day 1, and the other stroke occurred on postoperative day 5. The median length of hospital stay following LVAD implantation ranged from 16 to 73 days (median 53 days [IQR, 35–67 days]). Five patients (83%) were discharged from the hospital, 2 to acute inpatient rehab, 1 to a subacute rehabilitation facility, and 2 to home. Two patients (33%) were readmitted within 30 days for gastrointestinal bleeding and neuropathic pain. There was one (17%) 30 day hospital mortality due to

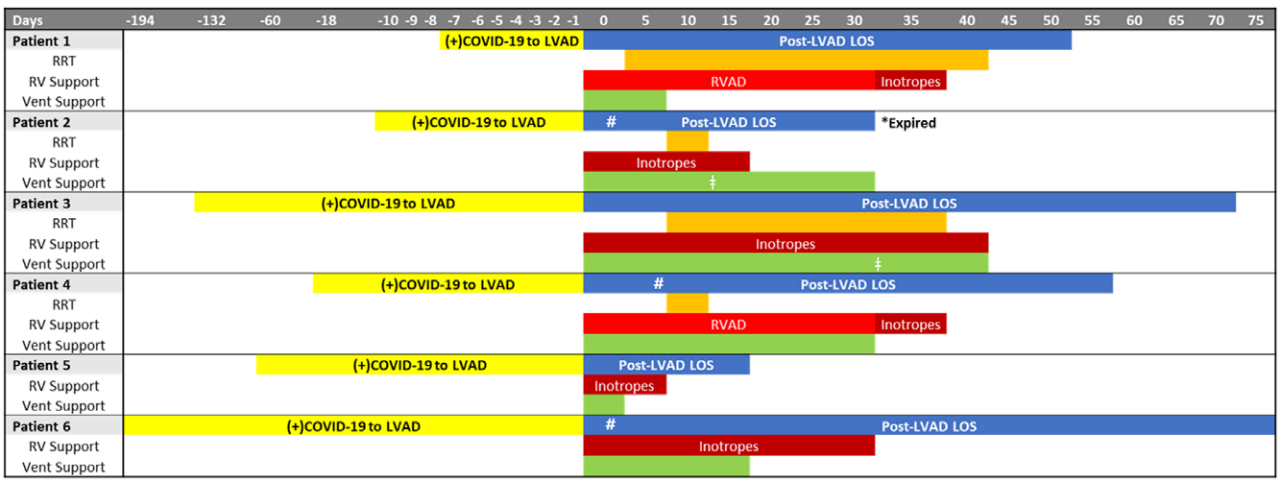

Figure 1. Perioperative course of LVAD Patients with a prior COVID-19 infection. LOS, length of stay; LVAD, left ventricular assist device; RRT, renal replacement therapy; RV, right ventricle; RVAD, right ventricular assist device; vent, ventilator; #, date of stroke; ǂ, date of tracheostomy. full color online

Table 5. Characteristics of LVAD Implantation in Patients With a Prior COVID-19 infection

Characteristic	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Demographics						
Age, years	56	64	59	47	61	61
Sex	M	M	M	F	M	M
BMI	37.2	31.6	30.0	31.0	19.4	21.9
Race/Ethnicity	Black	White	Black	Black	Hispanic	Black
Blood group	O	A	O	A	O	B
Medical characteristics						
Hypertension	Yes	Yes	Yes	Yes	Yes	Yes
Diabetes mellitus	Yes	Yes	No	Yes	No	No
Lung disease	Yes	No	Yes	No	No	Yes
Smoking history	No	Yes	No	Yes	Yes	Yes
Chronic kidney disease stage ≥3	No	Yes	Yes	Yes	Yes	No
Prior stroke	Yes	No	No	No	No	No
INTERMACS profile	3	3	3	3	3	3
LVAD device	HM3	HM3	HM3	HM3	HM3	HM3
LVAD intention (BTT or DT)	DT	DT	DT	DT	DT	DT
Time from +SARS-CoV-2 PCR to LVAD, days	7	20	132	18	61	194
Supplemental oxygen	Yes	No	No	No	No	Ukn
Post-LVAD outcomes						
Duration on LVAD support, days (IQR)	194	33	172	243	45	140
Days from LVAD surgery to discharge	50	30	71	55	16	73
Days from LVAD surgery to extubation	7	30	38	14	3	14
Tracheostomy	No	Yes	Yes	No	No	No
RVAD support	Yes	No	No	Yes	No	No
CRRT	Yes	Yes	Yes	Yes	No	No
Renal Recovery	Yes	Yes	Yes	Yes	–	–
Stroke	No	Yes	No	Yes	No	Yes
Pump thrombosis/malfunction	No	No	No	No	No	No
Alive at end of follow up	Alive	Deceased	Alive	Alive	Alive	Alive

BTT, bridge to Transplant; CRRT, continuous renal replacement therapy; DT, destination therapy.

multisystem organ failure following stroke and the decision to withdraw care. Postoperative courses are detailed in Figure 1.

Discussion

To our knowledge, this is the largest single-center experience describing the clinical course of COVID-19 in 28 patients on LVAD support. Of these patients, nine (32%) died at the end of follow up, five (18%) during their index hospitalization for COVID-19. Admission to the ICU and need for mechanical ventilation were associated with mortality. Additionally, we performed six LVAD implants in patients who had COVID-19. All six patients had a severely complicated postoperative LVAD course, and there was one (17%) 30 day mortality following a massive stroke.

Impact of COVID-19 in Established LVAD Patients

Even when age is taken into consideration, the death rate in our cohort was significantly higher than the population wide case fatality rate in the United States, which stands at 1.8%.[10,11] We observed that an admission to the ICU and the need for mechanical ventilation were associated with an increased risk of mortality in our LVAD patients diagnosed with COVID-19. However, patients in our study requiring ICU admission and intubation were significantly sicker, and in multisystem organ failure compared with our patients treated in the ICU that did not require intubation. While the RECOVERY trial showed that the use of steroids in patients with severe COVID-19 was associated with increased survival,[4] we observed an increased odds of mortality in patients who received systemic steroids. The median time from diagnosis to steroid initiation was 2 days, which could have reduced the therapeutic potential of steroid therapy. Furthermore, LVAD patients have many other systemic derangements, as well as a lower cardiovascular reserve (5), that may have compounded the effect of the virus and made steroids less beneficial in this group. Further investigation into the benefits and timing of steroid use in COVID-19 patients on mechanical circulatory support is needed.

Two patients who were properly connected to their LVAD equipment were found unresponsive at home and in cardiopulmonary arrest, 9 and 183 days after discharge from their COVID-19 hospitalization. There was no recorded LVAD dysfunction, and while autopsies were not performed, there is high clinical suspicion that these two patients died from a stroke or acute pulmonary embolism following their COVID-19 infection. Additionally, two (7%) of our 28 established LVAD patients who contracted COVID-19 presented with clinical and laboratory findings suggestive of hemolysis. Although not confirmed by autopsy, one of the patients who presented with hemolysis expired within 48 hours of presentation to the emergency room with evidence of device thrombosis. The patient presented with a plasma-free hemoglobin of 208 mg/dL, total lactate dehydrogenase of 16,659 unit/L, aortic valve opening despite increasing pump speeds, and pump parameters clinically confirming device thrombosis in the setting of cardiogenic shock as the primary manifestation of his COVID-19 infection.[6] The other patient was successfully managed with medical therapy. Several studies have shown an increased risk of thromboembolism in patients with COVID-19, likely from endothelial injury, platelet activation, and concomitant cytokine storm.[14–17] These risks may further exaggerate the physiologic changes and inherent risks associated with LVAD therapy.[5,6] Our findings suggest that LVAD patients with COVID-19 may be more prone to thromboembolic events due to the combined risks associated with the infection and LVAD therapy.

Triaging and Managing COVID-19 in LVAD Patients

The strategies used to treat and manage COVID-19 rapidly evolved throughout the phases of the pandemic. As a result, there were several challenges that we faced while caring for LVAD patients who contracted the illness. Early in the pandemic, we triaged most patients with symptoms of or close-contact exposure to COVID-19 to the emergency room. Often, these patients were admitted to a COVID-19 isolation unit, and frequently to a higher level of care than necessary for close observation because data were limited regarding the natural history of the disease. To minimize exposure, COVID-19 patients were cared for directly by the medical ICU with remote monitoring from the LVAD team. While management of these patients requires a judicious balance between isolation precautions and availability of clinical experts, the ability of the advanced heart failure team to directly assess patients when there are signs of clinical deterioration is essential because mild COVID-19 rapidly progressed in some of our LVAD patients.

As our experience with COVID-19 advanced, there were improvements in the recognition, prevention, and clinical management of the disease, which significantly improved throughput and helped prevent our resources from being overwhelmed during subsequent surges of the pandemic. Furthermore, our LVAD clinic solidified its telehealth capabilities, which allowed for more consistent patient triaging and outpatient follow up. The utilization of telemedicine, videoconferencing, and remote monitoring from a patient, staffing, and educational perspective is necessary in programs where it has not previously been used.[5,18] Toward the later stages of the pandemic, we were able to develop more protocol-driven policies to standardize LVAD care in our patients.

Outcomes in Newly Implanted Patients with a History of COVID-19 Infection

All six patients who had COVID-19 within a 6-month period before LVAD implantation had unusually complex postoperative complications and prolonged hospital lengths of stay. Most patients experienced severe RVF requiring prolonged support with inotropes or a right ventricular assist device, acute renal dysfunction requiring renal replacement therapy, and prolonged respiratory failure with elongated ventilatory support times or tracheostomy. Three patients (50%) had ischemic strokes on postoperative day 1 (n = 2) and day 5 (n = 1), a significantly higher stroke event rate than previously seen at our center and published in this patient population.[7] The short- and long-term impact of COVID-19 on end-stage heart failure patients is unknown; therefore, the timing of advanced surgical interventions needs to be carefully considered.

The myriad of complications we observed in patients receiving a LVAD after having COVID-19 is out of proportion with what we routinely observe in our performance improvement database and INTERMACS registry. This could be related to the known effects of SARS-CoV-2 on endothelial dysfunction, inflammation, oxidative stress, and platelet activation.[4] As a result, our critically ill patients on intra-aortic balloon pump and high-dose inotropic support with a relatively recent history of COVID-19 were likely at a higher risk of morbidity and mortality following LVAD surgery. This is consistent with other studies showing an association between worse outcomes and a COVID-19 diagnosis in the preoperative and postoperative periods.[20,21]

Despite known risk factors, our patients with a history of COVID-19 were declined for heart transplantation due to various reasons, and therefore LVAD therapy was considered urgent and necessary to improve their long-term outcomes. While optimal timing of surgery after COVID-19 remains unknown, delaying LVAD implant may have to be weighed against the severity of illness. Special attention while discussing the potential risks and benefits of LVAD therapy in these patients is reasonable, and as a medical community, we must be mindful of the potential effects of COVID-19 on the surgical and postoperative period following device implantation.

Limitations

This study has inherent limitations as a single-center retrospective review. In addition, the study is limited by the small number of patients included and inconsistent treatment approaches. As a retrospective, observational study with no control group, the analysis shows some interesting correlations, but no specific causation. There was a wide range of patient presentations within a small cohort, which also limited the ability to draw specific conclusions.

Conclusion

We present the largest single-center experience of LVAD patients with COVID-19. The rate of morbidity and mortality in this patient population is high, likely as a result of their medical complexities, underlying comorbid conditions, and the effect of the virus. Patients implanted with a LVAD after having COVID-19 have a prolonged postoperative course and appear to be at an increased risk for multisystem organ failure and stroke. Further understanding of the progression of COVID-19 and the impact on LVAD patients is required to improve outcomes.

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