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Case report

Total Joint Arthroplasty in Patients With an Implanted Left Ventricular Assist Device

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ABSTRACT

Left ventricular assist devices (LVADs) may be used as bridge therapy or destination therapy in heart failure patients. Total joint arthroplasty may improve the functional status of patients limited by arthritis. This retrospective case series evaluated patients with an implanted LVAD who underwent a total joint arthroplasty at 1 institution from 2012 to present. Five patients underwent 12 surgeries with 7 primary arthroplasties and 5 revisions. Their mortality, length of stay, coagulopathic events, incidence of infection or revision arthroplasty, and heart transplantation were evaluated, and is the largest study to date of this population. Two patients expired from thrombotic events while 3 progressed to heart transplantation. Joint arthroplasty is feasible in patients with an implanted LVAD with expected risk and perioperative multidisciplinary collaboration.

Introduction

Heart failure is a cause of significant morbidity and mortality, and the advent of left ventricular assist devices (LVADs) has dramatically improved the survival rates of patients with advanced stage heart failure [1–3]. LVADs may be used as a bridge to heart transplant or as destination therapy in patients unable to undergo heart transplantation. The Randomized Evaluation of Mechanical Assistance in the Treatment of Congestive Heart Failure (REMATCH) trial demonstrated that LVADs used as destination therapy are superior to medical management with 1-year-survival rates of 52% and 25%, respectively, [3–5]. Hariri et al. [6] have described long-term survival rates of 75%, 53%, and 45% in patients with an implanted LVAD at 1-, 3-, and 5-year intervals, respectively. As the number of patients treated with LVADs increase, so does their need for noncardiogenic, quality-of-life surgeries such as total joint arthroplasties (TJAs). Additionally, patients are assessed on cardiovascular fitness as part of the transplant evaluation to determine their rehabilitation potential [7]. Arthroplasty has been shown to improve cardiovascular fitness in patients limited by arthritic pain, thus improving candidacy for transplantation [8,9].

A study conducted by Garatti et al. [4] and a review article by Brown et al. [10] found that several noncardiogenic surgeries in LVAD patients are feasible and may be without significant morbidity or mortality. However, there are no studies examining the outcomes of patients undergoing TJAs with a history of an implanted LVAD. Few case reports of patients undergoing total knee and total hip arthroplasties (TKA and THA) with an implanted LVAD exist [11,12]. One case report by Walton et al. [11] describes a patient who underwent a THA and improved his fitness score enough to qualify for cardiac transplantation. The second report by Leonard and Davis [12] describes 2 patients who underwent TKA. Both suffered gastrointestinal (GI) bleeds related to anticoagulation within 4 months after surgery. One patient passed away from methicillin resistant staphyloccocus aureus bacteremia 8 months after surgery.

The purpose of this case series is to evaluate patient morbidity and mortality, hospital length of stay, progression to heart transplantation, incidence of infection, incidence of bleeding or thrombotic complications, and arthroplasty survival in patients who underwent a TJA with an implanted LVAD compared to those in orthopaedic literature. To our knowledge, this is the largest report of TJA in patients with implanted LVADs for a case series of an unusual problem.

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Table 1
Associated outcomes for each patient with each column indicating the procedure and specific complications and costs associated with each procedure.

Patient	Procedure	Length of stay	Bleeding/thrombosis	Transfusions	Revisions	Infections	Death	Transplantation	Direct cost	Average cost	Change in cost
1	R TKA	7	Transfusions (perioperative)	1	0	0	No	Yes	Not available		
	L TKA	4	LVAD thrombus	0							
2	L TKA	11		0	0	0	Yes	No	$13,203	9360	$3842.58
	R TKA	8	Stroke 3 mo later	0					$11,925	9411	$2514.26
3	L TKA	6	Transfusions	4	0	**2**	Yes	No	$13,171	9411	$3760.70
	Rev. L TKA	21	(perioperative)	4	1-Spacer				$22,950	17,658	$5291.80
	Rev. L TKA	9		3	1-Replant				$24,428	9411	$15,016.98
	Rev. L TKA	15	Stroke 10 mo later	2	1-DAIR				$21,952	18,675	$3277.70
					3 Total						
4	Rev. L THA	15	Transfusions (perioperative)	1	1-Explant MoM with infection	**1**	No	Yes	$30,853	14,585	$16,268.20
	Rev. L THA	11		4	1-Replant				$27,564	31,108	−$3544.49
	R THA	8	0	0	0				$19,468	9411	$10,057.66
5	L THA	10	Transfusions (perioperative)	3	0	0	No	Yes	$15,717	9411	$6306.64

Rev., revision; R, right; L, left; MoM, metal-on-metal.

Material and methods

All patients who underwent TJA at a single institution by 3 fellowship-trained arthroplasty surgeons during a 9-year period were evaluated based on clinical records. A database query of the electronic medical record using TJA and LVAD placement current procedural terminology codes from 2012 to present were used to find eligible patients. All patients that underwent a TJA at our institution with an LVAD implanted prior to arthroplasty were included in the study. Exclusion criteria included patients that had an implanted device that was not an LVAD such as a right ventricular assist device or patients that underwent heart transplantation prior to TJA. Ten patients with a total of 18 joint replacement surgeries were identified. Four patients were excluded for having an right ventricular assist device without an LVAD, and 1 patient was excluded for heart transplantation prior to TJA. A power analysis was not conducted given this study was a retrospective case series. Five patients were eligible, of which 3 underwent bilateral procedures and 2 underwent revision arthroplasty. There was a total of 5 primary TKAs, 2 primary THAs, 3 revision TKAs, and 2 revision THAs to give a total of 12 operations. Please refer to Table 1 for further details. This study was ethically approved by the institutional review board committee.

The medical records of the study population were reviewed to find length of stay, coagulopathic events within 1 year, incidence of infection until the last clinical follow-up, incidence of revision arthroplasty, and progression to heart transplantation.

All patients were admitted to the hospital the day prior to their TJA for anticoagulation management. All were evaluated by the cardiology and cardiothoracic surgery teams prior to their orthopaedic procedure for cardiac optimization and anticoagulation management and were followed up by those same teams throughout their inpatient stay.

Results

The electronic medical records were reviewed, and 5 eligible patients who underwent TJA were found. Three underwent bilateral procedures, and 2 underwent revision procedures to give a total of 12 surgeries. The average length of stay for each patient was 10.4 days compared to the institution's average of 1.8 days. Patients were discharged to a skilled nursing facility in 6 of 12 surgeries, with the remaining 6 discharged to home with a home health service. All patients suffered a bleeding or thrombotic event. Eight of 12 (75%) surgeries required transfusions intraoperatively compared to the 18.93% transfusion rate of primary TJA patients reported in literature [13]. One of the 5 suffered an LVAD thrombus. Two of the 5 patients passed away secondary to a stroke at 22 and 32 months after LVAD implantation, or 16 months and 20 months after primary arthroplasty. Three of the 5 went on to successful heart transplantation. Two patients underwent revision arthroplasty. One patient underwent a 2-stage revision (2/5 revision surgeries) for metal-on-metal wear debris with concomitant infection in a total hip, and 1 patient suffered 2 infections which resulted in a 2-stage revision and debridement, antibiotic, and implant retention (DAIR) several months later for subsequent infection (3/5 revision surgeries) (See Tables 1 and 2). Greater detail is given in discussion.

Discussion

The purpose of this study was to examine patient outcomes following TJA in the setting of a previously implanted LVAD. This is the largest study of the outcomes in TJA in patients with an implanted LVAD [11,12], with 2 previous case reports. LVADs have

Table 2
This table depicts the average and total for each complication.

Total procedures	12
Average length of stay	10.41
Bleeding complications	3
Average transfusions	1.83 units/patient (8/12 cases)
Total revisions	5
Total infections	3
Total deaths	2
Total transplantations	3
Average change in cost	$6279.20

become critically important as bridge therapy to transplantation or as destination therapy to maintain life. If the LVAD is used as a bridge therapy, the criteria for transplantation include evaluation of a VO2 max test or a 6-minute walk test. Patients with severe arthritis may not be able to complete those tests secondary to pain and risk losing eligibility for heart transplantation [7,14]. TJA plays an important role in improving cardiovascular fitness in patients whose activity has been limited by arthritic pain [8,9]. This study supports that hypothesis, as 3 of our 5 patients were able to improve their functional status after arthroplasty and qualified for a successful heart transplantation. Interestingly, 1 patient's cardiomyopathy was attributed to systemic cobaltism from wear debris in a metal-on-metal hip done prior to his heart disease diagnosis [15]. Revision arthroplasty not only removed the source of the metal debris wear but also allowed the patient to progress to a successful heart transplantation. The role of TJA in LVAD patients remains largely unexamined. This case series shows the potential benefits of arthroplasty in patients with an LVAD whose function may be limited by arthritic pain. However, this series also shows these patients do suffer greater complications and costs.

Several complications following LVAD implantation have been described, with the most common including infection (25%-50%), stroke (13%-29%), and GI bleeding (25%-40%) [2,3,11,16].

Despite the risks, arthroplasty may have significant benefits to the patient's quality of life by decreasing pain, improving activity level, and subsequent improved cardiovascular health. Several case reports documented improvement in a patient's Harris Hip score, ambulatory distance, and ambulatory independence from gait aids following THA [11,12]. Ries et al. [8,9] have conducted studies evaluating the cardiovascular health of patients with osteoarthritis who underwent TJA compared to patients who underwent medical management and found significant improvement in cardiovascular fitness following arthroplasty. The authors attribute this improvement to the resumption of routine physical activities. Ries et al. contend that arthroplasty may be a therapeutic measure in patients with heart disease whose activity is limited by arthritic joint pain by allowing them to resume physical activity and improve their cardiovascular health [8,9].

The longer length of stay in LVAD patients may be attributed to several factors including anticoagulation management and physical rehabilitation. All patients were admitted the day prior to surgery for anticoagulation management and progressed slower with physical therapy than the average arthroplasty patient at this institution. The average arthroplasty patient at this institution met ambulatory goals including transferring to and from a car, ambulating the halls with an assistance device, rising from a toilet, and climbing stairs by postoperative day 2, while patients from this study met those goals at an average of 10.4 days (±4.7 days) with a range of 4-21 days. The etiology of the slower progression of rehab is unclear but may be due to an overall lower level of physical activity and endurance due to severe heart failure. The longer length of hospital stay is consistent with previous case reports which reported a 5- to 6-day length of stay range [11,12,17].

Table 3
Outcomes for revision arthroplasty in this study.

Total procedures	5
Average length of stay	14.2
Bleeding complications	1
Average transfusions	2.8 units/case
Total revisions	5
Total infections	3
Total deaths	1
Total transplantations	1

Anticoagulation remains a challenge in LVAD patients. Annualized rates of device thrombosis, GI bleeding, and major stroke are 8%-11%, 25%-40%, and 13%-29%, respectively, [18]. Balancing the risks of a bleeding and thrombotic event is difficult in this population. This study showed 8 of 12 (75%) surgeries required transfusions either intraoperatively or during their hospital stay. Two of 5 (40%) patients suffered a mortality from hemorrhagic strokes within 1 year of their arthroplasty. This percentage is much larger than the 1-year mortality for TJA reported by Inacio et al. [19] with mortality rates of 1.1%, 0.9%, 2.2%, and 4.3% for primary THA and TKA and revision THA and TKA procedures, respectively. Patients supported by an LVAD have been shown to have 20-fold the incidence of stroke compared to the general population, and it is significantly higher than that observed in other cardiovascular conditions such as atrial fibrillation or mechanical heart valves [20]. Similarly, Walton et al. [11] and Leonard and Davis [12] reported all patients in their case reports required perioperative transfusions, and 2 of those 3 patients suffered GI bleeds related to their anticoagulation. The anticoagulation regimen differs among patients. All patients in this study were anticoagulated with coumadin and aspirin at home but were anticoagulated with heparin or dabigatran perioperatively, depending on their history of heparin-induced thrombocytopenia. No patient suffered bleeding complications at the surgical site, but all patients required perioperative transfusions or suffered a bleeding or thrombotic event within 1 year of arthroplasty.

This transfusion rate is greater than the 18.93% transfusion rate reported by Danninger et al. [13] in TJA. Two patients suffered a hemorrhagic stroke, and 1 patient suffered an LVAD thrombus that went on to successful heart transplantation. The balance between anticoagulants and antiplatelets in the setting of an LVAD is delicate and requires diligent management. Discussions with the patient's cardiologist and cardiothoracic surgeon should be performed preoperatively to optimize the patient prior to surgery, and close follow-up with those services should be maintained while the patient remains in the hospital.

Two patients underwent revision arthroplasty in this study. The risk of periprosthetic joint infection (PJI) as reported by Jamsen et al. [21] and Dietz et al. [22] showed an incidence of 1%-2% of PJI in total knees and total hips. In this study, 1 patient originally was found to have *Streptococcus viridans* PJI with associated bacteremia after primary arthroplasty. She underwent a successful 2-stage revision arthroplasty 3 months later. She then suffered a periprosthetic dislocation and was found to have a prosthetic *Staphylococcus epidermis* infection. She was treated with closed reduction and DAIR. She tolerated the procedure well and had no complaints regarding her knee until she suffered an intraparenchymal hemorrhage 10 months later and passed away. She had no complications from her LVAD but did require perioperative transfusions of 2-4 units of packed red blood cells at her index surgery, 2-stage revision arthroplasty, and a DAIR procedure.

One other patient underwent revision arthroplasty for metallosis and concomitant *S. epidermidis* infection. The 2-stage revision effectively removed the source of his infection as well as the source

of the metallosis that contributed to his cardiomyopathy. He was extremely satisfied with his procedure and went on to successful heart transplantation, as well as primary THA on his contralateral side. Table 3 shows the data on revision arthroplasty complications.

Infection is a common cause of LVAD mortality, with some studies reporting a 20% mortality within 6 months [23]. *Staphylococcus* and *Pseudomonas* species are the most common causative organisms in LVAD infections, and their infectivity is believed to be derived from their ability to form biofilms [1,23,24]. Most infections have an average time-to-occurrence of 6 months [1,25]. Current recommendations state there is limited evidence that cardiac disease or congestive heart failure is a risk factor for the development of PJIs [26]. However, there are currently no studies assessing PJIs in patients with implanted LVADs.

The mortalities described in this study at 22 and 32 months after LVAD implantation align with the outcomes reported by the REMATCH trial with 1- and 2-year survival rates of 56% and 33%, respectively, [27]. Goldstein et al. [28] evaluated outcomes in the MOMENTUM 3 clinical trial to assess how many patients previously deemed ineligible for heart transplantation changed their status to a transplant candidate or used their therapy as a bridge to transplantation with the independent variable being a HeartMate II or HeartMate III device (Abbott, Chicago, IL). They found 13.5% of the patients originally deemed as transplant-ineligible underwent heart transplantation within 2 years of LVAD implantation; unlike this case series which showed 3 of 5 (60%) patients improved their candidacy enough to undergo heart transplantation. Furthermore, Hasin et al. [29] found that those patients with an implanted LVAD who performed poorly on the 6-minute walk test (<300 meters) had increased mortality, and this persistent exercise intolerance was independently associated with reduced survival. Those studies show that LVAD patients are not frequently changed from destination therapy to bridge therapy, and poor mobility with persistent exercise intolerance is an independent predictor of mortality. Identifying LVAD patients whose functional performance is limited by arthritic pain may have profound outcomes in improving patient mobility, exercise tolerance, and candidacy to transplantation. This case series demonstrated a high rate of conversion to transplantation after TJA in patients limited by arthritic pain when compared to previous literature. Additionally, the mortalities shown in this case series align with previously reported mortality rates in LVAD patients and illustrate examples where arthroplasty failed to extend the life of those patients.

There are several limitations to this study including patient population size and that this study occurred at a single institution. A study population of 5 patients undergoing 12 procedures is not adequately powered to show statistical significance in any of the outcome measures but remains the largest study to date. All patients had several comorbidities including diabetes, obesity, and hypertension that may act as cofounders to their hospital length of stay and risk of bleeding and mortality. Future studies should collect functional scores such as the Knee Society Score and Harris Hip Score to determine the functional change in patients who undergo arthroplasty with an implanted LVAD. The type of anticoagulation and antiplatelet medication may be an additional cofounder that attributes to bleeding risk but is beyond the scope of this study.

Conclusions

This retrospective case series examined 5 patients who underwent TJA and revision TJA from 2012 to present to give a total of 12 surgeries. This study showed that 3 of 5 patients who underwent TJA improved their cardiovascular health and were successfully treated with heart transplantation. This study showed a higher rate of progression to heart transplantation in patients who underwent TJA with an implanted LVAD compared to the rate previously reported in literature. However, arthroplasty in patients with an implanted LVAD is not without risk. Two of 5 patients are deceased secondary to complications from a stroke, which is consistent with the mortality rate reported within 2 years of LVAD implantation by current literature. There is insufficient power to determine if these differences are significant or if they are correlated. TJA in patients with an implanted LVAD are associated with higher hospital length of stay, perioperative blood transfusions, and complications related to bleeding and thrombosis compared to the average patient undergoing TJA at our institution. Arthroplasty in patients with an implanted LVAD is feasible but requires multidisciplinary collaboration, rigorous anticoagulation management, and appropriate discussion of the risks associated with the procedure prior to intervention.

Conflicts of interest

K. L. Garvin is in the editorial or governing board of Wolters Kluwer Health and Lippincott Williams & Wilkins and is a board or committee member in American Board of Orthopaedic Surgery. C. W. Hartman is a paid consultant for Smith &Nephew and OsteoRemedies; receives research support as a principal investigator from Smith & Nephew, Pfizer, and BioFire Diagnostics; is a board or committee member in Mid-American Orthopaedic Association. The remaining 2 authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.07.021.

Informed patient consent

The author(s) confirm that written informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

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