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Favorable Outcomes with Ventricular Assist Device Exchange

Megan Carroll[1*], Meghan Tooman[2], Markian Bochan[3], Christopher Salerno[4], and Ashwin Ravichandran[4]

[1] Indiana University School of Medicine, Indianapolis, IN
[2] Statistical Research Solutions, LLC., Indianapolis, IN
[3] Infectious Disease of Indiana and St. Vincent Hospital, Indianapolis, IN
[4] St. Vincent Heart Center, Indianapolis, IN

*Corresponding author: *megmcarr@iu.edu*

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Abstract

Left ventricular assist device (LVAD) therapy remains a vital therapeutic option for patients with end-stage heart failure. Unfortunately, adverse events can occur and progress to require consideration for device exchange once the failure of medical management becomes evident, especially when heart transplantation is not possible in a timely manner. The aim of this analysis is to describe the incidence and outcomes of LVAD exchanges at our institution. Between April 2008 and May 2017, 397 patients underwent LVAD implantation, with 32 of those patients subsequently receiving exchange upon the recommendation of our multidisciplinary team due to refractory infection (n=12), device malfunction (n=5), hemolysis (n=9) and pump thrombosis (n=6). The average time from index implant to exchange was 580.6 days, with an average length of stay of 18.2 days. Survival at 3 months was 84.4%, 75.0% at 1 year and median at 8.3 years after exchange. The most common adverse events, occurring in less than 1/3 of the population, included bleeding, infection and stroke. This study suggests that LVAD exchange can be an effective and definitive mechanism for the treatment of otherwise potential fatal pump complications in highly select patients.

Keywords: Left ventricular assist device (LVAD), device infections, advanced heart failure, cardiac transplantation, VAD exchange

Introduction

Heart failure is the leading cause of hospitalizations annually, with recent estimates of Americans 40 years or older facing a 20% lifetime risk, a prevalence of over 9 million Americans by 2030. [1] A significant proportion of patients will unfortunately go on to fail medical therapy, requiring the use of advanced treatment strategies for end-stage heart failure. While many patients at this stage can be successfully treated with transplantation, a large number have comorbidities that prevent eligibility for the therapy, or have unacceptably prolonged wait times, thereby making durable left ventricular assist device (LVAD) support their most viable therapeutic option.[2-3] However, serious complications necessitating device exchange can include pump thrombosis, hemolysis and infection, posing challenging management scenarios for those who remain ineligible for transplantation after LVAD or have a prolonged wait time and experience a complication while on mechanical support. [4]

Risk factors for adverse events leading to exchange commonly include deviation from standardized implant and immediate/long-term management techniques, advanced age, immunosuppressed states such as diabetes, elevated blood pressure and patient non-compliance.[5-8] Methods to improve outcomes and decrease adverse events include careful instruction on routine maintenance of the driveline, accurate monitoring of anticoagulant and antiplatelet therapy and aggressive antibiotic therapies when indicated (oral and parenteral), guided by culture data in consultation with an infectious disease specialist.

Unfortunately, some patients still progress to consideration for LVAD exchange once the failure of medical management becomes evident, especially when transplantation is not possible in a timely manner. This analysis describes the incidence and outcomes of LVAD exchange procedures at our institution.

Methods

A retrospective analysis of our institution's LVAD database was performed. During a 9-year period, 397 patients underwent LVAD implantation between April 2008 and May 2017, with 32 of those patients subsequently receiving LVAD exchange between September 2009 and March 2017. Only initial pump exchange patients were included in the reviewed cohort. The reasons for exchange included: refractory infection, evidence of device malfunction, hemolysis and pump thrombosis. Surgical approach varied based on device and indication for exchange and included subcostal or full sternotomy approaches.

Descriptive analysis, Kaplan-Meier survival estimates and time to first event were then calculated. Outcomes of interest included death, hemolysis, pump thrombosis, stroke, right heart failure, bleeding and infection. The time between initial implant and exchange, length of post-operative hospital stay, discharge location and average time to follow-up after discharge were monitored to provide an objective standard for post-operative patient management.The decision to exchange the device was defined by the failure of medical therapy as determined by an interdisciplinary team of cardiologists, infectious disease specialists and surgeons. Specific criteria for exchange in cases of infection included refractory

infection as guided by physical examination, laboratory, culture and imaging data despite appropriate culture-guided antibiotic therapy. Ongoing laboratory and pump parameters were used to define hemolysis and pump thrombosis according to the accepted Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) definitions.[3] Infection data, concomitant medications and antibiotic history were collected to investigate the most common risk factors and pathogens involved and any possible correlations with surgical outcomes.
The surgical approach focused on incision type – patients required sternotomy when complete device extraction was necessary to address their reason for pump exchange. In cases of infection, full sternotomy was only performed when infection ascended beyond the pump pocket.

Results

Baseline demographics, surgical approach, reviewed models and patient status can be found in Table 1.

Table 1. Baseline Characteristics (HMII - HeartMate, HVAD - Heartware Ventricular Assist Device, BTT - Bridge to Transplantation, DT - Destination Therapy)

	Deciding Factor for Exchange	
	Infection (N = 12)	**Other (N = 20)**
Demographics		
Age : Average	**44.5**	**52.8**
Gender: Males	**10**	**13**
Race		
Caucasian	**12**	**15**
African American	**0**	**5**
BMI (kg/m^2) : Average	**32.8**	**31.2**
VAD Model Exchanges		
HMII → HMII	**9**	**17**
HVAD → HVAD	**1**	**2**
HMII → HVAD	**2**	**1**
Incision Type		
Subcostal	**8**	**13**
Sternotomy	**4**	**7**
Status		
BTT	**6**	**7**
DT	**6**	**13**

Reason for exchange in the overall cohort included infection (n=12), hemolysis (n=9), pump thrombosis (n=6) and pump malfunction (n=5) (Table 2). Pump malfunction included driveline or internal wire fracture (n=2), pump migration (n=2) and detachment of outflow graft (n=1). Of note, 71.4% of patients going on to exchange were diagnosed and treated for infection during the evaluated timeline. The most common infections included Staphylococcus (40%), Pseudomonas (11.4%) and Enterococcus (8.6%); however, some patients had more than one isolated bacteria responsible for their infections (Table 3). Appropriate antibiotics were guided by culture data, with a median treatment course of 184 days before exchange. The average time from index implant to exchange was 580.6 days, with an average length of stay after exchange of 18.2 days.

Table 2. Deciding Factor for Exchange

Deciding Factor for Exchange	
Infection	**12**
Hemolysis	**9**
Pump Thrombosis	**6**
Pump Malfunction	**5**

Table 3. Organism Culture prior to Exchange (MSSA - Methicillin Sensitive Aureus, CoNS - Coagulase Negative Staphylococcus)Staphylococcus Aureus, MRSA - Methicillin Resistant Staphylococcus

Organism cultured prior to exchange							
MSSA	MRSA	CoNS	Pseudomonas	Acinetobacter	Aerococcus viridans	Stenotrophomonas	Proteus
5	2	2	2	1	1	1	1
**4 patients with double infection at the time of exchange*							

Twenty-seven patients (77.1%) were discharged directly home following the exchange, 5 (14.3%) to a long-term care skilled nursing facility or acute rehabilitation unit and 5 died within 90 days. Causes of death included intracerebral hemorrhage (2), respiratory failure (1), mycotic aneurysm (1) and cardiac arrest (1). Survival at 3 months for the combined cohorts was 84.4%, 75.0% at 1 year and median 8.3 years after exchange. Survival post exchange for the infection group was 92% and 83.% at 3 months and 1 year, respectively, while survival "other" group was 80% and 70% at those same time intervals (Figure 1). Adverse events experienced after initial exchange are included in Table 4. The most common complications included stroke, recurrent infection and

gastrointestinal (GI) bleed. Five patients eventually went on to cardiac transplantation.

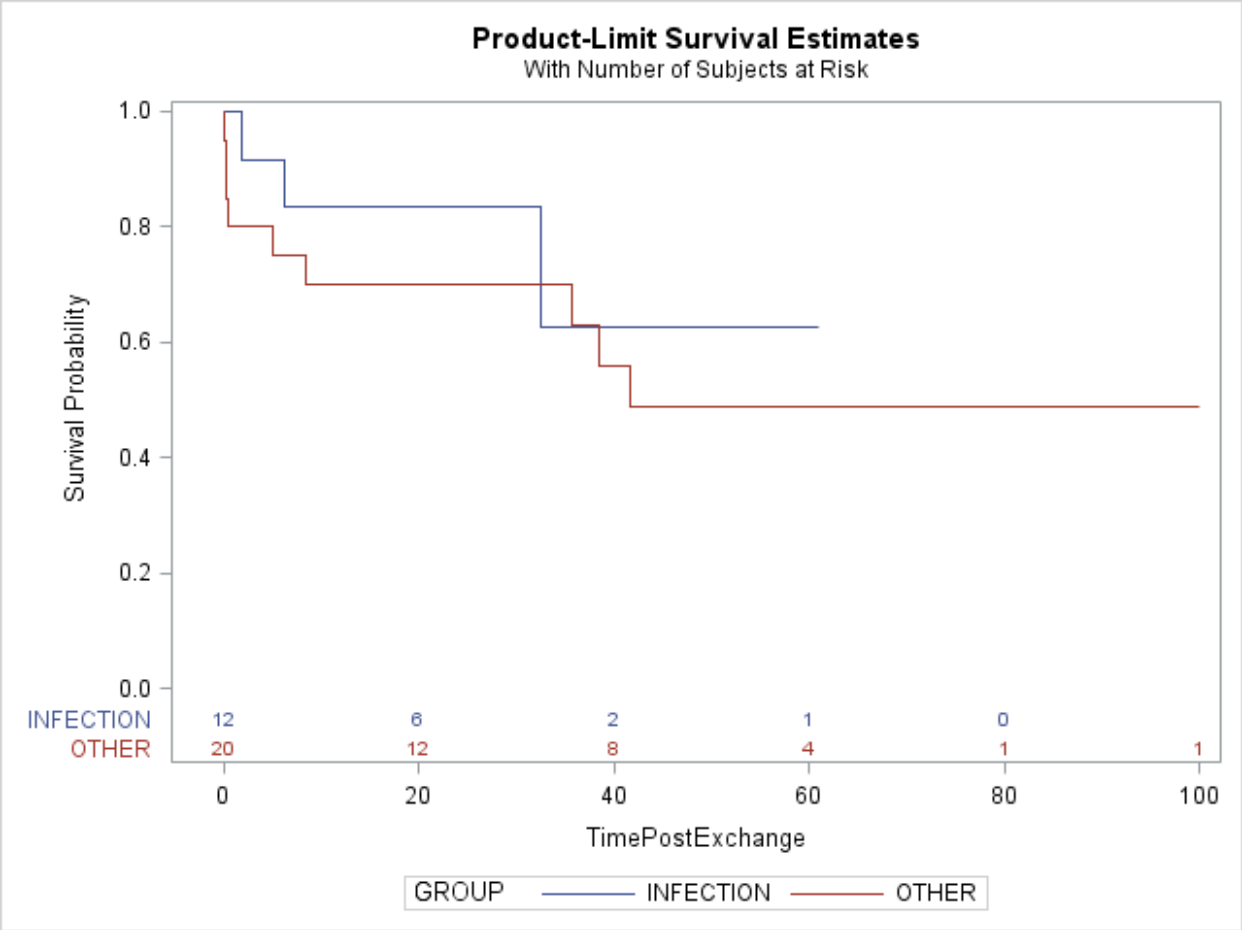

Figure 1. Kaplan Meier Curve of Survival for Infection vs. Other

The survival post exchange at 3 months is 92% for the infection group, and at 1 year is 83.%. Survival post exchange for the 'other' group at 3 months is 80%, and at 1 year is 70%. With small sample sizes, p-values were not calculated. The overall median survival was > 8.3 years

Median survival was calculated only within the reviewed time frame. There were 12 deaths after exchange with average survival time of at least 2.5 years. Within the 12 patients exchanged due to infection, there were 3 mortalities with average time to death at 1.1 years. One patient died after 52 days.

Table 4. Post Exchange Adverse Events

Post Exchange Adverse Events (N=32)		
Event	**N**	**Average Time to Event (years)**
Hemolysis	4	1.2
Right Heart Failure	2	1.6
Other Bleed	4	1.3
Gastrointestinal Bleeding	7	0.6
Stroke	12	0.6
Transient ischemic Attack	1	0.13
Ischemic	3	0.3
Intracranial Hemorrhage	8	0.7
Infection	13	0.6

Discussion

In an era of a growing advanced heart failure population, strategies other than the often-limited option of cardiac transplantation must be considered. If LVAD utilization increases with this mounting population, so do the potential for downstream complications such as pump thrombosis, hemolysis, and infection. Even if heart transplantation remains an option for these complex patients after a LVAD complication, the appropriate organ may not become available in adequate time, risking further deterioration and critical illness. Our data indicates these patients can be safely exchanged with reasonable post-operative courses, short post-operative length of stays and positive long-term outcomes, with rates of survival in this analysis of re-operative patients being slightly lower than the current rates of post-operative survival with continuous flow devices.[3] To our knowledge, this is the largest study of LVAD exchanges yet to be reported. Notably, for the patients with infection, the risks associated with the exchange are entirely acceptable in comparison to the risks associated with the near certain progression of disseminated infection. Each patient's historical factors, physical characteristics, laboratory, culture and imaging data were used to determine the diagnosis and extent of infection. The exchange was only undertaken after an interdisciplinary team (representing cardiology, infectious disease, and surgery) determined failure of medical therapy. Individual patient characteristics such as adherence to medical recommendations, psychosocial factors, surgical history, antibiotic history and extent of infection were carefully considered before undertaking the task of an exchange. Furthermore, type of bacterial infection and the ability for complete eradication by stringent washout before re-implantation of a new device with subsequent long-term antibiotics was weighed against any potential morbidity or mortality from the procedure, the ability to undergo a full

sternotomy if necessary and a shared-decision making process with the aforementioned factors in mind.

While the risk factors for exchange are not always clear, we attempt to adhere to the instructions for use for the particular LVAD being implanted, inclusive of anticoagulation and antiplatelet therapies, as well as the PREVENT recommendations for peri-operative and long-term management of HeartMate II patients. We pay close attention to the recommendations from the PREVENT guidelines for intra-operative considerations, heparin bridging, and pump speeds > 9,000 RPMs. We also advise patients to change their driveline dressings using sterile precautions daily in the early post-operative phase, not shower until fully incorporated and change dressings when showering or at least twice weekly thereafter. Our infectious disease team assesses patients preoperatively and during the immediate post-operative period, and as needed should any infectious issues arise. Additionally, many studies demonstrate elevated blood pressure with an increased risk of adverse events, with the best examples coming from the Heartware VAD populations.[10,11] As doppler blood pressure most closely approximates systolic blood pressure and mean arterial blood pressure,[12] our center's practice is to aim for a goal of <90mm Hg.

While patient adherence is often an issue, modification and attention to the specifics of medical management following LVAD implantation can have a substantial impact on post-surgical complications and improved quality of life.[6] Our multidisciplinary team inclusive of surgical, medical, infectious disease, hematology, supportive/palliative care, pharmacy, nursing and social work colleagues continually re-educate patients on the importance of adherence to best practices regarding blood pressure, anticoagulation and driveline management. Based on our experience, we propose that LVAD exchanges only be performed once such an interdisciplinary committee has convened and determined that a device complication is indeed refractory to medical therapy. In preparation for exchange, a risk mitigation plan to prevent need for re-exchange must be in place to aid in long-term monitoring and support as part of the patient's treatment plan as a bridge to transplantation or destination therapy.

Study Limitations

Not all possible confounding variables were recorded or adjusted for in this study. While confounding patient characteristics (compliance, psychosocial barriers and financial limitations) were considered during the evaluation for exchange, it is difficult to objectively quantify these risk factors as associated with long-term outcomes after each exchange. This patient population also experienced careful evaluation and counseling by Palliative/Supportive Care Medicine specialists to aid in decision making and management of chronic pain, fatigue and distress. This counsel may have resulted in the patient opting against device exchange as a potential option, particularly if a full exchange was recommended – the exact number of patients who opted against exchange in this situation is not available. The limited size of this study along with the other stated limitations do not necessarily allow these findings to be generalizable to an entire LVAD population.

Finally, the retrospective nature of the study contributes to possible bias and discrepancies in collecting and reviewing data.

Clinical Implications

The results of our study suggest that LVAD exchange can be an effective and definitive mechanism for the treatment of otherwise potentially fatal pump complications in highly select patients. Complex patients such as those analyzed in our cohort can be safely exchanged with outcomes that improve both longevity and quality of life. Patients reported ability to complete ADLs, return to work and ambulate with more easily allowing further enjoyment of life. No specific, formalized quality of life data was uniformly available in this retrospective review. Risks associated with the exchange procedure are minimal in comparison to the risks associated with the potential for disseminated infection or disease worsening arising from ongoing pump malfunction. If patients are continually educated on the care of their device and have a reliable support system in place, LVAD exchange should be considered in cases where no other solutions are available in a timely fashion.

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