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Risk factors of readmission to acute care hospital among individuals with heart failure and left ventricular assist device (LVAD) at inpatient rehabilitation setting (STROBE compliant article)

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Abstract

In post-acute care hospital setting, the heart failure (HF) individuals with left ventricular assist device (LVAD) have about 30% of transfer to acute care hospitals which requires readmission. There is relative increase in cost and mortality due to the readmission.

The goal of this study is to identify possible risk factors at Inpatient Rehabilitation Unit (IRU) to decrease the rate of readmission to acute care hospitals.

This study is retrospective study at the Inpatient Rehabilitation Unit (IRU)

Twenty one individuals with HF and LVAD were admitted to IRU. We determined 2 subgroups. One is the readmission group (Readmission) and the other is the control group (Control). Readmission (n = 6) is the individuals who were transferred to acute care hospital, and Control (n = 15) is the individuals who were discharged.

To compare Readmission group with Control group and evaluate demographic, laboratory, and functional outcome parameters. Main Outcome Measures are Body Mass Index (BMI), International Normalized Ratio (INR), and Functional independence measure (FIM).

At admission, INR in Readmission group was 3.4 ± 1.2 and in Control group was 2.2 ± 0.5 with a statistically significant p value ($P = .004$) and FIM score in Readmission group was 81.2 ± 15.9 and in Control group was 96.3 ± 11.5 with a statistically significant p value ($P = .023$).

The study showed the individuals with HF and LVAD at IRU had high INR and low FIM which may be the cause for readmission and need more attentive care. This data can help identify the factors causing readmission and help reduce the rate of readmission. Further evaluation is necessary to determine the cause for readmission.

Abbreviations: ACC = American college of cardiology, ACH = acute care hospital, AHA = American heart association, AICD = automated implantable cardioverter defibrillator, BMI = body mass index, BUN = blood urea nitrogen, CDC = centers for disease control and prevention, CI = confidence interval, DM = diabetes mellitus, FIM = functional independence measure, GI = gastrointestinal, Hb = Hemoglobin, Hct = Hematocrit, HF = heart failure, INR = international normalization ratio, IRB = institutional review board, IRU = inpatient rehabilitation unit, LOS = length of stay, LVAD = left ventricle assist device, MAP = mean arterial pressure, SD = standard deviation, WBC = white blood cell.

Keywords: FIM, INR, LVAD, readmission, risk factor

1. Introduction

Heart failure (HF) is a complex clinical syndrome, commonly presents with dyspnea, reduced exercise tolerance, and edema. It results from any structural or functional cardiac abnormalities. Centers for Disease Control and Prevention (CDC) reported that about 6.5 million adults in United States have heart failure. Heart

failure was a contributing cause of 1 in 8 deaths in 2017. It costed an estimate of $30.7 billion in 2012. The prevalence of HF continues to increase and is estimated to increase more than 8 million people in the United States by 2030.[1,2] The American Heart Association (AHA) and American College of Cardiology (ACC) classified HF into 4 stages (A-to-D) by severity. Stage D, which comprises about 10% of HF is an advanced HF characterized by progressive or persistent symptoms, recurrent de-compensation, and severe cardiac dysfunction despite medical optimization. One-year mortality rate of those with advanced HF can be as high as 75%.[3] For these patients with advanced HF, Left Ventricular Assist Device (LVAD) has been widely used as the bridge to heart transplant who are not immediately able to undergo heart transplantation or as the destination therapy who are not eligible to heart transplantation.[4] Morbidity, mortality, and physiologic function have been improved after LVAD procedure.[3,5] Nonetheless, 20% of patients with an LVAD experience continued severe HF.[6] Also, these patients require frequent readmissions. Recurrent readmissions are one of the major factors for the increase in cost for managing HF patients with LVAD. The average hospital cost per readmission was about $35,000 with reference to the Nationwide Readmission Database with patients undergoing LVAD implantation between January 2013 and November 2014 who survived the index hospitalization.[7] Not only the high cost but also increased mortality were reported. One-year all-cause mortality was 19% in patients with early readmission as compared to 1% with no early readmission (Hazard Ratio 15.5, $P = .01$).[8]

In post-acute care hospital setting, the HF patients with LVAD have 26%(36 of 138)–27.4%(76 of 277) of readmission to acute care hospitals within 30 days.[9,10] From the previous several studies, the common cause of readmission in LVAD patients was bleeding, stroke, LVAD thrombosis, and device-related infection.[5,9,11–13] The most common cause was bleeding, one-third of patients treated with LVAD.[12,13]

The goal of this study is to identify possible risk factors for the transfer to acute care hospital among individuals with LVAD at inpatient rehabilitation unit (IRU) setting. Readmission can be incredibly stressful to patients and family with high financial cost and increased mortality. Acknowledging possible factors might be the first step to prevent readmission.

2. Methods

This is a retrospective study approved by the institutional IRB (IRB number 2019-11026) analyzing the data retrieved from electronic health records of individuals admitted to IRU during the period of January 2017 to December 2019. Informed consent was not given because this work was retrospective study.

2.1. Study design and population
2.1.1. Subgroups. Study population are individuals with the diagnosis of HF and LVAD who are admitted to IRU from acute care hospitals from January 1, 2017 to December 31, 2019. Electronic health records of all the study population were reviewed. We classified 2 subgroups. One is the readmission group (Readmission) in which individuals were transferred to acute care hospital, and the other is the control group (Control) in which individuals were discharged home.

2.1.2. Data. To compare readmission group with control group, parameters like demographic, laboratory, and functional out-

come were abstracted from electronic medical records who were admitted at the IRU. The data included are demographics [age, gender, height, weight, body mass index (BMI), length of stay (LOS), length of time from LVAD implantation to admission to IRU], laboratory [hemoglobin (Hb), hematocrit (Hct), the counts of white blood cell (WBC), platelet, lymphocyte, sodium, blood urea nitrogen (BUN), creatinine, mean arterial pressure (MAP), speed of device pump, and international normalized ratio (INR)], and functional outcome measure which is functional independence measure (FIM). The FIM is an 18-item patient classification tool designed to uniformly assess 6 domains – activities of daily living, bladder and bowel management, transfers, mobility, communication, and social cognition. Each of the 18 individual task areas is scored on a 7-point Likert Scale, ranging from 1 = total assistance to 7 = complete independence. Final summed scores rage from 18 to 126.

There might be confounding factors for the comparison of 2 groups, such as anticoagulant medication and comorbidities. Therefore, data collected included comorbidities like diabetes and pressure sore, doses of anticoagulant (warfarin) and anti-thrombotic (aspirin). Relevant LVAD data were obtained, including LVAD model type, pump speed. MAP was measured using Doppler ultrasound. Reasons for transfers from IRU to acute care hospital were gathered.

From the previous several studies, the common cause of readmission in LVAD patients was bleeding, stroke, LVAD thrombosis, and device-related infection.[5,9,11–13] So, primary outcome measures were BMI, INR, and FIM. All data were retrieved at admission.

2.2. Statistical analysis

Continuous variables were shown as mean ± standard deviation (SD), and confidence intervals (CI). Categorical variables like gender, with or without comorbidities, LVAD model type were expressed as frequency (%). All missing data were excluded for analysis.

For intergroup comparison, the Fisher exact test is used with respect to categorical variables and Student t test was applied to continuous variables to compare differences in age, BMI, INR, WBC, hemoglobin, platelet, and FIM. Statistical significance imputed with the probability statistic $P < .05$. IBM SPSS version 22 was used for data analysis.

3. Results

3.1. Demographics

A total of 21 individuals with ACC/AHA stage D advanced heart failure, and LVAD were included in this study. The participants included 17 men and 4 women, ages 24 to 73 at the time of admission to IRU (mean [SD] age, 58.3 ± 13.6 years). All participants had ejection fraction less than 30%, New York Heart Association class III or IV. There was no difference between Readmission group and Control group at ejection fraction. Ten of the patients had ischemic cardiomyopathy, and 11 patients had nonischemic cardiomyopathy. Eighteen patients (86%) of the cohort underwent LVAD implantation for permanent use, known as destination therapy and 3 patients for bridge to transplantation. 16 (76%) of the patients had a HeartMate III LVAD, and 5 patients had a HeartMate II LVAD.

Table 1

Participant characteristics.

Demographics	Control (N = 15)	Readmssion (N = 6)	P value
Age, y	57.1 ± 11.9	59.5 ± 17.8	.717
Gender			
Men, n (%)	12 (80)	5 (83)	1.000
BMI, kg/m^2	28.5 ± 5.7	26.5 ± 8.8	.537
Comoridities			
DM, n (%)	9 (60)	4 (67)	1.000
Indication, n (%)			
Destination	14 (93)	4 (67)	.375
Bridge to transplantation	1 (7)	2 (33)	.375
Length of time from LVAD implantation to admission to rehabilitation, d	32.5 ± 27.3	36.1 ± 10.6	.666
Length of stay, d	20.3 ± 13.1	12.7 ± 5.0	.069
LVAD model type, n (%)			
Heart Mate II	2 (13)	2 (33)	.660
Heart Mate III	13 (87)	4 (67)	.660

Mean ± SD; BMI = body mass index, DM = diabetes mellitus, LVAD = left ventricle assist device.

The mean (SD) length of time from LVAD implantation to admission to IRU was 34.7 (23.4) days.

The readmission group included 6 individuals, who were transferred to an acute care hospital. The control group included 15 individuals, who were discharged home under family supervision and home health care.

The reasons for transfer to ACH were loss of energy secondary to gastrointestinal (GI) bleeding (1), pulmonary hemorrhage (1), sternal infection (1), sepsis secondary to multiple drug-resistant infection (1), respiratory distress secondary to anxiety (1), and depression (1).

No statistically significant differences between 2 groups were showed demographically including BMI, age, gender, comorbidity like diabetes mellitus (DM), length of time to IRU, and LVAD model type (Table 1). The average LOS in the IRU for the readmission group was 12.7 ± 5.0 compared to the mean LOS for the control group was 20.3 ± 13.1. However, the differences were not statistically significant (P = .069).

3.2. Laboratory assessment

INR was statistically significantly, high in the readmission group 3.4 ± 1.2, compared with the control group 2.2 ± 0.5, (P = .004). For the difference between 2 groups, t value was −3.27 and 95% confidence interval (CI) was −0.65 to 0.14 (Table 2). There were no differences between 2 groups in anticoagulation dose (2–6 mg) and antithrombotic dose (81 mg).

No other laboratory values were significantly different between 2 groups including WBC, Hb, Hct, platelet count, lymphocyte count, sodium, BUN, and creatinine (Table 2).

Also, MAP and the speed of LVAD pump were not significantly different between groups (Table 2).

There were missing data, for lymphocyte 2 in the control group, for MAP 3 in the control group and 2 in the readmission group, for speed of device pump 5 in the control group and 3 in the readmission group (Table 2).

3.3. Functional status

FIM score was statistically significantly low at the readmission group 81.2 ± 15.9, compared with the control group 96.3 ± 11.5 (P = .023). For the difference between 2 groups, t value was 2.45 and 95% CI was 2.2 to 28.1 (Table 2).

4. Discussion

The data showed high INR and low FIM might be clinical predictors for transfer to acute care hospital in individuals with advanced HF and LVAD in IRU. The readmission rate of our institution was 28.6%, compared to previous literature[14] with 36%. The decreasing factors in this study might include relatively smaller number of participants and specialized cardiopulmonary care unit in our IRU.

The reasons for transfer were bleeding 2, infection 2, and anxiety, & depression 2. It is similar to the previous study.[14] The previous study showed bleeding (26%) including persistent epistaxis, anemia, and GI bleeding, infection(18.5%) including fever, leukocytosis and bacteremia and cardiac origin(18.5%) including firing automated implantable cardioverter defibrillator

Table 2

Laboratory assessment and functional outcome at admission to rehabilitation.

	Control (N = 15)	Readmssion (N = 6)	t	95% CI	P value
WBC, count	9.3 ± 2.7	7.5 ± 2.7	1.40	−0.92 to 4.62	.179
Hb, g/dl	9.7 ± 1.4	9.4 ± 1.1	0.57	−1.00 to 1.75	.574
Hct, %	31.0 ± 4.1	29.8 ± 3.6	0.61	−2.86 to 5.22	.547
Platelet, count	349.7K ± 91.4	320.0K ± 136.0	0.58	−76.44 to 135.78	.565
lymphocyte, count	1.6 ± 1.1 (N = 13)	1.4 ± 0.7	0.31	−0.88 to 1.20	.758
Sodium, mEq/mL	138.5 ± 3.9	137.8 ± 2.1	0.25	−3.17 to 4.04	.804
BUN, mg/dL	29.5 ± 16.2	22.5 ± 11.4	0.97	−8.20 to 22.27	.346
Creatinine, mg/dL	1.3 ± 0.5	1.2 ± 0.4	0.12	−0.43 to 0.49	.905
INR	2.2 ± 0.5	3.4 ± 1.2	−3.27	−0.65 to 0.14	.004**
MAP, mmHg	88.7 ± 8.6 (n = 12)	81.5 ± 13.1 (n = 4)	1.27	−4.93 to 19.26	.224
Speed of device pump, cycle	5820.4 ± 1205.0 (n = 10)	6466.7 ± 2023.0 (n = 3)	−0.70	−2661.04 to 1367.71	.494
FIM	96.3 ± 11.5	81.2 ± 15.9	2.45	2.2 to 28.1	.023*

Mean ± SD; CI = confidence interval; WBC = white blood cell; Hb = hemoglobin; Hct = hematocrit; BUN = blood urea nitrogen; INR = international normalization ratio; MAP = mean arterial pressure; FIM = functional independence measure.

(AICD) and possible LVAD thrombosis and other complex reasons including altered mental status, respiratory distress, abdominal pain. Another previous study presented that bleeding (28.6%) including intracranial hemorrhage, gastrointestinal bleed, pulmonary problems (21,4%) including respiratory distress, pleural effusion, cardiac origin (14.3%) including ventricular tachycardia, right heart failure, and other reasons including sternal infection, hypoxia/orthostatic hypotension, urinary retention, hemolysis, pancreatitis.[15] From the nationwide readmissions database study, between 2013 and 2014, the common cause of readmission in LVAD patients was cardiac origin (23.8%), bleeding (13.4%), and infection (21%).[7] Also, it showed similar pattern compared to this study. However, in this study there were some differences from the previous studies.

Firstly, there were rare cardiac origin reasons. One possible explanation is the active communication between the specialized cardiopulmonary care unit and hospital staffs who performed LVAD implantation. The other possible explanation is the advancement of LVAD technology. While the type of LVAD of the previous study was heartmate II, axial-flow pump, that of this study was heartmate III, centrifugal-flow pump in most of the patient population, 17 out of 21 (81%). Centrifugal-flow pump is levitated magnetically, while axial-flow pump works by mechanical bearing. Recent study presented centrifugal-flow pump showed less pump thrombosis and stroke complication compared to axial-flow pump.[16]

Secondly, there were psychologic reasons like anxiety and depression. Recent study showed that among the readmission population with LVAD, anxiety and depression were 42.3% and 40.8% respectively.[17] It is quite inferable as this population with advanced HF and LVAD have several comorbidities associated who are on long term medication and need frequent hospital readmissions. Anxiety and depression symptoms could present as respiratory distress, fatigue, lethargy, and weakness. Psychologic factors are preventable and so should not be neglected.

5. INR

For the individuals with LVAD, the recommended antithrombotic treatment included aspirin 81 mg daily and anticoagulation therapy. Warfarin is required to prevent device thrombosis, cardioembolic event, and ischemic stroke. In this study, there was no significant difference in the dose of warfarin between the 2 groups, control group 4.0±1.6 mg, readmission group 4.2±1.6 mg (data not shown). But there were 4 out of 6 patients in the readmission group with INR more than 3.0, compared to none in control group.

The dose of warfarin is usually adjustable to the target range for the INR, 2.0 to 3.0 for the patients with LVAD. However even though the advancement of LVAD technology decrease thrombotic and stroke risk, the bleeding risk has not diminished.[18] Bleeding can occur frequently in the gastrointestinal tract, thoracic-pleural space, nose, and the brain.[19] If hemorrhagic stroke is discovered, then the INR should be reduced to less than 1.5 to prevent hemorrhage.[5]

Causes underlying LVAD-related bleeding are multifactorial. They are increased incidence of acquired von Willenbrand disease, impaired platelet aggregation related to high shear forces in the device, increased incidence of mucosal arteriovenous malformation, abnormal angiogenesis, and overuse of anticoagulation therapy.[11,12,20,21] Literature suggest that the most common site of bleeding in LVAD patients is gastrointestinal tract. Annual rates of GI bleeding are reported as 25% to 40%. After LVAD

implantation, there is fivefold increased risk of readmission with GI bleeding within 60 days.[22] To prevent re-bleeding, it suggests that care providers should ask history of bleeding, consider enteroscopy, and monitor cautious anticoagulation. An article suggested axial-flow LVADs are regularly treated with aspirin and warfarin typically with an INR goal of 1.5 to 2.5.[23] In recent pilot study suggests low-intensity anti-coagulation targeting an INR between 1.5 and 1.9 is achievable and safe with the centrifugal-flow cardiac pump in the 6-months post-implant.[24]

6. FIM

In this study, the lower scores of the readmission group were observed compared to the control group.

The FIM scores at admission was quite variable in the readmission group, but the individuals with anxiety and depression showed 67, 72. While the most people in the control group showed more than 80. The previous report showed the similar results to this study. Patients who were transferred and did not complete rehabilitation, scored 58.0 (n=11), while patients who completed rehabilitation without transfer scored 69.6 (n=37).[14] Compared to the previous study, this studys data showed the more favorable functional scores at admission. The possible reasons might be the smaller number of participants in this study and the longer length of time from LVAD implantation to admission at IRU, 34.7±23.4 compared to the previous study, 27.0±15.3.

Even though it is hard to conclude for smaller sample number, low score of FIM might show general deconditioning. There are many possible causes, bleeding, infection, psychologic factor or combined.

6.1. Comorbidities

Comorbid medical conditions for the readmission group included ischemic cardiomyopathy, chronic kidney disease, pleural effusion, obstructive sleep apnea, atrial fibrillation, hypertension, DM, obesity, gout, epistaxis, anxiety and depression.

For the control group, comorbidities included coronary artery disease, chronic kidney disease, atrial fibrillation, hypertension, DM, obesity, obstructive sleep apnea, gout, asthma, gastritis, anxiety, and bipolar disorder.

No differences between 2 groups were observed.

6.2. Study limitation

This study included small number of individuals admitted from a single institution. Future research is needed to collect more data from multi-center study and analyze each subgroup based on different factors for readmission.

Anxiety and depression were one of the main reasons for transfer to ACH. Even though the FIM score may show indirectly because it includes social cognition domain, we did not directly check the psychological assessment for anxiety and depression. It should be included in the future study. Routine psychologic evaluation might help to decrease transfer to ACH among individuals with HF and LVAD at IRU.

7. Conclusion

This study shows that the individuals with HF and LVAD at IRU, with high INR and low FIM might need more attentive care by targeted appropriate interventions that can help decrease

readmission rates and improve quality of life in this patient population with HF and LVAD at IRU.

Author contributions

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