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Research Article

Factors Associated With Readmission in Patients With Left Ventricular Assist Devices in South Korea

Hyeonji Kang,[1, 2] Mona Choi[3, *]

[1] College of Nursing, Graduate School of Yonsei University, Republic of Korea
[2] Department of Nursing, Samsung Medical Center, Republic of Korea
[3] College of Nursing and Mo-Im Kim Nursing Research Institute, Yonsei University, Republic of Korea

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SUMMARY

Purpose: Although left ventricular assist devices (LVADs) are increasingly used as a standard treatment for end-stage heart failure, few studies have explored LVAD-related readmissions. This study investigated the factors associated with readmission and nursing documentation in patients with LVADs.
Methods: A retrospective analysis was conducted on electronic medical records of patients who underwent LVAD implantation at a tertiary hospital in South Korea (January 2015–April 2023). Baseline and clinical characteristics and nursing documentation were analyzed using χ^2 test, Fisher's exact test, *t*-test, and logistic regression.
Results: Of the 127 patients (mean age: 61.31 ± 13.27 years, 81.1% men), 63.3% underwent LVAD implantation as a bridge to heart transplantation, and 85 (67.0%) were readmitted within 104 days. Bivariate analyses identified 17 variables significantly differing between readmission and nonreadmission groups. New York Heart Association (NYHA) class II [odds ratio (OR): 7.29], NYHA Class III (OR: 47.14), prothrombin time (OR: 32.65), and the presence of free-text nursing notes (OR: 7.58) were significant factors of readmission.
Conclusion: Nurses play a vital role in managing patients and helping to reduce readmission rates. In addition to the NYHA class and prothrombin time, this research highlights the critical importance of comprehensive nursing documentation. Specifically, 'free-text nursing notes' capture critical patient events and observations, such as nonsustained ventricular tachycardia, bleeding, and noncompliance, providing valuable insights for clinical decision-making and enhancing patient management to prevent unplanned readmissions. These findings highlight the importance of nursing roles in documentation, patient education, and personalized discharge planning to improve clinical outcomes for patients with LVADs.

Introduction

End-stage heart failure is a complex condition that does not respond to standard treatments and requires specialized interventions including inotropic support, heart transplantation, and mechanical circulatory support, such as left ventricular assist devices (LVADs) [1]. These devices have revolutionized treatment and increased the survival rates in patients with heart failure [2]. Although LVADs have been available for the treatment of end-stage heart failure patients in Korea since 2012, there has been no active implementation due to the financial burden on patients, and the number of procedures per year was less than 10 [3]. Because health insurance coverage for LVAD implantation was approved in September 2018, the number of procedures has increased to more than 50 cases annually [4].

After LVAD implantation, the management of heart failure symptoms and device maintenance becomes a dual challenge. Patients may need to be readmitted to the hospital if they develop unstable symptoms owing to inadequate self-care practice, including nutrition, exercise, LVAD driveline exit-site dressing, medication adherence, and daily life adaptation [5]. The readmission

Hyeonji Kang: https://orcid.org/0009-0009-5896-4615; Mona Choi: https://orcid.org/0000-0003-4694-0359
* Correspondence to: Mona Choi, College of Nursing and Mo-Im Kim Nursing Research Institute, Yonsei University, 50-1, Yonsei-ro, Seodaemun-gu, Seoul, 03722, Republic of Korea.
E-mail address: monachoi@yuhs.ac

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rates for patients with LVAD are notably high, with 27.3% within 30 days, 62.0% within 6 months of discharge, and most repeat readmissions occur within 1–2 years [6,7]. The readmission rates for patients with LVADs are significantly higher than those for patients undergoing other cardiovascular treatments. For instance, the 5-year readmission rate for patients who have undergone coronary artery bypass grafting is 25.0% and 31.2% for percutaneous coronary interventions [8]. The disproportionately high readmission rates observed in patients with LVADs are primarily attributable to the intricate challenges associated with managing LVAD-specific complications, including infections, bleeding, thrombosis, and device malfunctions [5,7]. These complexities emphasize the critical need for specialized postoperative care and monitoring for this patient population, which highlights the need to identify the factors associated with these readmissions to mitigate them.

Several previous studies, including those by Kutyifa et al [9] and Tripathi et al [10] have identified key causes of readmission after LVAD implantation, such as acute heart failure, infection, gastrointestinal bleeding, arrhythmia, cerebrovascular disease, and abnormal laboratory values. Additionally, a previous study that highlighted the significant role of psychosocial risk factors, such as lack of social support, decreased cognitive ability, drug abuse, and noncompliance with postdischarge treatment, in contributing to readmission [11]. Tripathi et al (2018) analyzed the factors influencing 90-day readmission among patients with LVADs in the United States and identified cardiac complications, bleeding, and infections as the most significant contributors to readmission [10]. Similarly, Agrawal et al (2018) focused on factors influencing 30-day readmission among patients with LVADs, and identified infections, bleeding, and device-related issues as the primary reason for readmission [12]. Furthermore, Hernandez et al (2015) examined the reasons for readmission in a cohort of 148 patients with LVADs and found that bleeding, thrombosis, anticoagulation complications, and infections were the predominant influencing factors [13]. These findings underscore the importance of continuous follow-up and comprehensive care even after LVAD implantation as repeated readmissions can lead to poor clinical outcomes, including reduced quality of life, increased mortality, and higher medical costs [14].

Nurses play a critical role in managing the complex care needs of patients with LVADs. Patients require complex treatment for physical and psychosocial conditions after LVAD implantation [15]. Nurses who manage patients with LVADs perform routine nursing activities, such as symptom assessment, medication administration, and safety management and advanced nursing care such as cardiac rehabilitation programs, electrocardiography monitoring, LVAD device maintenance, and emergency care [16,17]. Nurses provide care that is tailored to the patient's need and maintain nursing documentation [17,18], which contains the nurses' clinical judgment based on observation and is more frequently done when they are concerned about the patient's condition [19,20]. Therefore, nursing documentation can also provide useful information on factors associated with readmissions in patients with LVADs.

There is one study in South Korea that compared the group transferred to the acute care hospital and discharge groups of patients with LVADs admitted to the rehabilitation unit in 21 patients after LVAD implantation [21]. The study suggested that more attentive care should be provided to patients with high international normalized ratios and low functional independence to decrease readmission rates [21]. No studies have examined the factors associated with readmission and nursing documentation, highlighting the need for our research. Therefore, this study aims to identify the factors associated with readmission in patients with LVADs, compare the characteristics of those who are readmitted with those who are not, and analyze nursing documentation to elucidate how it influences patient outcomes.

Methods

Design

A retrospective study was conducted to identify factors associated with readmission, including those documented in nursing records, through a review of electronic medical records (EMRs).

Study setting and sampling

The study population comprised patients who underwent LVAD implantation at a tertiary medical center in Seoul, South Korea. This hospital was the first in the country to perform LVAD surgeries and currently holds the record for the highest number of such procedures in South Korea. The EMRs of all patients aged 19 years and older were reviewed. At this institution, the typical length of hospital stay following an LVAD implantation is approximately one month or longer. For patients with multiple readmissions, only the first readmission was included in the analysis.

Inclusion and exclusion criteria

The inclusion criteria were patients who underwent surgery with implantable ventricular assist device implantation, LVAD implantation, or left heart assist device procedures from January 2015 to April 2023. Exclusion criteria encompassed patients who underwent heart transplantation after LVAD implantation, those who died following LVAD implantation, those who died after discharge but before the first readmission, and patients with planned readmission for surgical procedures, examinations, or medication therapy.

Instrument with validity and reliability/data source

Baseline characteristics

The general characteristics of the patients included gender, age, employment status, course of hospitalization, the number of comorbidities, body mass index, etiology (such as history of ischemic cardiomyopathy, open heart surgery, atrial fibrillation, and cardiogenic shock), and discharge disposition.

Clinical characteristics

The clinical characteristics during the postoperative period included LVAD indication, length of hospital stay after LVAD implantation, presence and type of oxygen therapy, readmission to the intensive care unit (ICU) due to changes in the patient's condition, and a history of LVAD alarms.

Other clinical characteristics included systolic blood pressure, pulse, New York Heart Association (NYHA) class, ejection fraction, the number of medications, pain medications, sleeping medications, and laboratory values. These were the most recent results obtained before discharge from the general ward. Supplemental Table 1 presents the various time points at which different clinical characteristics were assessed throughout the study period.

Nursing documentation

To analyze nursing documentation in this study, we included nursing diagnoses, nursing records of signs and symptoms, and free-text nursing notes of patients with LVADs. Based on previous studies, nursing documentation was assessed for two weeks of discharge [22]. Nursing diagnoses included those of the North American Nursing Diagnosis Association-International (NANDA-I) classification [23] and those established for the management of cardiovascular patients with LVADs in the study hospital. After LVAD implantation, the study hospital requires nurses to document three mandatory nursing diagnoses for patients with LVADs: “decreased

cardiac output," "risk for bleeding: anticoagulation therapy," and "ventricular assist device." Among these, only the "decreased cardiac output" diagnosis includes a detailed drop-down list of signs and symptoms, as shown in Table 4, allowing for consistent comparison across all patients. The study also examined nine other nursing diagnoses established based on the individual condition of the patients, in addition to the mandatory nursing diagnoses.

In this study, free-text nursing notes refer to unstructured nursing data directly entered as free text. They are typically used to describe temporary critical patient events and observations that are not easily associated with a specific nursing diagnosis. Notably, the free-text nursing notes are typically documented only when a particular clinical event occurs with respect to the patient. Examples of free-text nursing notes included nonsustained ventricular tachycardia (NSVT), noncompliance (failure to comply with treatment instructions that are noted by specific symptoms such as falls), problems related to LVAD management, poor oral intake, and fever.

Data collection

The EMR data of patients with LVADs readmitted from January 1, 2015, to April 26, 2023, were extracted from the Clinical Data Warehouse of the study hospital. The data were extracted from the Clinical Data Warehouse of study hospital after prior approval was obtained from the data management team. In response to the researcher's request, the data management team retrieved the information using surgical code such as "implantable ventricular assist device," "left ventricular assist device insertion," and "left heart assist device procedure." Data were collected by reviewing the EMRs of the study hospital and recording the information on a structured survey form.

General and clinical characteristics were consolidated form admission records, progress notes, and test results. Surgery-related characteristics were identified from surgical records. The NYHA class was determined based on documentation of the LVAD specialist nurse, while nursing documentations were extracted from the electronic nursing record.

For the free-text nursing notes, the researcher personally itemized the data and subsequently organized and utilized the extracted data. Finally, the entire process, including the completion of the structured survey form and analysis of the free-text nursing notes, was reviewed and validated by a medical doctor and the head nurse of the cardiology department to ensure accuracy.

Data analysis

Baseline characteristics, clinical characteristics, and nursing documentation were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations. The differences in characteristics between the readmission and nonreadmission groups were determined using *t* test for continuous variables based on normality and Chi-square test for normally distributed categorical data and Fisher's exact test for nonparametric categorical data. Factors associated with readmission were identified using multiple logistic regression analyses. The model included variables that showed significant differences between the readmission and nonreadmission groups in bivariate analyses, and the Hosmer–Lemeshow test was used to assess the goodness of fit of the model. Data were analyzed using IBM SPSS Statistics (version 27; IBM Corp., Armonk, NY, USA).

Ethical considerations

This study was approved by the institutional review board of the Samsung Medical Center (IRB File No.: 2023-04-072-004) for the analysis of data retrieved from EMRs. The EMR data were extracted from the Clinical Data Warehouse without personal identification information.

Results

A total of 147 patients with LVAD implantation were extracted from the EMRs, and 127 patients who met the eligibility criteria were included in this study. We excluded three patients (2.0%) who had heart transplantation before discharge, 10 (6.8%) who died before and after discharge, and seven (4.8%) under the age of 19 years. Of the 127 patients, 85 (67.0%) were readmitted with an average of 103.78 (±142.07) days between the initial discharge and readmission (range: 3–644 days).

Notably, LVAD alarm was the most common cause of readmission (20.8%), followed by worsening cardiac symptom (13.0%) and LVAD-related infection (12.0%); neurologic and noncardiac symptom accounted for 9.8%, while gastrointestinal bleeding and other bleeding were identified as 8.7%. Following arrhythmia (7.6%), other infections (5.4%), pump malfunction (3.2%), and respiratory failure (1.0%) were also identified as causes of readmission (Supplemental Fig. 1).

Baseline characteristics of patients admitted for LVAD implantation

Sixty-seven (78.8%) patients were male, and the average age of patients with LVADs was significantly higher in the readmission group than that in the nonreadmission group (63.89 ± 12.70 vs. 56.10 ± 13.00; $t = -3.23$, $p = .002$). There was a significant difference in the employment status, with 54 patients (63.5%) in the readmission group being unemployed compared to 16 (38.1%) in the nonreadmission group ($\chi^2 = 7.74$, $p = .021$). The average body mass index was 23.46 kg/m^2 in the readmission group and 25.31 kg/m^2 in the nonreadmission group, showing a significant difference ($t = 3.05$, $p = .003$). Ischemic (52.9%) and dilated (54.8%) cardiomyopathies were the most common etiologies in the readmission and nonreadmission groups, respectively (Table 1).

Clinical characteristics of patients after LVAD implantation

Table 2 shows the clinical characteristics of patients after LVAD implantation. Overall, the indication of LVAD implantation was destination therapy in 37.0% and bridge to transplantation (BTT) in 63.0% of patients. The average pulse on the day of discharge was 88.33 in the readmission group and 78.90 in the nonreadmission group, indicating a significant difference ($t = -3.86$, $p < .001$). The most common NYHA class after LVAD implantation for the readmission group was Class II (58.8%), followed by Class III (35.3%) and Class IV (2.4%). This was significantly different from the nonreadmission group ($\chi^2 = 27.47$, $p < .001$).

Oxygen therapy was provided to 43 patients (50.6%) in the readmission group and to 10 (23.8%) patients in the nonreadmission group, with a significant difference between the two groups ($\chi^2 = 8.29$, $p = .004$). Owing to changes in patient's condition after LVAD implantation, 34.1% of the patients in the readmission group experienced an ICU stay compared to 4.8% in the nonreadmission group ($\chi^2 = 13.13$, $p < .001$). Before discharge, 67.1% of the patients in the readmission group had a history of LVAD alarm compared to 28.6% in the nonreadmission group ($\chi^2 = 16.78$, $p < .001$). Pain medication use was higher ($\chi^2 = 4.33$, $p = .037$) in the nonreadmission group (78.6%) than in the readmission group (60.0%).

Several laboratory test results show the differences between the two groups. The averages of platelet count ($t = 2.21$, $p = .029$) and estimated glomerular filtration rate ($t = 2.89$, $p = .005$) of the readmission group were lower than those of the nonreadmission group. The averages of prothrombin time (PT) ($t = -4.61$, $p < .001$) and the N-terminal pro-B-type natriuretic peptide ($t = -2.75$, $p =$

Table 1 *Baseline Characteristics of Patients Admitted for LVAD Implantation (n = 127).*

Characteristics	Categories	Readmission (n = 85)	Nonreadmission (n = 42)	Total (n = 127)	χ^2 or t	*p*
		n (%) or mean ± SD				
Gender	Men	67 (78.8)	36 (85.7)	103 (81.1)	0.87	.351
	Women	18 (21.2)	6 (14.3)	24 (18.9)		
Age, years		63.89 ± 12.70	56.10 ± 13.00	61.31 ± 13.27	−3.23	.002
Employment status	Unemployed	54 (63.5)	16 (38.1)	70 (55.1)	7.74	.021
	Employed	23 (27.1)	21 (50.0)	44 (34.6)		
	Leave of absence	8 (9.4)	5 (11.9)	13 (10.3)		
Course of hospitalization	Outpatient clinic	23 (27.4)	13 (31.0)	36 (28.6)	0.45	.797
	Emergency room	30 (35.7)	16 (38.0)	46 (36.5)		
	Transfer	31 (36.9)	13 (31.0)	44 (34.9)		
Number of comorbidities		4.90 ± 2.28	4.76 ± 2.27	4.85 ± 2.27	−0.34	.735
BMI (kg/m^2)		23.46 ± 2.87	25.31 ± 3.70	24.11 ± 3.29	3.05	.003
Etiology	ICMP	45 (52.9)	13 (31.0)	58 (45.7)	5.52	.106[a]
	DCMP	36 (42.3)	23 (54.8)	59 (46.5)		
	HCMP	2 (2.4)	3 (7.1)	5 (3.9)		
	STEMI	2 (2.4)	3 (7.1)	5 (3.9)		
Cardiac device	Yes	38 (44.7)	13 (31.0)	51 (40.2)	2.21	.137
	No	47 (55.3)	29 (69.0)	76 (59.8)		
Open heart surgery	Yes	14 (16.5)	3 (7.1)	17 (13.4)	2.11	.146
	No	71 (83.5)	39 (92.9)	110 (86.6)		
Previous PCI	Yes	37 (43.5)	18 (42.9)	55 (43.3)	0.01	1.000
	No	48 (56.5)	24 (57.1)	72 (56.7)		
Atrial fibrillation	Yes	35 (41.2)	14 (33.3)	49 (38.6)	0.73	.393
	No	50 (58.8)	28 (66.7)	78 (61.4)		
Cardiogenic shock	Yes	16 (18.8)	6 (14.3)	22 (17.3)	0.40	.525
	No	69 (81.2)	36 (85.7)	105 (82.7)		
Discharge disposition	Home	82 (96.5)	41 (97.6)	123 (96.9)	0.12	1.000[a]
	Facility	3 (3.5)	1 (2.4)	4 (3.1)		

Note. BMI = body mass index; DCMP = dilated cardiomyopathy; HCMP = hypertrophic cardiomyopathy; ICMP = ischemic cardiomyopathy; LVAD = left ventricular assist device; PCI = percutaneous coronary intervention; SD = standard deviation; STEMI = ST-segment elevation myocardial infarction.
[a] Fisher's exact test.

.007) of the readmission group were significantly higher than those of the nonreadmission group (Table 2).

Nursing documentation of patients with LVADs

The average number of nursing diagnoses was significantly higher in the readmission group than in the nonreadmission group (4.85 ± 1.53 vs. 4.29 ± 0.89; $t = -2.60$, $p = .010$). According to the protocol of the study hospital, all patients after LVAD implantation had three nursing diagnoses, “decreased cardiac output,” “risk for bleeding: anticoagulation therapy,” and “ventricular assist device.” Except those, the three most frequent nursing diagnoses were “risk for infection” (75.6%), “ineffective airway clearance” (21.3%), and “risk for transmission of infection” (13.4%). Nurses charted the nursing diagnoses of “ineffective airway clearance” (28.2% vs. 7.1%; $\chi^2 = 7.47$, $p = .006$) and “risk for aspiration” (15.3% vs. 2.4%; $\chi^2 = 4.78$, $p = .034$) significantly more for those who were readmitted than for those who were not (Table 3).

Nursing records of signs and symptoms as structured nursing data under the nursing diagnosis of “decreased cardiac output” were analyzed. The presence of nursing records of signs and symptoms was significantly higher in the readmission group than in the nonreadmission group (61.2% vs. 26.2%; $\chi^2 = 13.76$, $p < .001$). In the readmission group, pitting edema was the most common symptom (27.1%), followed by fatigue (18.8%) and dyspnea on exertion (14.1%). Regarding fatigue, 18.8% of the patients in the readmission group had it compared to 2.4% in the nonreadmission group ($\chi^2 = 6.56$, $p = .010$).

Free-text nursing notes are unstructured nursing data entered directly as free text to document temporary critical patient events and observations. There was a significant difference between the two groups in the presence of free-text nursing notes, with 49.4% in the readmission group and 16.7% in the nonreadmission group ($\chi^2 = 12.72$, $p < .001$). In the readmission group, NSVT was the most frequent note (38.8%), followed by noncompliance (11.8%) and other bleeding (10.6%) (Table 4).

Factors affecting readmission in patients with LVADs

Table 5 presents the results of the logistic regression analysis. The Hosmer–Lemeshow goodness-of-fit test indicated adequate model fit ($\chi^2 = 11.49$, p = .175). This result indicates that the model is appropriate and adequately fits the data, with no significant discrepancies between the observed and predicted values.

The odds ratio (OR) values for NYHA Class II [OR: 7.29, 95% confidence interval (CI) = 1.01–52.73] and NYHA Class III (OR: 47.14, 95% CI = 2.71–819.95) were found to be statistically significant, indicating that patients in these classes have a substantially higher likelihood of readmission than those in NYHA Class I. Specifically, the OR for NYHA Class II is 7.3, meaning that these patients are 7.3 times more likely to be readmitted than those in Class I. For NYHA Class III, the OR is 47.1, suggesting that patients in this class are 47.1 times more likely to be readmitted than those in Class I.

Additionally, the OR value for PT (OR: 32.65, 95% CI = 3.50–304.75) was statistically significant, showing that patients with elevated PT levels have a higher likelihood of readmission than those with normal PT levels. This result underscores the significance of PT as a predictor of readmission risk.

Finally, the OR value for the presence of free-text nursing notes (OR: 7.58, 95% CI = 1.61–35.79) was also statistically significant, showing that patients with free-text nursing notes are more likely to be readmitted than those without them. Specifically, the OR is 7.6, indicating that these patients are 7.6 times more likely to be readmitted and highlighting the presence of free-text nursing notes as a significant predictor of readmission risk.

Discussion

This study aimed to investigate the factors associated with readmission after LVAD implantation. In this study, 85 out of 127 patients (67.0%) were readmitted, with the first readmission occurring an average of 104 days after discharge. This is a higher

Table 2 *Clinical Characteristics of Patients after LVAD Implantation (n = 127).*

Characteristics	Categories	Readmission (n = 85)	Nonreadmission (n = 42)	Total (n = 127)	χ^2 or t	*p*
		n (%) or mean ± SD				
LVAD indication	DT	39 (45.9)	8 (19.0)	47 (37.0)	8.68	.003
	BTT	46 (54.1)	34 (81.0)	80 (63.0)		
SBP[a]		95.66 ± 11.22	96.26 ± 8.72	95.86 ± 10.43	0.31	.760
Pulse[a]		88.33 ± 13.60	78.90 ± 11.41	85.19 ± 13.62	−3.86	< .001
NYHA class	Class I	3 (3.5)	14 (33.3)	17 (13.4)	27.47	< .001[b]
	Class II	50 (58.8)	25 (59.5)	75 (59.1)		
	Class III	30 (35.3)	3 (7.2)	33 (26.0)		
	Class IV	2 (2.4)	-	2 (1.5)		
Length of hospital stay (days)		53.78 ± 50.29	36.50 ± 37.57	48.06 ± 47.03	−1.97	.051
EF (%)		24.75 ± 7.80	26.61 ± 9.06	25.42 ± 8.23	0.77	.448
Oxygen therapy	Yes	43 (50.6)	10 (23.8)	53 (41.7)	8.29	.004
	No	42 (49.4)	32 (76.2)	74 (58.3)		
Type of oxygen therapy	NP	21 (48.8)	9 (90.0)	30 (56.6)	5.36	.125
	HFNC	11 (25.6)	1 (10.0)	12 (22.6)		
	T-tube	10 (23.3)	0 (0.0)	10 (18.9)		
	H/V	1 (2.3)	0 (0.0)	1 (1.9)		
ICU stay	Yes	29 (34.1)	2 (4.8)	31 (24.4)	13.13	< .001
	No	56 (65.9)	40 (95.2)	96 (75.6)		
LVAD alarm	Yes	57 (67.1)	12 (28.6)	69 (54.3)	16.78	< .001
	No	28 (32.9)	30 (71.4)	58 (45.7)		
Number of medications[a]		12.44 ± 3.47	12.21 ± 2.84	12.36 ± 3.26	−0.36	.721
Pain medications[a]	Yes	51 (60.0)	33 (78.6)	84 (66.1)	4.33	.037
	No	34 (40.0)	9 (21.4)	43 (33.9)		
Sleeping medications[a]	Yes	43 (50.6)	15 (35.7)	58 (45.7)	2.51	.113
	No	42 (49.4)	27 (64.3)	69 (54.3)		
WBC count (m^3/mL)		6.78 ± 1.97	6.84 ± 1.47	6.80 ± 1.81	0.19	.852
Hemoglobin (g/dL)		9.98 ± 1.10	10.19 ± 1.12	10.05 ± 1.11	1.03	.305
Platelet (× 1,000/mL)		246.94 ± 85.54	288.23 ± 121.07	260.70 ± 100.24	2.21	.029
PT (INR)[a]		2.06 ± 0.41	1.73 ± 0.30	1.94 ± 0.41	−4.61	< .001
NT-proBNP (× 1,000/pg/mL)		4.97 ± 5.84	3.01 ± 2.17	4.32 ± 5.01	−2.75	.007
Sodium (mmol/L)		137.52 ± 3.19	137.38 ± 2.87	137.48 ± 3.08	−0.25	.807
Potassium (mmol/L)		4.11 ± 0.53	4.16 ± 0.39	4.13 ± 0.49	0.60	.552
BUN (mg/dL)		17.89 ± 12.69	14.39 ± 9.18	16.72 ± 11.72	−1.59	.114
Creatinine (mg/dL)		1.27 ± 1.27	0.92 ± 0.49	1.15 ± 1.08	−1.76	.081
Estimated GFR (mL/min/1.73 m^2)		60.09 ± 39.10	81.79 ± 40.94	67.32 ± 40.87	2.89	.005
CRP (mg/dL)		1.71 ± 1.66	1.54 ± 1.33	1.66 ± 1.55	−0.61	.545

Note. BTT = bridge to transplantation; BUN = blood urea nitrogen; CRP=C-reactive protein; DT = destination therapy; EF = ejection fraction; GFR = glomerular filtration rate; HFNC = high-flow nasal cannula; H/V = home ventilator; ICU = intensive care unit; INR = international normalized ratio; LVAD = left ventricular assist device; NP = nasal prolongation; NT-proBNP = N-terminal pro-B-type natriuretic peptide; NYHA = New York Heart Association; PT = prothrombin time; SBP = systolic blood pressure; SD = standard deviation; T-tube = tracheotomy tube; WBC = white blood cell.

[a] Values on the day of discharge.

[b] Fisher's exact test.

readmission rate than that observed in a United States study, where 53.1% of readmissions occurred within 90 days [10].

We found that the most common causes of readmission were "LVAD alarm," "cardiac symptom" aggravation, and "infection (LVAD-related)." These results are similar to those in previous studies, showing that LVAD factors and heart failure symptoms, including LVAD-related infection and pump events, are the common causes of readmission [24]. Another study identified infection and bleeding as the highest-ranking causes of readmission [10]. Therefore, further research is needed on the causes of readmission in South Korea.

The indication for BTT had more readmissions than those for destination therapy. Patients who undergo LVAD implantation for BTT have been reported to experience higher mortality within 90 days of implantation [25]. Therefore, rehabilitation and return to daily life should be planned in advance for this group. We found that more patients in the readmission group than in the nonreadmission group were transferred to the ICU because of worsening conditions. A prior study showed that ICU transfer following LVAD implantation was frequent and significantly associated with one-year mortality after discharge [26]. Patients who undergo LVAD implantation and are subsequently admitted to the ICU should be closely monitored and managed to prevent adverse events.

Before discharge, more than half of the patients in the readmission group had a history of LVAD alarm, indicating that a lack of harmony between the patient's native heart and the LVAD device. Low-flow alarms potentially indicate hypotension, right heart failure, thrombus, and arrhythmia, and suction alarms indicated reduction in the pump flow; thus, nurses should be aware of the status of LVAD devices at all times when caring for patients with LVADs [27,28].

This study also aimed to analyze the nursing documentation for patients with LVADs to examine the impact of nursing care on readmission. Nursing documentation reflects patients' health concerns and can be used to predict clinical outcomes [19,29]. Furthermore, nursing documentation plays a crucial role in capturing patients' information and making nursing performance visible [30–32]. In this study, the nursing diagnosis of "ineffective airway clearance" showed statistically significant differences between the two groups, and the readmission group had a longer duration of oxygen therapy than the nonreadmission group. This suggests the need for respiratory intervention and education for patients receiving oxygen therapy after LVAD implantation to evaluate cardiopulmonary function and prevent respiratory failure.

The nursing documentations show signs and symptoms under the nursing diagnosis of "decreased cardiac output," such as frequent pitting edema, fatigue, and dyspnea on exertion. Free-text nursing notes also provided information regarding changes in the patients' conditions, including frequent observations of NSVT, bleeding, and noncompliance. In particular, ventricular

Table 3 *Nursing Diagnoses for Patients with LVAD (n = 127).*

Characteristics	Readmission (n = 85)	Nonreadmission (n = 42)	Total (n = 127)	χ^2 or t	*p*
	n (%) or mean ± SD				
Number of nursing diagnoses	4.85 ± 1.53	4.29 ± 0.89	4.66 ± 1.38	−2.60	.010
Decreased cardiac output	85 (100.0)	42 (100.0)	127 (100.0)	-	-
Risk for bleeding: Anticoagulation therapy	85 (100.0)	42 (100.0)	127 (100.0)	-	-
Ventricular assist device[a]	85 (100.0)	42 (100.0)	127 (100.0)	-	-
Risk for infection	63 (74.1)	33 (78.6)	96 (75.6)	0.30	.583
Ineffective airway clearance	24 (28.2)	3 (7.1)	27 (21.3)	7.47	.006
Risk for transmission of infection[a]	12 (14.1)	5 (11.9)	17 (13.4)	0.12	.730
Risk for aspiration	13 (15.3)	1 (2.4)	14 (11.0)	4.78	.034[c]
Impaired skin integrity	9 (10.6)	1 (2.4)	10 (7.9)	2.61	.163[c]
Management of arrhythmia[a]	5 (5.9)	4 (9.5)	9 (7.1)	0.57	.477[c]
Impaired swallowing	4 (4.7)	1 (2.4)	5 (3.9)	0.40	1.000[c]
Excess fluid volume	4 (4.7)	1 (2.4)	5 (3.9)	0.40	1.000[c]
Acute confusion	8 (9.4)	0 (0.0)	8 (6.3)	4.22	.052[c]
Others[b]	10 (11.8)	3 (7.1)	13 (10.2)	0.65	.542[c]
Total (multiple responses)	407	178	585		

Note. LVAD = left ventricular assist device; SD = standard deviation.
[a] These are nursing diagnoses that have been established for the management of cardiovascular patients with LVADs in the study hospital, although they are not part of the NANDA-I classification.
[b] Others include impaired gas exchange, impaired urinary elimination, risk of electrolyte imbalance, and risk of ineffective peripheral tissue perfusion.
[c] Fisher's exact test.

Table 4 *Nursing Records and Free-text Nursing Notes for Patients with LVAD (n = 127).*

Categories	Readmission (n = 85)	Nonreadmission (n = 42)	Total (n = 127)	χ^2 or t	*p*
	n (%)				
Nursing records of signs and symptoms					
Yes	52 (61.2)	11 (26.2)	63 (49.6)	13.76	< .001
No	33 (38.8)	31 (73.8)	64 (50.4)		
Signs and symptoms under the nursing diagnosis of "decreased cardiac output"					
Pitting edema	23 (27.1)	5 (11.9)	28 (22.0)	3.76	.053
Fatigue	16 (18.8)	1 (2.4)	17 (13.4)	6.56	.010
Dyspnea on exertion	12 (14.1)	2 (4.8)	14 (11.0)	2.51	.141[c]
Dizziness	6 (7.1)	3 (7.1)	9 (7.1)	0.00	1.000[c]
Nausea/vomiting	6 (7.1)	1 (2.4)	7 (5.5)	1.18	.424[c]
Dyspnea	2 (2.4)	2 (4.8)	4 (3.1)	0.54	.599[c]
Palpitation	2 (2.4)	1 (2.4)	3 (2.4)	0.00	1.000[c]
Tachycardia	2 (2.4)	0 (0.0)	2 (1.6)	1.00	1.000[c]
Peripheral coldness	1 (1.2)	0 (0.0)	1 (0.8)	0.50	1.000[c]
Irritability	1 (1.2)	0 (0.0)	1 (0.8)	0.50	1.000[c]
Total (multiple responses)	71	15	86		
Free-text nursing notes					
Yes	42 (49.4)	7 (16.7)	49 (38.6)	12.72	<.001
No	43 (50.6)	35 (83.3)	78 (61.4)		
Details of free-text nursing notes					
NSVT	33 (38.8)	13 (31.0)	46 (36.2)	0.75	.385
Other bleeding (epistaxis, hemoptysis, and hematuria)	9 (10.6)	3 (7.1)	12 (9.4)	0.39	.749[c]
Noncompliance	10 (11.8)	2 (4.8)	12 (9.4)	1.61	.334[c]
Pain	7 (8.2)	1 (2.4)	8 (6.3)	1.63	.269[c]
GI bleeding	5 (5.9)	0 (0.0)	5 (3.9)	2.57	.170[c]
Neurological change	5 (5.9)	0 (0.0)	5 (3.9)	2.57	.170[c]
LVAD management[a]	4 (4.7)	1 (2.4)	5 (3.9)	0.40	1.000[c]
LVAD wound problem	3 (3.5)	2 (4.8)	5 (3.9)	0.11	1.000[c]
Poor oral intake	5 (5.9)	0 (0.0)	5 (3.9)	2.57	170[c]
Fever	3 (3.5)	1 (2.4)	4 (3.1)	0.12	1.000[c]
Others[b]	8 (9.4)	0 (0.0)	8 (6.3)	4.22	052[c]
Total (multiple responses)	92	23	115		

Note: GI = gastrointestinal; LVAD = left ventricular assist device; NSVT = nonsustained ventricular tachycardia.
[a] LVAD management included dressing, battery replacement, range of physical movements, daily living precautions, and management of LVAD alarms.
[b] Others include abdominal discomfort, delirium, depression, dysuria, cardiac device shock, international normalized ratio (INR) prolongation, sleep disorder, and syncope.
[c] Fisher's exact test.

arrhythmias and bleeding have been reported as significant causes of readmission in patients with LVADs [12,13]. Although not statistically significant, a previous study considering the factors of primary caregivers [6] suggests that nurses must not only assess and document critical changes in patient status and therapeutic adherence by both the patient and their caregiver but also maintain continuity in nursing care to prevent readmissions. Therefore, nurses should provide patients with individualized nursing intervention such as symptom control, nutrition, and physical activity to patients depending on their stage of recovery [33–35].

Table 5 *Factors Associated with Readmission in Patients with LVAD (n = 127).*

	Categories	B	S.E.	Wald	*p*	OR	95% CI
Age		−.02	0.03	0.47	.495	0.98	0.92–1.04
BMI		−0.15	0.11	1.93	.165	0.86	0.69–1.06
Employment status (Ref: unemployed)	Employed	−.35	0.79	0.20	.656	0.70	0.15–3.29
	Leave of absence	−.08	1.20	0.01	.941	0.92	0.09–9.65
Pain medication	Yes	.08	0.77	0.01	.917	1.08	0.24–4.86
LVAD indication (Ref: DT)	BTT	−.62	0.88	0.49	.482	0.54	0.10–3.00
Pulse		.003	0.03	0.01	.919	1.00	0.95–1.06
NYHA class (Ref: Class I)	II	1.99	1.01	3.88	.049	7.29	1.01–52.73
	III	3.85	1.46	6.99	.008	47.14	2.71–819.95
Oxygen therapy	Yes	.43	0.76	0.32	.570	1.54	0.35–6.76
ICU stay	Yes	1.59	1.02	2.44	.119	4.92	0.67–36.34
LVAD alarm	Yes	.50	0.76	0.43	.512	1.65	0.37–7.30
Platelet count		−.003	0.00	0.88	.349	0.98	0.99–1.00
PT (INR)		3.49	1.14	9.36	.002	32.65	3.50–304.75
NT-proBNP		.000	0.00	0.12	.726	1.00	1.00–1.00
Estimated GFR		−0.001	0.01	0.02	.889	1.00	0.98–1.02
Number of nursing diagnoses		−0.15	0.31	0.22	.639	0.86	0.47–1.59
Nursing records of signs and symptoms	Yes	.06	0.68	0.01	.930	1.06	0.28–3.98
Free-text nursing notes	Yes	2.03	0.79	6.55	.011	7.58	1.61–35.79
Intercept		−2.40	4.70	0.26	.609	0.09	
Nagelkerke R^2 = .642							
The Hosmer–Lemeshow goodness-of-fit test = 11.490 (p = .175)							

Note. BMI = body mass index; BTT = bridge to transplantation; CI = confidence interval; DT = destination therapy; GFR = glomerular filtration rate; ICU = intensive care unit; INR = international normalized ratio; LVAD = left ventricular assist device; NT-proBNP = N-terminal pro-B-type natriuretic peptide; NYHA = New York Heart Association; OR = odds ratio; PT = prothrombin time; S.E. = standard error.

Logistic regression revealed that the factors associated with the readmission of patients with LVAD were NYHA classes II and III, increased PT, and the presence of free-text nursing notes. These findings are consistent with previous studies that highlighted NYHA Class and PT as significant risk factors [7,22]. The results of a previous study that revealed a statistically significant difference in medication adherence based on medication knowledge [36] showed that nurses can play a critical role in supporting patients to improve their medication self-efficacy and adherence for the maintenance of appropriate PT levels.

Nurses should evaluate and provide strategies for managing heart failure symptoms, support patients on anticoagulation therapy before discharge, and emphasize the importance of recognizing bleeding risks post discharge [6,37]. Furthermore, nurses also play a vital role in conducting regular follow-ups to manage LVADs and facilitating smooth transitions of care in collaborating caregivers [38]. This not only helps patients during their hospital stay but also supports them in their daily lives after discharge by encouraging the practice of physical, psychological, and social self-care [39]. Proactive monitoring by nurses for early signs of deterioration, coupled with timely nursing interventions, is essential in reducing the risk of readmissions. Accurate assessment and appropriate response are therefore essential when providing nursing care to patients with LVADs.

Nurses in clinical settings must closely monitor symptoms in patients with LVADs. The findings from this study can help identify the specific symptoms reported by patients, thus offering a solid foundation for guiding appropriate interventions.

Strengths and Limitations

This study has a strength as it is the first study to attempt to identify the factors involving readmission of patients with LVADs in South Korea. Our study raises the awareness of healthcare professionals, especially nurses, about the factors associated with the readmission of patients with LVADs. Nurses should be aware of the critical importance of nursing documentation that accurately reflects the patient's condition for monitoring and nursing care planning.

This study has several limitations. First, it was conducted using EMR records from a single institution, which may limit the generalizability of the findings. However, it is noteworthy that the study hospital has the highest number of LVAD implantations and patient cases in South Korea to date, making the results significant within this context. Second, data collection was limited to the in-hospital period, preventing the evaluation of postdischarge factors such as diet, exercise, daily activities, and sleep patterns on readmission. Moreover, unlike previous studies [5,7] that examined readmission risk factors at multiple timepoints after discharge, this study lacks long-term follow-up data. Future research should incorporate comprehensive data on postdischarge conditions at multiple timepoints to provide a deeper understanding of risk factors. Additionally, nursing diagnoses included those in the NANDA-I classification and those in the local codes of the study hospital. In the future, it would be preferable to record these diagnoses using standardized nursing terminologies to facilitate a multicenter study.

Conclusions

This study identified key factors associated with readmission in patients with LVADs, including NYHA classes II and III, elevated PT, and the presence of free-text nursing notes. Patients who report symptoms related to decreased cardiac output, have NYHA Class II or higher, require maintenance of therapeutic PT levels, or have condition changes documented in the free-text nursing notes should receive individualized discharge counseling. The findings of this study provide valuable insights into the preoperative and postoperative clinical status and nursing documentation of patients with LVADs, underscoring the importance of early identification of readmission risk factors, such as LVAD alarm, worsening cardiac symptom, infection, or bleeding. These results may help guide nurses in developing individualized care strategies to minimize readmission risks.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Appendix A. Supplementary data

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