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Association of Hospital Volume with 30-Day Readmission Following Left Ventricular Assist Device Implantation

Udhay Krishnan, MD¹, Aayush Visaria, MPH², Samprit Banerjee, PhD³, Luke K. Kim, MD¹, Maria G. Karas, MD¹, Irina Sobol, MD¹, Evelyn M. Horn, MD¹, Parag Goyal, MD MSc^{1,4}

¹Division of Cardiology, Department of Medicine, Weill Cornell Medicine (New York, NY)

²Rutgers New Jersey Medical School (Newark, NJ)

³Department of Healthcare Policy & Research, Weill Cornell Medicine (New York, NY)

⁴Division of General Internal Medicine, Department of Medicine, Weill Cornell Medicine (New York, NY)

Readmissions within 30 days after left ventricular assist device (LVAD) implantation are common, occurring in 30% of patients (1). This is important because 30-day readmissions increase patient morbidity and are costly to the healthcare system. Recent studies have shown an inverse relationship between hospital procedural volume and readmission rates for other interventions performed in patients with HF including trans-catheter mitral valve repair and trans-catheter aortic valve replacement (2, 3). Whether a similar relationship exists for LVAD implantation is unknown. The purpose of this study was to examine whether LVAD hospital volume was independently associated with 30-day all-cause readmission rates after LVAD implantation using the Nationwide Readmissions Database (NRD).

Details of the NRD have been described previously (2). Briefly, the NRD is the largest nationally-representative all-payer inpatient administrative database in the United States. We examined patients aged ≥ 18 years discharged alive following LVAD implantation in January–November 2014 using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) code 37.66. Similar to prior studies, we excluded patients discharged in December 2014 since patients are only tracked across hospitals within a given calendar year and complete 30-day readmission data is not available for December. We also excluded patients with missing data for length of stay or patient linkage number because this precluded identification of a 30-day readmission.

To determine hospital volume quartile for LVAD implantation, we calculated the total number of LVAD implantations performed at each hospital between January 1st and December 31st 2014, and classified patients into quartiles based on hospital volume. The primary outcome was 30-day all-cause readmission.

To determine whether LVAD hospital volume was independently associated with 30-day all-cause readmission, we constructed a multivariable logistic regression model incorporating: age, sex, payer status, income quartile, discharge disposition, Elixhauser weighted comorbidity index (4), coronary artery disease, atrial and ventricular arrhythmias, use of mechanical circulatory support, and pre-implant and post-implant length of stay.

For all analyses, we accounted for the complex survey design by using stratification and cluster variables. We weighted the data to produce nationally-representative estimates. For missing data (11% for pre- and post-implant length of stay; 2.9% for income quartile; 1.1% for payer status), we used multiple imputation. We conducted analyses using SAS 9.4 (Cary, North Carolina). All p-values were two-sided with significance threshold <0.05.

We examined 1,311 eligible patients who underwent LVAD implantation from 80 hospitals. Mean age was 56.1±0.5 years and 32.3% were women (Table). Median hospital volume in 2014 was 40 LVAD implantations. The majority of LVAD implantations were performed in large, urban, teaching hospitals across all quartiles. In-hospital mortality rates were similar between the lowest (23 implantations) and highest volume quartiles (16.1% vs. 12.4%, p=0.11).

Overall, 27% (95% CI 25-30%) of patients were readmitted within 30 days of discharge following LVAD implantation. The 30-day readmission rates were similar across hospital volume quartiles—lowest quartile 26.6% (95% CI 22-32%); second quartile 27% (95% CI 23-34%), third quartile; 25.7% (95% CI 22-32) and highest quartile; 29.9% (95% CI 25-35). In multivariable-adjusted analysis, there was no association between LVAD hospital volume and 30-day readmission rate (Table).

To ensure the robustness of our findings, we performed a sensitivity analysis where we repeated the analysis using different volume cutoffs described in a prior study (5): very low (10 LVAD procedures), low (11-30), medium (31-50) and high (51). Our findings were similar—the adjusted odds ratio of 30-day readmission for very low volume (vs. high volume) was 0.94 (95% CI 0.67-1.32). We also repeated the analysis treating LVAD hospital volume as a continuous variable, revealing an odds ratio of 1.00 (95% CI 0.99-1.01).

In this nationwide study of LVAD recipients, we found that LVAD hospital volume was not associated with 30-day readmissions following LVAD implantation. Previous studies examining the impact of hospital volume on short-term outcomes after LVAD implantation have focused primarily on in-hospital mortality with conflicting results. Two prior studies using administrative data prior to 2012 found LVAD hospital volume and surgeon volume to be independent predictors of mortality (10, 11). However, a more contemporary analysis of INTERMACS data did not show an association between hospital volume and mortality (6). To our knowledge, this is the first study to examine the association of LVAD hospital volume with 30-day readmissions following LVAD implantation. Our observation that readmission rates were similar across volume quartiles is reassuring, and likely reflects standardized practice patterns which include meticulous blood pressure control, driveline care, and anticoagulation management as well as post-implant follow-up by a multi-disciplinary team. Consequently, outcomes may be less dependent on the surgical experience of a hospital.

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Table 1.

Differences According to LVAD Hospital Procedure Volume, N (%) unless otherwise noted

	Entire Cohort	1 st Quartile (23)	2 nd Quartile (24-40)	3 rd Quartile (41-49)	4 th Quartile (50)	P-value
Number	1,311	324	354	325	308	
Age, mean years (SD)	56.1 (0.5)	56.6 (1.0)	54.6 (1.3)	56.4 (0.8)	56.7 (0.7)	0.39
Male sex	1035 (77.7)	260 (77.4)	274 (78.3)	256 (77.4)	245 (77.7)	0.58
Discharge Disposition						0.03
Home without services	418 (27.6)	115 (33.3)	120 (35.9)	92 (20.9)	91 (22.8)	
Short-term hospital	44 (2.7)	4 (1.0)	15 (3.6)	15 (3.9)	10 (2.3)	
Skilled Nursing Facility or Other	127 (11.8)	32 (9.7)	19 (6.0)	20 (6.0)	56 (21.5)	
Home Health Care	722 (57.9)	173 (56.0)	200 (54.6)	198 (69.2)	151 (53.4)	
Elixhauser Comorbidity Index, mean (SD)	24.9 (1.4)	25.2 (1.3)	23.8 (3.9)	27.2 (2.0)	23.8 (3.9)	0.07
Comorbidities: Cardiac						
Coronary Artery Disease	619 (46.9)	163 (49.2)	163 (45.5)	156 (51.5)	137 (43.1)	0.79
Atrial Fibrillation/Flutter	689 (52.8)	161 (48.6)	198 (55.0)	168 (54.7)	162 (52.5)	0.98
Ventricular Arrhythmia	617 (9.7)	154 (51.8)	168 (45.9)	155 (50.9)	140 (47.3)	0.90
Comorbidities: Non-Cardiac						
Alcohol Abuse	32 (2.0)	12 (2.9)	7 (1.8)	5 (1.2)	8 (2.1)	0.34
Chronic pulmonary disease	233 (18.3)	54 (18.1)	68 (19.8)	56 (17.2)	55 (18.2)	0.97
Coagulopathy	441 (35.4)	102 (32.9)	121 (35.7)	119 (38.0)	99 (35.1)	0.95
Depression	151 (12.0)	37 (12.5)	33 (9.4)	43 (13.2)	38 (12.5)	0.40
Diabetes, uncomplicated	323 (22.9)	85 (24.5)	91 (24.7)	82 (24.1)	65 (19.6)	0.81
Hypertension	571 (43.4)	138 (42.3)	147 (41.7)	163 (55.8)	123 (36.3)	0.20
Liver disease	35 (2.4)	10 (2.9)	11 (2.7)	6 (1.5)	8 (2.5)	0.77
Fluid and electrolyte disorders	836 (65.2)	216 (68.8)	238 (66.6)	201 (63.5)	181 (63.1)	0.89
Obesity	243 (18.1)	67 (20.7)	79 (22.7)	54 (20.7)	43 (14.1)	0.23
Paralysis	30 (2.6)	8 (3.1)	7 (2.3)	10 (4.0)	5 (1.6)	0.14
Peripheral vascular disorders	106 (8.0)	34(11.2)	29 (8.2)	23 (7.0)	20 (6.4)	0.06
Renal failure	620 (48.4)	144 (44.4)	152 (40.7)	168 (54.6)	156 (52.0)	0.12
In-Hospital Events/Procedures						
Mechanical Circulatory Support	421 (35.9)	98 (32.6)	84 (24.6)	134 (48.8)	105 (36.7)	0.08
Pre-implant length of stay, median (IQR)	3 (8-14)	6 (2-17)	8 (2-15)	8 (3-15)	8 (4-12)	0.06
Post-implant length of stay, median (IQR)	20 (15-32)	24 (18-34)	19 (14-30)	19 (14-32)	20 (15-29)	0.001
Hospital Characteristics						

	Entire Cohort	1 st Quartile (23)	2 nd Quartile (24-40)	3 rd Quartile (41-49)	4 th Quartile (50)	P-value
Large Hospital	1170 (91.1)	248 (79.7)	334 (95.3)	325 (100)	263 (89.4)	0.17
Teaching	1304 (99.3)	317 (97.0)	354 (100)	325 (100)	308 (100)	0.69
Private, Not-profit	1116 (88.8)	262 (79.6)	254 (76.4)	292 (93.4)	308 (100)	0.06
Large Metropolitan Location	1110 (78.7)	251 (71.9)	276 (68.8)	325 (100)	258 (74.7)	0.12
Association with 30-day All-Cause Readmission						
Unadjusted Odds Ratio (95% Confidence Interval)	--	0.90 (0.61-1.33)	0.77 (0.51-1.16)	0.86 (0.55-1.34)	Reference	
Adjusted Odds Ratio (95% Confidence Interval)	--	0.89 (0.67-1.17)	0.81 (0.62-1.06)	0.74 (0.51-1.05)	Reference	

SD – Standard Deviation, IQR – Interquartile Range

P-value calculated using Rao-Scott Chi-Square test for categorical variables and design-adjusted ANOVA for continuous variables.