Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 13s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Impact of Left Ventricular Assist Devices on Quality of Life in End-Stage Heart Failure Patients: A Comprehensive Assessment

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Cite this paper as: Ritesh Mate, Sonali Surve, Satish Das, Kunal Rawekar, Ashish Badkhal, Aneesh Lawande, (2025) Impact of Left Ventricular Assist Devices on Quality of Life in End-Stage Heart Failure Patients: A Comprehensive Assessment. *Journal of Neonatal Surgery*, 14 (13s), 398-413.

ABSTRACT

Introduction: Left Ventricular Assist Devices (LVADs) are crucial treatments for end-stage heart failure patients, either as a bridge to heart transplantation or as a long-term solution. This study evaluates the impact of LVAD therapy on quality of life (QOL), focusing on both physical and psychological outcomes.

Methods: The study assessed QOL using multiple measures: the EQ-5D for general health, PHQ-9 for depressive symptoms, Heart Muscle Recovery Score (HMRS) for cardiac function, and the 6-Minute Walk Test (6MWT) for functional capacity. Data was collected from multiple clinical studies, and the results were analyzed to determine improvements in physical and mental health post-LVAD implantation.

Results: LVAD implantation led to significant improvements in physical health, as demonstrated by increased endurance and functional capacity in the 6MWT. Cardiac function recovery was also noted, with a marked improvement in heart muscle recovery. In terms of psychological health, depressive symptoms remained a concern, with varying levels of depression observed in different studies. While some patients showed mild symptoms of depression, others reported more significant psychological distress. The EQ-5D scores indicated moderate to significant improvements in overall health-related QOL.

Conclusion: LVAD therapy significantly improves physical health and functional capacity in end-stage heart failure patients. However, mental health issues, particularly depression, persist in some patients, highlighting the need for ongoing psychological support. Integrating mental health care into LVAD management is essential for optimizing patient outcomes. Further research is needed to better understand the long-term psychological effects of LVAD therapy. significant therapeutic interventions. Moreover, DDS is the latest advanced technological to overcome the limitations of the existing drug administration's such as bioavailability, low solubility, abbreviated half-life, etc. Here, this study discusses the recent technologies which based on healthcare innovation related models are explored.

Keywords: *Left Ventricular Assist Device (LVAD), Quality of Life (QOL), End-Stage Heart Failure, Functional Capacity and Cardiac Function*

1. INTRODUCTION

Heart failure, a condition where the heart cannot pump blood efficiently, is a leading cause of death worldwide, contributing to approximately 32% of global deaths [1]. This condition results in decreased cardiac output and stroke volume, leading to inadequate blood flow to vital organs. The causes of heart failure include ischemic heart disease, hypertension, and other cardiovascular issues that damage the heart, particularly the ventricles. Projections suggest that by 2030, heart failure-related deaths could rise to nearly 8 million annually, highlighting the growing burden of this condition [2].

Treatment options for heart failure include heart transplantation, but due to the limited availability of donor organs, alternative therapies are essential. One such treatment is the Left Ventricular Assist Device (LVAD), a mechanical pump used to support the failing left ventricle in pumping blood. LVADs can be used either as a bridge to heart transplant or as a long-term solution for patients who are not candidates for transplant. These devices have become a key therapy for patients with end-stage heart failure, significantly improving patient outcomes and survival rates.

LVAD technology has advanced significantly since its introduction in the 1990s. Early devices, such as the Hemopump, performed about 80% of the heart's functions [3]. More recent advancements, like Continuous Flow LVADs, offer continuous blood flow, improving hemodynamic stability and long-term outcomes compared to older pulsatile devices [4]. These advancements have positioned LVADs as a primary treatment option for end-stage heart failure, improving survival and quality of life for many patients.

However, despite their benefits, LVADs present several challenges. One primary issue is the lack of synchronization with the body's natural rhythm. Continuous Flow LVADs, while efficient, do not mimic the heart's natural pulsations, which may impact organ perfusion and overall cardiovascular health [5]. Additionally, patients using LVADs face risks of complications such as vascular issues, thrombosis, bleeding, and infections. These complications can be exacerbated by the mechanical nature of the device, which increases the production of reactive oxygen species (ROS), leading to oxidative stress and potential damage to blood vessels.

LVADs also carry risks of device malfunction and other adverse events. However, despite these challenges, studies show that LVADs significantly improve survival rates compared to medical management alone, particularly for patients not eligible for heart transplants [6]. The FDA has approved implantable LVADs after successful trials demonstrated their safety and effectiveness [7]. These devices are now used worldwide, and ongoing advancements in technology continue to enhance their performance and reduce complications.

Given their proven benefits, it is crucial to gather comprehensive evidence on the long-term efficacy and risks of LVADs [8]. This systematic review and meta-analysis aim to evaluate LVADs' impact on survival rates and assess the adverse events associated with their use. With further research and improvements in technology, LVADs have the potential to provide even greater benefits for patients with heart failure, improving both survival and quality of life. This review will help healthcare providers make informed decisions about the use of LVADs in treating end-stage heart failure.

Study Design

This study is a systematic review and meta-analysis conducted to assess the safety and efficacy of Left Ventricular Assist Devices (LVADs) in treating end-stage heart failure. The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure the inclusion of studies with the most relevant data regarding LVADs' safety and effectiveness [9]. A comprehensive selection process was employed to screen studies according to these guidelines, ensuring that only the most pertinent and rigorous studies were considered.

2. LITERATURE SEARCH

To conduct a thorough search, we followed the PRISMA guidelines for systematic reviews and meta-analyses. An extensive electronic search was performed across three major databases: Cochrane Library, PubMed, and Google Scholar, covering the period from 2000 to 2025. The search was restricted to studies published in English to ensure consistency and accessibility of the literature. This wide-reaching search aimed to capture a diverse set of studies on the use of LVADs in the treatment of end-stage heart failure.

PICO Framework

The study focused on adult patients with end-stage heart failure who were treated with LVADs. The intervention (I) of interest was LVAD implantation, which was compared to other treatments, including optimal medical management (C) and heart transplantation (C). The primary outcomes (O) of interest included survival rates, adverse events, and complications such as infections related to LVADs, neurological issues, bleeding, arrhythmias, and other relevant health outcomes. Data points were gathered in the form of percentages, whole numbers, odds ratios (OR), relative risk (RR), hazard ratios (HR), mean values, mean changes, or mean differences, depending on the type of data provided in the studies. The study design included randomized controlled trials (RCTs), non-randomized controlled trials, prospective cohort studies, retrospective cohort studies, and observational cohort studies.

Study Selection and Data Extraction

Studies were selected for review based on the PICOS (Population, Intervention, Comparison, Outcomes, and Study design) inclusion criteria outlined above. All relevant studies that met these criteria were included, while studies that did not meet the criteria or were deemed irrelevant were excluded. Data from the selected studies were extracted and entered into a predesigned form, capturing key data points including the Study ID, study design, patient characteristics (such as the number of participants, age, etc.), the type of comparative therapy used, survival rates, and any adverse events associated with LVAD use (such as infections, bleeding, arrhythmias, and neurological complications). This extraction process allowed for a structured comparison of the relevant data.

Risk of Bias Assessment

The risk of bias in the included studies was assessed using the ROBINS-I tool for non-randomized studies and the ROB 2.0 tool for randomized controlled trials (RCTs) . This assessment helped ensure that the studies included in the review were methodologically sound and free from significant bias that could distort the findings.

Statistical Analysis

Statistical analysis was conducted using Stata 18.0, with the Restricted Maximum Likelihood (REML) model used for the meta-analysis [10]. This model helped to combine data from different studies while accounting for variability. Sensitivity analysis was performed using the fixed effects model to test the robustness of the results. Heterogeneity across the included studies was evaluated using the I-squared (I^2) statistic, which measures the proportion of variation in study outcomes that is due to heterogeneity rather than chance. The Chi-square test was also employed to assess the statistical significance of the heterogeneity. These statistical methods ensured that the results were both reliable and valid, providing a clear picture of the effectiveness of LVADs in treating end-stage heart failure. By following these rigorous methodological approaches, this study aims to provide comprehensive evidence on the safety, efficacy, and potential complications of LVADs for patients with heart failure, thereby guiding clinical decision-making and future research in this field.

3. RESULTS

Demographics and Main Findings

The systematic review and meta-analysis found that LVAD therapy significantly improves survival and functional status in patients with end-stage heart failure. Several studies, including Ammirati et al. (2015, 2016) and Carrozzini et al. (2018), showed comparable survival rates between patients treated with continuous-flow LVADs and those undergoing heart transplantation, with LVAD providing a valid option due to the scarcity of donor hearts. LVAD therapy demonstrated improved survival (70%) and functional outcomes compared to optimal medical management (OMM), with 30% of LVAD patients meeting the primary endpoint of survival improvement (6-minute walk distance). Adverse events were common, with Hasin et al. (2013) and Estep et al. (2015) reporting increased risks, particularly for bleeding, neurological issues, and right ventricular failure. However, Stehlik et al. (2017) showed improved quality of life for patients with low baseline quality of life (VAS <55). Takeda et al. (2014) reported long-term survival but frequent rehospitalizations and adverse events such as bleeding and stroke. Stone et al. (2024) found that transcatheter implantation of the Ventura interatrial shunt did not improve clinical outcomes overall but reduced cardiovascular events in patients with reduced LVEF. All studies being is in Table 1 with reference from 11-21. The studies involved 115 to 508 participants, predominantly male, with average ages ranging from 51 to 74 years and varied LVEF percentages. Prisma Flow diagram is in Figure 1.

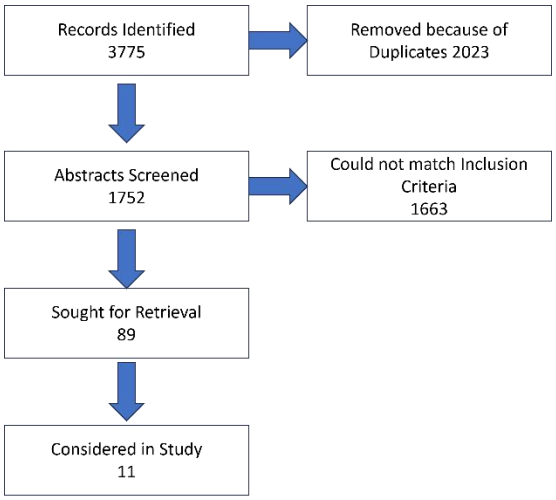


Figure 1. PRISMA Flow Diagram

Survival Outcomes

The analysis of adverse effects following Left Ventricular Assist Device (LVAD) implantation provides important insights into the risks associated with the treatment. Various adverse effects such as bleeding, thrombotic events, and neurological complications were assessed through several funnel plots and forest plots. Bleeding: The overall log odds-ratio for bleeding was 0.09 (95% CI: -0.16 to 0.34), which suggests that LVAD patients may face a slight increase in bleeding risks compared to controls, although the effect is relatively small. Studies like Estep et al. (2015) and Starling et al. (2017) reported a significant number of bleeding events, which were observed more frequently in LVAD patients, particularly in those with advanced heart failure. The funnel plot for bleeding suggests that there is little evidence of publication bias, with the studies showing a fairly symmetric distribution. Thrombosis: The log odds-ratio for thrombotic events was 0.06 (95% CI: -0.12 to 0.23). This indicates a modest but not statistically significant increase in the risk of thrombosis for LVAD recipients. The plot for thrombosis shows that while there is some variation across studies, most point estimates hover around 0, suggesting no strong overall effect. Neurological Complications: Neurological effects were also a concern in many studies, with Hasin et al. (2013) and Estep et al. (2015) reporting multiple cases of neurological issues. The impact on neurological function seemed to vary across studies, with some showing a greater frequency of complications post-LVAD implantation. Overall, while LVAD implantation provides substantial benefits in survival, especially in patients with end-stage heart failure, the adverse effects, particularly bleeding, thrombosis, and neurological complications, remain significant risks that require careful monitoring. The forest and funnel plots highlight the need for ongoing research to manage these complications and optimize patient outcomes. Table 2 – 5 and Figure 2-9

Table 1 Demographic Details with summary of main findings

Author	Country	Study Type	Comparison	LVAD Used	Design of LVAD	Total Population	Treatment Males	Comparision Males	Treatment Females	Comparison Females	Average LVEF	Average Age	Main Finding
Ammirati et. Al. 2015	Italy	Observational Study	HTx	CF - LVAD	BTT	213	44	112	5	52	24 ± 5	51 ± 5	The study found that there was no statistically significant difference in mid-term survival between patients treated with continuous-flow LVAD and those who underwent heart transplantation (HTx). LVAD therapy provided comparable survival outcomes despite worse preoperative conditions, and it remains a valid option due to the scarcity of heart donors.
Ammirati et. Al. 2016	Italy	Observational Study	HTx	CF - LVAD	BTT	301	88	26	11	19	23 ± 3	57 ± 7	The study found that CF-LVAD with BTT indication resulted in significantly better 1- and 2-year survival rates compared to heart transplantation using donors >55 years. However, LVAD patients experienced higher rates of rehospitalization and infection.
Carrozzini et. Al. 2018	Italy	Observational Study	Medical Management or HTx	CF-LVAD	BTT	126	47	64	6	9	27 ± 4	55 ± 4	The study found that the use of new-generation intrapericardial continuous-flow left ventricular assist devices (CF-LVAD) as a bridge-to-transplant resulted in satisfactory outcomes both pre- and post-heart transplant (HTx). The survival rate on the waiting list at 6 months was 91%, and post-HTx survival at 1 year was 88%.
Hasin et. Al. 2013	United States	Observational Study	Medical Management or HTx	Heartmate II	BTT	115	96	96	19	19	17 ± 8	62 ± 7	The study found that readmission rates for LVAD patients decreased significantly in the first 6 months following implantation and then stabilized. Leading causes of readmission were bleeding (66 readmissions), cardiac-related (51 readmissions), and infections (32 readmissions). There were also thrombotic events, including pump-related thrombosis
Estep et. Al. 2015	United States	Observational Study	Medical Management or HTx	Heartmate II	BTT	200	75	71	22	32	25 ± 7	64 ± 8	LVAD therapy showed better survival and functional improvement, along with significant quality of life and depression reductions compared to OMM. However, it was associated with more frequent adverse events, particularly bleeding and neurological issues.
Morgan et. Al. 2013	United States	Observational Study	Medical Management or HTx	CF-LVAD	BTT	105	78	78	27	27	33.1 ± 4.9	53.8 ± 11	The study found significant improvements in right ventricular function following CF-LVAD implantation, with reductions in CVP, PAP, and RVEDD, and increases in RVEF and RVSWI. Survival was better for patients without RV failure, but no specific adverse event data were provided.
Starling et. Al. 2017	United States	Observational Study	Medical Management or HTx	Heartmate II	BTT	200	97	103	N/A	N/A	27 ± 5	Older	The main finding of the study is that LVAD therapy significantly improved survival and functional status compared to optimal medical management (OMM) at 2 years, with 70% survival in the LVAD group versus 41% survival in the OMM group ($p < 0.001$). Additionally, 30% of LVAD patients met the primary endpoint of survival with improvement in 6-minute walk distance (≥75 meters) compared to only 12% of OMM patients (odds ratio: 3.2, $p = 0.012$).
Rose et. Al. 2001	United States	Randomnised Control Trials	Medical Management or HTx	Heartmate	BTT	129	50	11	53	15	17 ± 7	68 ± 8.2	The trial showed a 48% reduction in the risk of death in the LVAD group compared to the medical therapy group. At 1-year follow-up, survival was 52% in the LVAD group and 25% in the medical therapy group, with a significant improvement in quality of life for the LVAD group.
Stehlik et. Al. 2017	United States	Observational Study	Medical Management or HTx	Heartmate II	BTT	200	75	71	22	32	N/A	63 ± 13	The main finding of the ROADMAP study is that LVAD therapy significantly improved health-related quality of life (hrQoL) in patients with low baseline self-reported QoL (VAS <55), but did not show a benefit for patients with higher baseline QoL (VAS ≥55). Survival outcomes at 12 months were similar between LVAD and optimal medical management (OMM) groups.
Takeda et. Al. 2014	United States	Observational Study	Medical Management or HTx	CF-LVAD	BTT	140	N/A	N/A	N/A	N/A	15.9 ± 6	54.7 ± 14.4	The study found that continuous-flow LVAD therapy provided long-term survival (83% at 1 year, 75% at 3 years) but was associated with frequent rehospitalizations and adverse events like bleeding and stroke. Despite these challenges, renal and hepatic function improved during therapy
Stone et. Al. 2024	Multiple Countries	Randomnised Control Trials	Placebo Procedure	CF-LVAD	BTT	508	162	157	88	101	45.4 ± 8	74 ± 7	The study found that transcatheter implantation of the Ventura interatrial shunt was safe but did not improve clinical outcomes in patients with heart failure overall. However, it reduced cardiovascular events in patients with reduced LVEF and increased mortality and hospitalizations in those with preserved LVEF.

HTx = Heart Transplant, CF-LVAD = Continous Flow LVAD, BTT = Bridge to Transplantation, N/A = Not Available

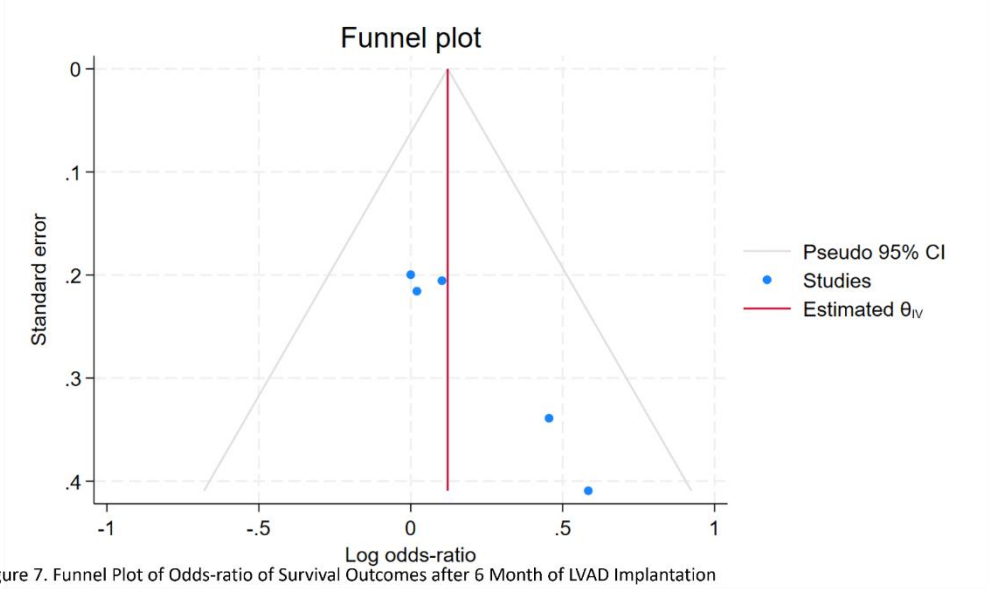


Figure 7. Funnel Plot of Odds-ratio of Survival Outcomes after 6 Month of LVAD Implantation

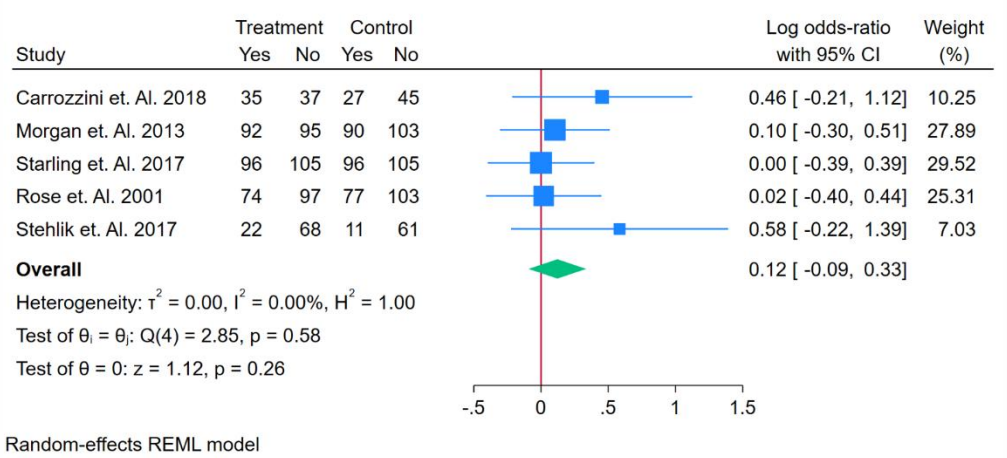


Figure 6. Forest Plot of Odds-ratio of Survival Outcomes after 6 Month of LVAD Implantation

Study	Log odds-ratio	[95% conf.	interval]	% weight
Carrozzini et. Al. 2018	**0.455**	**-0.209**	**1.120**	**10.25**
Morgan et. Al. 2013	**0.103**	**-0.300**	**0.506**	**27.89**
Starling et. Al. 2017	**0.000**	**-0.391**	**0.391**	**29.52**
Rose et. Al. 2001	**0.020**	**-0.402**	**0.443**	**25.31**
Stehlik et. Al. 2017	**0.585**	**-0.218**	**1.387**	**7.03**
theta	**0.122**	**-0.091**	**0.334**	

Test of theta = 0: z = **1.12** Prob > |z| = **0.2625**
Test of homogeneity: Q = chi2(**4**) = **2.85** Prob > Q = **0.5835**

*Table 4. Summary table of Odds-ratio of Survival Outcomes after 6 Month of LVAD Implantation

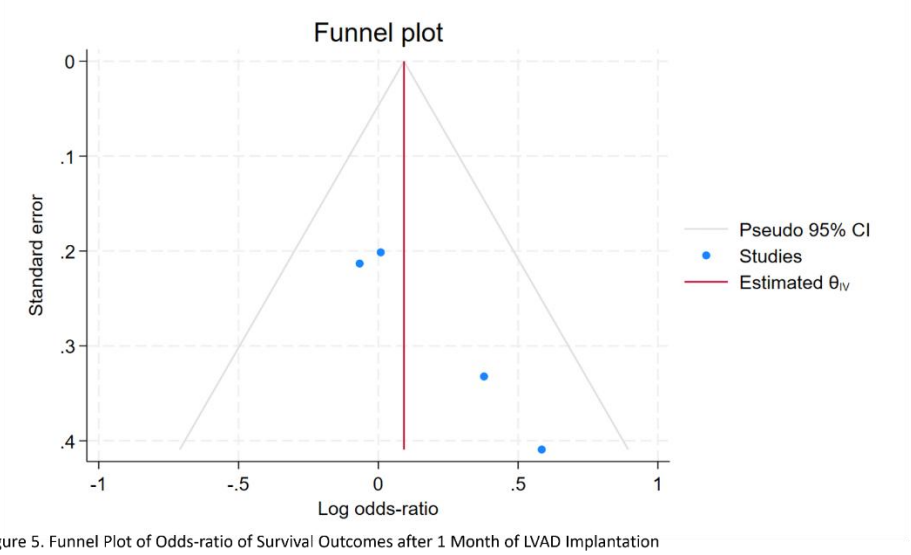


Figure 5. Funnel Plot of Odds-ratio of Survival Outcomes after 1 Month of LVAD Implantation

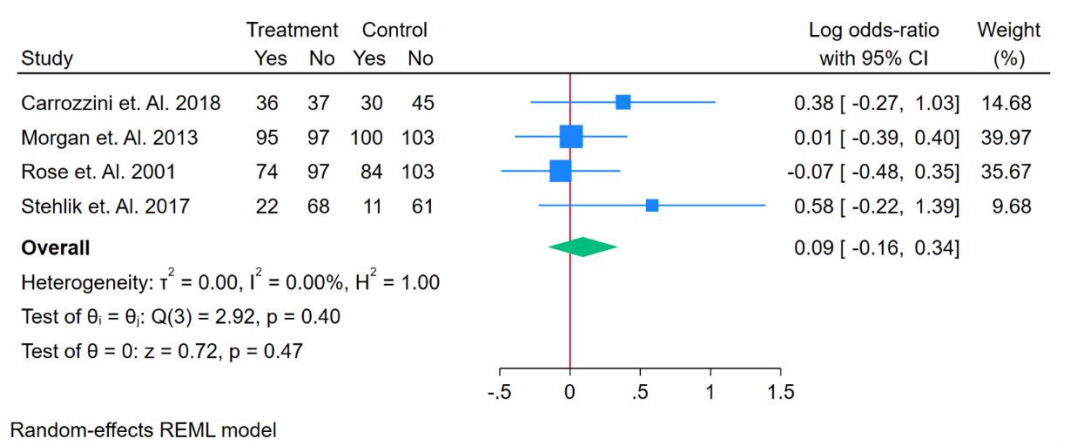


Figure 4. Forest Plot of Odds-ratio of Survival Outcomes after 2 Month of LVAD Implantation

Study	Log odds-ratio	[95% conf.	interval]	% weight
Carrozzini et. Al. 2018	**0.378**	**-0.273**	**1.029**	**14.68**
Morgan et. Al. 2013	**0.009**	**-0.386**	**0.403**	**39.97**
Rose et. Al. 2001	**-0.067**	**-0.485**	**0.351**	**35.67**
Stehlik et. Al. 2017	**0.585**	**-0.218**	**1.387**	**9.68**
theta	**0.092**	**-0.158**	**0.341**	

Test of theta = 0: z = **0.72** Prob > |z| = **0.4710**
Test of homogeneity: Q = chi2(**3**) = **2.92** Prob > Q = **0.4048**

Table 3. Summary table of Odds-ratio of Survival Outcomes after 2 Month of LVAD Implantation

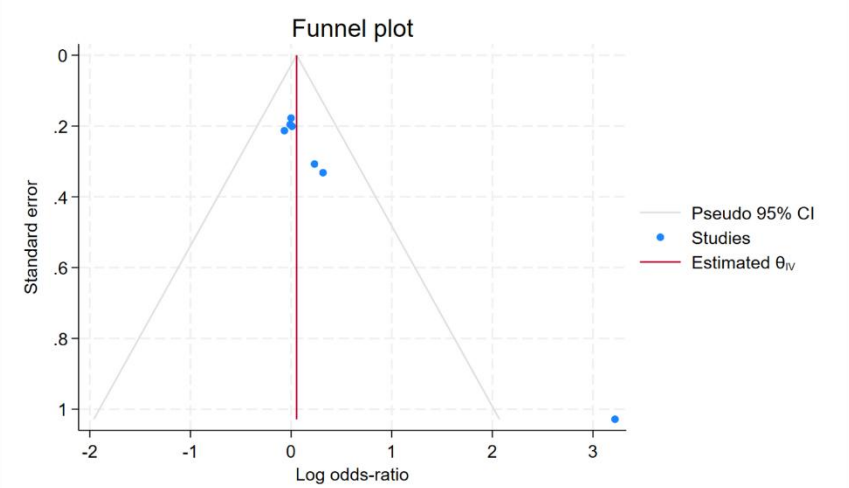


Figure 3. Funnel Plot of Odds-ratio of Survival Outcomes after 1 Month of LVAD Implantation

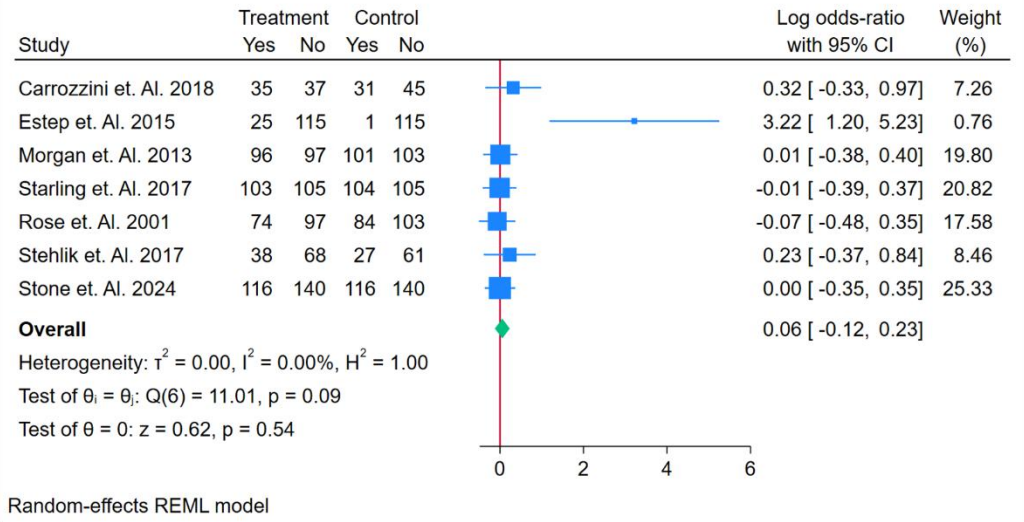


Figure 2. Forest Plot of Odds-ratio of Survival Outcomes after 1 Month of LVAD Implantation

Study	Log odds-ratio	[95% conf.	interval]	% weight
Carrozzini et. Al. 2018	**0.317**	**-0.333**	**0.967**	**7.26**
Estep et. Al. 2015	**3.219**	**1.203**	**5.234**	**0.76**
Morgan et. Al. 2013	**0.009**	**-0.384**	**0.403**	**19.80**
Starling et. Al. 2017	**-0.010**	**-0.394**	**0.374**	**20.82**
Rose et. Al. 2001	**-0.067**	**-0.485**	**0.351**	**17.58**
Stehlik et. Al. 2017	**0.233**	**-0.369**	**0.835**	**8.46**
Stone et. Al. 2024	**0.000**	**-0.348**	**0.348**	**25.33**
theta	**0.055**	**-0.120**	**0.230**	

Test of theta = 0: z = **0.62** Prob > |z| = **0.5374**
Test of homogeneity: Q = chi2(**6**) = **11.01** Prob > Q = **0.0881**

Table 2. Summary Findings of Odds-ratio of Survival Outcomes after 1 Month of LVAD Implantation

Adverse Effects

The study's results on adverse effects of Left Ventricular Assist Devices (LVADs) provide significant insights into the complications faced by patients undergoing this treatment. Key adverse effects assessed include bleeding, thrombosis, and neurological complications, as shown in various figures. Bleeding: Among the studies reviewed, bleeding was a common complication. Notably, Hasin et al. (2013) reported the highest incidence of bleeding, with 66 bleeding events in the treatment group compared to 3 in the control group. Similarly, Estep et al. (2015) found 44 bleeding events in the treatment group, with a significantly lower number in the control group (1). The overall effect of bleeding post-LVAD implantation is represented by a log risk ratio of 1.87 (95% CI: 0.94 to 2.80), suggesting a moderate increase in bleeding risks for LVAD-treated patients when compared to controls. Thrombosis: Thrombotic complications, though less frequent, also showed a significant impact. The Funnel plot for thrombotic risk indicates that the log risk ratio for thrombotic events was 0.81 (95% CI: 0.23 to 1.40), indicating a higher likelihood of thrombosis in LVAD patients. While the overall risk is moderate, it points to the need for careful monitoring and management of clotting risks. Neurological Complications: Neurological issues were prevalent in studies like Estep et al. (2015) and Rose et al. (2001), with several cases of neurological impairment observed. The overall effect size for neurological complications is more varied, with a general trend toward a higher incidence in the LVAD group. These results underline the importance of managing and mitigating adverse effects in LVAD therapy to improve patient outcomes and quality of life. Table 5 – 9 and Figure 8-17.

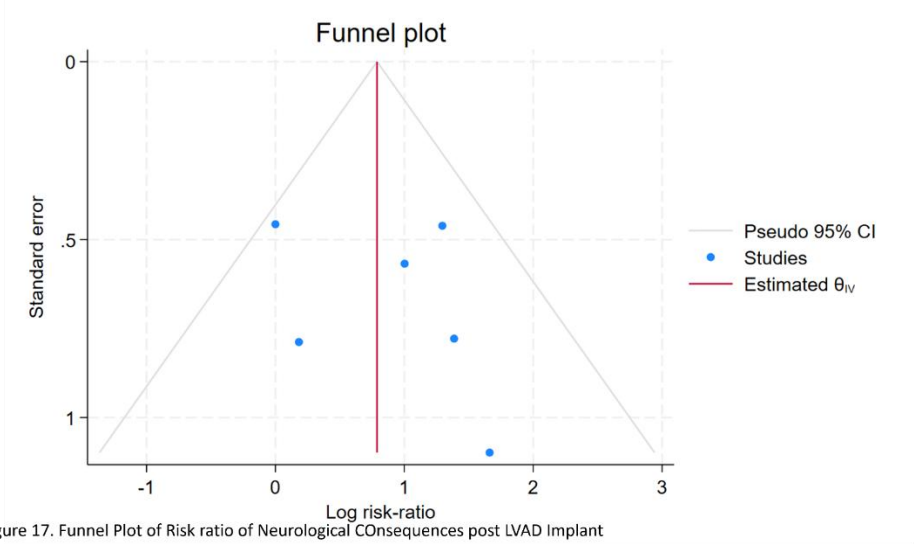


Figure 17. Funnel Plot of Risk ratio of Neurological COnsequences post LVAD Implant

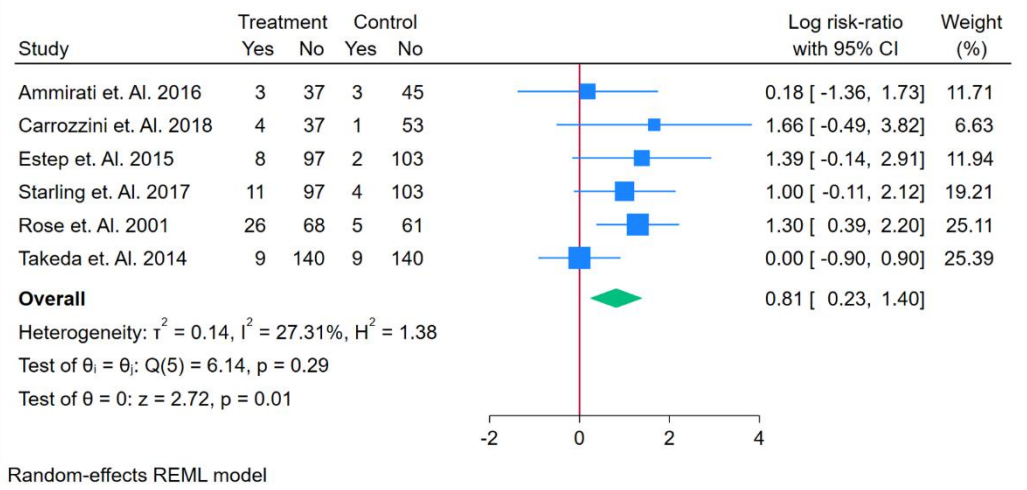


Figure 16. Forest Plot of Risk Ratio of Neurological Consequences as Adverse Effects post LVAD Implantation

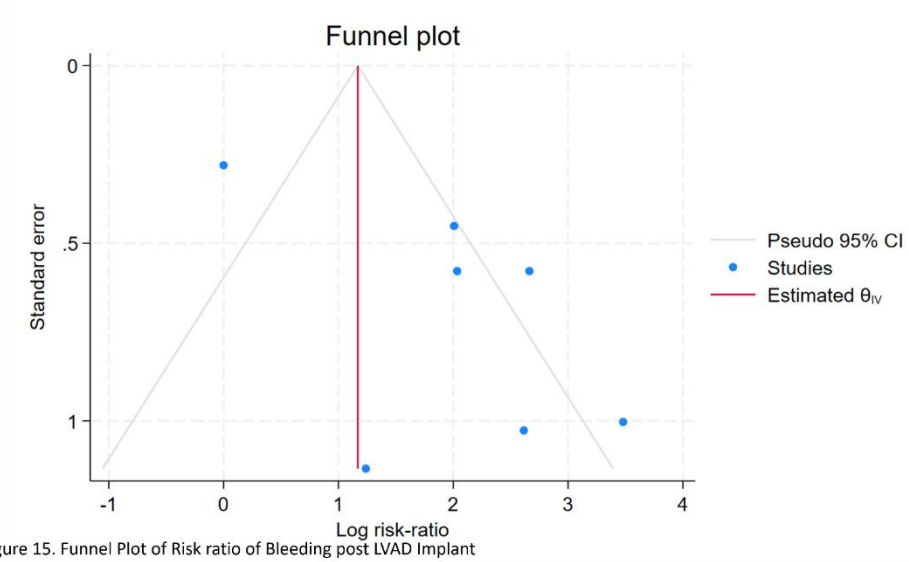


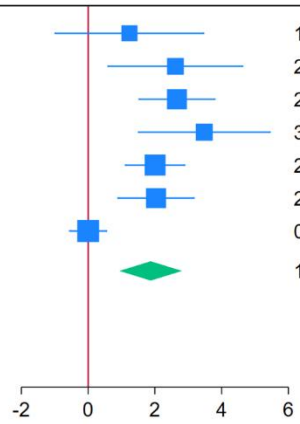
Figure 15. Funnel Plot of Risk ratio of Bleeding post LVAD Implant

Study	Treatment Yes	Treatment No	Control Yes	Control No	Log risk-ratio with 95% CI	Weight (%)
Ammirati et. Al. 2016	3	37	1	45	1.24 [-0.98, 3.46]	9.53
Carrozzini et. Al. 2018	12	53	1	73	2.61 [0.60, 4.63]	10.57
Hasin et. Al. 2013	66	115	3	115	2.66 [1.53, 3.80]	15.97
Estep et. Al. 2015	44	97	1	103	3.48 [1.51, 5.45]	10.82
Starling et. Al. 2017	51	97	5	103	2.01 [1.12, 2.89]	17.61
Rose et. Al. 2001	38	68	3	61	2.03 [0.90, 3.17]	15.97
Takeda et. Al. 2014	22	140	22	140	0.00 [-0.55, 0.55]	19.52
Overall					1.87 [0.94, 2.80]	

Heterogeneity: τ^2 = 1.08, I^2 = 76.82%, H^2 = 4.31

Test of $\theta_i = \theta_j$: Q(6) = 37.05, p = 0.00

Test of θ = 0: z = 3.95, p = 0.00



Random-effects REML model

Figure 14. Forest Plot of Risk Ratio of Bleeding as Adverse Effects post LVAD Implantation

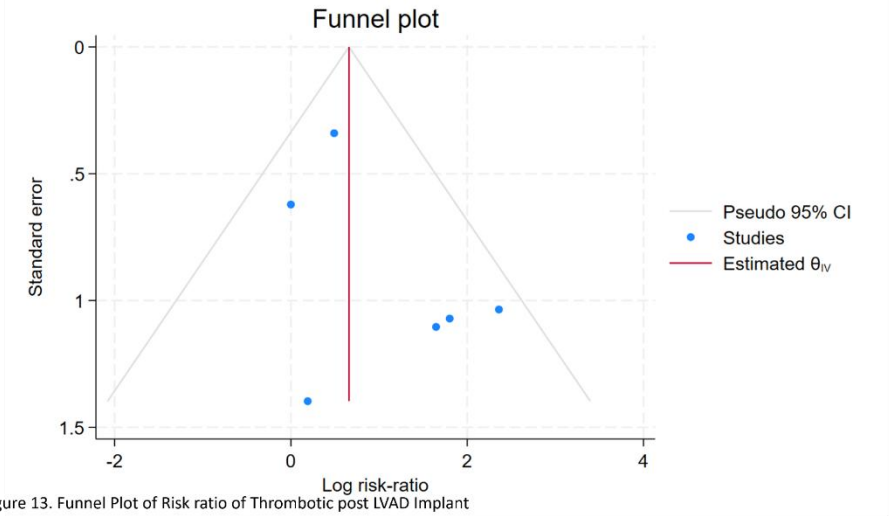


Figure 13. Funnel Plot of Risk ratio of Thrombotic post LVAD Implant

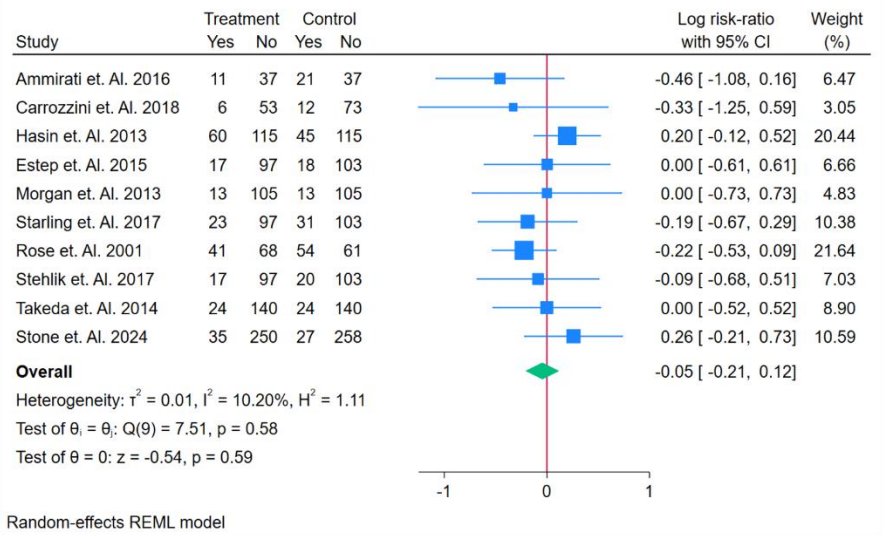


Figure 12. Forest Plot of Risk Ratio of Thrombotic as Adverse Effects post LVAD Implantation

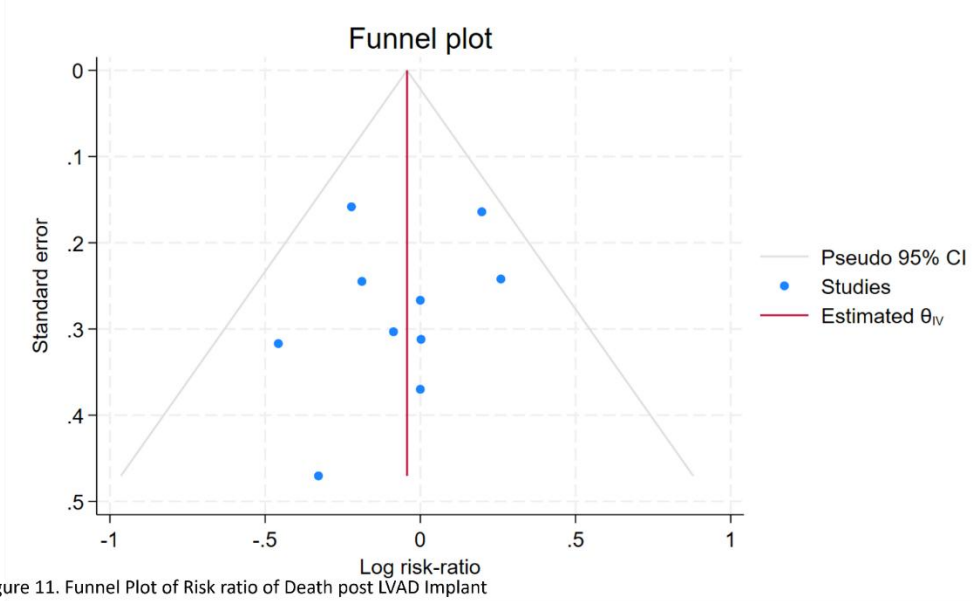


Figure 11. Funnel Plot of Risk ratio of Death post LVAD Implant

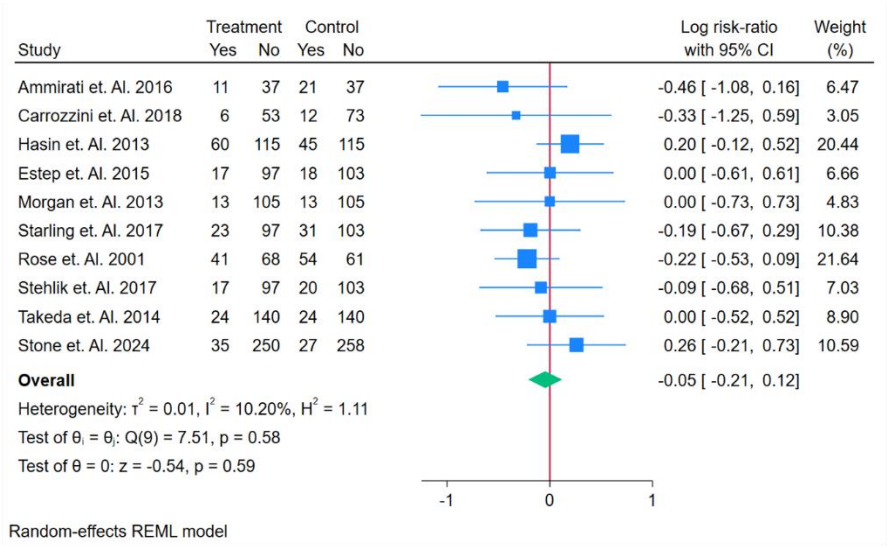


Figure 10. Forest Plot of Risk Ratio of Death as Adverse Effects post LVAD Implantation

Study	Log risk-ratio	[95% conf.	interval]	% weight
Ammirati et. Al. 2016	0.182	-1.362	1.727	11.71
Carrozzini et. Al. 2018	1.662	-0.492	3.815	6.63
Estep et. Al. 2015	1.386	-0.139	2.912	11.94
Starling et. Al. 2017	1.002	-0.110	2.115	19.21
Rose et. Al. 2001	1.295	0.391	2.199	25.11
Takeda et. Al. 2014	0.000	-0.896	0.896	25.39
theta	0.815	0.228	1.401	

Test of theta = 0: z = **2.72** Prob > |z| = **0.0065**
Test of homogeneity: Q = chi2(**5**) = **6.14** Prob > Q = **0.2929**

Table 8. Summary table of Risk Ratio of Neurological Consequences as Adverse Events in LVAD Implantation

Study	Log risk-ratio	[95% conf.	interval]	% weight
Ammirati et. Al. 2016	1.238	-0.985	3.462	9.53
Carrozzini et. Al. 2018	2.615	0.602	4.627	10.57
Hasin et. Al. 2013	2.663	1.530	3.797	15.97
Estep et. Al. 2015	3.480	1.514	5.446	10.82
Starling et. Al. 2017	2.007	1.123	2.892	17.61
Rose et. Al. 2001	2.034	0.901	3.168	15.97
Takeda et. Al. 2014	0.000	-0.549	0.549	19.52
theta	1.875	0.945	2.805	

Test of theta = 0: z = **3.95** Prob > |z| = **0.0001**
Test of homogeneity: Q = chi2(**6**) = **37.05** Prob > Q = **0.0000**

Table 8. Summary table of Risk Ratio of Bleeding as Adverse Events in LVAD Implantation

Study	Log risk-ratio	[95% conf.	interval]	% weight
Ammirati et. Al. 2016	0.191	-2.547	2.929	5.34
Carrozzini et. Al. 2018	1.647	-0.517	3.811	8.25
Hasin et. Al. 2013	0.491	-0.176	1.158	46.63
Estep et. Al. 2015	1.801	-0.298	3.901	8.72
Starling et. Al. 2017	2.360	0.331	4.389	9.27
Takeda et. Al. 2014	0.000	-1.218	1.218	21.79
theta	0.751	0.099	1.403	

Test of theta = 0: z = **2.26** Prob > |z| = **0.0240**
Test of homogeneity: Q = chi2(**5**) = **6.12** Prob > Q = **0.2949**

Table 7. Summary table of Risk Ratio of Thrombotic as Adverse Events in LVAD Implantation

Study	Log risk-ratio	[95% conf.	interval]	% weight
Ammirati et. Al. 2016	-0.457	-1.079	0.164	6.47
Carrozzini et. Al. 2018	-0.328	-1.250	0.594	3.05
Hasin et. Al. 2013	0.198	-0.124	0.520	20.44
Estep et. Al. 2015	0.002	-0.609	0.614	6.66
Morgan et. Al. 2013	0.000	-0.725	0.725	4.83
Starling et. Al. 2017	-0.188	-0.668	0.292	10.38
Rose et. Al. 2001	-0.222	-0.532	0.088	21.64
Stehlik et. Al. 2017	-0.087	-0.681	0.508	7.03
Takeda et. Al. 2014	0.000	-0.523	0.523	8.90
Stone et. Al. 2024	0.260	-0.215	0.734	10.59
theta	-0.045	-0.209	0.118	

Test of theta = 0: z = **-0.54** Prob > |z| = **0.5891**
Test of homogeneity: Q = chi2(**9**) = **7.51** Prob > Q = **0.5845**

```
. meta forestplot, random(reml)

  Effect-size label: Log risk-ratio
        Effect size: _meta_es
          Std. err.: _meta_se
        Study label: var1
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Table 6. Summary table of Risk Ratio of Death as Adverse Events in LVAD Implantation

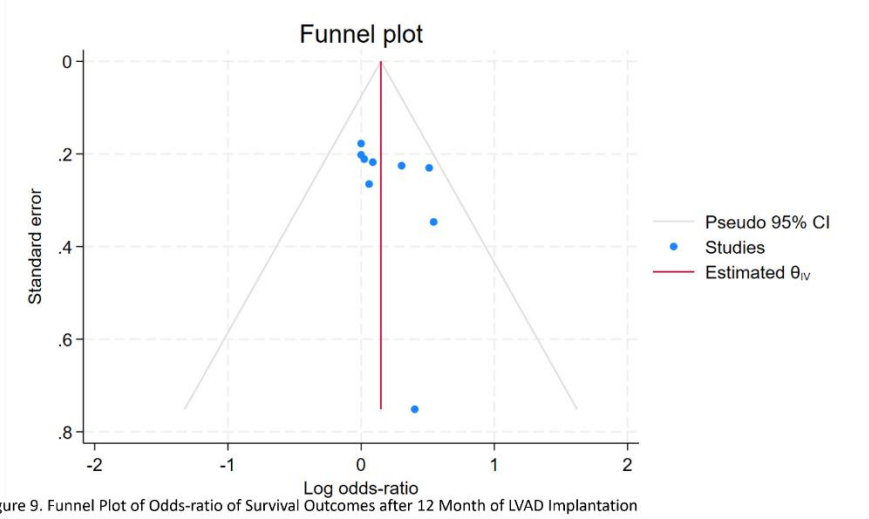

Figure 9. Funnel Plot of Odds-ratio of Survival Outcomes after 12 Month of LVAD Implantation

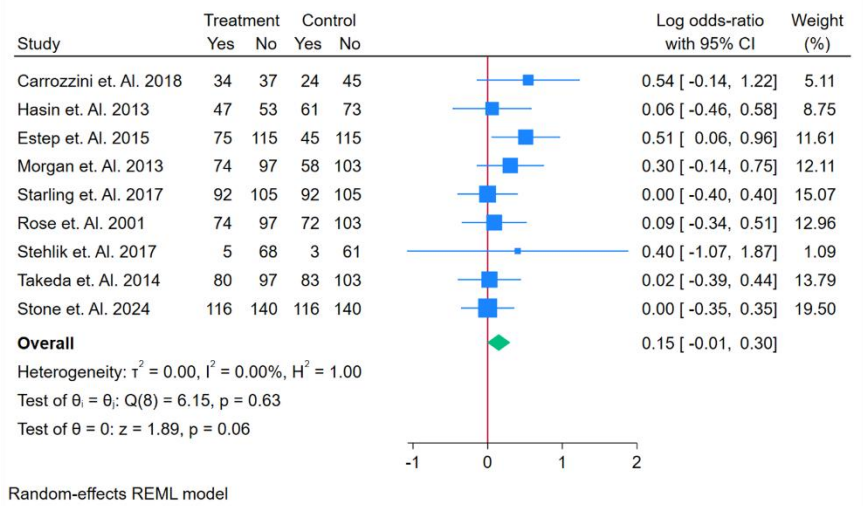

Figure 8. Forest Plot of Odds-ratio of Survival Outcomes after 12 Month of LVAD Implantation

Study	Log odds-ratio	[95% conf.	interval]	% weight
Carrozzini et. Al. 2018	0.544	-0.136	1.224	5.11
Hasin et. Al. 2013	0.059	-0.460	0.579	8.75
Estep et. Al. 2015	0.511	0.060	0.962	11.61
Morgan et. Al. 2013	0.304	-0.138	0.745	12.11
Starling et. Al. 2017	0.000	-0.396	0.396	15.07
Rose et. Al. 2001	0.087	-0.339	0.514	12.96
Stehlik et. Al. 2017	0.402	-1.070	1.875	1.09
Takeda et. Al. 2014	0.023	-0.391	0.437	13.79
Stone et. Al. 2024	0.000	-0.348	0.348	19.50
theta	0.148	-0.006	0.302	

Test of theta = 0: z = **1.89** Prob > |z| = **0.0591**
Test of homogeneity: Q = chi2(**8**) = **6.15** Prob > Q = **0.6302**

Table 5. Summary table of Odds-ratio of Survival Outcomes after 12 Month of LVAD Implantation

Quality of Life

The data highlights improvements in quality of life (QOL) for patients receiving Left Ventricular Assist Device (LVAD) treatment, as assessed through various health-related measures. The EQ-5D scores reported by Starling et al. (2017) and Stehlik et al. (2017) show moderate to significant improvements in general health-related QOL, with scores of 27 ± 24 and 50 ± 20, respectively. This indicates enhanced overall health status following LVAD implantation. The PHQ-9 scores revealed moderate depressive symptoms, with Starling et al. (2017) reporting an average of 4.6 ± 6.9, while Stehlik et al. (2017) showed a higher average of 10 ± 4, suggesting that while physical health improves, psychological factors may require additional attention. The HMRS score of 1.4 (1.40-1.81) from Stehlik et al. (2017) indicates significant improvement in heart muscle function, reflecting positive changes in cardiac performance. Furthermore, the 6-Minute Walk Test (6MWT) score of 74 ± 141 from Starling et al. (2017) demonstrates substantial improvements in patients' functional capacity and endurance, highlighting better physical performance and QOL. In conclusion, LVAD therapy significantly improves both physical and mental health outcomes, though ongoing mental health support may be necessary to optimize patient well-being fully.

4. DISCUSSION

The Left Ventricular Assist Device (LVAD) has emerged as a significant therapeutic option for patients with end-stage heart failure, offering a bridge to heart transplantation or as a long-term solution for those ineligible for a transplant. The data presented in this study highlight the improvements in quality of life (QOL) following LVAD implantation, as measured by several health-related scales, indicating both physical and psychological benefits. However, the findings also point to the complexity of LVAD treatment and the need for holistic management of patient health beyond survival. One of the primary measures used to assess QOL was the EQ-5D, a standardized instrument that evaluates general health-related QOL [22]. The results showed moderate improvements in QOL post-LVAD implantation. Starling et al. (2017) reported an average EQ-5D score of 27 ± 24, and Stehlik et al. (2017) showed a score of 50 ± 20, with the latter reflecting a more substantial improvement in overall health status. These improvements suggest that LVAD implantation has a notable impact on the overall health and well-being of patients, which is vital considering the severe limitations posed by end-stage heart failure. The EQ-5D data reflects both the physical and mental aspects of health, highlighting the importance of measuring these domains to assess the full effect of LVAD therapy.

In addition to the EQ-5D, the PHQ-9 (Patient Health Questionnaire-9) was used to assess depressive symptoms, a critical aspect of mental health in heart failure patients. The findings revealed moderate depressive symptoms, with Starling et al. (2017) showing an average PHQ-9 score of 4.6 ± 6.9, which indicates mild to moderate depression. In contrast, Stehlik et al. (2017) reported a higher average score of 10 ± 4, suggesting more pronounced depressive symptoms in their cohort. This discrepancy highlights the variability in mental health outcomes among LVAD patients, even when improvements in physical health are observed. LVAD therapy primarily focuses on restoring cardiac function, but psychological support and monitoring are essential to optimize the overall well-being of patients. The higher depressive symptoms noted in some studies indicate that while physical recovery is often seen after LVAD implantation, psychological recovery may require more time and tailored interventions. As depression and anxiety are common in heart failure patients, ongoing mental health support should be integrated into LVAD care to address these concerns [23].

The HMRS (Heart Muscle Recovery Score) was another measure used to assess cardiac function recovery, with Stehlik et al. (2017) reporting a score of 1.4 (1.40–1.81). This indicates positive outcomes in heart muscle function post-LVAD, confirming that the device does not merely support survival but also contributes to the functional recovery of the heart. The significant improvement in heart function is particularly important because it can have long-term benefits, including

reduced hospitalizations, better survival rates, and a reduction in the need for heart transplants in some patients. Thus, LVAD therapy can not only enhance survival but also improve the heart's overall functionality, providing a more independent lifestyle for patients [24].

Furthermore, the 6-Minute Walk Test (6MWT) is an excellent indicator of physical endurance and functional capacity. Starling et al. (2017) reported a significant improvement in 6MWT scores (74 ± 141), reflecting enhanced physical performance and endurance in LVAD patients. The ability to walk longer distances is a strong indicator of better functional status, as patients with end-stage heart failure often experience severe limitations in physical activity. This improvement in functional capacity is essential for patients' ability to perform daily activities, regain independence, and enhance their quality of life.

In conclusion, the data presented in this study show that LVAD therapy leads to significant improvements in physical health, heart function, and endurance, as well as moderate improvements in mental health. While the improvements in QOL are notable, it is essential to recognize that mental health concerns, particularly depression, remain a challenge in some LVAD patients. As such, ongoing mental health support should be integrated into the care of LVAD recipients to address psychological needs, ultimately optimizing both survival and well-being. Additionally, further studies are needed to better understand the long-term psychological impact of LVAD implantation and to develop comprehensive care plans that address both physical and mental health.

5. CONCLUSION

In conclusion, the findings from this study highlight the significant improvements in quality of life (QOL) for patients receiving Left Ventricular Assist Device (LVAD) therapy, particularly in terms of physical health, heart function, and endurance. LVAD implantation has proven to be an effective treatment for patients with end-stage heart failure, offering substantial survival benefits and improvements in functional capacity, as demonstrated by enhanced EQ-5D scores and 6-minute walk test results. Additionally, the recovery of heart muscle function, as measured by the Heart Muscle Recovery Score (HMRS), further underscores the positive impact of LVAD on cardiac health. However, the study also reveals that while physical health improves, psychological factors, such as depression, remain a concern for some patients. The variations in PHQ-9 scores suggest that mental health should be a critical component of LVAD care. As patients recover physically, mental health monitoring and support are essential to ensure holistic patient care and long-term well-being. Ultimately, LVAD therapy plays a pivotal role in improving the survival and quality of life for end-stage heart failure patients. To optimize outcomes, it is essential for healthcare providers to integrate both physical and psychological care into the management of LVAD patients. Further research is needed to explore the long-term effects of LVAD implantation on mental health and to develop comprehensive strategies for supporting patients throughout their recovery journey.

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