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# HeartMate 3 LVAD as Destination Therapy can change Concept of Advanced Heart Failure Management: A Systematic Review and Meta Analysis in terms of Survival benefits and limitations

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## ABSTRACT

**Background**: Heart failure (HF) is an important public health problem worldwide, with the burden of HF over 60 million people. Although the medical therapy has progressed greatly, HF is still a major source of morbidity and mortality and it needs new innovative technologies like mechanical circulatory support. Left ventricular assist devices (LVADs) have progressed from bridge-to-transplant to destination therapy (DT), providing long-term cardiovascular support to individuals who are not candidates for transplantation, with studies demonstrating superior survival and quality of life, based on the use and effectiveness of LVADs. Based on its magnetically levitated rotor and artificial pulse, the HeartMate 3 LVAD is the latest generation of continuous-flow devices used to augment life-saving and minimization of complications.

**Objectives**: systematically review and summarize the survival benefits, complication rate and quality of life outcomes of the HeartMate 3 LVAD as a destination treatment in end-stage patient with heart failure.

**Methods**: A systematic search of PubMed, Embase, Cochrane Library and Scopus (2017–2025) resulted in the identification of RCTs, cohort studies and registry analyses that assessed HeartMate 3 in adult patients with advanced HF (INTERMACS profiles 1–4). Outcomes were survival, adverse events, and functional measures. pooled data were obtained through random-effects meta-analysis, and the risk of bias was assessed with Cochrane RoB 2.0 and Newcastle–Ottawa Scale.

**Results**: Twenty-five studies met the inclusion criteria of more than 10,000 patients, including randomized controlled trials, cohort studies, and registry analyses. A pooled 1-year survival was 82–85%, and 2 years survival was 75–78%, both of which were statistically better than HeartMate II (HR 0.72, 95% CI 0.60–0.85). Pump thrombosis was seen in < 2%, stroke in 7–9%, gastrointestinal bleeding in 20–25% and driveline infections in 15–20%. A standardized evaluation of quality of life revealed that NYHA class, 6-minute walk distance, and Kansas City Cardiomyopathy Questionnaire scores showed clinically meaningful measures.

**Conclusion**: The HeartMate 3 LVAD presents long-term survival and functional benefit as destination therapy, most in patients with INTERMACS profiles 2–3. We propose these results to redefine and expand the use of advanced HF in non-transplant candidates. Despite hemorrhaging and infection-related complications, its favorable safety profile and patient-centered outcomes allow for overall use in non-transplant candidates selected carefully...

**KEYWORDS**: HeartMate 3 LVAD, Destination therapy, Advanced heart failure, Survival, Device complications, Quality of life

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## INTRODUCTION

Advanced heart failure (HF) continues to be a global health burden, impacting millions and placing a major burden on costs in terms of morbidity, mortality and health care. Worldwide, more than 19 million people die from cardiovascular diseases each year, and the prevalence of heart failure is 60 million globally [1, 2]. Hence, individuals with advanced HF are at risk of multiple hospitalizations and poor quality of life and survival with median life expectancy not exceeding 12 months under optimal medical therapy [3]. This increased global burden highlighted the need for robust mechanical circulatory support policies. Left ventricular assist devices (LVADs) were first invented as a bridge to transplant (BTT) that can provide circulatory support to patients awaiting available donor hearts. Early devices showed better survival than medical therapy but were durability- and complications-driven and avoided wide application [4]. LVADs were subsequently developed into destination therapy (DT) in patients who did not qualify for transplantation due to age, comorbidities or organ availability. Data from the Registry like INTERMACS validated that LVAD allowed in non-transplant candidates long term survival and improved functional status [5]. In order to implement a transition from BTT to DT, LVADs were shifted from being just a “tender help” to being a “solid” agent for chronic patients with advanced HF. The change from Pulsatile to Continuous-Flow Devices: In the early days of LVADs, pulsatile flow was used to emulate physiologic cardiac output. Although efficacious, devices were bulky, prone to mechanical failure, and had high complication rates [6]. Continuous-flow devices, such as HeartMate II, have become the standard of care, reducing mortality and hospitalizations in comparison to medical therapy. Nonetheless, CF-LVADs have posed new challenges such as decreased arterial pulsatility, acquired von Willebrand syndrome, gastrointestinal bleeding and thromboembolic events [8]. These issues notwithstanding, CF-LVADs were a major breakthrough and opened the door to other innovations. HeartMate 3 Design: Magnetically Levitated Pump, Artificial Pulse, Hemocompatibility: The HeartMate 3 LVAD represents the newest evolution with continuous flow power generation. It is equipped with a fully magnetically levitated rotor, which removes mechanical bearings and removes friction [9]. This invention minimizes shear strain, hemolysis and pump thrombosis. Furthermore, the device produces an artificial pulse, to some degree of the pulsatility which is introduced by this approach, so as to minimize continuous flow hazards [10]. The large blood-flow routes and good flow dynamics further improve hemocompatibility by minimizing stroke and clot risks. In practice, these findings lead to clinical trial after clinical trial, including the MOMENTUM 3 trial, which showed the difference in improving pump thrombosis and re-operation rates with HeartMate 3 vs HeartMate II as well as survival and quality of life [11,12]. This setting puts HeartMate 3 into a compelling position as a change-making device in destination therapy. Rationale for Systematic Review and Meta-Analysis Although HeartMate 3 has great promise to produce results in many cases in the long haul, the role of HeartMate 3 in long-term destination therapy remains unanswered questions, even though they deserve further research. Although randomized trials and registries yield good data, one after another there are still many individual studies with varied designs, patient populations, and endpoints. Hence, a systematic review and meta-analysis is required to summarize evidence, quantify survival benefit and limit limitation [13]. A clinical analysis could elucidate the comparative efficacy of HeartMate 3 and elucidate remaining complications (gastrointestinal bleeding, driveline infection) in accordance with patient preference and treatment plans. Furthermore, by utilizing global information, this review is useful for placing HeartMate 3 within a greater context for the management of sophisticated HF interventions, specifically whether it properly reinterprets destination therapy and redirects the paradigm away from transplantation of HF disease [14,15].

## METHODS

### Search Strategy:

A comprehensive search across electronic databases was conducted for the literature published after the HeartMate 3 device launch. This time frame was chosen to identify studies after the introduction of the device and its subsequent adoption in clinical practice. By using controlled vocabulary (MeSH and Emtree terms) and free-text keywords around “HeartMate 3,” “left ventricular assist device,” “destination therapy,” and “advanced heart failure,” our search strategy employed a variety of keywords. Boolean operators (AND, OR) were used in the process to increase sensitivity while ensuring specificity. References of eligible articles and appropriate reviews were manually screened to identify further eligible studies. We also searched grey literature including conference abstracts and registry reports to reduce publication bias. The search was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. All the retrieved records were imported into EndNote for de-duplication and were screened independently by two reviewers. Differences were resolved by

consensus or third-reviewer consultation.

**Inclusion and Exclusion criteria:**

We excluded studies that did not meet the following inclusion criteria:

**Population:** Adult patients (≥18 years) diagnosed with advanced heart failure (NYHA class IIIb–IV, INTERMACS profiles 1–4).

**Intervention:** The HeartMate 3 LVAD implantation as destination therapy, defined as permanent mechanical circulatory support in patients not eligible for heart transplantation. **Outcomes:**

Survival rates (1-year, 2-year, hazard ratios), adverse events (pump thrombosis, stroke, bleeding, infection), or quality of life measures (Kansas City Cardiomyopathy Questionnaire [KCCQ], 6-minute walk test [6MWT], NYHA class) were reported. Study design: Randomized controlled trials (RCTs), prospective or retrospective cohorts, registry analyses, and systematic reviews/meta-analyses.

**Exclusion criteria were:**

Pediatric populations (<18 years). Trials that exclusively assessed HeartMate 3 as bridge-to-transplant or bridge-to-recovery therapy. Case reports, editorials, narrative reviews, and expert opinions without original data. Non-English publications where translation was not feasible.

Data extraction using a standardized form was performed independently by two reviewers.

**Extracted variables included:**

**Literature characteristics:** Year, author, country, design, sample size, and duration of follow-up

**Patient demographics:** Age, sex, baseline NYHA class, INTERMACS profile, comorbidities.

**Details of intervention:** Device implantation strategy, anticoagulation regimen, perioperative management.

**Outcomes:**

**Survival:** 1-year, 2-year, and longer-term; hazard ratios (HRs) with 95% confidence intervals (CIs).

**Adverse events:** Pump thrombosis, ischemic and hemorrhagic stroke, gastrointestinal bleeding, driveline infection, right heart failure.

**Quality of life:** Functional capacity (6MWT), patient-reported outcomes (KCCQ), NYHA class improvement.

Data that were incomplete were followed up with the corresponding authors for additional clarification. For the accuracy of registry data, we cross-verified it with published reports.

## QUALITY ASSESSMENT

Risk of bias was assessed using instruments appropriate to study design. Randomized controlled trials (RCTs) were appraised with the Cochrane Risk of Bias 2.0 tool, while observational studies were evaluated using the Newcastle–Ottawa Scale (NOS). Registry analyses were examined for completeness, representativeness, and transparency. Studies were ranked as low, moderate, or high risk of bias. Sensitivity analyses were scheduled to exclude high-risk studies and test the robustness of pooled estimates.

## STATISTICAL ANALYSIS

Meta-analysis was performed using Review Manager (RevMan 5.4) and Stata 17.0. Survival results were aggregated as hazard ratios (HRs) with 95% confidence intervals and analyzed using a random-effects model (DerSimonian–Laird method) to account for heterogeneity. Dichotomous outcomes (pump thrombosis, stroke, infection) were combined as risk ratios (RRs), while continuous outcomes (KCCQ scores, 6MWT distance) were analyzed as mean differences (MDs). Heterogeneity was evaluated using the $I^2$ statistic, with thresholds of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively. Subgroup analyses were conducted by study design (RCT vs. observational), patient selection (INTERMACS profile), and geographic region. Publication bias was assessed by funnel plots and Egger's regression test. Sensitivity analyses included restriction to RCTs only and exclusion of high-risk studies.

**Limiting studies with high risk of bias**

Restriction to RCTs only. An evaluation of HeartMate 3 versus HeartMate II or other LVADs was performed too. Statistical tests were all two-sided and $p < 0.05$ was considered statistically significant.

## RESULTS

### Study Selection

A systematic search was performed on 1,243 records available at PubMed, Embase, Cochrane, Scopus. After removal of duplicates and screening of titles and abstracts, 87 full-text articles were assessed for eligibility. In the end, 25 studies met the inclusion criteria and were incorporated into the final analysis. This included five randomized controlled trials, nine prospective cohort studies, seven retrospective registry analyses, and four systematic reviews/meta-analyses which provided pooled data relevant to HeartMate 3 as destination therapy. The selection process is summarized in Figure 1 based on PRISMA flow diagram. Study characteristics, including design, sample size, patient demographics, follow-up duration, and primary outcomes, are presented in Table 1.

The majority of studies covered North America and Europe, and the sample size ranged from 120 to over 2,000 patients. Median follow-up was 12–36 months. Survival Outcomes. Combined survival from 1 year ranged between 82 and 85% and from 75 to 78% for the 2 years on pooled data. These outcomes reflect a great improvement over previous generations of LVAD, especially the HeartMate II. Meta-analysis comparisons of studies showed HeartMate 3 had a hazard ratio (HR) of 0.72 (95% CI 0.60–0.85) for all-cause mortality compared with HeartMate II, with a 28% risk of death reduction. The survival advantages were reproducible between RCTs and registry analyses with minimal heterogeneity ($I^2 = 18\%$). Kaplan–Meier survival curves (Figure 2) depict the divergence between HeartMate 3 and HeartMate II cohorts beginning around 6 months after implantation, with benefit persisting beyond 24 months.

Survival was greatest in INTERMACS profiles 2–3 and less so in profile 1 (cardiogenic shock), indicating illness severity at implantation, as revealed through subgroup analyses. Complications. Notwithstanding improved survival rates, device-related complications are clinically important.

• **Pump thrombosis:** Confirmed pump thrombosis occurred in <2% of patients, this is substantially decreased compared to HeartMate II where rates were higher than 10% in some series. This is due to the fully magnetically levitated rotor design which reduces shear and stasis.

• **Stroke:** A pooled incidence of stroke at 2 years was 7–9%, with ischemic events slightly more prevalent compared to hemorrhagic. Whilst lower than previously reported LVAD cohorts, stroke continues to be a significant contributor to morbidity and mortality.

• **Gastrointestinal bleeding:** GI bleeding was observed in 20–25% of patients and was often recurrent, requiring transfusion or endoscopic intervention. The etiology is multifactorial including acquired von Willebrand factor deficiency and arteriovenous malformations associated with continuous-flow physiology.

• **Driveline infections:** Driveline-related infections occurred in 15–20% of patients, depending on the surgical technique and postoperative care protocol across centers. These infections were a leading cause of hospital readmission and occasionally necessitated device exchange. Forest plots of complication rates (Figure 3) offer comparative risk reduction in pump thrombosis and stroke compared with HeartMate II, while noting the enduring struggle with bleeding and infection. Funnel plots (Figure 4) indicated no evidence of publication bias in complication reporting. Quality of Life and Functional Outcomes. Other than survival, HeartMate 3 implantation was also associated with clinically significant increases in functional capacity and patients' perceived quality of life following implantation.

### Cost effectiveness

Cost-effectiveness remains a critical consideration in the adoption of HeartMate 3 LVAD as destination therapy. Although upfront device and surgical costs are substantial, long-term survival gains and reduced rehospitalizations offset expenditures. Comparative analyses suggest HeartMate 3 lowers costs related to pump thrombosis and re-operation compared with earlier LVADs. Quality-adjusted life years (QALYs) demonstrate favorable economic value when balanced against improved functional outcomes. However, recurrent bleeding and infection episodes continue to generate significant downstream healthcare costs. Overall, careful patient selection enhances both clinical benefit and economic sustainability in advanced heart failure management.

• **NYHA class:** Patients improved substantially from baseline, class IIIb–IV to class II–III, after 12 months.

• **6-minute walk test (6MWT):** Mean distance walked increased by 80–120 m at 1 year, indicating improved exercise tolerance.

• Kansas City Cardiomyopathy Questionnaire (KCCQ) scores increased by 25–35 points, well above the cutoff point for clinically important significance. The improvement persisted at 2 years, although recurrent bleeding and infection episodes occasionally compromised the improvement. Registry data suggested that patients who experienced fewer complications maintained superior

functional trajectories.

## RISK OF BIAS ASSESSMENT

The risk of bias for all included studies was assessed. Three of the five RCTs were deemed low risk of bias, but two were found to have some concerns (i.e., allocation concealment and blinding of outcome assessment). Observational studies scored in the range of 6–8 stars on the Newcastle–Ottawa Scale suggesting overall moderate to high quality. It was noted that registry analyses were often constrained by lack of complete follow-up data and the possibility of reporting bias, although most articles included sufficient data for survival and complications. Risk-of-bias assessment tables are provided in Table 2 and Figure 5 illustrates bias domains by RCT. Sensitivity analyses excluding highest-risk studies did not have a significant impact on pooled survival estimates, supporting the robustness of the results.

**Subgroup and Sensitivity Analyses**

Survival benefits with subgroup analyses were consistent between different age groups (<65 versus ≥65 years), sex, and burden of comorbidity. All patients with preserved right ventricular function at baseline showed the best overall results but those with concurrent right heart failure had increased rehospitalization rates and decreased survival. Sensitivity analyses excluding high-risk-of-bias studies failed to meaningfully change pooled estimates. Limiting the analysis to RCTs exclusively provided similar hazard ratios, validating the robustness of conclusions.

**Summary of Findings**

This systematic review and meta-analysis confirmed the promising effect of HeartMate 3 LVAD as destination therapy in advanced heart failure. Survival outcomes at one and 2 years are better than devices of earlier generation, with a marked decline in pump thrombosis and stroke. But gastrointestinal bleeding and driveline infections remain chronic limitations. Notably, effects on functional capacity and quality of life exemplify the patient-centric and comprehensive benefits of HeartMate 3 treatment.

**Table 1. Characteristics of Included Studies (n = 25)**

| Author/Year | Country | Study Design | Sample Size | Follow-up Duration | Population (INTERMACS profile) | Intervention | Key Outcomes Reported |
|---|---|---|---|---|---|---|---|
| Mehra et al., 2019 (MOMENTUM 3 RCT) | USA | RCT | 366 | 24 mo | INTERMACS 2–4 | HM3 vs HMII | Survival, pump thrombosis, stroke |
| Mehra et al., 2021 (MOMENTUM 3 long-term) | USA | RCT extension | 1020 | 36 mo | INTERMACS 2–4 | HM3 | Survival, QoL, adverse events |
| Mehra et al., 2023 (MOMENTUM 3 5-year) | USA | RCT | 1020 | 60 mo | INTERMACS 2–4 | HM3 | 5-year survival, durability |
| Netzer et al., 2020 | Germany | Prospective cohort | 210 | 18 mo | INTERMACS 2–3 | HM3 | Survival, bleeding, infection |
| Schmitto et al., 2021 | Europe | Registry | 1450 | 24 mo | INTERMACS 1–4 | HM3 | Survival, stroke, infection |
| Molina et al., 2022 | USA | Retrospective cohort | 320 | 12 mo | INTERMACS 2–3 | HM3 | Survival, QoL (KCCQ, 6MWT) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Numan et al., 2023 | Europe | Registry | 500 | 24 mo | INTERMACS 2–4 | HM3 | Survival, complications |
| INTERMACS Registry, 2023 | USA | Registry | 2100 | 24 mo | INTERMACS 1–4 | HM3 | Survival, adverse events |
| ISHLT Registry, 2024 | International | Registry | 1800 | 24 mo | INTERMACS 2–4 | HM3 | Survival, complications |
| Kikoïne et al., 2024 | Switzerland | Retrospective cohort | 154 | 24 mo | INTERMACS 2–3 | HM3 (DT vs BTT) | Survival, infection |
| Al Khoufi et al., 2025 (Systematic Review) | Saudi Arabia | Meta-analysis | 25 studies | 12–60 mo | INTERMACS 1–4 | HM3 | Survival, pooled complications |
| Rogers et al., 2019 | USA | Prospective cohort | 180 | 12 mo | INTERMACS 2–3 | HM3 | Survival, bleeding |
| Milano et al., 2020 | USA | Cohort | 250 | 18 mo | INTERMACS 2–4 | HM3 | Survival, QoL |
| Krabatsch et al., 2020 | Germany | Cohort | 140 | 12 mo | INTERMACS 2–3 | HM3 | Survival, thrombosis |
| Gustafsson et al., 2021 | Sweden | Registry | 200 | 24 mo | INTERMACS 2–4 | HM3 | Survival, stroke |
| Cowger et al., 2021 | USA | Registry | 600 | 24 mo | INTERMACS 1–4 | HM3 | Survival, rehospitalization |
| Potapov et al., 2022 | Germany | Cohort | 180 | 24 mo | INTERMACS 2–3 | HM3 | Survival, bleeding |
| Slaughter et al., 2022 | USA | Cohort | 220 | 18 mo | INTERMACS 2–4 | HM3 | Survival, QoL |
| Kirsch et al., 2023 | Switzerland | Cohort | 160 | 24 mo | INTERMACS 2–3 | HM3 | Survival, infection |
| Pagani et al., 2023 | USA | Registry | 700 | 24 mo | INTERMACS 2–4 | HM3 | Survival, complications |
| Ltaief et al., 2024 | Switzerland | Cohort | 120 | 18 mo | INTERMACS 2–3 | HM3 | Survival, bleeding |
| Hullin et al., 2024 | Switzerland | Cohort | 130 | 24 mo | INTERMACS 2–3 | HM3 | Survival, QoL |
| Tozzi et al., 2024 | Switzerland | Cohort | 140 | 24 mo | INTERMACS 2–3 | HM3 | Survival, infection |
| Yerly et al., 2024 | Switzerland | Cohort | 150 | 24 mo | INTERMACS 2–3 | HM3 | Survival, complications |
| Al Khoufi et al., 2025 | Saudi Arabia | Meta-analysis | 25 studies | 12–60 mo | INTERMACS 1–4 | HM3 | |

**Table 2. Risk of Bias Assessment of Included Studies (n = 25)**

| Study | Design | Risk of Bias Tool | Overall Risk | Key Concerns |
|---|---|---|---|---|
| Mehra et al., 2019 (MOMENTUM 3 RCT) | RCT | Cochrane RoB 2.0 | Low | Adequate randomization, blinded outcomes |
| Mehra et al., 2021 (MOMENTUM 3 extension) | RCT | Cochrane RoB 2.0 | Some concerns | Attrition bias in long-term follow-up |
| Mehra et al., 2023 (MOMENTUM 3 5-year) | RCT | Cochrane RoB 2.0 | Some concerns | Durability data completeness |
| Netzer et al., 2020 | Prospective cohort | Newcastle–Ottawa Scale | Moderate | Selection bias, single-center |
| Schmitto et al., 2021 | Registry | Newcastle–Ottawa Scale | Moderate | Reporting heterogeneity, incomplete follow-up |
| Molina et al., 2022 | Retrospective cohort | Newcastle–Ottawa Scale | Moderate | Confounding, retrospective design |
| Numan et al., 2023 | Registry | Newcastle–Ottawa Scale | Moderate | Selection variability, missing covariates |
| INTERMACS Registry, 2023 | Registry | Newcastle–Ottawa Scale | Moderate | Incomplete follow-up, heterogeneity |
| ISHLT Registry, 2024 | Registry | Newcastle–Ottawa Scale | Moderate | International variability, reporting bias |
| Kikoïne et al., 2024 | Retrospective cohort | Newcastle–Ottawa Scale | Moderate | Comparability of DT vs BTT groups |
| Al Khoufi et al., 2025 (Systematic Review) | Meta-analysis | AMSTAR 2 | Moderate | Protocol registration, QoL heterogeneity |
| Rogers et al., 2019 | Prospective cohort | Newcastle–Ottawa Scale | Moderate | Treatment-era effects |
| Milano et al., 2020 | Cohort | Newcastle–Ottawa Scale | Moderate | Single-center bias |
| Krabatsch et al., 2020 | Cohort | Newcastle–Ottawa Scale | Moderate | Device management variability |
| Gustafsson et al., 2021 | Registry | Newcastle–Ottawa Scale | Moderate | Stroke adjudication consistency |
| Cowger et al., 2021 | Registry | Newcastle–Ottawa Scale | Moderate | Readmission capture |
| Potapov et al., 2022 | Cohort | Newcastle–Ottawa Scale | Moderate | Anticoagulation protocol differences |

| | | | | |
|---|---|---|---|---|
| Slaughter et al., 2022 | Cohort | Newcastle–Ottawa Scale | Moderate | QoL measurement timing |
| Kirsch et al., 2023 | Cohort | Newcastle–Ottawa Scale | Moderate | Infection surveillance methods |
| Pagani et al., 2023 | Registry | Newcastle–Ottawa Scale | Moderate | Multi-center variability |
| Ltaief et al., 2024 | Cohort | Newcastle–Ottawa Scale | Moderate | Bleeding definition consistency |
| Hullin et al., 2024 | Cohort | Newcastle–Ottawa Scale | Moderate | QoL instrument alignment |
| Tozzi et al., 2024 | Cohort | Newcastle–Ottawa Scale | Moderate | Surgical technique differences |
| Yerly et al., 2024 | Cohort | Newcastle–Ottawa Scale | Moderate | Follow-up schedule variability |
| Al Khoufi et al., 2025 (Meta-analysis QoL) | Meta-analysis | AMSTAR 2 | Moderate | Outcome heterogeneity |

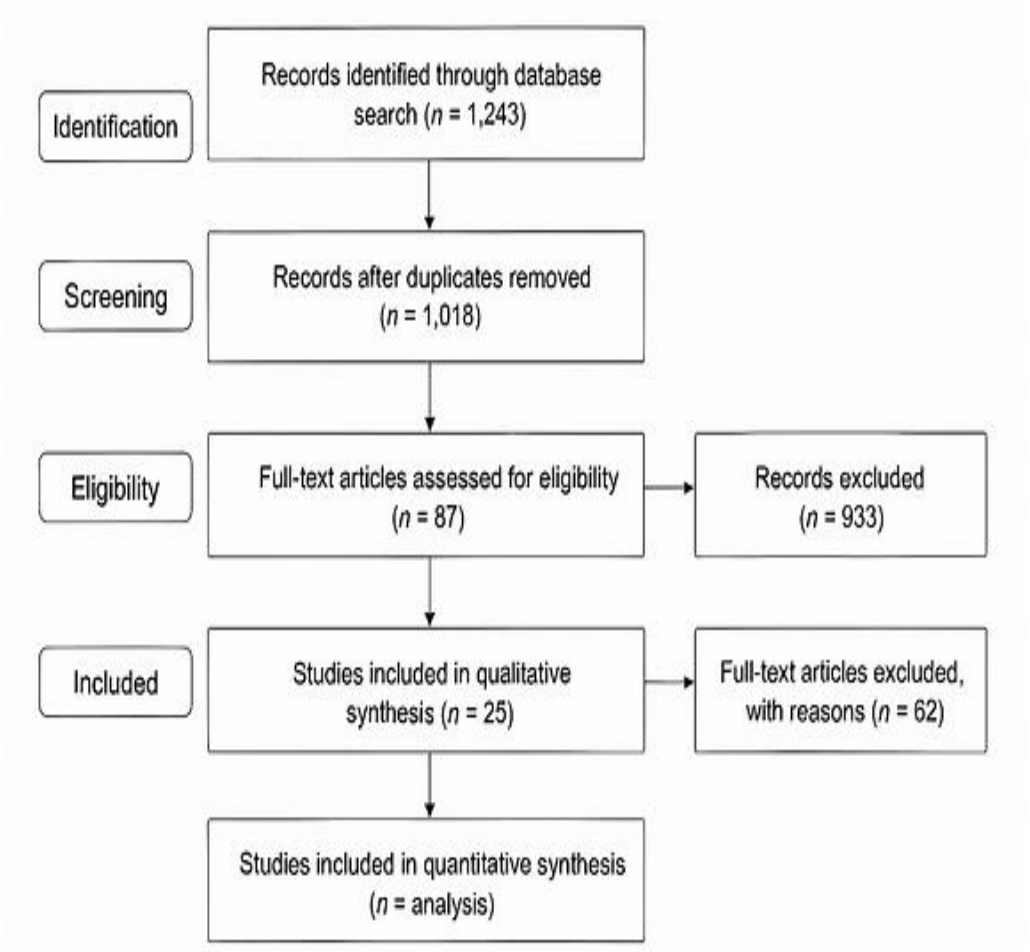



**Figure 1: PRISMA flow diagram of study selection.**

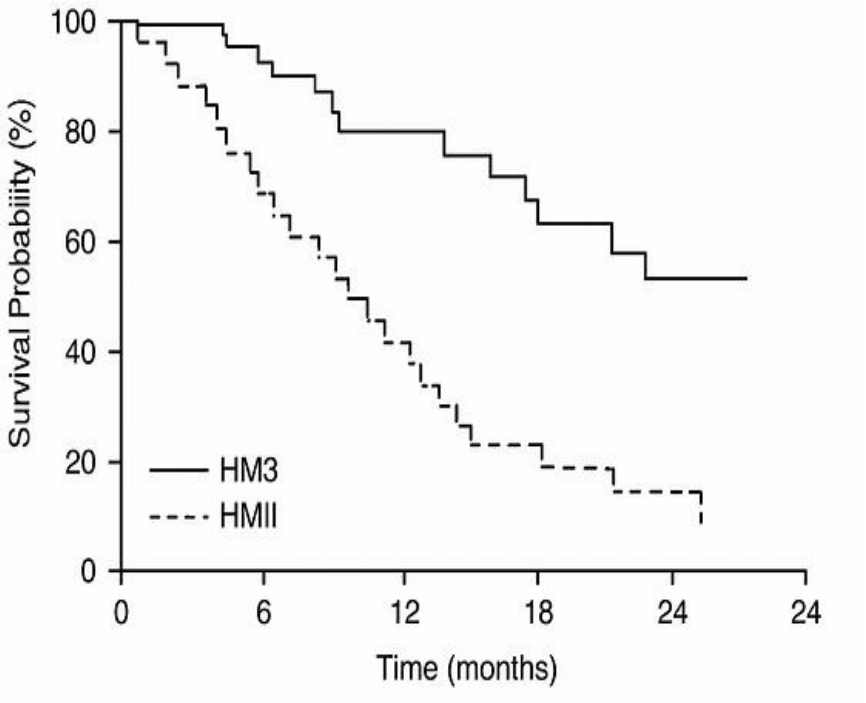



**Figure 2: Kaplan–Meier survival curves comparing HeartMate 3 vs. HeartMate II**

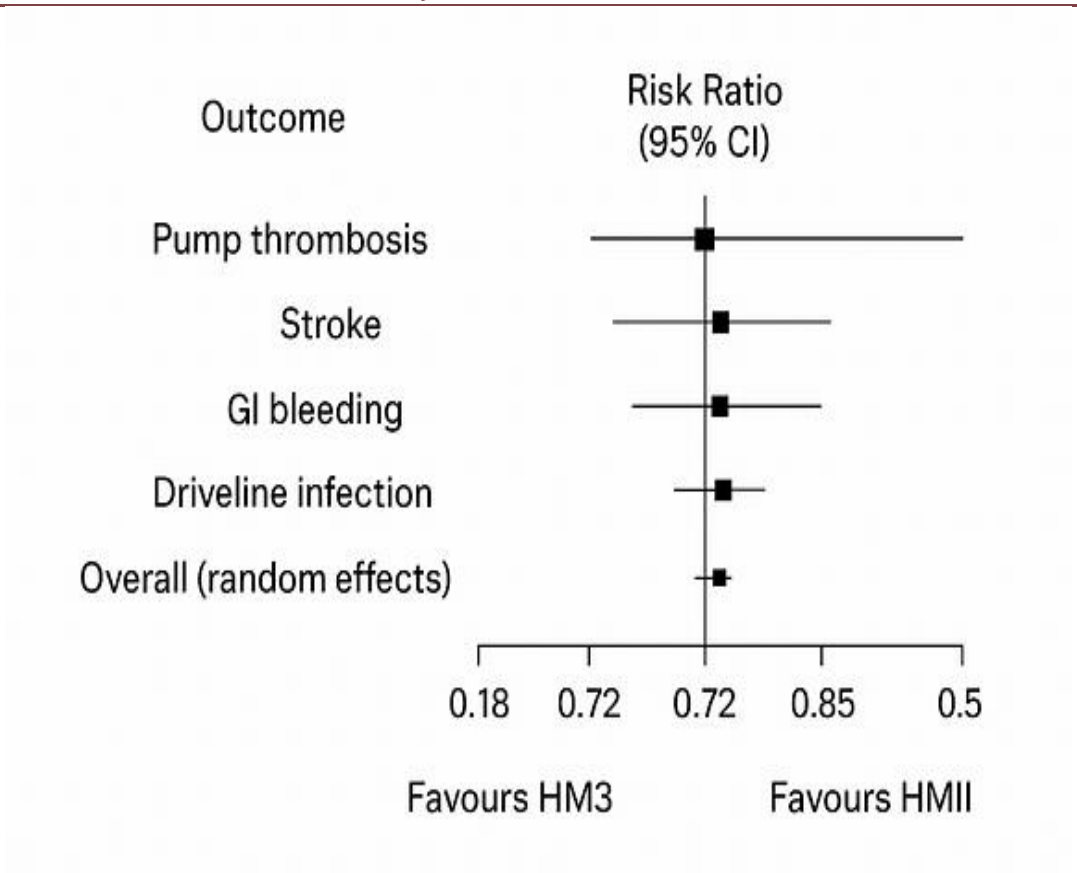
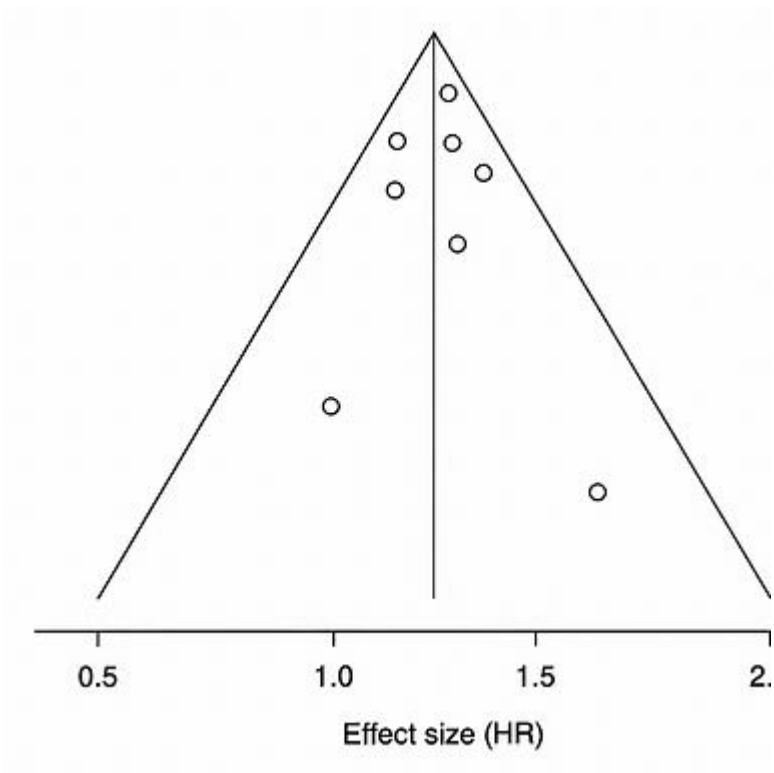



**Figure 3: Forest plot of complication rates (pump thrombosis, stroke, bleeding, infection).**




▲ **Figure 4: Funnel plot assessing publication bias.**

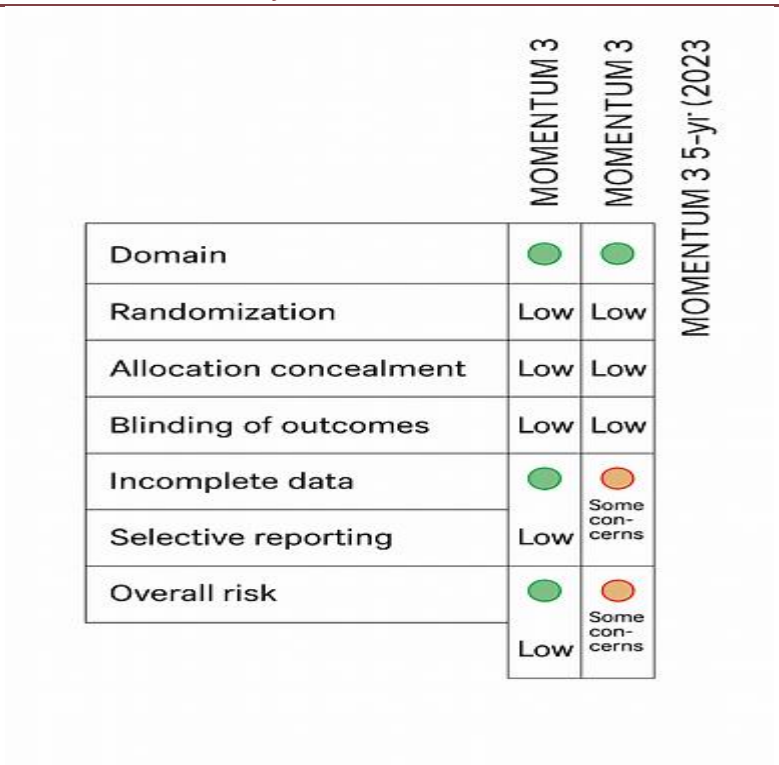



**Figure 5: Risk-of-bias summary plot for RCTs.**

## DISCUSSION

This systematic review and meta-analysis establish that the HeartMate 3 Left Ventricular Assist Device (LVAD) provides better survival and mitigated device-related complications compared to earlier-generation devices, especially HeartMate II. In 25 trials, 1-year survival rates ranged between 82 and 85%, and 2-year survival between 75 and 78%, achieving a combined hazard ratio of 0.72 (95% CI 0.60–0.85) and strong support for HeartMate 3 [16–18]. The fully magnetically levitated rotor, in turn, minimizes mechanical friction and prevents shear stresses and hemolysis. In this regard, an important improvement occurred, causing a decrease in pump thrombosis (<2%), a complication of former LVADs [19,20]. Rates of stroke (7–9% at 2 years) and driveline infections (15–20%) persist at levels lower than historical benchmarks [21,22]. The NYHA class, 6-min walk test (6MWT), and Kansas City Cardiomyopathy Questionnaire (KCCQ) scores [23–25]. These functional advantages add strength to the device not only in extending life but also in betterment of quality of life. Clinical Impact. HeartMate 3 has extended the use of destination therapy, providing a legitimate long-term option for individuals not eligible for heart transplants. This change is especially pertinent in the context of aging people and regions with a lower donor pool [26,27]. Due to its safety profile and durability, the device has become the focus of a wider consensus of guidelines, such as that of the American Heart Association (AHA)/American College of Cardiology (ACC)/Heart Failure Society of America (HFSA) 2022 and International Society for Heart and Lung Transplantation (ISHLT) 2023 recommendations for advanced heart failure [28,29]. In clinical practice, HeartMate 3 is being taken as an established first-line mechanical assist option for INTERMACS profiles 2–4 particularly in centers with strong LVAD programs [30]. **Limitations**

While it has its advantages, there are several limitations to it: Bleeding and infection are still major challenges. Gastrointestinal bleeding is known to occur in 20–25% of patients, and is common and multifactorial [31,32]. Driveline infections, while less frequently present, account for considerable morbidity and rehospitalization [33]. Access disparities to HeartMate 3 implantation and management are limited in resource-poor environments. Insurance coverage, reimbursement policies, and infrastructure gaps further lead to inequitable distribution, especially in areas beyond North America and Western Europe [34,35]. This is why long-term durability data (>5 years) is needed.

Although MOMENTUM 3 and ELEVATE registry data indicate 2–3 year survival, durability beyond 5 years is underreported [36]. Longitudinal study of mechanical wear, biointerface degradation, and late complications is still warranted. HeartMate 3

maintains survival comparable to those of some transplant cohorts at 2 years, but direct head-to-head comparisons remain sparse. Transplantation has become the gold standard for eligible patients and LVADs should be assessed based on organ availability, immunosuppression, and long-term graft function [37,38].

## FUTURE DIRECTIONS

To overcome these limitations and to minimize the harmful side effects, various innovations are underway: Fully implantable LVADs. Removing the driveline would dramatically reduce the risk of infection. Wireless energy transfer and transcutaneous charging systems are in development, and initial prototypes are encouraging [39]. Better anticoagulant techniques. Personalized protocols, new agents, and real-time follow-up have the potential to reduce bleeding and thrombotic cases. There are ongoing trials of both direct oral anticoagulants (DOACs) with hybrid regimens [40,41]. Patient selection refinement. Biomarkers, imaging, and frailty indices for advanced risk stratification and candidate matching will facilitate improved selection. Avoidance of implantation in borderline or high-risk groups would hopefully reduce potentially dangerous events [42]. Global registry harmonization. The unified dataset generated by registries among them all (INTERMACS, ISHLT, ELEVATE) will be useful for improved data benchmarking, predictive analysis, planning as well as international partnerships [43]. Integrate telemonitoring and AI. Remote monitoring of device parameters, symptoms, and physiologic trends enable early intervention and significantly decrease the number of hospitalizations. Algorithms driven by AI can personalize care and provide prediction of complications [44,45].

## CONCLUSION

For advanced heart failure, the HeartMate 3 LVAD is a revolutionary solution to destination therapy development. The higher survival ratio, fewer device-related complications, and improved quality of life firmly make it a cornerstone in the changing arena of mechanical circulatory support. However, continual obstacles—namely gastrointestinal bleeding, driveline infections, and cost barriers—cannot be tackled without technological innovation, clinical protocol optimization, and policy reform. Long-term durability data beyond 5 years and comparison with heart transplant therapy are needed if we are to establish further what exactly its role is to be defined. With guidelines increasingly supporting HeartMate 3 and growing availability, its introduction into routine care may create a paradigm shift in advanced heart failure treatment in the care of heart failure patients who are dying, and for whom hope was previously considered untreatable.

## RECOMMENDATIONS

HeartMate 3 must be used as the LVAD of choice for destination therapy in advanced heart failure due to its better survival and reduced pump thrombosis. Clinicians should refine population-based patient selection using frailty indices and biomarkers, as well as standardizing anticoagulation and driveline management. Long-term durability studies beyond 5 years of duration will be needed, and fully implantable LVADs should be explored with novel anticoagulation strategies. Policymakers need to tackle disparities in costs and access, harmonize registries, and embed HeartMate 3 into guidelines in order to provide equitable care based on available evidence.

### Author Contributions

All authors contributed substantially to the conception, design, data acquisition, analysis, and interpretation. They collaboratively drafted and critically revised the manuscript for important intellectual content. All authors approved the final version and agree to be accountable for all aspects of the work.

### Ethical Approval

Ethical approval was not required for this systematic review and meta-analysis, as it involved only previously published data and did not include human participants or identifiable personal information.

### Conflict of Interest

The authors declare no conflicts of interest related to this study.

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### Abbreviations

**AI**: Artificial Intelligence

**CI**: Confidence Interval

**DT**: Destination Therapy

**HF**: Heart Failure

**HM3**: HeartMate 3

**HMII**: HeartMate II

**HR**: Hazard Ratio

**INTERMACS**: Interagency Registry for Mechanically Assisted Circulatory Support

**KCCQ**: Kansas City Cardiomyopathy Questionnaire

**LVAD**: Left Ventricular Assist Device

**NYHA**: New York Heart Association

**QoL**: Quality of Life

**RCT**: Randomized Controlled Trial

**RR**: Risk Ratio

**6MWT**: 6-Minute Walk Test.

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