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Original Article

Pre-transplant hemodynamic profiles of patients with ischemic vs. non-ischemic cardiomyopathy: insights from a retrospective single-center study

Mohammad Reza Movahed[1,2], Shiva Aminnia[1]

[1]University of Arizona Sarver Heart Center, Tucson, AZ, The United States; [2]University of Arizona College of Medicine, Phoenix, AZ, The United States

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Abstract: Objectives: Heart transplantation remains the last resort for patients with end-stage heart failure. The clinical and hemodynamic profiles of these patients may differ depending on the underlying etiology of cardiomyopathy. This study aimed to evaluate pre-transplant hemodynamic characteristics in patients with ischemic versus non-ischemic cardiomyopathy. Methods: We conducted a retrospective analysis of 170 adult patients who underwent orthotopic heart transplantation at a single center. Patients were categorized based on the etiology of heart failure as either ischemic or non-ischemic cardiomyopathy. Preoperative hemodynamic and echocardiographic parameters were compared between the groups. Results: Of the 170 patients, 45.2% had ischemic cardiomyopathy. These patients were significantly older than those with non-ischemic cardiomyopathy (53.2 vs. 46.7 years, P<0.01). However, no significant differences were observed between the two groups in pulmonary capillary wedge pressure (17.9 ± 8.0 vs. 17.4 ± 9.5 mmHg), mean pulmonary artery pressure (29.4 ± 10.9 vs. 27.3 ± 12.6 mmHg), or left ventricular ejection fraction (21.4 ± 10.8% vs. 23.3 ± 12.5%). Conclusion: While ischemic cardiomyopathy patients were older, their preoperative hemodynamic and echocardiographic profiles were closely similar to those with non-ischemic cardiomyopathy.

Keywords: Heart transplantation, hemodynamics, advanced heart failure, heart failure etiology, non-ischemic cardiomyopathy, ischemic cardiomyopathy, pulmonary artery pressure, systolic dysfunction, cardiac transplantation, organ transplantation

Introduction

Heart failure (HF) is a complex and clinically diverse syndrome affecting over 64 million individuals worldwide [1, 2]. It poses a significant public health burden due to the high rates of hospitalization, morbidity, and mortality [3, 4]. In 2021, major global cardiovascular societies established a universal definition and classification system for heart failure (HF): HF is characterized as a clinical syndrome presenting with symptoms and/or signs resulting from structural and/or functional cardiac abnormalities, supported by elevated natriuretic peptide levels and/or objective indicators of pulmonary or systemic congestion [5].

Despite advances in medical and surgical treatments that have improved survival and quality of life of patients with heart failure, a subset of patients experiences progressive, treatment-resistant symptoms that significantly impair daily functioning and are associated with high mortality. This condition is classified as end-stage or advanced heart failure, also referred to as Stage D by the American College of Cardiology (ACC) and American Heart Association (AHA), indicating end-stage or refractory HF that necessitates specialized interventions [6, 7]. For patients with end-stage heart failure who are unresponsive to optimal medical therapy, heart transplantation remains the gold standard and often the only life-saving therapeutic option [8, 9].

The underlying cause of cardiomyopathy in transplant candidates may influence both pre-transplant clinical characteristics and post-transplant outcomes. The two primary etiolo-

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gies among transplant recipients are ischemic cardiomyopathy (ICMP), which typically results from chronic coronary artery disease and myocardial infarction, and non-ischemic cardiomyopathy (NICMP), which includes idiopathic, genetic, infectious, and inflammatory causes [10, 11]. These subtypes differ in their pathophysiology mechanisms, demographic distribution, and comorbidities. For instance, patients with ICMP have a higher burden of atherosclerotic disease and associated risk factors, whereas NICMP mostly presents in younger patients and may be associated with fewer systemic comorbidities [12, 13].

In advanced heart failure, particularly due to non-ischemic cardiomyopathy (NICMP), clinical decision-making often relies on parameters such as ejection fraction (EF), pulmonary artery pressures, and right ventricular (RV) function. In this setting, invasive hemodynamic assessment plays a central role in evaluating transplant eligibility [14]. While these markers are still used to evaluate patients before heart transplantation, they may not fully reflect the underlying coronary or myocardial pathophysiology, and further research is needed to evaluate their efficacy in determining the underlying cause of advanced cardiomyopathy [15].

Prior research has documented differences between ICMP and NICMP in terms of clinical presentation, echocardiographic parameters, hemodynamic profiles, and outcomes [13, 16]. Several studies have examined the influence of etiology on long-term outcomes after heart transplantation, including survival, graft function, and rejection rates [11, 13]. However, relatively few studies have focused specifically on preoperative hemodynamic and echocardiographic characteristics [17-19]. Moreover, there is a discrepancy between the results of the previous studies, some have shown that by the time patients are referred for heart transplantation, hemodynamic parameters such as pulmonary pressures, pulmonary vascular resistance, and transpulmonary gradients are similar across different heart failure etiologies. In contrast, other research suggests that pretransplant hemodynamic profiles may still differ based on etiology [17-20].

Overall, these inconsistencies highlight the need for further research to clarify if baseline differences exist between patients with ischemic and non-ischemic cardiomyopathy. In this study, we aimed to determine whether the underlying etiology of cardiomyopathy is associated with distinct preoperative hemodynamic profiles that could have implications for transplant management.

Methods

Study design

This retrospective, single-center study included adult patients with advanced heart failure (HF) who underwent orthotopic heart transplantation (HT) at the University of Arizona Medical Center were included. A total of 170 patients were included based on the availability of complete hemodynamic and echocardiographic data. No formal sample size calculation was performed due to the retrospective nature of the study; the study size reflects the total number of eligible patients available during the study period. Other inclusion criteria were age ≥18 years, the availability of complete demographic information, a defined etiology of HF, complete documented pre-transplant hemodynamic, echocardiographic data, and availability of post-transplant outcome data. Furthermore, this study used data exclusively from registered patients at the University of Arizona. We excluded patients with incomplete records or unclear heart failure etiology and those younger than 18 years old. Additionally, all patient data were reviewed, and any cases with discrepancies between the primary diagnosis (pre-transplant) and the secondary diagnosis (post-transplant pathological evaluation) were excluded from the analysis.

Ethical approval was obtained from the University of Arizona Institutional Review Board (IRB) before data collection and analysis.

Data collection

Baseline demographic and clinical characteristics were extracted from the institutional transplant database. These included age, sex, and etiology of heart failure, categorized as ischemic cardiomyopathy (ICMP) or non-ischemic cardiomyopathy (NICMP). Additionally, preoperative hemodynamic and echocardiographic parameters were collected from the recorded database, including left ventricular ejection fraction (LVEF), mean pulmonary artery pres-

sure (mean PAP), and pulmonary artery wedge pressure (PAWP).

In all patients, before transplantation, left ventricular ejection fraction(LVEF) was assessed using transthoracic echocardiography and calculated via the biplane Simpson's method by the current American Society of Echocardiography guidelines [21].

PCWP and mPAP values were extracted from right heart catheterization reports conducted as part of standard pre-transplant evaluation. All measurements were performed using Swan-Ganz catheters and recorded at end-expiration, by institutional and national guidelines. A typical procedure is described previously in detail [21, 22]. An 8.5 Fr sheath is placed over the wire into the femoral vein. Next, a Swan-Ganz catheter is advanced into the right chambers and finally into the wedge position. Pressures were measured using wave forms in each chamber. This is accomplished by slowly inflating the balloon while watching the monitor. The post-capillary pressure (PCWP) represents an indirect measurement of the pressure inside the left atrium. Final reported pressures were made after the cardiologist reviewed the tracers and made final reports based on his interpretation of the data. Echocardiographic parameters were measured in standard fashion by an echocardiographer and corrected and confirmed by the reading cardiologist.

Patients were stratified into two groups based on the underlying etiology of cardiomyopathy-ICMP or NICMP-to facilitate comparative analysis. Ischemic cardiomyopathy (ICMP) was defined as the presence of a prior myocardial infarction or significant coronary artery disease, characterized by ≥70% stenosis in the proximal or mid-segments of at least one major epicardial coronary artery. Non-ischemic cardiomyopathy (NICMP), on the other hand, was defined by the absence of coronary artery disease, the presence of non-obstructive disease (<70% stenosis), or obstructive disease (≥70% stenosis) confined to a branch vessel [23, 24].

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Missing data was minimal (<5% for all variables) and handled using complete-case analysis. No imputation methods were applied. Continuous variables were assessed for normality using the Shapiro-Wilk test. Variables with a normal distribution were reported as means ± standard deviation (SD), while non-normally distributed data were summarized as medians with interquartile ranges (IQR). Categorical variables were presented as frequencies and percentages.

Group comparisons for categorical variables were conducted using the Chi-square test, with Fisher's exact test applied when expected frequencies were low. Independent sample t-tests were used to compare normally distributed variables for continuous variables, while the Mann-Whitney U test was employed for non-normally distributed variables. All statistical tests were two-tailed, and a p-value <0.05 was considered indicative of statistical significance.

Results

Among the 170 patients with advanced heart failure who had undergone orthotopic heart transplantation, 77 (45.2%) had ischemic cardiomyopathy (ICMP), and 93 (54.8%) had non-ischemic cardiomyopathy (NICMP). The mean age of the study population was 49.6 years. Patients with ICMP were significantly older than those with NICMP (53.2 vs. 46. years, P<0.01) (**Figure 1**).

Other baseline characteristics, including gender, were similar between the two study groups (**Table 1**).

Hemodynamic parameters and ejection fraction

Hemodynamic assessment of the patients before transplantation showed no significant differences in pulmonary capillary wedge pressure (PCWP) or mean pulmonary arterial pressure (mPAP) between the two study groups. The mean pulmonary capillary wedge pressure was 17.9 ± 8.0 mmHg in the ICMP group and 17.4 ± 9.5 mmHg in the NICMP group. Mean pulmonary arterial pressure (mPAP) was 29.4 ± 10.9 mmHg in patients with ICM and 27.3 ± 12.6 mmHg in patients with NICMP (**Figures 2**, **3**).

The mean left ventricular ejection fraction (LVEF) was 21.4 ± 10.8% in the ICMP group and

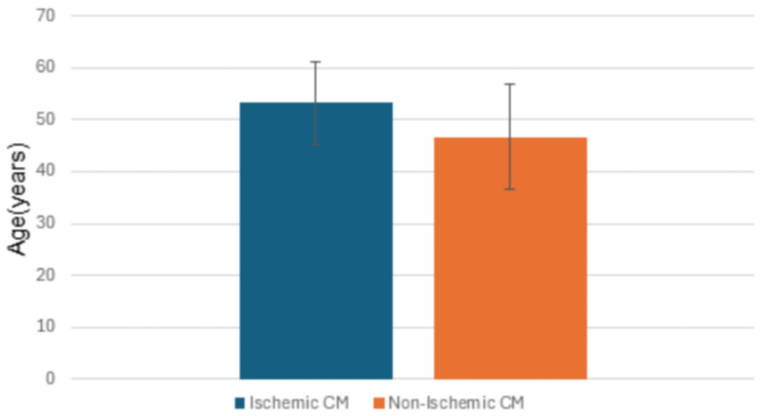

Figure 1. Comparison of the mean age between the Ischemic CMP and Non-ischemic CMP groups. The mean age was significantly higher in patients with ischemic cardiomyopathy (P<0.01).

23.3 ± 12.5% in the NICMP group, with no statistically significant difference between groups (**Figure 4**).

Discussion

In this study, we assessed the clinical and hemodynamic profiles of 170 individuals undergoing orthotopic heart transplantation, with a focus on identifying potential differences based on the underlying etiology. Nearly half of our study population had ischemic cardiomyopathy (ICMP), and the remainder had non-ischemic cardiomyopathy (NICMP). The primary distinction between these groups was age: as expected, patients with ICMP were significantly older than those with NICMP. Interestingly, pre-transplant hemodynamic profiles-including pulmonary capillary wedge pressure (PCWP) and mean pulmonary arterial pressure (mPAP)-and left ventricular ejection fraction (EF), were not significantly different between the two groups.

This age difference we observed, is consistent with prior research showing that ICMP typically affects older individuals [13, 25, 26]. For example, in a registry-based study by Tymińska et al., in 2022, which analyzed 895 patients with heart failure and reduced ejection fraction (HFrEF), patients with ICMP had a median age of 66.5 years, significantly older than patients with non-ischemic dilated cardiomyopathy (NIDCM), whose median age was 58.2 years (P<0.001). This age difference also reflects the chronic progression of atherosclerotic disease, which gives rise to ICMP and accumulates over time. Along with age, the ICMP group typically bears a heavier burden of comorbidities such as diabetes, hypertension, and chronic kidney disease, conditions that are commonly associated with aging and long-standing coronary artery disease [13]. These observations emphasize the importance of considering age-related factors in the evaluation, timing, and management of transplant candidates with ICMP, as they may influence clinical presentation and post-transplant outcomes.

The key observation in our study is that patients undergoing heart transplantation have comparable hemodynamic profiles, regardless of the underlying cardiac etiology. This finding is particularly important, as it suggests that by the time patients reach the point of transplant evaluation, their cardiac function and hemodynamic compromise may have converged, regardless of the original disease mechanism. In our view, this emphasizes the idea that transplant evaluation should not rely on etiology alone but should instead emphasize physiologic markers of decompensation and functional reserve.

Our results echo those reported by Ortiz et al., who studied 422 patients with advanced heart failure undergoing heart transplantation and found that clinical and hemodynamic parameters, including pulmonary pressures, pulmonary vascular resistance, and transpulmonary gradients, were largely similar across different heart failure etiologies (ischemic heart disease (IHD), dilated cardiomyopathy (DCM), and valvular diseases) in transplant candidates [19]. Similarly, a study by Drazner et al. [20] found no significant differences in pulmonary arterial or capillary wedge pressures between ischemic and non-ischemic groups among patients being assessed for transplantation. These observations support the hypothesis that by the time patients reach transplant evaluation, advanced disease progression may homogenize clinical and hemodynamic profiles across etiologies, thereby diminishing the prognostic relevance of the underlying cause.

Notably, this pattern extends to systolic dysfunction as well. Several prior studies have also demonstrated that EF alone is not efficient in

Table 1. Demographic and hemodynamic characteristics of the study population

Characteristic	Ischemic CM (n = 77)	Non-Ischemic CM (n = 93)	*p*-value
Age (years)	53.2	46.7	P<0.01
PCWP (mmHg)	17.9 ± 8.0	17.4 ± 9.5	NS
Mean PAP (mmHg)	29.4 ± 10.9	27.3 ± 12.6	NS
Ejection Fraction* (%)	21.4 ± 10.8	23.3 ± 12.5	Ns

*Left Ventricular Ejection Fraction, PCWP: Pulmonary capillary wedge pressure, Mean PAP: mean pulmonary arterial pressure, NS: not significant.

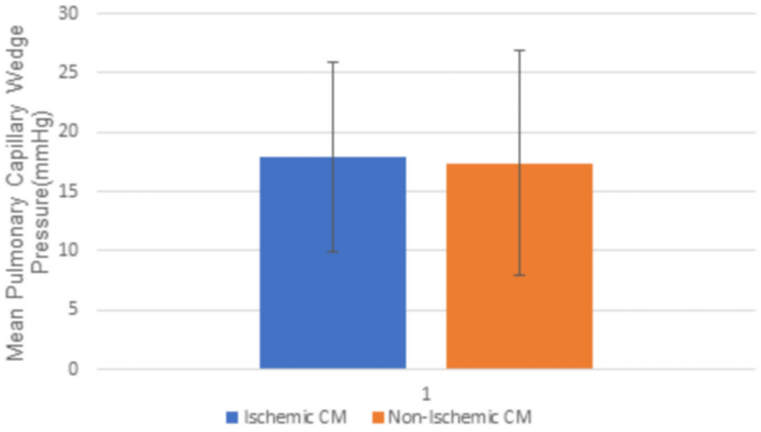

Figure 2. Comparison of Pulmonary capillary wedge pressure between the Ischemic CMP and Non-ischemic CMP groups. Statistical analysis showed no significant difference between the two study groups before transplantation.

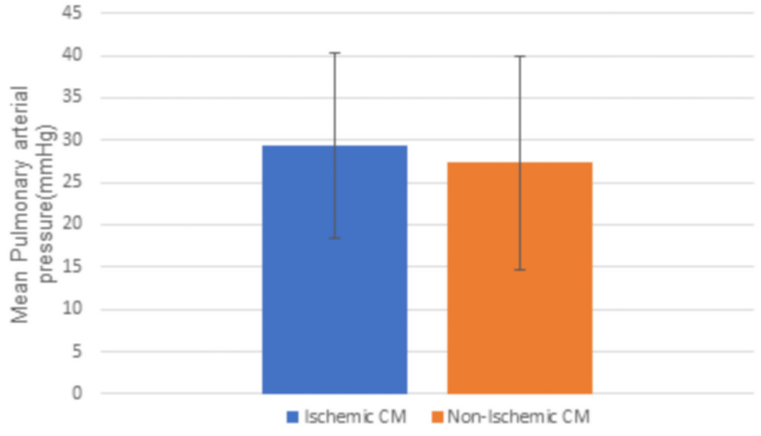

Figure 3. Comparison of mean Pulmonary arterial pressure between the Ischemic CMP and Non-ischemic CMP groups. Statistical analysis showed no significant difference between the two study groups before transplantation.

distinguishing symptom severity or transplant urgency, as both ischemic and non-ischemic cardiomyopathy can present with similarly reduced systolic function at advanced stages of disease [10, 27-29]. For instance, like our results, in a study by Ottaviani et al., both ischemic (ICMP) and non-ischemic cardiomyopathy (NICMP) groups had similar degrees of reduced LVEF and overlapping pathological features in explanted hearts [28]. These findings reinforce that end-stage heart failure represents a final common pathological pathway, regardless of etiology, and that LVEF alone may not reflect disease severity in advanced stages.

However, some studies have reported different hemodynamic profiles in patients with advanced HF due to ischemic and nonischemic causes. For instance, Ghio et al. reported higher rates of pulmonary hypertension and elevated transpulmonary gradients in patients with dilated cardiomyopathy (DCM) compared to those with ischemic heart disease (IHD) in a cohort of 377 heart failure patients [18]. More recently, Bayram et al. compared 470 patients with ICMP and NICMP with end-stage heart failure undergoing evaluation for heart transplantation, and found that patients with ICMP were generally older, had a higher prevalence of cardiovascular risk factors, and demonstrated significantly higher pulmonary artery pressures (systolic and mean), pulmonary vascular resistance (PVR), and transpulmonary gradients compared to those with NICMP [17]. These discrepancies could, in part, reflect differences in institutional selection criteria for transplantation, variations in the timing of hemodynamic

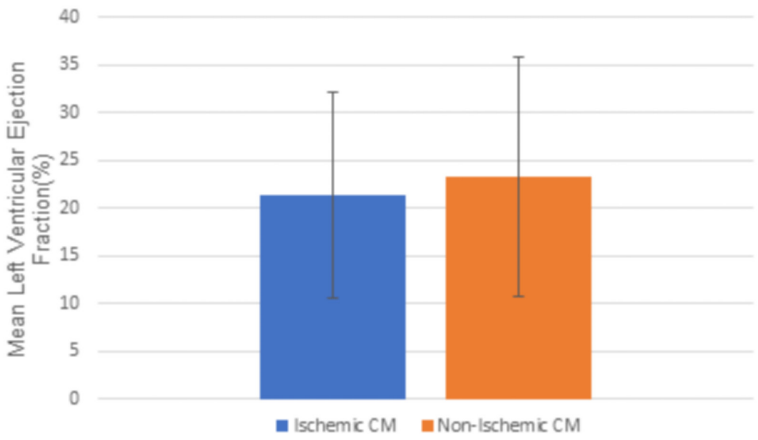

Figure 4. Comparison of mean Left ventricular ejection fraction (LVEF) between the Ischemic CMP and Non-ischemic CMP groups. Statistical analysis showed no significant difference between the two study groups before transplantation.

assessment during disease progression, or unmeasured confounders such as medication use and comorbid conditions. These differences also highlight the need for further investigations to clarify these patterns.

Overall, our findings may indicate that the routine markers of systolic dysfunction (EF and Hemodynamic profile) have limitations in determining the cause of advanced cardiomyopathy and guiding transplant decisions. Clinical decisions should instead be grounded in a comprehensive assessment of functional status, hemodynamic compromise, and individual risk factors.

From a clinical point of view, the older age of ICMP patients may have implications for post-transplant outcomes and comorbidity profiles. Tailored preoperative counseling may be warranted in this subgroup. Conversely, younger NICMP patients may benefit from a broader range of mechanical support options or longer-term bridging strategies.

Strengths and limitations

A major strength of our study is the availability of complete pre-transplant hemodynamic and echocardiographic data. Furthermore, our analysis was conducted within a uniform institutional protocol for transplant evaluation, minimizing practice variability.

However, several limitations must be acknowledged. This was a retrospective, single-center study, which may limit the generalizability of our findings. We did not assess outcomes beyond the time of transplantation, such as survival, rejection, or quality of life, which could provide a more comprehensive understanding of the impact of cardiomyopathy etiology. Additionally, potential confounders such as renal function, comorbidities, and medication use were not included in this analysis and should be addressed in future studies.

Conclusion

In conclusion, ischemic cardiomyopathy patients undergoing heart transplantation were significantly older than their non-ischemic counterparts but had similar preoperative hemodynamic and functional profiles. Our findings suggest that while ischemic cardiomyopathy is linked to older age, the extent of cardiac dysfunction and hemodynamic compromise at transplant is comparable across etiologies. Further studies are needed to determine whether these similarities translate into comparable post-transplant outcomes.

Disclosure of conflict of interest

None.

Abbreviations

ICMP, Ischemic cardiomyopathy; NICMP, non-ischemic cardiomyopathy; PCWP, Pulmonary capillary wedge pressure; LVEF, left ventricular ejection fraction; mPAP, mean pulmonary arterial pressure.

Address correspondence to: Dr. Mohammad Reza Movahed, University of Arizona Sarver Heart Center, 1501 North Campbell Avenue, Tucson, AZ 85724, The United States. Tel: 949-400-0091; E-mail: Rmova@aol.com

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