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THOUGHTS & PROGRESS

Does the distance between residency and implanting center affect the outcome of patients supported by left ventricular assist devices? A multicenter Italian study on radial mechanically assisted circulatory support (MIRAMACS) analysis

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Abstract

Background: Patients with LVAD require continuous monitoring and care, and since Implanting Centers (ICs) are more experienced in managing LVAD patients than other healthcare facilities, the distance between patient residency and IC could negatively affect the outcomes.

Methods: Data of patients discharged after receiving an LVAD implantation between 2010 and 2021 collected from the MIRAMACS database were retrospectively analyzed. The population was divided into two groups: A ($n = 175$) and B ($n = 141$), according to the distance between patient residency and IC ≤ or >90 miles.

The primary endpoint was freedom from Adverse Events (AEs), a composite outcome composed of death, cerebrovascular accident, hospital admission because of GI bleeding, infection, pump thrombosis, and right ventricular failure. Secondary endpoints were incidences of mortality and complications. All patients were followed-up regularly, according to participating center protocols.

Results: Baseline clinical characteristics and indications for LVAD did not differ between the two groups. The mean duration of support was 25.5 ± 21 months for Group A and 25.7 ± 20 months for Group B ($p = 0.79$). At 3 years, freedom from AEs was similar between Group A and Group B ($p = 0.36$), and there were no differences in rates of mortality and LVAD-related complications.

Conclusions: Distance from the IC does not represent a barrier to successful outcomes as long as regular and continuous follow-up is provided.

KEYWORDS

distance, left ventricular assist device, outcomes

1 | INTRODUCTION

The improvement in Left Ventricular Assist Device (LVAD) outcomes has led to an increasing number of patients who are supported by this long-term mechanical circulatory support and who are able to improve their quality of life, and be reintegrated into their communities, often far from the Implant Center (IC).[1,2]

However, patients with LVAD require continuous monitoring and periodic checks in order to prevent and treat as soon as possible any complication related to the device or to the anticoagulation treatment.[1–3] Since ICs are more experienced in managing LVAD patients than other healthcare facilities, the distance between patient residency and IC could negatively affect the outcomes.

The Multicenter Italian Study on Radial Mechanically Assisted Circulatory Support (MIRAMACS) offers to collect data from patients with totally implantable continuous-flow ventricular assist devices by experienced Italian centers, with the goal of running a national registry.[4] Using the data of the MIRAMACS, we aimed to analyze the impact of distance from the IC on LVAD patients' outcomes.

2 | METHODS

Data of patients discharged after receiving an LVAD implantation between 2010 and 2021 and collected into the MIRAMACS database were retrospectively analyzed. Distance between the patient residency and IC was calculated as straight distance, using the zip codes of patients. Since previously employed in literature,[4] a 90-mile threshold was chosen to divide the population into two groups: Groups A and B, according to a distance between patient residency and IC less than or equal to or >90 miles.

The primary endpoint was freedom from Adverse Events (AEs), a composite outcome composed of death, cerebrovascular accident, GI bleeding, infection, pump thrombosis, and right ventricular failure.

The secondary endpoints were incidences of mortality and complications during the study period.

2.1 | Patient follow-up

After discharge, patients were followed-up by means of regular outpatient visits: every month in Bologna and Bergamo ICs and every 2 months in all other participating ICs. During outpatient visits, each patient underwent clinical examination, laboratory tests, echocardiogram, technical LVAD consultation, and driveline exit-site inspection.

The anticoagulation dose, patient parameters, laboratory tests, and LVAD functioning were also checked in-between ambulatory visits either by shared care with specialized local physicians or by telemonitoring. This latter was performed by sharing clinical and laboratory data, VAD parameters, and pictures or videos with a 24/7 Help Desk Center led by the VAD coordinator through a dedicated application or via e-mail. The VAD coordinator could also perform a video call with patients and vice versa.

2.2 | Statistical analysis

Continuous variables were expressed as mean ± standard deviation. Categorical variables were expressed as absolute frequency and percentage. Comparisons were evaluated using the χ^2 test for categorical variables, and analysis of variance (ANOVA) or Kruskal–Wallis test for continuous variables. Freedom from Adverse Event curves was obtained by the Kaplan–Meier analysis and compared with the log-rank test. Patients were censored at the time of HTx or device explant for recovery. Incident events were calculated for secondary endpoints. All statistics were performed using the Statistical Package for Social Sciences (SPSS) program (Chicago, IL, USA).

3 | RESULTS

There were 175 patients who lived within 90 miles (group A) of the IC and 141 patients who lived beyond 90 miles (group B).

Overall, patients lived at a median distance from IC of 37 miles (interquartile range 15–123 miles). Patients of Group B lived in the top distance quartile, with a median distance from IC of 347 miles (interquartile range 165–456 miles). Patients of Group A lived at a median distance of 24 miles from IC (interquartile range 11–44 miles).

Baseline clinical characteristics and indications for LVAD did not differ between the two groups as shown in Table 1. Group A received a higher percentage of centrifugal flow pumps compared with Group B (75% vs 63% respectively, $p = 0.02$).

The mean duration of support was 25.5 ± 21 months for Group A and 25.7 ± 20 months for Group B ($p = 0.79$).

Outpatient clinical visits and total hospitalization rates were similar between the two groups. However, Group B patients received more hospitalization in local facilities than Group A patients ($p < 0.01$).

Freedom from Adverse Events was similar between Group A and Group B patients, being 59 ± 4% and 38 ± 4% vs 56 ± 4% and 35 ± 4% at 1 and 2 years, respectively ($p = 0.36$; Figure 1).

TABLE 1 Demographic data

	Group A ($n = 175$)	Group B ($n = 141$)	p
Male sex, *n* (%)	158 (90)	125 (89)	0.72
Age, mean ± SD	60 ± 11	60 ± 11	0.69
Etiology			0.37
Ischemic, *n* (%)	78 (45)	52 (37)	–
Idiopathic dilative, *n* (%)	72 (41)	68 (48)	–
Other, *n* (%)	25 (15)	21 (15)	–
Bridge-to-transplantation, *n* (%)	88 (50)	72 (51)	0.91
Destination therapy, *n* (%)	87 (50)	69 (49)	0.91
Axial flow pump, *n* (%)	43 (25)	52 (37)	0.02
Centrifugal flow pump, *n* (%)	132 (75)	89 (63)	0.02
INTERMACS Class			0.13
INTERMACS Class 1, *n* (%)	21 (12)	9 (7)	–
INTERMACS Class 2, *n* (%)	43 (25)	47 (33)	–
INTERMACS Class 3, *n* (%)	77 (44)	55 (39)	–
INTERMACS Class 4, *n* (%)	34 (19)	30 (21)	–
Pulmonary wedge pressure, mean ± SD	23 ± 8	21 ± 10	0.15
Central venous pressure, mean ± SD	10 ± 5	9 ± 4	0.58
Mean pulmonary artery pressure, mean ± SD	34 ± 13	32 ± 11	0.29
Creatinine, mean ± SD	1.3 ± 0.5	1.3 ± 0.4	0.83
Total bilirubine, mean ± SD	1.1 ± 0.7	1.2 ± 0.7	0.6
Intra-aortic baloon pump, *n* (%)	16 (9)	17 (12)	0.46
Atrial fibrillation, *n* (%)	27 (15)	11 (8)	0.06

Abbreviation: INTERMACS, interagency registry for mechanically assisted circulatory support.

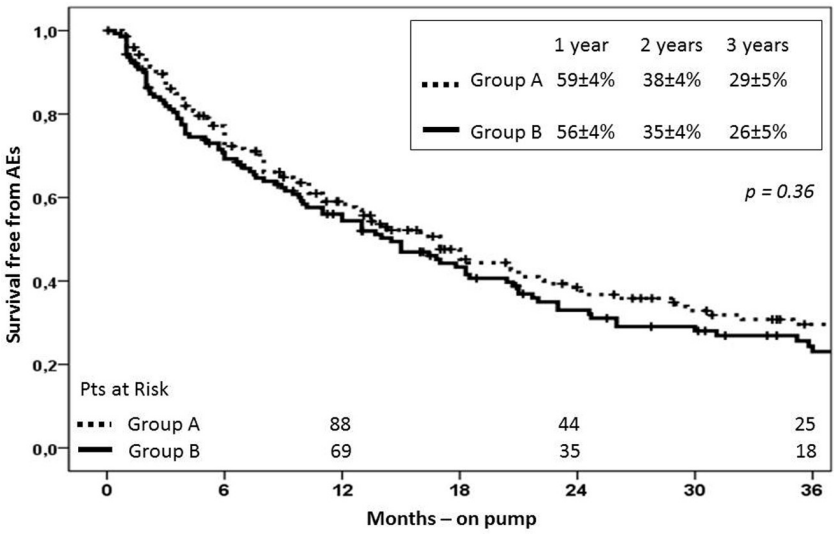

FIGURE 1 Kaplan–Meier curves showing freedom from adverse events according to groups

During the study period, Group A patients were less likely to receive Heart Transplantation compared with Group B (14% vs 27%, $p = 0.01$). No cases of device explant for recovery were reported.

There were 59 deaths in Group A and 49 in Group B, which accounted for 0.158 and 0.162 events-per-patient years (EPPY), respectively ($p = 0.88$). Causes of mortality were similar between the two groups as shown in Table 2.

Overall, infections, neurological events, GI bleeding, pump thrombosis, and right ventricular failure occurred in a total of 85 (27%), 63 (20%), 31 (10%), 31 (10%), and 29 (9%) patients, respectively. There were no differences in

TABLE 2 Causes of mortality

	Group A ($n = 59$)	Group B ($n = 49$)	p
Causes of mortality			0.53
Cerebrovascular accident, *n* (%)	20 (37)	12 (25)	
Sepsis, *n* (%)	9 (17)	8 (17)	
Multi-organ failure, *n* (%)	5 (9)	4 (8.5)	
Pump thrombosis, *n* (%)	3 (5.5)	6 (13)	
Neoplasia, *n* (%)	3 (6)	4 (8.5)	
Right ventricular failure, *n* (%)	3 (5.5)	5 (11)	
Gastrointestinal bleeding, *n* (%)	1 (2)	1 (2)	
VAD malfunction, *n* (%)	0 (0)	2 (4)	
Other, *n* (%)	10 (18)	5 (11)	

Abbreviation: VAD, ventricular assist device.

TABLE 3 Incidence rate of death and complications

Event per patient years (EPPY)	Group A	Group B	p
Death	0.158	0.162	0.88
Cerebrovascular accident	0.097	0.089	0.77
Pump thrombosis	0.035	0.059	0.13
Gastrointestinal bleeding	0.043	0.049	0.71
Driveline infection	0.110	0.145	0.13
Right ventricular failure	0.041	0.046	0.69
Outpatient visits	6.812	6.601	0.48
Total hospitalizations	0.349	0.417	0.35
Hospitalization in local facilities	0.071	0.215	<0.01

the incidence rate of such complications according to patient residency within 90 miles of the IC or 90 miles away, as reported in Table 3.

4 | DISCUSSION

Caring for LVAD patients requires complex and specialized management, and the distance between the patient residency and the IC could adversely influence the quality of care during the follow-up period, thus compromising the outcomes.

In fact, previous studies demonstrated that living far from specialized care facilities negatively affects patient outcomes, probably reflecting delays in diagnosis and treatment or suboptimal follow-up programs.[5–8]

The main finding of this multicenter study, however, is that the distance between LVAD patient residency and the IC > 90 miles did not seem to affect freedom from Adverse Events, rates of mortality, and LVAD-related complications at mid-term.

In a previous study, Ravichandran et al.[5] demonstrated that patients living >90 miles from an IC had an inclination toward worse survival but fewer complications and thus speculated that delayed care could be responsible for increased mortality from unaddressed complications.

In the present study, regular ambulatory visits, telemonitoring, and periodical sharing of patient information with a local trained physician were likely to contribute to the satisfactory results reported independently from the patient's place of living.

Telemonitoring could offer several benefits including early detection of complications and continuous evaluation of patient conditions, and data of the pump. Moreover, it seemed to reduce patient anxiety related to the device, increasing direct communication with the VAD team.[9] However, to sustain frequent remote controls, a consistent VAD coordinator program is fundamental, particularly in large-volume ICs.[10]

On the other hand, shared health programs have proven to be effective strategies in delivering care and improving outcomes in complex and chronic conditions.[11] Nevertheless, as LVAD patients require unique and highly specialized care, they experience unfavorable outcomes when followed-up in nonspecialized facilities.[12] Thus, shared care with local facilities remains an attractive way to follow-up with patients, provided that LVAD-specific resources and trained staff are available. Our data indicated that local facilities could guarantee assistance to patients who reside at a greater distance from implant centers. In cases requiring hospitalization, ICs are actively involved with local providers in order to manage the acute phase of complications.

The dissemination of LVAD-specific care knowledge is also important to face urgent or emergent needs in the rapidly enlarging population of LVAD patients, by empowering local healthcare facilities.[13]

Interestingly, this study revealed a low rate of right ventricular dysfunction, likely reflecting careful patient selection and follow-up.

This study was based on a retrospective analysis of a multi-institutional registry and thus subject to possible inaccuracies. Variability among participating centers exists regarding HTx policies, and this could reflect the higher rate of HTx in Group B. Moreover, one of the participating ICs was not an HT Center and enrolled a large number of patients with bridge-to-transplant indication living within

90 miles, this may have influenced the lower HTx rate in Group B.

In conclusion, distance from the IC does not represent a barrier to a successful outcome as long as a thorough follow-up is provided.

CONFLICT OF INTEREST

The authors have no conlficts of interest to declare.

AUTHORS' CONTRIBUTION

Concept/design: Andrea Lechiancole, Antonio Loforte; *Data analysis/interpretation*: Andrea Lechiancole, Antonio Loforte; *Drafting the article*: Andrea Lechiancole; *Critical revision of the article*: Andrea Lechiancole, Antonio Loforte, and Ugolino Livi; *Approval of the article: all authors; Statistics*: Andrea Lechiancole; and *Data collection*: Andrea Lechiancole, Marina Comisso, Attilio Iacovoni, and Gregorio Gliozzi.

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