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Five years of a self-sustaining heart transplant program in the Canary Islands

Maria del Val Groba-Marco, MD,[a,b,*] Vicente Peña-Morant, MD,[c] Francisco González-Vílchez, PhD,[d] Mario Galván-Ruiz, MD,[a] Miguel Fernandez-de-Sanmamed, MD,[a] Jose Luis Romero-Lujan, MD,[e] Francisco Portela-Torron, MD,[f] Eduardo Jose Caballero-Dorta, PhD,[a] Alicia Pérez-Blanco, PhD,[g] and Antonio García-Quintana, MD[a]

[a]*Cardiology Department, Hospital Universitario de Gran Canaria Dr. Negrín, Las Palmas de Gran Canaria, Spain*
[b]*Departamento de Ciencias Medicas y Quirurgicas, Universidad de Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain*
[c]*Transplant Coordination Unit, Hospital Universitario de Gran Canaria Dr. Negrín, Las Palmas de Gran Canaria, Spain*
[d]*Servicio de Cardiología, Hospital Universitario Marqués de Valdecilla, Santander, Cantabria, Spain*
[e]*Department of Critical Care, Hospital Universitario de Gran Canaria Dr. Negrín, Las Palmas de Gran Canaria, Spain*
[f]*Department of Cardiac Surgery, Hospital Universitario de Gran Canaria Dr. Negrín, Las Palmas de Gran Canaria, Spain*
[g]*Organización Nacional de Trasplantes, Madrid, Spain*

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One significant challenge in heart transplant (HT) is the shortage of grafts and underutilization of the donor pool. This study analyzes the unique characteristics of the HT program in the Canary Islands, established in 2019, which operates with a predominantly self-sustaining donor pool. A retrospective review of the Spanish HT Registry and National Transplant Organization reports between 2020 and 2024 revealed that 97% of transplanted hearts originated from local donors. The geographical constraints of the islands create an unresolved issue with ischemic time, prompting the Canary region to establish a new HT program based on donation after circulatory death and extended criteria donors. These 2 initiatives have increased the donor pool and transplantation rates, while maintaining ethical allocation and comparable survival rates. This model highlights how regional programs can improve the underutilized donor pool and transplantation opportunities, offering a framework for future initiatives to optimize donation.

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*Corresponding author: Maria del Val Groba-Marco, MD, Hospital Universitario de Gran Canaria Dr. Negrín, Barranco de la Ballena S/N, 35010 Las Palmas de Gran Canaria, Spain.

E-mail addresses: marivalgroba@hotmail.com, vpenmor@gobiernodecanarias.org, cargvf@gmail.com, mariogalvanr@hotmail.com, mikefdsg@gmail.com, jromluj@gobiernodecanarias.org, fportor@gobiernodecanarias.org, ecabdor@gobiernodecanarias.org, aperezb@sanidad.gob.es, agarquil@gobiernodecanarias.org.

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On the one hand, a self-sustaining program aims to diminish reliance on external donors by establishing a continuous and self-sufficient supply of organs at a local level over time. However, this approach raises concerns about its feasibility, ethical, logistical, and clinical implications. On the other hand, the growing demand for transplantable organs far exceeds the available supply, resulting in severe shortages and significant disparities, that may be influenced by geographical factors.[1]

In Spain, the distribution of donated organs is carried out under the coordination of the Organización Nacional de Trasplantes, which oversees and manages the donation and transplant process based on clinical urgency, compatibility, and geographical areas of transplantation.[2] However, remote regions may encounter challenges that impede both access to and equitable distribution of donated organs from other areas. Conversely, programs in more centralized regions may have difficulties in obtaining organs sourced from these remote territories.

Building upon the findings from our previous publication,[3] which detailed the establishment of a novel heart transplant (HT) program at the Hospital Universitario de Gran Canaria Dr. Negrín in the Canary Islands (the first of its kind in a European ultraperipheral region), this study assesses the program's progression and clinical outcomes through an extended follow-up and a comprehensive comparative analysis with other Spanish programs between 2020 and 2024. It aims to identify potential areas for improvement and optimization of transplant activity. Previously, Canarian residents were compelled to seek HT at mainland centers,[4] underscoring the critical need for a locally accessible program. To conduct this study, data were retrospectively collected from the Spanish HT Registry and Organización Nacional de Trasplantes transplant and donation reports.

The first HT in the Canary Islands was performed in December 2019, followed by 15, 17, 22, 21, and 22 HT in subsequent years. Overall, since the start of the HT program, 97% (95/98) of all procedures were conducted using local donors. Notably, only 2 hearts procured from Murcia (1,733 km away) and 1 from Madrid (2,048 km away) were transplanted in 2022 and 2023, all under urgent listing criteria (Figure 1). Additionally, only 11 local hearts were transplanted on the mainland. This is remarkable considering that the average exchange rate of donor hearts between the different Spanish transplant areas was 49%.[5]

Table 1 describes the main characteristics of recipients, donors, and procedures during 2020 and 2024. Compared to the rest of Spain, recipients in the Canary Islands had a similar age profile (55.3 ± 10.8 vs 53.0 ± 12.5, $p = 0.076$), a higher prevalence of dilated nonischemic cardiomyopathy (45.4% vs 34.3%, $p = 0.02$), lower glomerular filtration rate (62.2 vs 74.9 ml/min/1.73 m^2, $p < 0.001$), and less frequent history of previous cardiac surgery (16.3% vs 34.1%, $p < 0.001$).

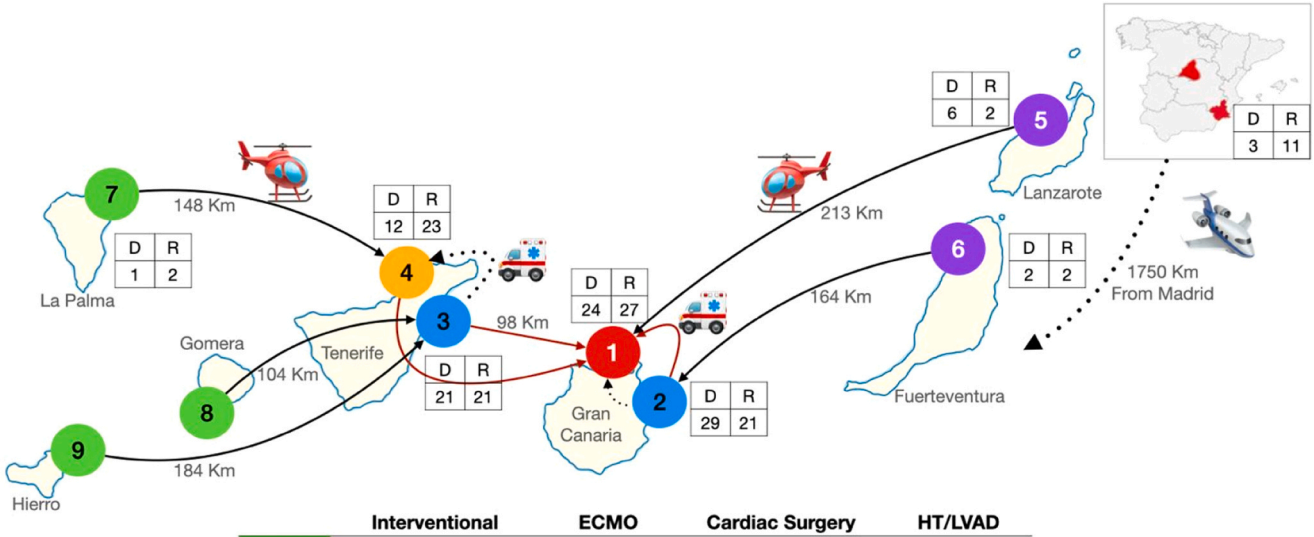

Figure 1 The Canarian Heart Transplant Model, organized based on the characteristics and facilities of hospitals, as well as the origins of donors and recipients, during the period from November 2019 to December 2024. 1: Hospital Universitario de Gran Canaria Doctor Negrín. 2: Complejo Hospital Universitario Materno-Infantil. 3: Hospital Universitario Nuestra Señora de Candelaria. 4: Hospital Universitario de Canarias. 5: Hospital Universitario Doctor José Molina. 6: Hospital General de Fuerteventura. 7: Hospital Universitario de La Palma. 8: Hospital Nuestra Señora de Guadalupe. 9: Hospital Insular Nuestra Señora de los Reyes. D, donors; ECMO, extracorporeal membrane oxygenation; HT, heart transplant; LVAD, left ventricular assist device; R, recipients.

Table 1 Recipient, Donor, and Procedure Characteristics of the Canarian Heart Transplant Program Compared to the Rest of the Adult Spanish Heart Transplant Programs in the Spanish Heart Transplant Registry (2020-2024)

Characteristics	SHTR (n = 1,305)	HUGCDN (n = 97)	p-value
Recipients			
Age (years)	52.96 ± 12.45	55.27 ± 10.80	0.076
> 60 (%)	32.1	32.0	0.98
Male sex (%)	73.0	80.4	0.11
Body mass index (kg/m^2)	25.44 ± 4.15	24.99 ± 4.20	0.30
Underlying etiology (%)			0.02
Nonischemic dilated	34.3	45.4	
Ischemic	35.2	36.1	
Other	30.6	18.6	
Pulmonary vascular resistance (U. Wood)	2.00 ± 1.34	1.95 ± 0.98	0.70
Glomerular filtration rate (ml/min/1.73 m^2)	74.90 ± 27.94	62.20 ± 23.69	< 0.0001
Bilirubin > 2 mg/dl (%)	11.7	14.6	0.40
Insulin-dependent diabetes (%)	22.3	23.7	0.752
Moderate-severe chronic obstructive pulmonary disease (%)	8.0	5.2	0.31
Previous infection (%)	15.8	5.2	0.005
Previous cardiac surgery (%)	33.2	16.5	0.001
Type of transplant (%)			0.42
Isolated transplant	95.6	99.0	
Heart retransplant (%)	2.5	1.0	
Combined	2.0	-	
Pretransplant mechanical ventilation (%)	8.0	8.3	0.90
Urgent transplant (%)	41.0	7.2	< 0.0001
Pretransplant circulatory support (%)			< 0.0001
No	60.6	81.4	
Balloon pump	0.7	9.3	
Extracorporeal membrane oxygenation	11.3	7.2	
Ventricular support	27.5	2.1	
Donor and procedures			
Age (years)	44.06 ± 12.71	47.37 ± 12.64	0.01
> 45 (%)	53.3	59.8	0.21
> 60 (%)	6.13	15.5	< 0.0001
Male sex (%)	65.2	85.6	< 0.0001
Female donor-male recipient	17.1	9.3	0.046
Recipient/donor weight	1.09 ± 0.23	1.17 ± 0.26	< 0.01
Cause of death (%)			< 0.02
Trauma	21.6	28.9	
Stroke	60.0	45.4	
Other	18.4	25.8	
Pretransplant cardiac arrest (%)	20.5	37.1	< 0.0001
Predonation echocardiogram (%)			< 0.001
Not performed	0.39	-	
Normal	99.1	94.9	
Mild generalized dysfunction	0.5	5.2	
Donation after circulatory death (%)	13.1	20.6	0.04
Ischemia time (min)	191.7 ± 73.3	151.9 ± 48.0	< 0.0001
≤120 (%)	20.7	27.8	0.0001
120-180 (%)	21.8	49.5	
180-240 (%)	33.0	16.5	
> 240 (%)	24.4	6.2	
Bicaval surgical technique (%)	79.6	97.9	< 0.0001

Abbreviations: HUGCDN, Hospital Universitario de Gran Canaria Dr. Negrín; SHTR: Spanish Heart Transplant Registry.
Values are expressed as percentage or mean ± standard deviation.

In the Canarian HT program, pretransplant circulatory assistance use was lower than in the rest of Spain (20% vs 36.9%, $p < 0.001$). The intra-aortic balloon pump was the most used bridge to HT (9.6% vs 0.7%, $p < 0.001$), with an average support duration of 15 ± 18 days. Notably, patients under intra-aortic balloon pump support were classified as nonurgent (without nationwide or regional prioritization).[6] Consequently, fewer transplants were performed under urgent criteria (7.2% vs

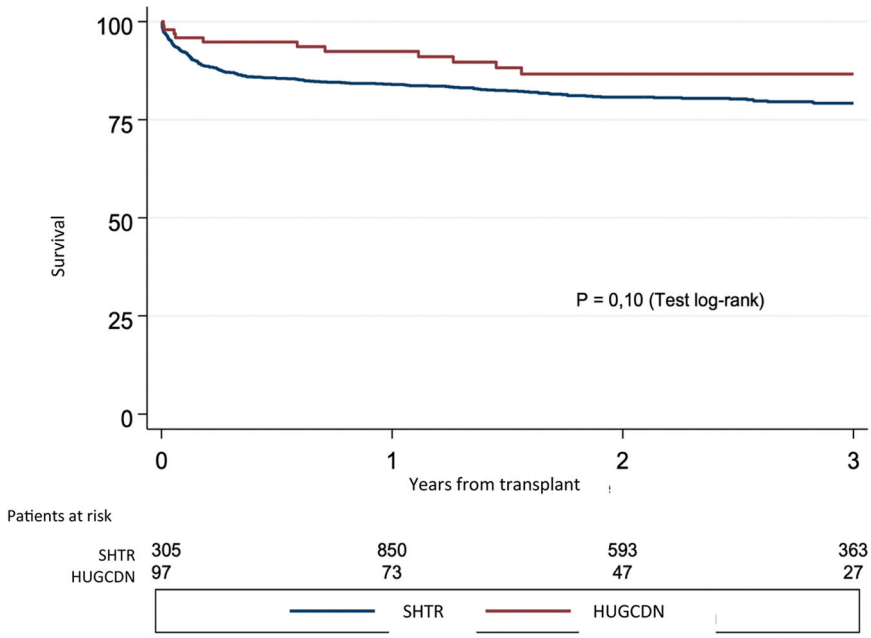

Figure 2 Comparison of the survival curves after heart transplant for the January 2020 and December 2024 period. HUGCDN, Hospital Universitario de Gran Canaria Dr. Negrín; SHTR, Spanish Heart Transplant Registry. Red = HUGCDN and blue = SHTR.

41.0%, $p < 0.001$), limiting national prioritization without negatively impacting nonprioritized patients' access to transplantation. Additionally, the average waiting time was markedly shorter (34.2 vs 92.4 days, $p = 0.001$), even while primarily relying on local donors.

Donors in the Canarian HT program were older (47.4 vs 44.1 years, $p = 0.01$), with a higher proportion aged over 60 (15.5 vs 6.13, $p < 0.002$). They were also more frequently male (85.7 vs 64.6%, $p < 0.001$) and less frequently female donors matched to male recipients (9.3 vs 17.1%, $p = 0.046$). An echocardiogram was performed before donation in all cases, and a higher percentage of hearts with mild global was utilized (5.2 vs 0.5%, $p < 0.001$). Remarkably, ischemia times were shorter in Canary Islands despite the challenges posed by a multi-inland region (151.9 vs 191.7 minutes, $p < 0.001$), underscoring the effectiveness of coordination and logistics.

In Spain, HT from controlled donation after circulatory death (DCD) using thoraco-abdominal normothermic regional perfusion and static cold-storage began in 2020 with 4 donors. In the Canary Islands, the program was initiated in 2021 with 1 HT, followed by 4, 7, and 8 HT in subsequent years, achieving 36% of all the procedures performed in 2024. Overall, the Canarian HT program demonstrated a significantly higher percentage of DCD procedures throughout the study (20.6% vs 13.1%, $p = 0.04$), substantially expanding the available donor pool.

A 266% increase in heart donation rates was observed when comparing the 5-year period preceding the HT program to the 5-year period following its implementation (7.4% vs 27.1%), revealing previously underutilized donor potential and the positive impact of local transplantation activity.[5] Additionally, transplant and indication rates, in these periods, also rose by 117% (4.8% vs 10.4%) and 30% (8.7% vs 11.3%), respectively,[5] likely due to relocation barriers to mainland programs, showing a substantial enhancement in access to HT. Survival rates were similar in the Canarian program compared to the rest of the Spanish programs (Figure 2), reflecting the effectiveness and reliability of the program.

While the strategies implemented in the Canarian HT program have successfully met the local demand for transplants, additional measures are being considered to broaden the donor retrieval radius nationwide, particularly for patients listed in urgent situations.[7,8]

In conclusion, although initially perceived as a limitation, the constraints imposed by the location of the Islands indeed facilitated the establishment of an almost self-sustaining program, with most recipients receiving organs from local donors. This achievement has been made possible through the rapid incorporation of DCD and the use of expanded-criteria donors, which have significantly increased the heart donor pool. Furthermore, the limited accessibility of hearts procured from the Canary Islands for urgent, prioritized patients in mainland HT programs, coupled with the Canarian program's low rate of transplants performed under urgent criteria, has contributed to this unique approach. This HT program is a successful model that can serve as research framework to enhance donation practices and optimize transplantation protocols, while maintaining ethical standards of equity. Moreover, it provides a valuable example for developing future programs that might otherwise be considered unfeasible.

Data availability

Data available upon request.

Disclosure statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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CRediT authorship contribution statement

Maria del Val Groba-Marco, Vicente Peña-Morant, Francisco González-Vílchez, Francisco Portela-Torron, Jose Luis Romero-Lujan, Mario Galvan-Ruiz, Miguel Fernandez-de-Sanmamed, Alicia Pérez-Blanco, Eduardo Caballero-Dorta, and Antonio Garcia-Quintana participated in the performance of the research and validation. Mariadel Val Groba-Marco, Vicente Peña-Morant, Francisco González-Vílchez, Vicente Peña-Morant, Jose Luis Romero-Lujan, Alicia Pérez-Blanco, and Antonio Garcia-Quintana participated in the research design, writing of the paper, editing and revision. Maria del Val Groba-Marco, Vicente Peña-Morant, Francisco González-Vílchez, and Antonio Garcia-Quintana participated in the methodology, statistical analysis, and project administration.

Author agreement

All authors have seen and approved the final version of the manuscript being submitted.

Institutional review board

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of Comité de Ética de la Investigación/Comité de Ética de la Investigación con Medicamentos de Las Palmas (protocol code 2022-606-1 and date of approval January 13, 2023).

Informed consent

Informed consent was obtained from all subjects involved in the study.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used CHAT-GPT to improve readability and writing. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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