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Outcomes of Heart Transplant Donation After Circulatory Death

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ABSTRACT

BACKGROUND Heart transplantation using donation after circulatory death (DCD) allografts is increasingly common, expanding the donor pool and reducing transplant wait times. However, data remain limited on clinical outcomes.

OBJECTIVES We sought to compare 6-month and 1-year clinical outcomes between recipients of DCD hearts, most of them recovered with the use of normothermic regional perfusion (NRP), and recipients of donation after brain death (DBD) hearts.

METHODS We conducted a single-center retrospective observational study of all adult heart-only transplants from January 2020 to January 2023. Recipient and donor data were abstracted from medical records and the United Network for Organ Sharing registry, respectively. Survival analysis and Cox regression were used to compare the groups.

RESULTS During the study period, 385 adults (median age 57.4 years [IQR: 48.0-63.7 years]) underwent heart-only transplantation, including 122 (32%) from DCD donors, 83% of which were recovered with the use of NRP. DCD donors were younger and had fewer comorbidities than DBD donors. DCD recipients were less often hospitalized before transplantation and less likely to require pretransplantation temporary mechanical circulatory support compared with DBD recipients. There were no significant differences between groups in 1-year survival, incidence of severe primary graft dysfunction, treated rejection during the first year, or likelihood of cardiac allograft vasculopathy at 1 year after transplantation.

CONCLUSIONS In the largest single-center comparison of DCD and DBD heart transplantations to date, outcomes among DCD recipients are noninferior to those of DBD recipients. This study adds to the published data supporting DCD donors as a safe means to expand the heart donor pool. (J Am Coll Cardiol 2023;82:1512–1520) © 2023 the American College of Cardiology Foundation. Published by Elsevier. All rights reserved.

Over the past 3 years, heart transplantation from donation after circulatory death (DCD) donors is increasingly being performed to expand the donor pool.[1,2] It is estimated that the use of DCD donors could increase heart transplant volume by approximately 30%.[3] According to data from the United Network for Organ Sharing (UNOS), 347 DCD hearts were transplanted by U.S. centers in 2022, a 68% increase compared with 2021, when 206 DCD hearts were transplanted.[4,5] During the first 6 months of 2023, more than 254 DCD hearts have been recovered, accounting for approximately

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13.3% of all U.S. heart transplants this year (compared with 8.7% in 2022, 5.7% in 2021, and 3.3% in 2020).[6] The increase in DCD heart transplantation has resulted in a higher transplantation rate and shorter wait times for listed candidates.[7,8] However, there are limited data on key outcomes among recipients of DCD hearts compared with recipients of hearts from brain dead (DBD) donors.[2,9-16]

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In Europe and Australia, where modern DCD heart transplantation has been practiced since 2014, studies suggest noninferior outcomes among recipients of DCD compared with DBD hearts.[1,2,11,17] Outcomes among U.S. recipients of DCD hearts have largely been limited to small single-center series[13,15,18] and analyses of the UNOS database.[9,10] In the one randomized controlled trial to date, recipients of DCD hearts recovered with the use of ex vivo machine perfusion (EVP) had no significant difference in survival to 6 months compared with recipients of DBD hearts recovered with the use of static cold storage.[16] There have been no reports on the influence of DCD heart transplants on cardiac allograft vasculopathy (CAV) or rehospitalizations, and few reports that include outcomes among recipients of DCD hearts recovered with the use of normothermic regional perfusion (NRP).[15,19] Our center began performing DCD heart transplantation in January 2020 and has since performed more than 120 DCD transplants, the majority recovered with the use of NRP. We sought to compare outcomes among our DCD recipients with outcomes among contemporary DBD recipients.

METHODS

STUDY POPULATION. We performed a retrospective review of patients aged ≥18 years undergoing heart transplantation at Vanderbilt University Medical Center (VUMC) from January 1, 2020, to January 28, 2023. Patients undergoing multiorgan transplantation were excluded. Patients referred by the Veterans Affairs (VA) system undergo transplant at VUMC but are followed and managed after hospital discharge by the Nashville VA Hospital. VA patients were included in analyses of outcomes during index transplantation admission but were censored at hospital discharge for all postdischarge outcomes other than mortality. Hearts from DBD donors were recovered with the use of either EVP (Organ Care System Heart; Transmedics) or static cold storage. Hearts from DCD donors were recovered with the use of either EVP or NRP using previously defined techniques.[15,16] Post-transplantation management of recipients including induction, immunosuppression, and rejection, and CAV surveillance was according to center protocol, without modifications based on DCD vs DBD donor status.

DATA COLLECTION, DEFINITIONS, AND STUDY OUTCOMES. This study was approved by the Institutional Review Board at VUMC. Recipient data and operative characteristics were abstracted from the electronic medical record. Donor data were abstracted from the UNOS database. Sex mismatch was defined as a male donor into a female recipient or female donor into a male recipient. Size mismatch was defined as donor weight <70% of recipient weight. The Wernovsky inotrope score[20] was calculated using the highest doses of each inotrope during the defined time window by means of the following formula: dopamine dose (μg/kg/min) + dobutamine dose (μg/kg/min) + 100 × epinephrine dose (μg/kg/min). The vasoactive inotrope score[21] was calculated by taking the Wernovsky score and adding the highest dose of additional vasoactive medications by means of the following formula: Wernowsky inotrope score + 10 × milrinone dose (μg/kg/min) + 10,000 × vasopressin dose (U/kg/min) + 100 × norepinephrine dose (μg/kg/min).

The primary outcome was survival at 1-year after transplantation. Secondary outcomes included survival to hospital discharge and 30 days and 6 months after transplantation, severe primary graft dysfunction (PGD) as defined by the International Society for Heart and Lung Transplantation (ISHLT),[19] treated cellular or antibody-mediated rejection during the first post-transplantation year, and development of CAV ≥1 at 1 year after transplantation, graded according to the ISHLT consensus definition.[21] Other secondary outcomes included post-transplantation hospital length of stay and hospital readmission after index transplantation discharge.

STATISTICAL ANALYSIS. Data are presented as n (%) for categoric variables and as mean ± SD or median (IQR) for continuous variables. The Wilcoxon rank sum test was used to compare continuous variables, and the chi-square test was used to evaluate categoric variables. Kaplan-Meier curves were plotted for survival analyses, and log-rank tests were used to compare the survival curves for the 2 groups. Cox proportional hazard models were fit to estimate the HR for outcomes of interest between DCD and DBD donors. For those outcomes with a sufficient number of events, recipient age, sex, and race as well as donor age were adjusted for in the model. Statistical analyses were performed with the use of R version 4.2.2

ABBREVIATIONS AND ACRONYMS

CAV = cardiac allograft vasculopathy

DBD = donation after brain death

DCD = donation after circulatory death

EVP = ex vivo machine perfusion

LVAD = left ventricular assist device

NRP = normothermic regional perfusion

PGD = primary graft dysfunction

TABLE 1 Donor Characteristics

	DCD (n = 122)	DBD (n = 263)	*P* Value
Age, y	26 (21-33)	31 (25-40)	<0.001
Male	83 (68.0)	142 (54.0)	<0.001
Race			<0.001
White	78 (63.9)	157 (59.7)	
Black	3 (2.50)	41 (15.6)	
Other	41 (33.6)	65 (24.7)	
Body mass index, kg/m^2	26.4 (23.5-28.7)	26.1 (22.6-31.2)	0.77
Blood type			0.34
A	27 (30.0)	79 (35.0)	
B	6 (7.0)	16 (7.0)	
AB	0 (0.0)	6 (3.0)	
O	57 (63.0)	128 (55.0)	
Hypertension	7 (8.0)	40 (18.0)	0.02
Hepatitis C nucleic acid test positive	6 (5.0)	50 (19.0)	<0.001
Cigarette smoking history (>20 pack-y)	6 (5.0)	42 (16.0)	<0.001
Mechanism of death			0.002
Asphyxiation	6 (5.0)	8 (3.0)	
Blunt injury	31 (25.0)	38 (14.0)	
Cardiovascular	10 (8.0)	32 (12.0)	
Natural causes	3 (2.5)	7 (3.0)	
Drowning	0 (0.0)	2 (1.0)	
Drug intoxication	17 (14.0)	75 (28.5)	
Electrical	0 (0.0)	1 (0.5)	
Gunshot wound	14 (12.0)	27 (10.0)	
Intracranial hemorrhage/stroke	6 (5.0)	28 (11.0)	
Seizure	0 (0.0)	3 (1.0)	
None of the above	3 (2.5)	8 (3.0)	
Missing	32 (26.0)	34 (13.0)	
Drug use	58 (48.0)	169 (64.0)	0.002
Sex mismatch	14 (16.0)	60 (26.0)	0.04
Size mismatch	16 (18.0)	50 (22.0)	0.40
Donor left ventricular ejection fraction, %			0.001
<50	6 (5.0)	4 (1.5)	
50-54	5 (4.0)	13 (5.0)	
55-60	39 (32.0)	74 (28.0)	
>60	42 (34.0)	56 (21.0)	
Missing	30 (25.0)	116 (44.0)	
Predicted heart mass ratio	0.95 (0.85-1.09)	0.94 (0.82-1.08)	0.5
Distance from transplant center	233 (125-289)	233 (89-344)	0.66
Height, cm	178 (173-183)	170 (165-179)	<0.001
Weight, kg	82 (73-95)	77 (67-94)	0.07

Values are median (IQR) or n (%).
DBD = donation after brain death; DCD = donation after circulatory death.

(R Core Team). A 2-sided *P* value <0.05 was considered to be statistically significant.

RESULTS

DONORS AND RECIPIENTS. From January 2020 to January 2023, 385 patients underwent heart transplantation at our institution (Table 1), including 263 recipients of DBD hearts and 122 recipients of DCD hearts (Central Illustration). Median follow-up for the entire cohort was 511 days (IQR: 218-805 days).

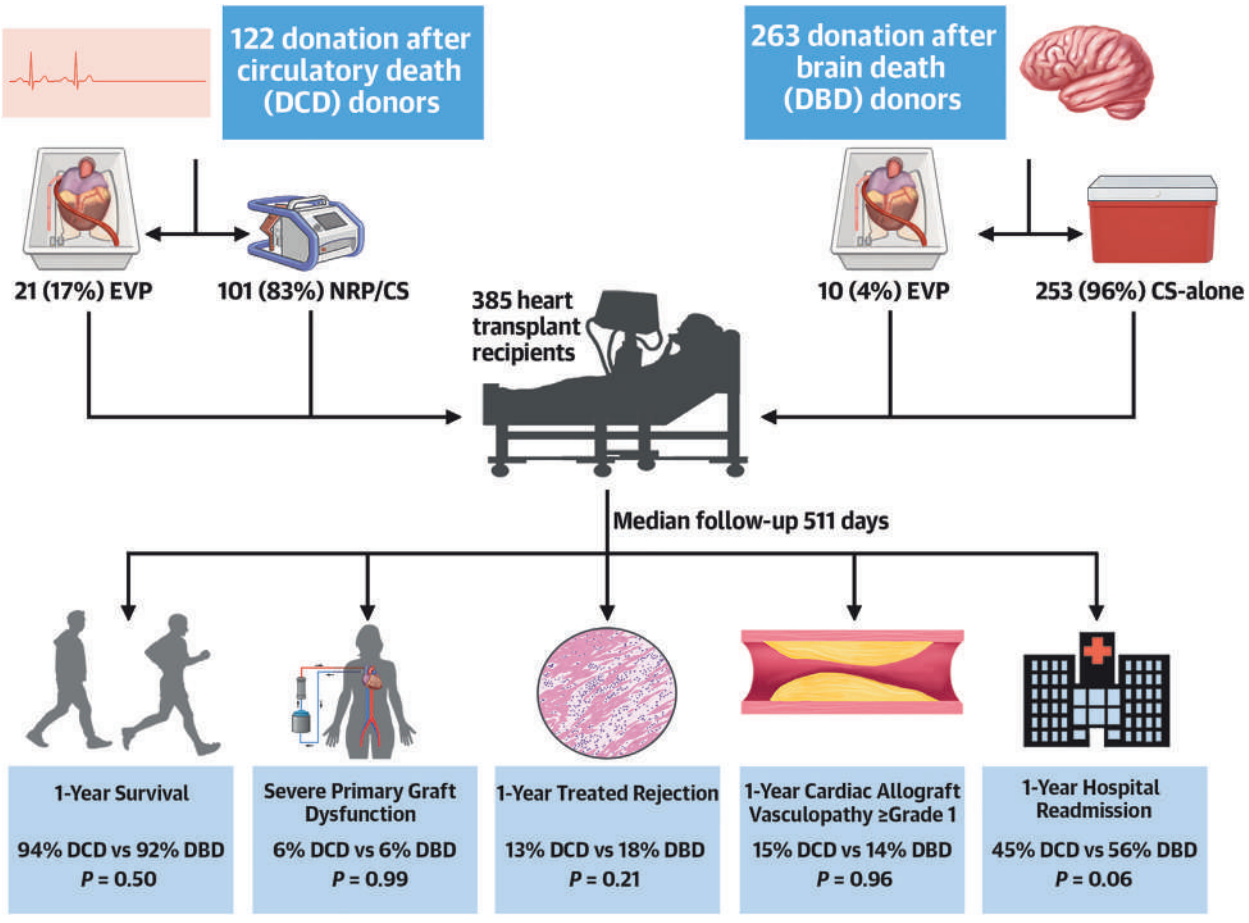
Donor characteristics, stratified by DCD or DBD, are outlined in Table 1. Compared with DBD donors, DCD donors were younger (median 26.0 years [IQR: 21.3-33.0 years] vs 31.0 years [IQR: 25.0-40.0 years]; $P < 0.001$), more likely to be male (68% vs 54%; $P < 0.001$), and more likely to be White (63.9% vs 59.7%; $P < 0.001$). In addition, DCD donors were less likely to have hypertension (7.8% vs 17.9%; $P = 0.024$), a >20 pack-year history of smoking (4.9% vs 16.0%; $P < 0.001$), and positive hepatitis C nucleic acid test results (4.9% vs 19.0%; $P < 0.001$). Finally, cause of death among DCD compared with DBD donors was more likely due to blunt injury (25.4% vs 14.4%) and less likely due to drug intoxication (13.9% vs 28.5%; $P = 0.002$ for all).

Among recipients, median age was 57.4 years (IQR: 48.0-63.7 years), 100 (26%) were women, and 279 (72.5%) were White. The baseline characteristics of recipients were similar in the 2 groups with the exception that DCD recipients were more often male (84% vs 70%; $P = 0.004$) and had higher body mass index (30.4 kg/m^2 [IQR: 26.1-34.8 kg/m^2] vs 28.8 kg/m^2 [IQR: 25.1-32.9 kg/m^2]; $P = 0.024$) and estimated glomerular filtration rate at transplantation (64.5 mL/min/1.73 m^2 [IQR: 47.2-82.8 mL/min/1.73 m^2] vs 55.0 mL/min/1.73 m^2 [IQR: 39.0-73.0 mL/min/1.73 m^2]) (Table 2). In addition, DCD recipients were less often hospitalized before transplantation (24.4% vs 49.2%; $P < 0.001$), less often on temporary mechanical circulatory support at time of transplantation (18.0% vs 31.6%; $P = 0.006$), and more often supported by a durable left ventricular assist device (LVAD) (36.1% vs 25.9%; $P = 0.04$). There were no significant differences between groups in age at transplantation, hypertension, diabetes, ischemic heart disease, previous tobacco use, blood type, or number of days on the waitlist (median 16.0 days [IQR: 5.0-56.0 days] DCD vs 14.0 days [IQR: 5.0-77.5 days] DBD; $P = 0.787$) (Table 1).

DCD donors were less likely than DBD donors to be used in a sex-mismatched transplantation (15.6% vs 26.2%; $P = 0.043$). There was no significant difference between groups in the likelihood of a size-mismatched transplantation. Predicted heart mass ratios in both groups were similar.

PERIOPERATIVE CHARACTERISTICS. Median distance from donor to recipient hospital was similar between DCD and DBD transplants (233 km [IQR: 125-289 km] vs 233 km [IQR: 89-343 km]; $P = 0.66$) (Table 3). Among DCD hearts, 21 (17%) were recovered using EVP while 101 (83%) were recovered using NRP followed by static cold storage. Among DBD hearts, 10 (4%) were recovered using EVP while 253 (96%) were

CENTRAL ILLUSTRATION **Characteristics and Outcomes of Hearts Donated After Circulatory Death**



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This study analyzed 385 heart-only transplant recipients, 122 (32%) of whom received hearts from donation after circulatory death (DCD) donors and 263 (68%) from donation after brain death (DBD) donors. Outcomes including 1-year survival, severe primary graft dysfunction, 1-year treated rejection, 1-year cardiac allograft vasculopathy ≥Grade 1, and 1-year readmissions were not significantly different between groups. CS = cold storage; EVP = ex vivo machine perfusion; NRP = normothermic regional perfusion.

recovered using static cold storage. The number of red blood cell, plasma and platelet transfusions within the first 48 hours after transplant were similar for both groups, as were the Wernovsky and vasoactive inotrope scores at 24 and 48 hours (Table 3).

OUTCOMES. There was no difference in 1-year post-transplantation survival between DCD (94.3%) and DBD (92.4%) recipients (HR: 0.77; 95% CI: 0.32-1.81; $P = 0.54$) (Table 4, Figure 1A). This finding was unchanged when adjusted for recipient age. Similarly, there were no significant differences between groups in survival to hospital discharge (93.4% DBD vs 94.5% DCD; HR: 0.72; 95% CI: 0.26-1.99; $P = 0.53$), to 30 days (95.1% DBD vs 96.7% DCD; HR: 0.67; 95% CI: 0.22-2.05; $P = 0.48$), or to 6 months (92.8% DBD vs 94.3% DCD; HR: 0.68; 95% CI: 0.25-1.85; $P = 0.45$) after transplantation (Table 4).

Incidence of severe PGD was similar between groups (5.7% DCD vs 5.7% DBD; HR: 1.00; 95% CI: 0.41-2.4; $P = 0.99$) (Table 4, Figure 1B). There were no differences between DCD and DBD recipients in the 1-year incidence of treated rejection (18% DCD vs 21% DBD; HR: 0.70; 95% CI: 0.37-1.31; $P = 0.26$) (Figure 1C), a finding that remained consistent after adjusting for recipient age, sex, and race and donor age (Table 4). There was also no difference in risk of CAV ≥ISHLT

TABLE 2 Recipient Characteristics

	DCD (n = 122)	DBD (n = 263)	*P* Value
Age, y	59 (49-64)	57 (48-63)	0.57
Male	102 (84.0)	183 (70.0)	0.004
Race			0.10
White	97 (80.0)	182 (69.0)	
Black	22 (18.0)	74 (28.0)	
Other	3 (2.0)	7 (3.0)	
Body mass index, kg/m^2	30.4 (26.1-34.8)	28.8 (25.1-32.9)	0.02
Wait list time	16 (5-56)	14 (5-78)	0.79
Status at transplantation			<0.001
1	3 (2.5)	13 (5.0)	
2	9 (7.5)	92 (35.0)	
3	18 (15.0)	39 (15.0)	
4	34 (28.0)	54 (20.5)	
5	0 (0.0)	9 (3.0)	
6	26 (21.0)	22 (8.5)	
Missing	32 (26.0)	34 (13.0)	
Blood type			0.36
A	40 (33.0)	102 (39.0)	
B	17 (14.0)	29 (11.0)	
AB	3 (2.0)	13 (5.0)	
O	52 (51.0)	119 (45.0)	
Ischemic HF etiology	44 (36.0)	82 (31.0)	0.34
Retransplantation	3 (2.5)	21 (8.0)	0.04
Hypertension	17 (14.0)	54 (21.0)	0.12
Diabetes mellitus	90 (74.0)	178 (68.0)	0.23
eGFR at transplantation, mL/min/1.73 m^2	65 (47-83)	55 (39-73)	<0.001
Smoking			0.50
Former	58 (48.0)	105 (40.0)	
Never	61 (50.0)	150 (57.0)	
Current	0 (0.0)	1 (0.4)	
Unknown	3 (2.0)	7 (2.6)	
Temporary MCS before surgery	22 (18.0)	83 (32.0)	0.006
Veterans Affairs patient	15 (12.0)	41 (16.0)	0.39
Durable LVAD before transplantation	44 (36.0)	68 (26.0)	0.04
Inpatient before transplantation	29 (24.0)	129 (49.0)	<0.001
Pretransplantation length of hospitalization, d	1 (0-2)	2 (1-12)	<0.001
Post-transplantation hospital length of stay, d	17 (13-26)	18 (13 –27)	0.57

Values are median (IQR) or n (%).

DBD = donation after brain death; DCD = donation after circulatory death; eGFR = estimated glomerular filtration rate; HF = heart failure; LVAD = left ventricular assist device; MCS = mechanical circulatory support.

Grade 1 at 1 year between the 2 groups (15% DCD vs 14% DBD; OR: 1.03; 95% CI: 0.32-3.4; $P = 0.96$) (Table 4).

Median hospital length of stay was similar between groups (DCD 17 days [IQR: 13-26 days] vs DBD 18 days [IQR: 13-27 days]; $P = 0.56$) and there was no difference between groups in hospital readmission within 30 days (33% DBD vs 26% DCD; HR: 0.82; 95% CI: 0.52-1.30; $P = 0.4$) or 1 year (56% DBD vs 45% DCD; HR: 0.82; 95% CI: 0.58-1.17; $P = 0.28$) (Figure 1D) after transplantation, including after adjustment for recipient age, sex, and race and donor age (Table 4).

DISCUSSION

Although hearts from DBD donors continue to account for the majority of hearts transplanted worldwide, adoption of DCD heart transplantation is increasing.[9] In the largest single-center comparison of DCD and DBD heart transplant outcomes to date, we found no significant difference in 1-year post-transplantation survival between groups. In addition, there were no significant differences between groups in key outcomes including severe PGD, incidence of treated rejection, and CAV ≥ISHLT Grade 1 at 1 year after transplantation.

Our findings are in keeping with those of other published reports demonstrating noninferior survival among DCD recipients compared to DBD recipients.[2,9-11,14] In the recently published randomized study by Schroder et al,[16] survival to 6 months after transplantation was 94% among recipients of DCD hearts recovered with the use of EVP compared with 90% among recipients of DBD hearts recovered with the use of static cold storage. One-year survival in our cohort was similar (94.3% DCD vs 92.4% DBD), despite differences in heart preservation strategies (83% NRP and 17% EVP in this study vs 100% EVP in the Schroder et al[16] study) and longer-term follow-up in our cohort. However, in contrast to previous studies that suggested increased rates of PGD among DCD recipients, we found no significant difference in rates of severe PGD between groups.[13,16,18] The reason for differences in PGD rates across studies is unclear but may be attributable to differences in organ recovery or preservation methods or in post-transplantation management strategies. In this study, the majority of DCD hearts (83%) were recovered with the use of NRP. This institutional preference for NRP is motivated by our early experience demonstrating satisfactory short-term outcomes with extended ischemia times without the need for ex situ perfusion during organ transport, as well as surgical expertise with NRP and cost savings compared with EVP.[15] Whether NRP confers superior ischemic reconditioning to the allograft compared with EVP remains to be determined. Our study was not powered to detect differences in severe PGD among DCD recipients based on recovery technique, and future studies will be needed to inform which procurement and preservation strategies yield optimal transplant outcomes. In addition, as other centers have demonstrated, increasing surgical experience with DCD recovery may be associated with decreased PGD rates over time.[10,12,13]

Reports have speculated that warm ischemia during DCD heart procurement may provoke inflammation leading to increased risk of rejection or vasculopathy.[22,23] In an analysis of the UNOS registry that compared 229 DCD and 7,267 DBD heart transplant recipients, acute rejection requiring treatment before the index discharge occurred significantly more frequently in DCD than in DBD recipients (14.7% vs 10.1%; $P = 0.03$).[9] In other studies, including the present study where follow-up time was much longer, there were no differences among DCD and DBD recipients in rates of treated rejection.[2] Whether increased rejection seen in other studies is a result of some programs using less induction or reduced maintenance immunosuppression in DCD recipients remains unclear.

This is the first study in the DCD era to report on risk of CAV at 1 year after transplantation, finding no significant difference between DCD and DBD recipients. Though speculative, it is possible that the absence of brain death and the ensuing catecholamine surge that otherwise takes place in the DBD donor may prevent or reduce endothelial dysfunction at the time of engraftment, which has been posited to be a risk factor for CAV development and progression.

Given the ethical and logistical considerations surrounding DCD withdrawal of care, coronary angiography in the DCD donor is often unavailable. With that in mind, the fact that DCD donors in our study tended to be younger and have fewer comorbidities than DBD donors likely reflects a deliberate donor selection bias in favor of DCD hearts unlikely to have atherosclerotic coronary disease based on their risk profiles. These findings are similar to those seen in other studies.[3,10,13,16,18,24] Among recipients in this study, DCD recipients tended to be less acutely ill at time of transplantation compared with DBD recipients. Nearly 50% of DCD recipients were listed at status 4 or lower, compared with 32% of DBD recipients. In addition, fewer DCD recipients required temporary mechanical circulatory support, and more were supported with durable LVADs. Although these findings might reflect selection bias for certain DCD candidate profiles, we do not think that this is the case, given programmatic openness to the DCD transplants for all listed candidates. Rather, the fact that there was a greater proportion of less sick recipients in the DCD group likely reflects expansion of the donor pool for all our listed patients—including those at lower listing status—during a time period when many centers were still not accepting DCD offers. Indeed, this same pattern has been identified in other comparisons of DCD and DBD heart transplants.[10,13,16] The presence of more patients with LVADs in the DCD group may have added increased risk to the transplant surgical procedure, given the

TABLE 3 Operative Characteristics

	DCD (n = 122)	DBD (n = 263)	*P* Value
Ex vivo machine perfusion	21 (17.0)	10 (4.0)	<0.001
Normothermic regional perfusion	101 (83.0)	0 (0.0)	N/A
Static cold storage only	0 (0.0)	253 (96.0)	N/A
RBC transfusions within 48 h, U	3 (2-6)	4 (2-9)	0.22
Plasma transfusions within 48 h, U	4 (2-6)	4 (2-8)	0.94
Platelet transfusions within 48 h, U	2 (1-3)	2 (1-4)	0.24
Wernovsky score (24 h)	8.1 (5.2-8.4)	8.1 (5.2-8.3)	0.98
Wernovsky score (48 h)	6.1 (5.1-8.3)	6.2 (5.1-8.2)	0.50
Vasoactive inotrope score (24 h)	8.5 (6.5-10.9)	8.5 (5.6-12.1)	0.99
Vasoactive inotrope score (48 h)	8.3 (5.4-10.8)	8.2 (5.5-10.8)	0.85

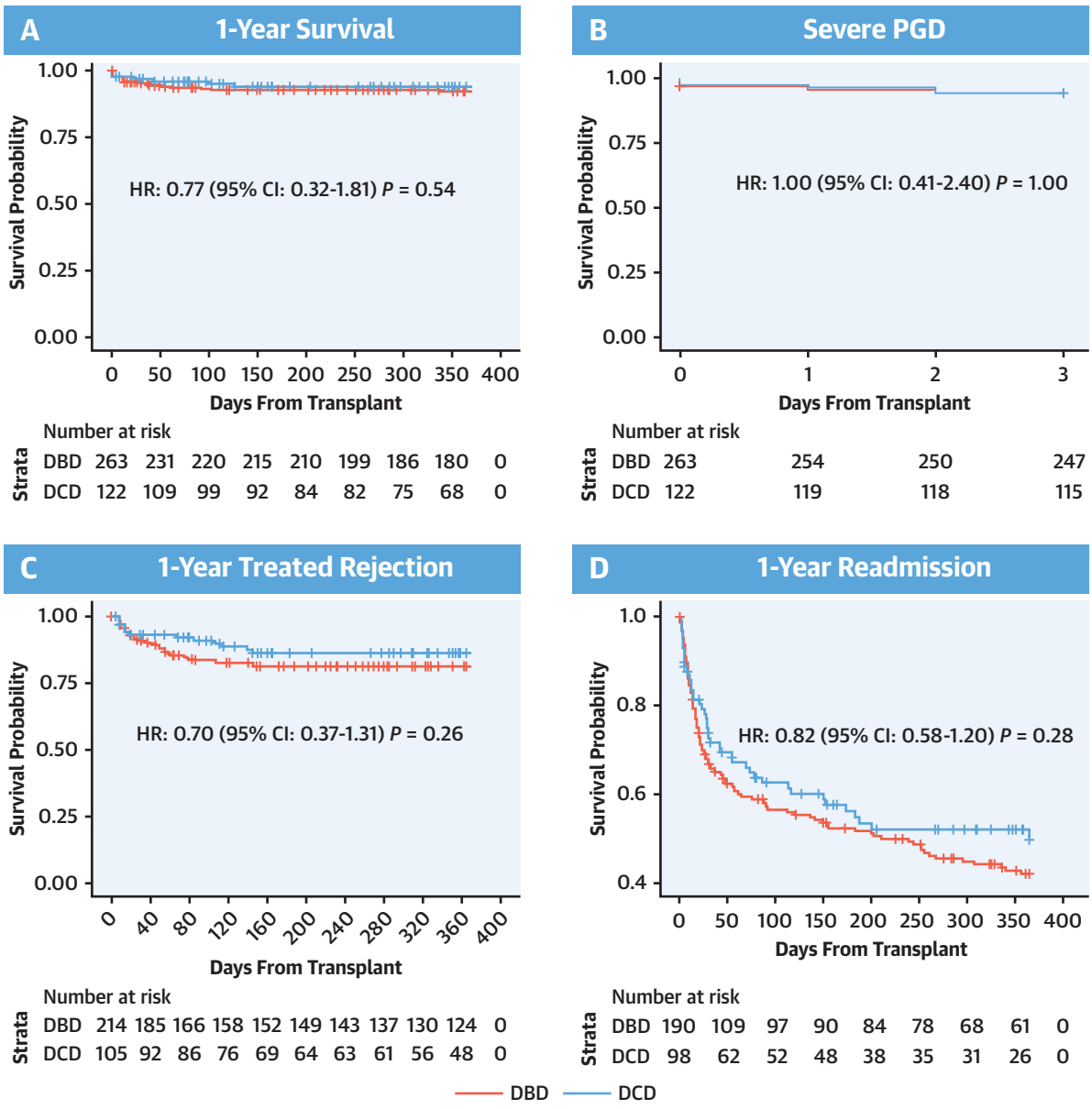
Values are n (%) or median (IQR).
DBD = donation after brain death; DCD = donation after circulatory death.

TABLE 4 Outcomes

	DCD	DBD	Unadjusted HR (95% CI) for DCD Compared With DBD	*P* Value for Unadjusted HR	Adjusted HR (95% CI) for DCD Compared With DBD	*P* Value for Adjusted HR
30-d post-transplantation mortality	4 (3.0)	13 (5.0)	0.67 (0.22-2.05)	0.48	N/A	N/A
6-mo post-transplantation mortality	7 (6.0)	19 (7.0)	0.80 (0.34-1.91)	0.62	N/A	N/A
1-year post-transplantation mortality	7 (6.0)	20 (8.0)	0.77 (0.32-1.81)	0.54	0.75 (0.32-1.80)[a]	0.52
In-hospital mortality	5 (4.0)	15 (6.0)	0.72 (0.26-1.99)	0.53	N/A	N/A
Severe primary graft dysfunction at 48 h after transplantation	7 (6.0)	15 (6.0)	1.00 (0.41-2.40)	1.00	1.00 (0.41-2.50)[a]	0.99
Treated rejection in 1 y	16 (13.0)	48 (18.0)	0.70 (0.37-1.31)	0.26	1.00 (0.52-2.00)[b]	0.97
CAV at 1 y after transplantation	4 (15.0)	16 (14.0)	1.03 (0.32-3.40)	0.96	N/A	N/A
30-d hospital readmission	32 (26.0)	87 (33.0)	1.2 (0.8-1.9)	0.40	1.2 (0.7-2.2)[b]	0.47
1 y post-transplantation hospital readmission	55 (45.0)	146 (56.0)	0.82 (0.58-1.20)	0.28	0.85 (0.56-1.28)[b]	0.43

Values are n (%) unless otherwise indicated. [a]Adjusted for recipient age. [b]Adjusted for recipient age, sex, and race and donor age.
CAV = cardiac allograft vasculopathy; DBD = donation after brain death; DCD = donation after circulatory death.

FIGURE 1 **Key Outcomes of DCD vs DBD Recipients**



Kaplan-Meier analysis demonstrates no significant differences in **(A)** 1-year survival, **(B)** severe primary graft dysfunction (PGD), **(C)** incidence of treated acute rejection in the first year after transplantation, or **(D)** hospital readmission in the first year after transplantation between recipients of DCD and DBD allografts. DBD = donation after brain death; DCD = donation after circulatory death.

higher risk of bleeding, transfusion requirements, and return to the operating room in post-LVAD heart transplantations.[25,26] Nonetheless, outcomes of patients in the DCD and DBD groups remained similar despite this potentially higher-risk group of patients being overrepresented in the DCD cohort.

STUDY LIMITATIONS. Our study is limited by its retrospective design as well as by a modest sample size that precluded the ability to adjust for all potentially confounding variables, explore meaningful differences among DCD recipients by organ recovery technique, and detect small but statistically

meaningful differences in outcomes between the groups, if they exist. Despite this, our findings reflect the largest single-center DCD vs DBD experience reported to date as well as the largest report of hearts recovered with the use of NRP. While the results at a single center may not be generalizable to all centers, programmatic consistency in donor selection practices, surgical techniques, and perioperative and postoperative management strategies reduces the likelihood that practice variation explains our results. VA patients were censored at index hospital discharge for all postdischarge outcomes other than mortality. Although this may have introduced selection bias concerning secondary outcomes, it seems unlikely given that candidate and donor selection criteria and postdischarge clinical management strategies are the same for all transplants, regardless of VA status. Follow-up in our study was limited to 1 year after transplantation, and studies are needed to elucidate longer-term outcomes and to better inform optimal DCD organ recovery and preservation techniques.

CONCLUSIONS

In this largest single-center comparison of DCD and DBD heart transplant outcomes to date, we found no significant difference in 1-year recipient survival or in rates of severe PGD, treated rejection, or CAV at 1 year after transplantation. Our findings add to the growing body of evidence in support of DCD heart transplantation.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS: Recipients of DCD hearts have 1-year outcomes similar to recipients of DBD hearts.

TRANSLATIONAL OUTLOOK: Longer-term comparative follow-up of recipients of DCD vs DBD hearts are needed to establish the safety and efficacy of DCD heart transplantation as well as optimum methods of tissue preservation.

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