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Original Article

Donor utilization in heart transplant with donation after circulatory death in the United States

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ABSTRACT

Heart transplantation using donation after circulatory death (DCD) was recently adopted in the United States. This study aimed to characterize organ yield from adult (≥18 years) DCD heart donors in the United States using the United Network for Organ Sharing registry. The registry does not identify potential donors who do not progress to circulatory death, and only those who progressed to death were included for analysis. Outcomes included organ recovery from the donor operating room and organ utilization for transplant. Multiple logistic regression was used to identify predictors of heart recovery and utilization. Among 558 DCD procurements, recovery occurred in 89.6%, and 92.5% of recovered hearts were utilized for transplant. Of 506 DCD procurements with available data, 65.0% were classified as direct procurement and perfusion and 35.0% were classified as normothermic regional perfusion (NRP). Logistic regression identified that NRP, shorter agonal time, younger donor age, and highest volume of organ procurement organizations were independently associated with increased odds for heart recovery. NRP independently predicted heart utilization after recovery. DCD heart utilization in the United States is satisfactory and consistent with international experience. NRP procurements have a higher yield for DCD heart transplantation compared with direct procurement and perfusion, which may reflect differences in donor assessment and acceptance criteria.

Abbreviations: DBD, donation after brain death; DCD, donation after circulatory death; DPP, direct procurement and perfusion; EVP, ex vivo perfusion; HT, heart transplantation; NRP, normothermic regional perfusion; OPO, organ procurement organization; OR, odds ratio; UNOS, United Network for Organ Sharing.

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1. Introduction

Organ donation after circulatory death (DCD) has expanded donor availability for heart transplantation (HT) internationally since 2014 and more recently in the United States since late 2019.[1-4] Early analyses in the United States have shown that DCD HT is associated with reduced waitlist times and equivalent early posttransplant survival compared with transplant using organs donated after brain death (DBD).[5-8]

DCD HT has rapidly expanded in the United States following encouraging waitlist and transplant outcomes from early adopting centers. More than 15% of US HT centers used DCD in 2021.[6] Importantly, improvements in procurement and preservation methods have addressed concerns regarding DCD heart procurement, including strategies to limit warm ischemia and platforms for donor heart assessment before implant. The first of these strategies, direct procurement and perfusion (DPP), uses ex vivo perfusion (EVP) of the donor heart to mitigate warm ischemia and allow biomolecular assessment. An alternative strategy is normothermic regional perfusion (NRP), which uses extracorporeal circulation after donor death to reanimate and assess the heart in situ. NRP may be paired with EVP or static cold storage for transport. Each strategy is associated with additional materials costs, personnel requirements, and logistical challenges compared with DBD procurements.

There is limited data regarding organ yield from DCD donors for HT. Existing literature is further limited to institutional series with significant heterogeneity between centers in DCD procurement strategies. The aim of this analysis was to characterize organ yield among DCD donors in the United States, assessed by rates of heart recovery, defined as explant and removal from the donor operating room, and utilization, defined as use of the recovered organ for HT.

2. Methods

This study was deemed exempt from review by the Institutional Review Board at the Medical University of South Carolina (Protocol #00124985). The United Network for Organ Sharing (UNOS) registry was used to identify adult heart donors (age, $\geq$18 years) from January 1, 2019, to June 30, 2022. Donors were grouped between DCD and DBD. The UNOS registry does not identify DCD donors who failed to progress to circulatory death after withdrawal of life-sustaining support, and therefore, this analysis did not assess rates of nonrecovery of DCD hearts due to failure to progress. Therefore, only those who underwent sternotomy for donor heart assessment were included for analysis.

DCD donors in the UNOS registry have hemodynamics recorded from withdrawal of life-sustaining support until circulatory death. This record was used to determine the agonal period, which represents the time during which the donor organs are subjected to warm ischemic injury. While definitions for the agonal period vary between studies, most US series, including the recently published DCD Heart Trial, define the agonal period as the time from which donor systolic blood pressure falls below 50 mmHg or peripheral oxygen saturation falls below 70% until circulatory death occurs.[8-10] These thresholds were used for the current study. Donor procurement strategies were identified as DPP vs NRP by the time from circulatory death until cross-clamp and delivery of cardioplegia (DPP, $\leq$20 minutes; NRP, $\geq$40 minutes). For those with times between 20 and 40 minutes (n = 4), procurements with greater than 40 minutes from onset of the agonal period to cardioplegia flush were deemed to be NRP (n = 3). One donor was unable to be classified and was excluded from analysis.

2.1. Statistical analysis

The primary outcomes were donor heart recovery, defined as donor heart explant and removal from the operating room, and utilization, defined as use of the organ for HT. Pearson correlation was used to characterize temporal changes in DCD heart procurement volumes and rates of DCD recovery and utilization. Categorical variables are presented as counts (percentages). Continuous variables were nonnormally distributed and are presented as medians (25th to 75th percentiles). Pearson's chi-square test was used to compare categorical variables unless frequencies were $<$5, in which case Fisher exact test was used. Kruskal-Wallis tests were used to compare continuous variables.

Univariate and multivariate logistic regression were used to calculate odds for organ recovery and utilization. Covariates associated with organ recovery or utilization with $P < .20$ on univariate analysis were included in multivariate models. A 2-sided P value of $<.05$ was considered statistically significant. Analyses were performed using Stata 16.1 (StataCorp).

3. Results

3.1. Donor characteristics

A flow diagram for donors identified for inclusion in this analysis is shown in Figure 1. There were 14 279 donors who were evaluated via sternotomy for heart procurement. Among these, 558 (3.9%) were DCD donors, who were all denoted as having undergone controlled (Maastricht III) procurements. Baseline characteristics of donors, grouped by DBD vs DCD, are summarized in Table 1. DCD donors were more likely to be male and white compared with DBD donors. A larger proportion of DCD donors were blood type O compared with DBD (67.7% vs 53.4%, $P < .001$), and DCD donors were less likely to have coronary angiograms completed (8.3% vs 38.6%, $P < .001$). There was no significant difference between DBD and DCD donors in the volume of heart procurements performed by their associated organ procurement organizations (OPOs).

3.2. Donor heart recovery and utilization

DCD hearts were more likely to be unrecovered after evaluation via sternotomy (10.4% vs 3.6%) and more likely to be nonutilized after recovery (7.5% vs 1.0%, $P < .001$) compared with hearts from DBD donors. Of all DCD heart donor hearts evaluated via sternotomy, 82.9% were used for HT. Multivariable logistic regression models for recovery and utilization are

summarized in Supplementary Table 1. After risk adjustment, DCD had an odds ratio (OR) of 0.34 (95% CI, 0.25-0.46; $P < .001$) for heart recovery after sternotomy relative to DBD donors and an OR of 0.14 (95% CI, 0.09-0.21; $P < .001$) for utilization for HT after recovery.

3.3. DCD-only analysis

There were 12 393 DCD organ donors in the observed study period. Among these, 11 856 (95.7%) gave consent for heart donation, of whom 558 (4.7%) were evaluated via sternotomy. Among these, 52 (9.3%) donors did not have hemodynamic data reported and were excluded from analysis. Therefore, 506 DCD heart donors were included in a DCD-only analysis. Population differences between DCD donors with nonmissing vs missing hemodynamic data are summarized in Supplementary Table 2 and include a younger median age (29 vs 31 years, $P = .040$), a lower proportion of concomitant lung procurement and utilization, and earlier procurement years (2019-2021 vs 2022) among patients with nonmissing data.

Among the 506 donors included for DCD-only analysis, 48 (9.5%) were not recovered after evaluation via a sternotomy, and 35 hearts (6.9%) were nonutilized after recovery. Of all DCD donor hearts evaluated via sternotomy, 83.6% were used for HT. Monthly volumes for DCD heart procurements, recoveries, and utilization rates are summarized in Figure 2. There was a significant increase in DCD heart procurements from December 2019 to May 2022 (Pearson's R = 0.845; $P < .001$). By month, the average recovery rate was 90.9% and did not significantly increase over time. The monthly utilization rate of recovered DCD hearts was 91.2%, with a trend toward positive change over time (Pearson's R = 0.35; $P = .052$).

There were 329 DCD procurements classified as DPP (65.0%) and 177 as NRP (35.0%). Times from death to delivery of cold cardioplegia are shown in Figure 3, and median time to cardioplegia was 9.3 minutes for DPP procurements compared with 68.7 minutes for NRP. Donor characteristics of DPP and NRP procurements are summarized in Table 2. Agonal time was longer in NRP compared with DPP (13.1 vs 10.9 minutes; $P = .025$). DCD donors procured using NRP more frequently had coronary angiograms completed prior to procurement (14.7% vs 4.6%; $P < .001$). NRP procurements were more likely to be facilitated by OPOs in the highest volume tertile of DCD procurements (70.1% vs 55.9%; $P = .001$) compared with DPP.

3.4. Predictors of organ recovery and utilization

Multivariable logistic regression for heart disposition among DCD donors is summarized in Table 3. NRP procurement was associated with higher odds for heart recovery compared with DPP (OR, 2.34; 95% CI, 1.05-5.19; $P = .037$). Other independent predictors of heart recovery included decreasing agonal time, decreasing donor age, and procurement at the highest volume tertile OPOs for DCD donors. NRP was also associated with higher odds for heart utilization after recovery compared with DPP (OR, 3.79; 95% CI, 1.40-10.24; $P = .009$). Agonal time, donor age, and OPO DCD volume were not significantly associated with heart utilization.

4. Discussion

This is the first analysis to report organ recovery and utilization rates among DCD heart donors in the United States. We report that more than one-tenth of DCD hearts are not recovered after sternotomy, and over 7% of recovered DCD hearts are not utilized for transplant. Overall utilization was 83% of DCD heart donors, and NRP procurement was associated with increased odds for heart recovery and utilization. This analysis establishes benchmarks for recovery and utilization rates among DCD heart procurements and summarizes practice patterns in the early adoption of DCD HT in the United States.

Pioneering centers for DCD HT have established precedents for organ recovery and utilization rates with both DPP and NRP strategies. Importantly, one of the most common reasons for

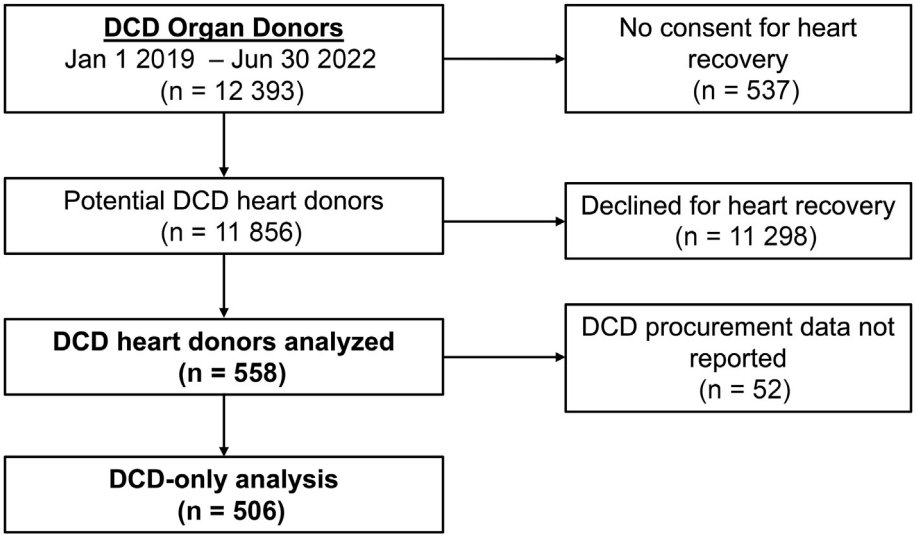

Figure 1. A flow diagram for donation after circulatory death (DCD) heart donors included for analysis.

Table 1
Demographic characteristics of heart donors, grouped by donation after brain death vs donation after circulatory death.

Variable	DBD N = 13 721 96.1%	DCD N = 558 3.9%	*P* value
Age (y)	30 (22-38)	29 (23-35)	.124
Male sex	9694 (70.6)	483 (86.6)	<.001
Race/ethnicity			<.001
White	8382 (61.5)	422 (76.2)	
Black	2328 (17.1)	52 (9.4)	
Hispanic	2559 (18.8)	71 (12.8)	
Other	362 (2.7)	9 (1.6)	
Mechanism of death			.001
Anoxia brain injury	6164 (44.9)	263 (47.1)	
Cerebrovascular event/ stroke	1691 (12.3)	37 (6.6)	
Head trauma	5495 (40.1)	241 (43.2)	
Other/unknown	371 (2.7)	17 (3.0)	
Body mass index (kg/m^2)	26.2 (22.6-30.6)	26.5 (23.6-30.8)	.018
History of diabetes	492 (3.6)	15 (2.7)	.246
History of hypertension	1877 (13.8)	61 (11.0)	.052
History of cigarette use			.402
Yes	1461 (10.6)	58 (10.4)	
No	11 947 (87.1)	492 (88.2)	
Unknown	313 (2.3)	8 (1.4)	
History of intravenous drug use			.468
Yes	2178 (15.9)	85 (15.2)	
No	11 278 (82.2)	466 (83.5)	
Unknown	264 (1.9)	7 (1.2)	
ABO blood type			<.001
A	4753 (34.9)	147 (26.3)	
B	1451 (10.6)	32 (5.7)	
AB	145 (1.1)	1 (0.2)	
O	7270 (53.4)	378 (67.7)	
Hepatitis C antibody positive	1355 (9.9)	47 (8.4)	.258
Left ventricular ejection fraction <55%	940 (6.8)	34 (6.1)	.487
Coronary angiogram completed	5242 (38.6)	45 (8.3)	<.001
OPO heart procurement tertile			.722
First	1949 (14.2)	86 (15.4)	
Second	4298 (31.3)	163 (29.2)	
Third	7474 (54.5)	309 (55.4)	

Categorical variables are presented as counts (percentages), and continuous variables are presented as median (interquartile range).
DBD, donation after brain death; DCD, donation after circulatory death; OPO, organ procurement organization.

organ nonrecovery in attended DCD procurements is the failure of the organ donor to progress to circulatory death after withdrawal of life-sustaining support. Institutional series have reported that this occurs in 14% to 22% of DCD heart donors and is a significant contributor to reduced organ yield compared with conventional DBD organ procurements.[1,2,9] This analysis captures only DCD donors who progressed to circulatory death and were evaluated via sternotomy and does not capture the proportion who failed to arrest.

Early adopting centers of DCD HT have reported utilization rates of 76% to 83% among donors who progressed to circulatory death.[1,2,9] While there have not been any robust analyses to compare recovery and utilization between DPP and NRP, a series from Royal Papworth Hospital presents data from a center that uses both strategies. Among 74 DPP and 25 NRP procurements from donors who progressed to circulatory death, heart utilization for transplant was 76% and 88%, respectively.[1] The most common reason for nonutilization after DPP was poor viability, suggested by plateauing or rising lactate levels and poor perfusion parameters during EVP. Among NRP organs, the sole reason for nonutilization was poor organ function after reperfusion in extracorporeal circulation.

Causes for organ nonrecovery and organ nonutilization after recovery differ between DPP and NRP, and these differences suggest causes for the greater likelihood of recovery and utilization among NRP-procured hearts in this analysis. In DPP, functional assessment of contractility after reanimation is limited to visual assessment without hemodynamic loading, as the left ventricle is vented during EVP. Therefore, surrogates of viability are assessed during EVP in lieu of measures of contractility. Centers using DPP have previously applied biomarker criteria to DCD hearts, including absolute lactate concentration of <5 mmol/L at the end of EVP and evidence of myocardial lactate extraction, whereas venous lactate concentration is lower than arterial lactate.[1,2] However, animal studies and an observational clinical study have failed to show that lactate concentrations and trends predict contractility after HT.[11-13] Additionally, investigators at Papworth noted that 65% of DCD hearts would have been nonutilized if they had applied stringent lactate cutoffs and

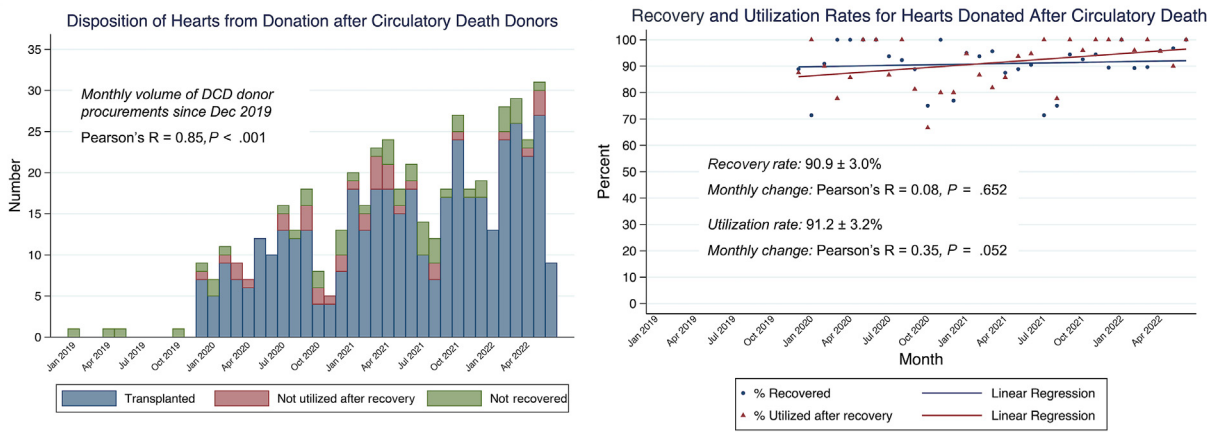

Figure 2. Monthly volume and disposition (*left*) and recovery and utilization rates (*right*) of donor hearts from donation after circulatory death (DCD) donors. Linear correlation excluded months prior to the first DCD transplantation in December 2019 and incomplete data from June 2022.

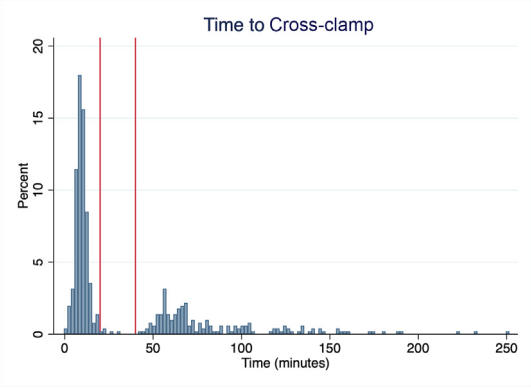

Figure 3. Time from death to cross-clamp and delivery of cold cardioplegia for heart donors undergoing donation after circulatory death. Red lines indicate time thresholds used to distinguish direct procurement and perfusion (≤20 minutes) versus normothermic regional perfusion (≥40 minutes).

extraction criteria, and both this center and St. Vincent's Hospital in Australia have liberalized their DPP organ utilization criteria over time.[2,11,14] Similarly, the recently published US DCD Heart Trial applied a broader criterion that DCD hearts needed only stable or downward trending lactate and stable perfusion levels prior to utilization for HT.[8] The lack of clear markers for viability may drive centers using DPP toward conservative cutoffs for DCD heart utilization. Indeed, in this analysis, DPP procurements were significantly associated with shorter agonal periods compared with NRP, which may reflect the avoidance of marginal organs with longer agonal periods with DPP.

Hearts procured using DPP must be cannulated onto an EVP platform for organ reperfusion and assessment, and issues with perfusion result in nonutilization. In the largest published series of DCD HT using DPP, Joshi et al[2] reported that the inability to perform EVP accounted for 35% of nonutilized DCD hearts at St. Vincent's Hospital. These failures were attributed most to thrombosis of the module filter on the TransMedics Organ Care System and insufficient donor blood collection to prime the perfusion circuit. Since adding tirofiban to their blood collection bag and streamlining blood collection with 2 additional surgical assistants, this center reported an improvement in DPP heart utilization from 68% to 89% since 2014.[2,14] Technical complications have driven nonutilization among NRP procurements as well. In the largest US series of NRP, Hoffman et al[9] reported that all 3 nonutilized hearts in their series were not recovered due to aortic dissection during cannulation in their early experience. This issue has not occurred since changing the aortic cannula used by the procurement team. Several institutional series report optimization of their DPP and NRP protocols, which have mitigated graft losses.[1,2,9] This learning curve described by early adopting centers is suggested in this current analysis of the US experience, which demonstrates a trend toward increasing utilization of DCD hearts over time and an increased likelihood of organ recovery among the highest volume OPOs performing DCD heart procurements.

Proponents of NRP procurement cite several favorable characteristics of this strategy. Critically, warm ischemic injury is limited in NRP compared with DPP. DPP requires time for blood priming and cannulation for EVP, accounting for a 7-minute difference in warm ischemic time compared with NRP.[1] As previously discussed, NRP also allows functional assessment of contractility under true hemodynamic loading conditions and may encourage the use of otherwise marginal DCD hearts. Messer et al[1] reported that they have utilized hearts after NRP despite increasing arterial lactate on EVP due to previously reassuring functional assessment in situ. Finally, NRP allows rapid reperfusion of abdominal organs and is associated with improved utilization and outcomes in kidney and liver transplantation compared with standard rapid recovery or DPP.[15-19] However, there exists controversy about whether DPP increases warm ischemic times during abdominal organ procurements.[20,21] This analysis found that NRP was associated with a higher rate of DCD liver utilization and may reflect ongoing concerns with DPP with regard to liver transplantation outcomes. However, further analysis is needed to characterize relationships between DCD heart procurement strategy and abdominal organ utilization. Additionally, although NRP is associated with higher rates of DCD heart utilization in this analysis, previous analyses have not

Table 2
Demographic characteristics of donation after circulatory death heart donors, grouped by procurement strategy, direct procurement and perfusion vs normothermic regional perfusion.

Variable	DPP	NRP	*P* value
	N = 329	N = 177	
	65.0%	35.0%	
Donor characteristics			
Age (y)	29 (23-35)	28 (22-34)	.122
Male sex	283 (80.0)	157 (88.7)	.393
Race/ethnicity			<.001
White	253 (77.6)	135 (76.7)	
Black	39 (12.0)	5 (2.8)	
Hispanic	30 (9.2)	32 (18.2)	
Other	4 (1.23)	4 (2.3)	
Mechanism of death			.232
Anoxia	157 (47.7)	79 (44.6)	
Cerebrovascular/stroke	26 (7.9)	8 (4.5)	
Head trauma	138 (42.0)	82 (46.3)	
Other/unknown	8 (2.4)	8 (4.5)	
Body mass index (kg/m^2)	26.6 (23.7-31.5)	26.3 (23.1-30.0)	.054
History of diabetes	9 (2.7)	3 (1.7)	.555
History of hypertension	38 (11.6)	17 (9.7)	.516
History of cigarette use			.314
Yes	36 (10.9)	12 (6.8)	
No	288 (97.5)	162 (91.5)	
Unknown	5 (1.5)	3 (1.7)	
History of intravenous drug use			.367
Yes	55 (16.7)	22 (12.4)	
No	270 (82.1)	152 (85.9)	
Unknown	4 (1.2)	3 (1.7)	
ABO blood type			.109
A	74 (22.5)	56 (31.6)	
B	22 (6.7)	9 (5.1)	
AB	1 (0.3)	0 (0.0)	
O	232 (70.5)	112 (63.3)	
Hepatitis C antibody positive	28 (8.5)	16 (9.0)	.840
Left ventricular ejection fraction <55%	23 (7.0)	10 (5.6)	.560
Coronary angiogram completed	15 (4.6)	26 (14.7)	<.001
Other organs procured			
Kidney	325 (98.8)	171 (96.6)	.105
Liver	229 (69.6)	120 (67.8)	.675
Pancreas	26 (7.9)	12 (6.8)	.648

(*continued on next page*)

Table 2 (*continued*)

Variable	DPP	NRP	*P* value
	N = 329	N = 177	
	65.0%	35.0%	
Lung	62 (18.8)	31 (17.5)	.712
Other organs transplanted			
Kidney	309 (93.9)	161 (91.0)	.217
Liver	176 (53.5)	117 (66.1)	.006
Pancreas	14 (4.3)	8 (4.5)	.889
Lung	42 (12.8)	23 (13.0)	.522
OPO DCD volume tertile			.001
First	78 (23.7)	19 (10.7)	
Second	67 (20.4)	34 (19.2)	
Third	184 (55.9)	124 (70.1)	
DCD procurement parameters			
Length of withdrawal phase (min)	6.2 (2.7-10.5)	4.9 (2.6-9.0)	.492
Length of agonal period (min)	10.9 (8.7-15.3)	13.1 (8.7-17.5)	.025
Time from death to cold cardioplegia (min)	9.3 (7.4-11.2)	68.7 (57.9-100.9)	<.001

Categorical variables are presented as counts (percentages), and continuous variables are presented as median (interquartile range).
DCD, donation after circulatory death; DPP, direct procurement and perfusion; OPO, organ procurement organization; NRP, normothermic regional perfusion.

shown a difference between DPP and NRP in graft function or early mortality after HT.[1,6,7]

DCD heart procurements incur significant costs as they require additional personnel, equipment, and consumables compared with DBD. Thus, DCD centers continue to balance the cost of attending "dry run" procurements against the risk of overutilizing marginal DCD organs, leading to an increase in primary graft dysfunction. Strategies to improve yield for DCD heart procurements are suggested by this analysis. First, donor age thresholds vary widely between DCD programs and may be used to optimize donor attendance. In published US protocols, Vanderbilt reports a donor age cutoff of 35, while both the US DCD Heart Trial and New York University's NRP program considered donors up to 49 years.[8-10] In this current analysis, DCD donors were not significantly younger than DBD donors, although younger age independently predicted recovery among DCD donors. Therefore, a lower donor age threshold may increase organ yield. Alternatively, aggressive programs may opt to attend a higher proportion of marginal DCD donor procurements despite the risk of organ nonutilization. However, routine coronary angiography is not performed in DCD donors as some OPO restrictions do not allow for invasive premortem assessment, and this may continue to justify conservative donor age thresholds. This analysis was unable to identify nonutilization due to coronary disease discovered after sternotomy, which occurred in 2.3% of DCD donors in the United Kingdom, where no premortem coronary assessments are performed.[1] However, variable restrictions on premortem assessments in the United States are likely to be one driver of organ nonutilization among attended DCD procurements.

There are several limitations to this study. Procurement data was missing for 9% of DCD donors, which may have introduced selection bias to the DCD-only analysis by overrepresenting younger donors and procurements occurring earlier in the study period. This may have impacted our findings regarding the impact of donor age and NRP (which has increased over time in the United States) on organ recovery and utilization.[6] Several variables in this analysis, including procurement strategy, agonal time, and time from death to cardioplegia, are derived from hemodynamic data for DCD donors and are subject to data entry and classification errors. Additionally, EVP is used in a significant proportion of DCD procurements. However, this variable is significantly missing (>7%) in the UNOS registry, thus limiting our description of NRP-procured hearts, which may be transported using EVP or static cold storage. Other procedural characteristics, such as premortem heparinization and location for donor withdrawal of care, differ between OPOs, which serve as regional mediators for allocation and procurement of organs in the United States and have been found to have substantial variations in DCD procurement protocols throughout the country.[22] These variations were not completely considered in our analysis. In addition, the experience of DCD procurement teams was not considered, as the UNOS registry does not identify accepting transplant centers unless the organ is utilized for transplant. Predicted organ travel distances are similarly not available for this reason. Lastly, the US DCD Heart Trial included 90 DCD HTs using DPP.[8] A significant proportion of DPP procurements in this analysis were likely included in that trial, and this may introduce selection bias due to the trial's adherence to donor eligibility criteria.

Table 3
Multivariable logistic regression model for heart recovery after sternotomy and heart utilization after recovery among organ donors undergoing donation after circulatory death.

Variable	Odds ratio (95% CI)	*P* value
Heart recovery		
NRP (DPP as reference)	2.34 (1.05-5.19)	.037
Agonal time (per min)	0.97 (0.95-0.98)	<.001
Donor age (per y)	0.94 (0.91-0.98)	.001
Donor OPO DCD volume tertile		
First	Reference	Reference
Second	1.49 (0.66-3.36)	.339
Third	2.66 (1.27-5.54)	.009
Heart utilization after recovery[a]		
NRP (DPP as reference)	3.79 (1.40-10.24)	.009
Agonal time (per min)	0.99 (0.97-1.02)	.549
Donor age (per y)	0.98 (0.94-1.03)	.494
Donor OPO DCD volume tertile		
First	Reference	Reference
Second	1.06 (0.34-3.35)	.917
Third	0.93 (0.38-2.31)	.882

DCD, donation after circulatory death; DPP, direct procurement and perfusion; NRP, normothermic regional perfusion; OPO, organ procurement organization.

[a] Model includes 458 donation after circulatory death donors whose hearts were recovered (direct procurement and perfusion, n = 261; normothermic regional perfusion, n = 162).

In this analysis of the UNOS registry, rates of heart recovery and utilization from DCD donors were acceptable and consistent with published data from early adopting centers. Predictors of organ recovery and utilization identified in this analysis distinguish donor characteristics that DCD HT centers have deemed favorable for organ utilization and summarize current practices as DCD HT expands nationally. As DCD presents an opportunity to expand the donor pool for HT, broader adoption of DCD HT will rely on evidence-backed strategies to identify high-risk DCD organs and increase donor yield for procurements.

Disclosure

A. Kilic serves as a speaker and consultant for Abiomed, 3ive, LivaNova, and Abbott. R. J. Tedford is a consultant for Medtronic, Abbott, Aria CV, Alleviant, Acceleron, Cytokinetics, Itamar, Edwards LifeSciences, Eidos Therapeutics, Lexicon Pharmaceuticals, and Gradient. He is the national coprincipal investigator for the RIGHT-FLOW clinical trial (Edwards) and serves on steering committees for Merck and Abbott and a research advisory board for Abiomed. He does hemodynamic core laboratory work for Merck.

Declaration of interests

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Arman Kilic reports a relationship with AbioMed Inc that includes: consulting or advisory and speaking and lecture fees. Arman Kilic reports a relationship with 3ive that includes: consulting or advisory and speaking and lecture fees. Arman Kilic reports a relationship with LivaNova that includes: consulting or advisory and speaking and lecture fees. Arman Kilic reports a relationship with Abbott that includes: consulting or advisory and speaking and lecture fees. Ryan Tedford reports a relationship with Medtronic that includes: consulting or advisory. Ryan Tedford reports a relationship with Abbott that includes: consulting or advisory. Ryan Tedford reports a relationship with Aria CV that includes: consulting or advisory. Ryan Tedford reports a relationship with Alleviant that includes: consulting or advisory. Ryan Tedford reports a relationship with Cytokinetics that includes: consulting or advisory. Ryan Tedford reports a relationship with Itamar that includes: consulting or advisory and funding grants. Ryan Tedford reports a relationship with Edwards Lifesciences Corporation that includes: consulting or advisory. Ryan Tedford reports a relationship with Eidos Therapeutics that includes: consulting or advisory. Ryan Tedford reports a relationship with Lexicon Pharmaceuticals Inc that includes: consulting or advisory. Ryan Tedford reports a relationship with Gradient that includes: consulting or advisory. Ryan Tedford reports a relationship with Merck that includes: consulting or advisory. Ryan Tedford reports a relationship with AbioMed Inc that includes: board membership.

Data availability

The data used for this analysis are available from the United Network for Organ Sharing/Organ Procurement Transplant Network. Because of the sensitive nature of the data accessed for this study, requests to access the dataset from qualified researchers trained in human subject confidentiality protocols may be sent to United Network for Organ Sharing/Organ Procurement Transplant Network.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajt.2023.07.019.

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