Donor heart refusal after circulatory death: An analysis of United Network for Organ Sharing refusal codes

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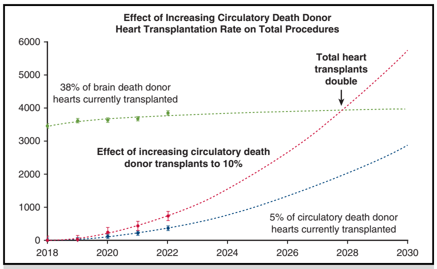
ABSTRACT

Objective: Donor hearts procured after circulatory death (DCD) may significantly increase the number of hearts available for transplantation. The purpose of this study was to analyze current DCD and brain-dead donor (DBD) heart transplantation rates and characterize organ refusal using the most up-to-date United Network for Organ Sharing (UNOS) and Organ Procurement and Transplantation Network data.

Methods: We analyzed UNOS and Organ Procurement and Transplantation Network DBD and DCD candidate, transplantation, and demographic data from 2020 through 2022 and 2022 refusal code data to characterize DCD heart use and refusal. Subanalyses were performed to characterize DCD donor demographics and regional transplantation rate variance.

Results: DCD hearts were declined 3.37 times more often than DBD hearts. The most frequently used code for DCD refusal was neurologic function, related to concerns of a prolonged dying process and organ preservation. In 2022, 92% (1329/1452) of all DCD refusals were attributed to neurologic function. When compared with DBD, DCD donor hearts were more frequently declined as the result of prolonged warm ischemic time (odds ratio, 5.65; 95% confidence interval, 4.07-7.86) and other concerns over organ preservation (odds ratio, 4.06; 95% confidence interval, 3.33-4.94). Transplantation rate variation was observed between demographic groups and UNOS regions. DCD transplantation rates are currently experiencing second order polynomial growth.

Conclusions: DCD donor hearts are declined more frequently than DBD. DCD heart refusals result from concerns over a prolonged dying process and organ preservation. Heart transplantation rates may be substantially improved by ex situ hemodynamic assessment, adoption of normothermic regional perfusion guidelines, and quality initiatives. (JTCVS Open 2024;18:91-103)



Minor improvements in DCD heart acceptance may substantially increase total transplants.

CENTRAL MESSAGE

Circulatory death donor (DCD) hearts are declined much more frequently than brain dead donors. DCD hearts are refused primarily over concerns of a prolonged dying process and organ preservation.

PERSPECTIVE

Transplantation rates may be improved by ex situ hemodynamic assessment, widespread adoption of NRP ethical and legal guidelines, and ongoing quality initiatives including refusal code adaptations. Projections based on recent rapid adoption of DCD donor hearts for transplantation indicate that even minor increases in donor heart acceptance may substantially increase total transplant procedures.

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Abbreviations and Acronyms

AATS	=	American Association for Thoracic Surgery
DBD	=	donation after brain death
DCD	=	donation after circulatory death
DPP	=	direct procurement and perfusion
FWIT	=	functional warm ischemic time
NRP	=	normothermic regional perfusion
OPTN	=	Organ Procurement and Transplantation Network
UNOS	=	United Network for Organ Sharing

▶ Video clip is available online.

Heart disease remains the leading cause of death in the United States, with 697,000 people dying from this disease in 2020.[1,2] One of the most promising developments for heart transplantation is the expansion of the donor pool by using organs that were donated after circulatory death (donation after circulatory death, or DCD). Although the total number of DCD donor heart transplantations is currently small, new procurement protocols and techniques have led to wider adoption and rapidly increasing transplantation rates.[3]

The first human heart transplantation was performed by Christian Barnard in 1967 and used what would today be considered a DCD donor organ.[4] Once the concept of brain death became legally accepted, transplantation of hearts from brain dead donors (donation after brain death, or DBD) was nearly exclusively adopted because donor heart hemodynamic function was known at the time of procurement and the potential injury from warm ischemia during circulatory death could be minimized or eliminated. The number of DBD donors has largely plateaued and does not meet demand. The Royal Papworth Hospital in the United Kingdom was an early adopter of DCD donor heart transplantation and in 2017 reported their experience, showing no significant difference in operative mortality for transplantation of hearts from DCD donors versus DBD donors.[5] After the introduction of DCD donors, Papworth increased overall heart transplant activity by 48% while showing no difference in survival or intensive care unit stay when compared with DBD donor heart transplants.[6] The first DCD heart transplantation in the United States was performed in 2019 at Duke University.[7] A recent randomized noninferiority trial demonstrated that risk-adjusted survival 6 months after transplantation with a DCD heart was not inferior to that after DBD heart transplantation.[8] Despite these results, when DCD donor hearts are offered to a recipient institution, they are frequently refused. The reasons for refusal of the donor heart are documented in the Organ Procurement and Transplantation Network (OPTN) refusal codes. These codes were updated in 2021 to improve relevance and provide greater detail on the reasons for organ refusal. The purpose of this study was to document current DCD and DBD heart transplantation rates and characterize organ refusal using the most up to date United Network for Organ Sharing (UNOS) and OPTN data.

METHODS

Study Population

UNOS DBD and DCD candidate, transplantation, and demographic data from 2020 through 2022 were analyzed. 2020-2022 DCD and DBD donor heart offer outcomes were analyzed to characterize transplantation practices. A retrospective review of OPTN heart and heart–lung transplantation 2022 refusal code data was also performed. Subanalyses were performed to characterize donor demographic variance, regional transplantation rate variance, and the potential effect of increasing use of DCD hearts for transplantation. These analyses were performed using publicly available data. Institutional review board approval was not required.

Study Definitions

The Uniform Determination of Death Act defines 2 types of death, irreversible cessation of all functions of the entire brain and irreversible cessation of circulatory and respiratory functions.[9] Thus, there are 2 different types of heart donors, DBD and those who have been declared dead based on circulatory criteria (ie, DCD).

TABLE 1. Comparison of demographic characteristics for DBD and DCD heart donors

Characteristics	DBD, n (%)	DCD, n (%)	*P* value
N (4223)	3853 (91.2)	370 (8.8)	<.001
Age, y			
<1	73 (1.9)	3 (0.8)	.134
1-5	122 (3.2)	0 (0)	.001
6-10	51 (1.3)	1 (0.3)	.079
11-17	270 (7)	20 (5.4)	.244
18-34	1923 (49.9)	244 (65.9)	<.001
35-49	1239 (32.2)	100 (27)	.043
50-64	172 (4.5)	2 (0.5)	<.001
65+	3 (>0.1)	0 (0)	.591
Female (n = 1210)	1152 (29.8)	58 (15.7)	<.001
Ethnicity (n = 4223)			
White/non-Hispanic	2285 (59.3)	275 (74.3)	<.001
Black/non-Hispanic	687 (17.8)	40 (10.8)	.001
Hispanic/Latino	750 (19.5)	48 (13.0)	.002
Unknown	0 (0)	0 (0)	N/A
Asian	64 (1.7)	3 (0.8)	.211
American Indian	40 (1)	2 (0.5)	.357
Pacific Islander	6 (0.2)	0 (0)	.447
Multiracial	21 (0.5)	2 (0.5)	.991

DBD, Donation after brain death; *DCD*, donation after circulatory death; *NA*, not available.

The OPTN is the federally established program responsible for overseeing the national organ transplant system in the United States, whereas UNOS is the nonprofit organization that operates under contract with OPTN to manage the day-to-day OPTN operations, including maintaining the waiting list and coordinating organ offers and transplants. The refusal codes pertain to the recipient, the donor, and Organ Procurement Organization/transplant hospital operational issues. In the majority of instances, the refusal codes are generated from a direct conversation between the recipient surgeon and the Organ Procurement Organization transplantation coordinator with no intermediary. The refusal codes were updated in 2021. They are detailed in Table E1.

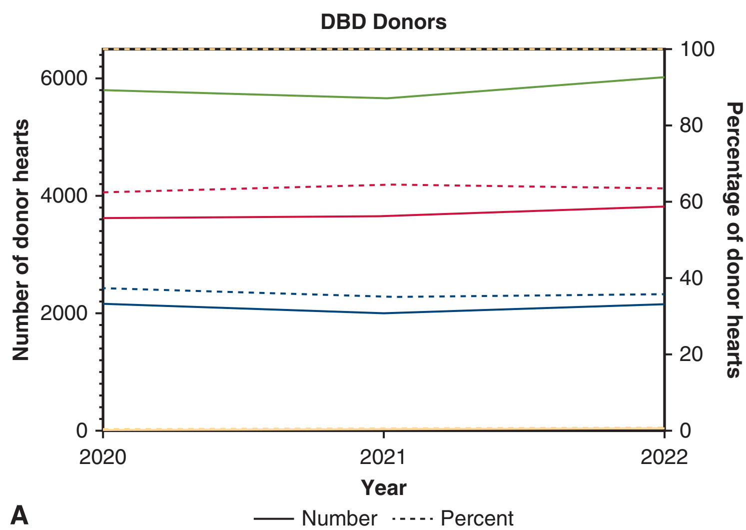
Outcomes were defined by OPTN as transplanted, declined, or discarded. Declined is defined as hearts that were refused for transplantation for medical, logistical, or personal reasons. Discarded is defined as hearts that were discarded and used for other purposes such as heart valve procurement and laboratory research.

Donor Characteristics, Refusal Code Analysis, and Results

Demographic data were collected for all heart donors in 2022. Comparison between DBD and DCD donors was performed. Similarly, refusal code data were compiled and DCD donor hearts were compared with DBD. The offer outcome data were sorted into 3 mutually exclusive categories: transplanted, declined, and discarded.

Statistical Analysis

Discrete variables are presented as counts and percentages. Odds ratios and their 95% confidence intervals with corresponding *P* values were reported. The estimated number of future DBD heart transplants was obtained using a logarithmic regression model, whereas future DCD heart transplant projections were based on current second-order polynomial growth using a regression model. Error bars surrounding means indicate standard deviations.



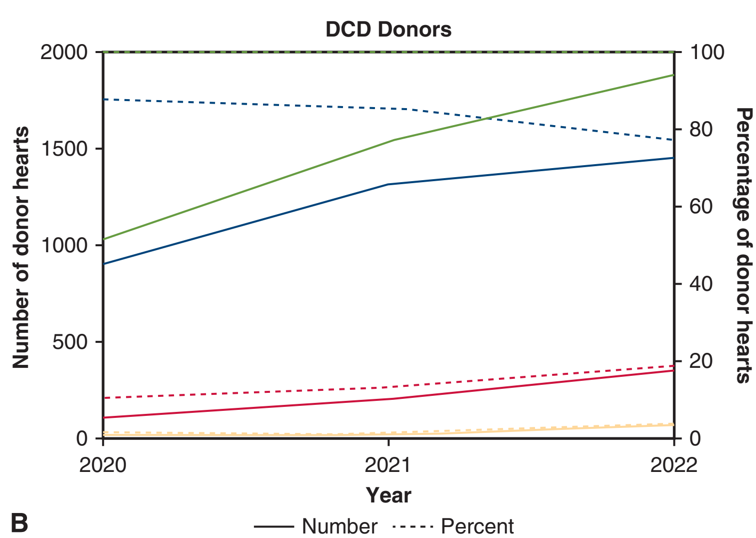
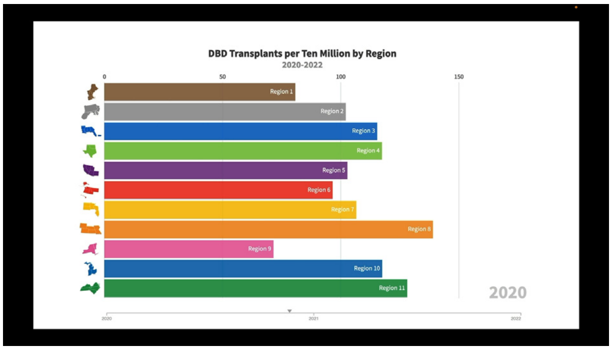
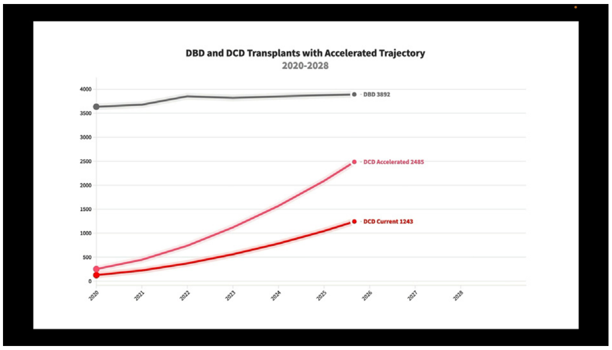


FIGURE 1. Cumulative number and percentage of DBD (A) and DCD (B) donor hearts as a function of time for each of the 3 OPTN-defined outcomes. *Solid lines* refer to the number of donor hearts, whereas *dashed lines* refer to the percentage of total donor hearts. The *green lines* represent total hearts that were offered, *blue lines* represent hearts that were declined and not transplanted, *red lines* indicate DBD hearts that were transplanted, and the *yellow lines* represent DBD hearts that were discarded and used for other purposes such as heart valve procurement and laboratory research. *DBD*, Donation after brain death; *DCD*, donation after circulatory death; *OPTN*, Organ Procurement and Transplantation Network.



VIDEO 1. Growth and variation in DBD transplantation by UNOS region. This video demonstrates the number of brain-dead donor hearts transplanted per 10 million population in each UNOS region. The timeline is shown on the x-axis. Although there appears to be some overall growth in the total number of transplanted brain death donor hearts, this may simply reflect recovery from the pandemic. A map of the UNOS regions and additional updated detail about each region can be found at https://unos.org/community/regions/. *DBD*, Donation after brain death; *UNOS*, United Network for Organ Sharing. Video available at: https://www.jtcvs.org/article/S2666-2736(24)00045-7/fulltext.

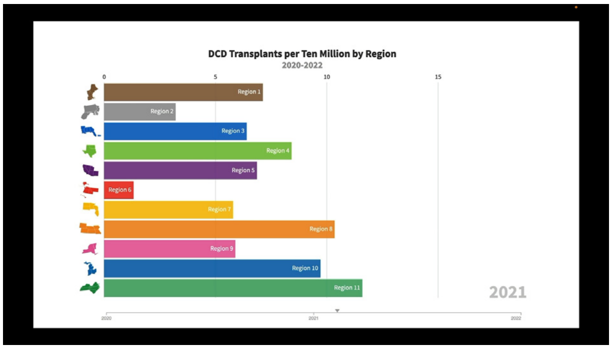


VIDEO 3. Regression model projection of heart transplantation from DBD and DCD donors including depiction of improved DCD use. The *top gray line* represents hearts transplanted from DBD donors, the *bottom red line* indicates hearts transplanted from DCD donors, and the *middle lighter red line* indicates hearts transplanted from DCD donors if the current usage rate was increased by 5%. These results suggest that the current DBD donor population is being optimally used and further dramatic increases are unlikely. Conversely, the current usage rate for DCD hearts appears to be increasing rapidly. Minor increases in DCD heart use could have the potential to substantially impact the total number of hearts available for transplantation within a decade. A logarithmic regression model was used to project future DBD heart transplantation. A second-order polynomial regression model was used to project future DCD heart transplantation based on recent rapid adoption of DCD donors. The respective regression equations are: $y = 200.6(x)+3459.5$ and $y = 18.357x^2 - 14.643x - 12.6$. A second-order polynomial regression model was also used to project future DCD heart transplantation if the current usage rate has improved from 5% to 10%. The regression equation calculated was $y = 36.714x^2 - 29.286x - 25.2$. *DBD*, Donation after brain death; *DCD*, donation after circulatory death. Video available at: https://www.jtcvs.org/article/S2666-2736(24)00045-7/fulltext.

RESULTS

Demographics

The UNOS database demonstrated a significantly lower proportion of DCD donors when compared with DBD donors in 2022. There were significantly fewer female, Black/non-Hispanic, and Hispanic/Latino DCD donors in comparison with DBD donors (Table 1). When waiting list mortality between 2017 and 2021 was stratified by age, children and adults 18 years of age and younger comprised the second largest group of waiting list deaths (Figure E1).



VIDEO 2. Growth and variation in DCD transplantation by UNOS region. Transplantation using circulatory death donor hearts appears to be exponentially increasing. This is the same depiction by region since 2020 as shown for the DBD hearts in Video 1 but on a smaller aggregate scale to demonstrate growth. Currently the number of circulatory death donor hearts is far smaller than brain death donor hearts. However, more widespread adoption of organ transplantation after circulatory death, combined with a much larger circulatory death donor population, should lead to rapid expansion of the total number of hearts available for transplantation. *DCD*, Donation after circulatory death; *DBD*, donation after brain death; *UNOS*, United Network for Organ Sharing. Video available at: https://www.jtcvs.org/article/S2666-2736(24)00045-7/fulltext.

DBD and DCD Heart Distribution

From 2020 to 2022, the distribution of transplanted and declined hearts between DBD and DCD donors varied substantially. In 2022 the number of DBD heart offers (6017) was substantially greater than DCD (1879). The proportion of DBD hearts that were eventually transplanted was 64.0% (n = 3853) whereas the proportion of DCD hearts that were transplanted was 19.7% (n = 370; $P < .001$) (Figure 1).

Regional UNOS data demonstrated substantial variation between DBD and DCD donor heart transplantation rates from 2020 to 2022. Variance as a fraction of total transplantations was substantially greater for DCD donor hearts (Videos 1 and 2). The United States UNOS regions are shown in Figure E2.

Regression modeling demonstrated that DBD donor heart transplantation has largely plateaued. Conversely, current DCD heart transplantation rates were found to be experiencing second-order polynomial growth. Therefore, even minor increases in the proportion of DCD donor hearts

TABLE 2. Standardized list of UNOS refusal codes used to decline organ offers

Category	Refusal code	Category	Refusal code
Donor/candidate matching	Donor age	Histocompatibility	No candidate serum
	Organ size		No donor cells
	Organ preservation		Positive physical crossmatch
	Organ damage/defect		Positive virtual crossmatch
	Prolonged cold ischemic time		Number of HLA mismatches
	Prolonged warm ischemic time	Disease transmission	PHS risk
	Biopsy unavailable		Positive screening test
	Unacceptable biopsy results		Donor infection
	Organ test results unavailable		Malignancy
Candidate specific	Candidate medically unsuitable		Epidemic/pandemic – donor
	Transplanted/pending transplant	Donor specific	Instability/high vasopressor use
	Transplant not needed		Donor medical history
	Requires multiple organ transplant		Prolonged downtime/CPR
	Epidemic/pandemic – candidate		Neurological function/not expected to arrest
	Financial ineligibility	Logistics	Resource constraint
	Candidate unavailable		Donor time constraint
	Candidate refused		Recovery team availability
			Transplant team/facility availability
			Transportation availability
			Exceeded policy response time

UNOS, United Network for Organ Sharing; *HLA*, human leukocyte antigen; *PHS*, Public Health Service Guideline ; *CPR*, cardiopulmonary resuscitation.

transplanted could result in substantial improvements in the total number of hearts available for transplantation. The impact of a 5% increase in the DCD donor heart transplantation rate is exemplified in Video 3.

Refusal Codes and Usage

UNOS refusal codes are divided into 6 categories (Table 2). Multiple codes could be used to refuse an organ offer. The codes were updated most recently in 2022. The

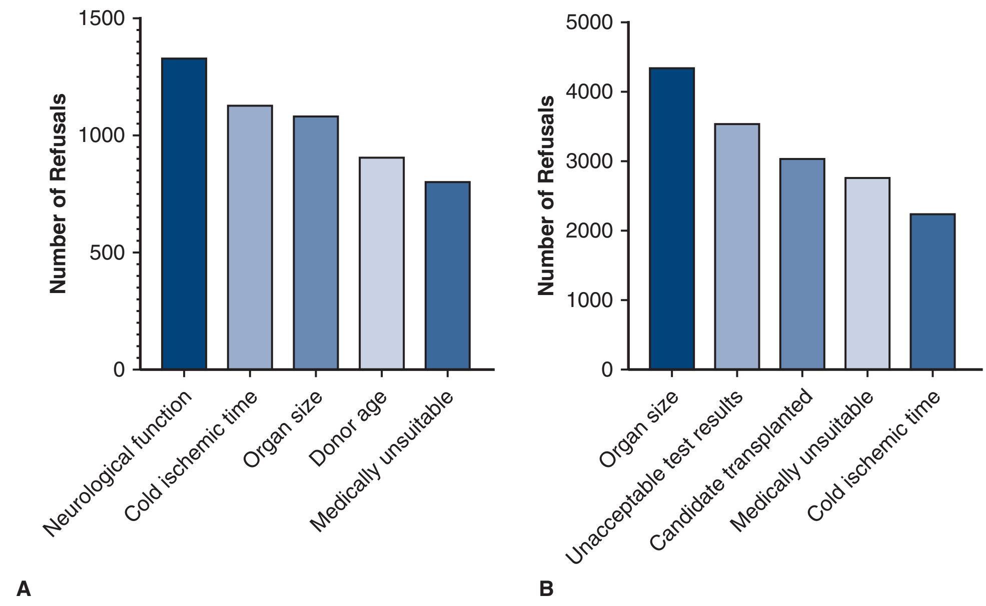


FIGURE 2. Number of times each code was used when refusing DCD and DBD donor hearts. Neurologic function/not expected to arrest and cold ischemic time were the most frequent refusal codes for DCD hearts (A). The 5 most frequently used codes to refuse DBD hearts are demonstrated (B). *DCD*, Donation after circulatory death; *DBD*, donation after brain death.

TABLE 3. Most significant refusal codes used for DCD hearts versus DBD hearts

Refusal code	OR, 95% CI	*P* value
Neurologic function	OR, 1319.33; CI, 724.22-2403.49	<.001
Warm ischemic time	OR, 5.65; CI, 4.07-7.86	<.001
Organ preservation	OR, 4.06; CI, 3.33-4.94	<.001
Cold ischemic time	OR, 2.53; CI, 2.28-2.82	<.001

DCD, Donation after circulatory death; *DBD*, donation after brain death; *OR*, odds ratio; *CI*, confidence.

codes were substantially changed so this analysis is limited to 2022 refusal code data (Table E1).

Neurologic function, prolonged ischemic times, and organ preservation were the most frequent codes used for DCD heart refusal (Figure 2, *A*, Table 3). Organ size and unacceptable organ-specific test results were the most frequent DBD refusal codes (Figure 2, *B*). Of note, organ size and medically unsuitable codes were frequently used for refusing both DCD and DBD hearts.

In addition to the aforementioned, when compared with DBD, DCD hearts were more frequently refused because of donor age, organ test result availability, candidate unavailability, donor family time constraints, and disaster/emergency management. When compared with DCD, DBD donor hearts were more frequently refused for donor history, instability/vasopressor use, prolonged downtime/CPR, organ damage/test results, and other candidate specific codes (Figure 3, Video Abstract). There were 11 DBD refusals based on neurologic function.

DISCUSSION

When compared with circulatory death, brain death is relatively infrequent. Nonetheless, DBD donors are currently used for most heart transplantations. The growth rate of DBD heart transplantation has plateaued at less than 1%/year.[10,11] This has led to renewed interest in transplanting DCD donor hearts.[3] Despite the frequency of circulatory death, the total number of DCD donor heart transplantations is small. We sought to document current DCD and DBD heart transplantation rates and elucidate the reasons for DCD donor heart refusal using the most up-to-date UNOS and OPTN data. To our knowledge, an analysis comparing DCD and DBD UNOS refusal codes has not been previously performed.

Previous studies have largely focused on DCD heart-procurement techniques, transplantation efficacy, and ethical considerations.[6,8,12] Brain death donors are typically preferred because cardiac function is known at the time of procurement. The donor heart will almost certainly support the recipient after transplantation. Conversely, it is less certain that donor heart function will support the recipient after circulatory death because hearts from DCD donors must go through the dying process, which includes an agonal period, a mandatory stand-off period, and the time required to establish some form of reperfusion. The aggregate of these times is known as the functional warm ischemic time (FWIT) during which the DCD donor heart is warm and unprotected. Limiting FWIT ensures that the donor heart will support the recipient but restricts the number of patients who otherwise qualify for DCD donation and may result in discarding hearts that are suitable for transplantation.

Unlike DBD donor heart offers, DCD offers are only potential offers. The offer and decision to accept or refuse a DBD donor heart is typically made after the donor has already been declared dead. Conversely, the initial decision to accept or refuse a DCD donor heart is made in prospect, before declaration of death, and is hindered by our limited ability to predict death. This is further complicated by institutional variation involving withdrawal of life support, declaration of circulatory death, and procurement protocols.[3,12] As a result, there is understandable reluctance to commit staffing and resources when the duration of the FWIT is unknown. This almost certainly accounts for the dominance of the DCD neurologic function/not expected to arrest, ischemic times, and organ preservation refusal codes in this analysis.

The 2023 American Association for Thoracic Surgery (AATS) Expert Consensus Document: Adult Cardiac Transplantation Utilizing Donors after Circulatory Death states that there is an urgent need for a better marker or parameter for assessing DCD donor heart suitability for transplantation.[3] Residual neurologic function may result in excessive donor organ damage from prolonged FWIT so assessment of suitability for transplantation is ideally performed after declaration of death. After death, DCD donor heart function can be assessed while the heart is still in the donor, ex situ, or after transplantation. Currently, the first hemodynamic assessment of donor heart function after DCD donor heart transplantation is typically performed after the heart is already in the recipient. Recent research on DCD direct procurement and cold perfusion (DPP) suggests that the critical time period from donor circulatory arrest to heart reperfusion is 10 minutes.[13] Cold static preservation techniques have improved, but recent evidence suggests DCD donor hearts may incur more damage from DPP than DBD donor hearts.[3] When the first assessment of DCD donor heart hemodynamic function will occur after transplantation, recipient surgeons are understandably cautious, and the AATS consensus recommends that the FWIT should be 30 minutes or less. This serves to maintain the current strict DCD donor criteria and may contribute to the low DCD heart transplantation rate (5%).[12,14] Normothermic regional perfusion (NRP) allows assessment of donor heart function after death by using cardiopulmonary bypass or extracorporeal membrane oxygenation to resuscitate the heart and restore

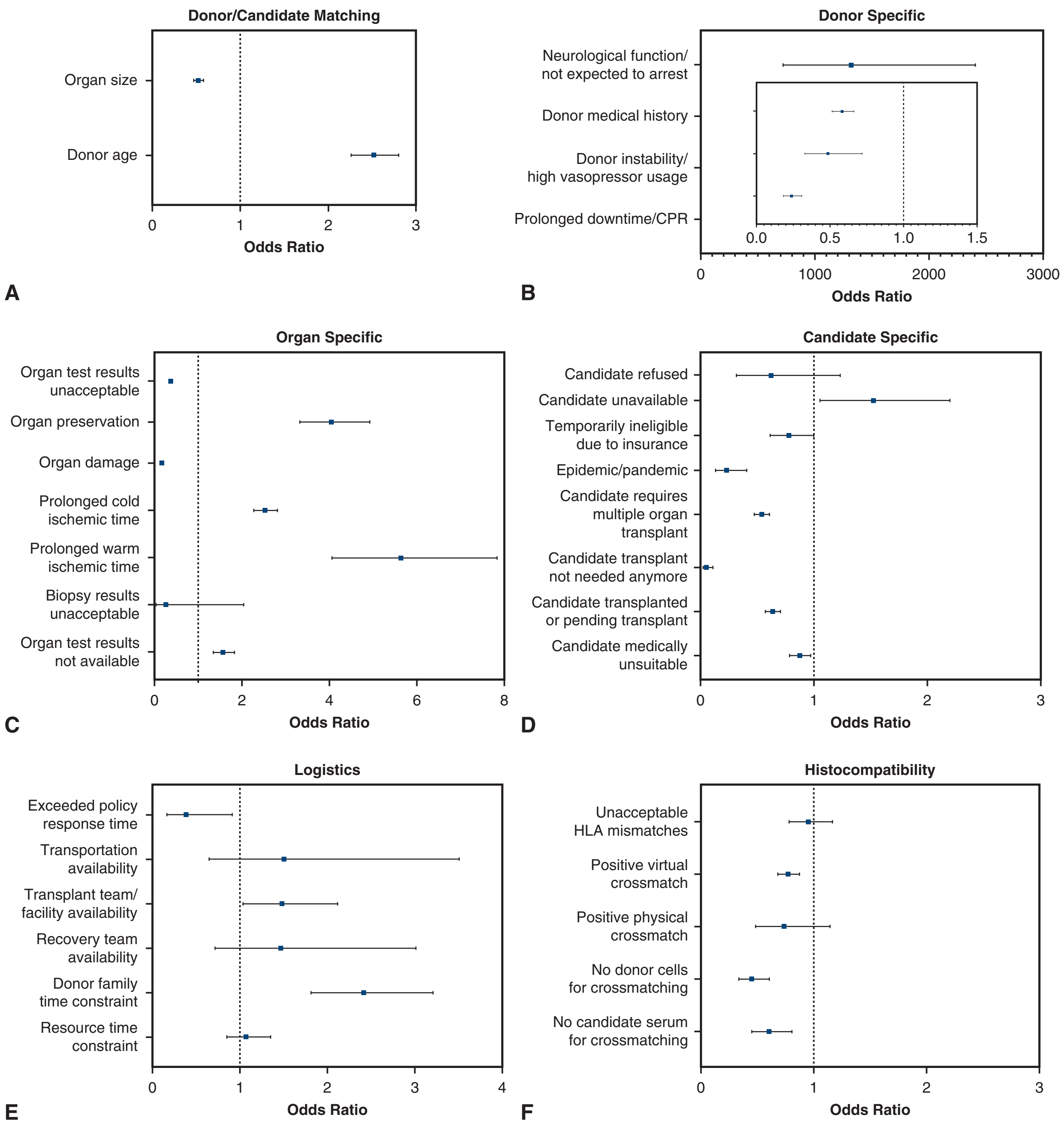


FIGURE 3. Refusal code use for DCD hearts compared with DBD hearts by category. When compared with DBD, DCD donor heart refusal codes were significantly more frequent for (A) donor age (OR, 2.52; 95% CI, 2.26-2.8); (B) neurologic function/not expected to arrest (OR, 1319.33; 95% CI, 724.22-2403.49); (C) organ preservation (OR, 4.06; 95% CI, 3.33-4.94), prolonged warm ischemic time (OR, 5.65; 95% CI, 4.07-7.86), prolonged cold ischemic time (OR, 2.53; 95% CI, 2.28-2.82), organ-specific test results not available (OR, 1.57; 95% CI, 1.35-1.83); (D) candidate not available (OR, 1.53; 95% CI, 1.06-2.2); (E) donor family time constraint (OR, 2.41; 95% CI, 1.81-3.2), and transplant team or facility not available (OR, 1.48; 95% CI, 1.04-2.12). There were no codes in the histocompatibility category that were more likely to be used to refuse DCD hearts (F). The categories disease transmission and other were also analyzed, but not included in this figure. For these 2 categories only one refusal code, disaster emergency management, was significant for use for DCD hearts as opposed to DBD (OR, 2.68; 95% CI, 1.15-6.21). The codes are more completely detailed in Table E1. Error bars indicate 95% CIs. *DCD*, Donation after circulatory death; *DBD*, donation after brain death; *OR*, odds ratio; *CI*, confidence interval; *CPR*, cardiopulmonary resuscitation; *HLA*, human leukocyte antigen.

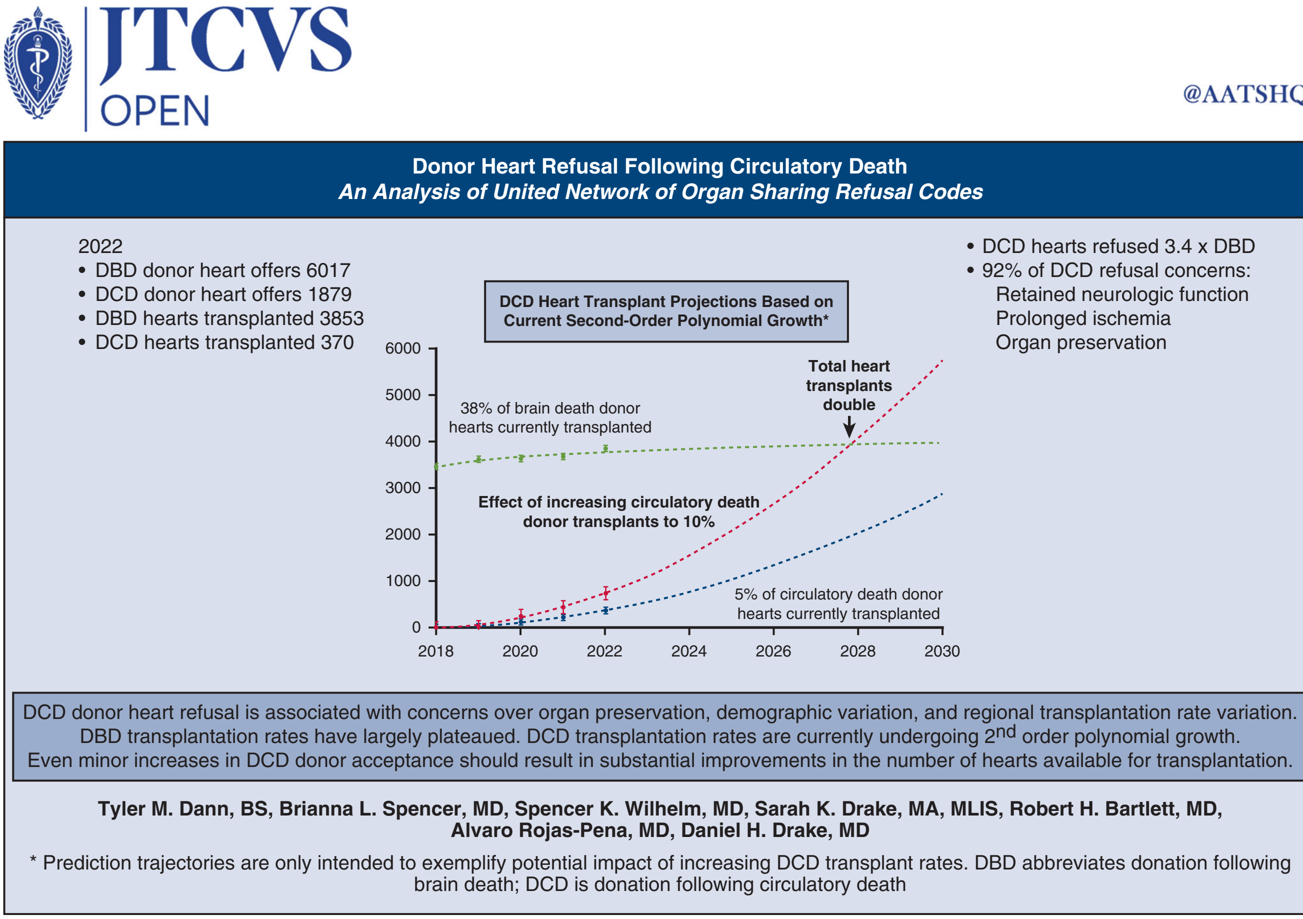


FIGURE 4. The methods, results, and implications of this analysis are briefly summarized.

cardiovascular function while the heart is still in the donor. Donor heart hemodynamic function can then be evaluated after death but before transplantation. Results have been promising.[15-18] However, there are significant ethical and legal concerns surrounding restoration of donor cardiovascular function after declaration of circulatory death.[12,19,20] These concerns limit the availability of NRP and may also contribute to low DCD transplantation rates. Given the FWIT restrictions imposed on DPP where the first DCD postmortem hemodynamic assessment of the donor heart is performed after transplantation and the ethical and legal concerns associated with NRP, it appears that donor heart assessment should be done after procurement but before transplantation.[3] The third option for determining DCD donor heart suitability for transplantation is normothermic ex situ heart perfusion with hemodynamic evaluation. Ex situ hemodynamic assessment can be performed after the heart is removed from the donor but before it is transplanted into the recipient. This avoids transplanting a heart with unknown functional status after circulatory death and eliminates the ethical and legal issues associated with restoring donor cardiovascular function after declaration of death.

This analysis provides compelling evidence that concerns over a prolonged dying process and preservation of donor heart function are the most common reasons for DCD donor heart refusal. Both ex situ and NRP hemodynamic assessments of donor heart suitability for transplantation should directly address these concerns. Ex situ hemodynamic assessment avoids the ethical or legal issues associated with NRP. Current clinical ex situ extracorporeal machine perfusion is limited to heart reanimation and basic metabolic assays and cannot perform hemodynamic assessments.[3,8] The AATS expert consensus states that "further work in this area is urgently required."[3] Hemodynamic assessment of DCD donor heart suitability for transplantation immediately before transplantation should relax donor selection criteria, facilitate identification of currently discarded hearts that are suitable for transplantation, and thereby substantially increase the number of hearts available for transplantation. Decreasing DCD donor demographic variation and other quality improvement initiatives should also increase the number of hearts available for transplantation.[21,22] Children comprise the second largest age group of waiting list deaths (Figure E1). Comprehensive, standardized donor heart acceptance criteria have led to fewer refusals and significantly more transplants.[23-25] Decreasing regional variation may also increase the total number of successful heart transplantation procedures.[21,22] Finally, improvements in UNOS refusal code detail should be considered.

Study Limitations

This study must be viewed in context. The field of DCD donor heart transplantation is rapidly evolving. There are only a few centers with significant DCD donor heart experience. There are important ongoing trials. Assessment of recipient program behavior is complicated and likely transient. Privatization of organ procurement and free-standing donor centers will almost certainly introduce additional complexities. This analysis is intended to provide insight into one area of a complex of multifaceted issues.

There are several other limitations. The data used in this study included both heart and heart/lung transplantation. Heart/lung donations may include additional refusal codes that do not appear in this analysis. The data presented detail the number of times a donor heart was refused and the number of times a refusal code was used. The data do not indicate how many refusal codes were used with each offer or if there was a tendency to group refusal codes. Refusal details were not sufficiently granular to identify recipient characteristics that might have resulted in refusal of a specific donor organ, for instance, a young recipient may have refused a heart from an older donor. Finally, prediction trajectories are only intended to exemplify the potential impact on aggregate transplantation volume of increasing DCD transplantation rates. There are too many variables and unknowns to allow for accurate prediction of actual transplant volumes or timelines.

CONCLUSIONS

The severe shortage of donor hearts limits the number of transplants available for patients with end-stage heart disease. When compared with DBD hearts, DCD hearts are declined more frequently and DCD transplantation rates are substantially lower. DCD donor hearts are refused over concerns of a prolonged dying process and preservation of donor heart function. Given the shortcomings of predicting circulatory death, further development of ex situ hemodynamic assessment and, where possible, increased adoption of NRP should provide important opportunities for documenting donor heart suitability for transplantation. Observed demographic and regional variations suggest that DCD heart transplantation rates may also be improved by quality initiatives, standardized policies, and NRP legal and ethical consensus. DCD transplantation rates are currently experiencing second order polynomial growth. Even minor increases in DCD donor heart acceptance may result in substantial improvements in the total number of hearts available for transplantation (Figure 4, Video 3).

Conflict of Interest Statement

D.H.D. reported patent royalties from Thompson Surgical Instruments. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: brain death, circulatory death, heart transplantation, organ donors, refusal codes, transplant donors, transplant recipients

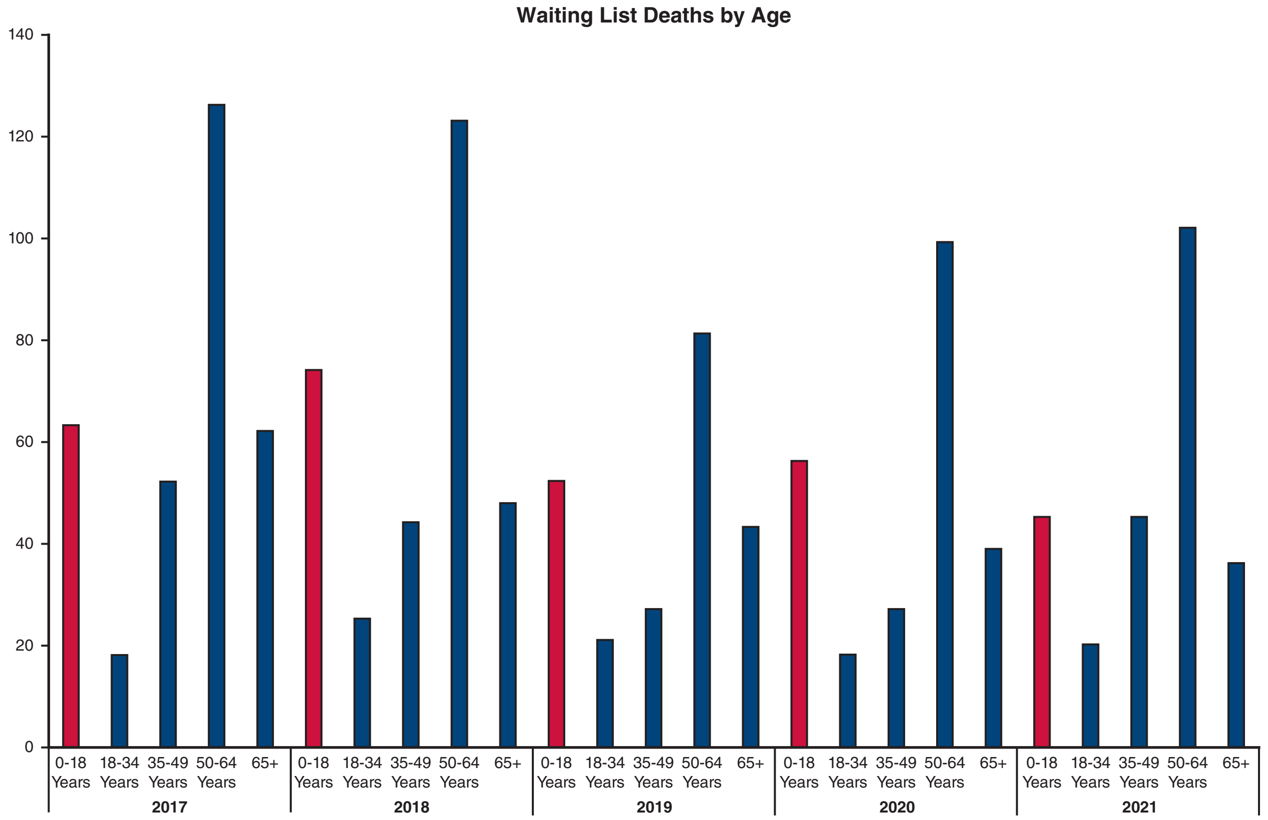

FIGURE E1. Organ Procurement and Transplantation Network waiting list deaths by age. Children (*red*) comprise the second largest group of waiting list deaths.

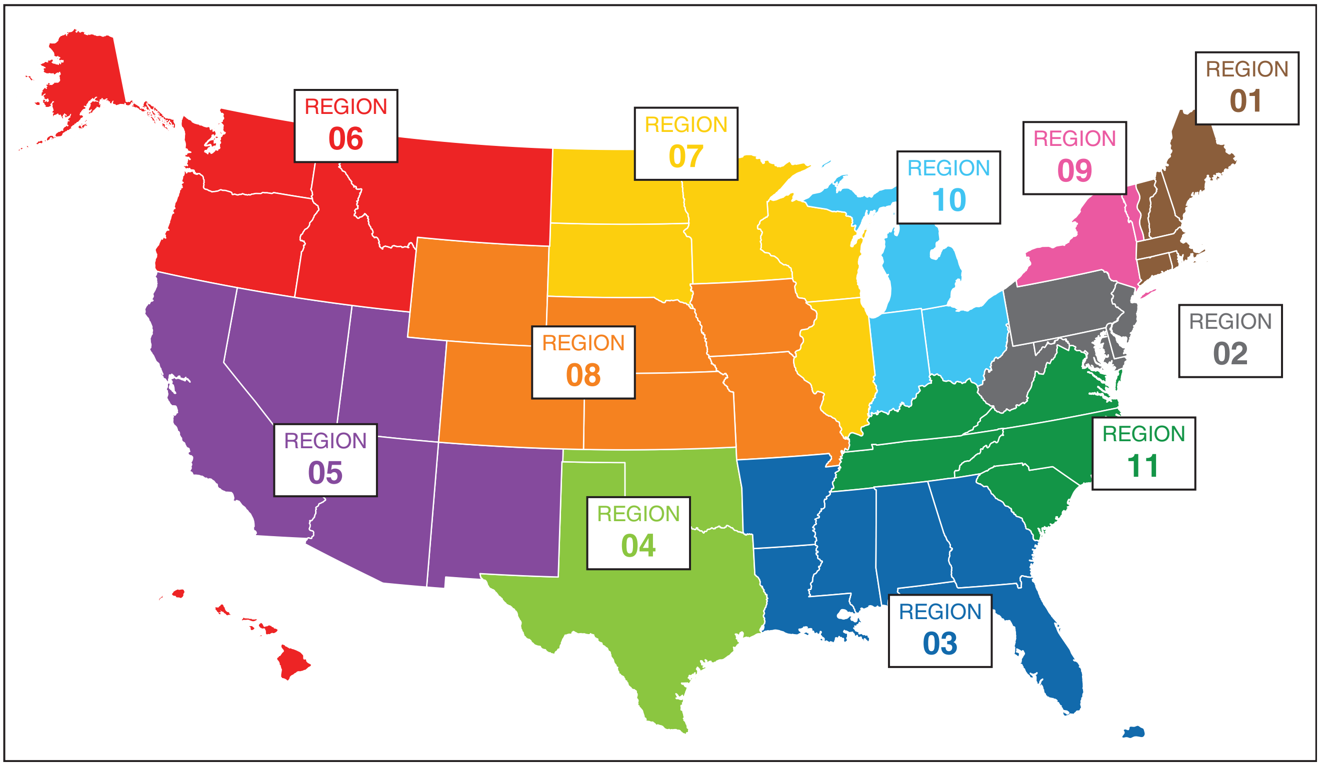

FIGURE E2. United States UNOS sharing regions map: https://unos.org/community/regions/. *UNOS*, United Network for Organ Sharing.

TABLE E1. 2021 Updated United Network for Organ Sharing refusal codes

Category	Refusal code
Donor/candidate matching	Donor age
	Organ size, specify
Organ specific	Organ preservation
	Organ anatomical damage or defect
	Actual or projected cold ischemic time too long
	Warm ischemic time too long
	Biopsy not available
	Biopsy results unacceptable
	Organ-specific test results not available
	Unacceptable organ specific test results
Candidate specific	Candidate temporarily medically unsuitable
	Candidate transplanted or pending transplant
	Candidate's condition improved/transplant not needed
	Candidate requires different laterality
	Candidate requires multiple organ transplant
	Epidemic/pandemic – candidate
	Candidate temporarily ineligible due to insurance/financial issue
	Candidate unavailable
	Candidate refused
Histocompatibility related	No candidate serum for crossmatching
	No donor cells/specimen for crossmatching
	Positive physical crossmatch
	Positive virtual crossmatch/unacceptable antigens
	Number of HLA mismatches unacceptable
Disease transmission risk	PHS risk criteria or social history
	Positive infectious disease screening test
	Donor infection or positive culture
	Malignancy or suspected malignancy
	Epidemic/pandemic - donor
Donor specific	Donor medical history
	Donor instability/high vasopressor usage
	Prolonged downtime/CPR
	DCD donor neurofunction/not expected to arrest
	VCA graft appearance or quality
Logistics	Resource time constraint
	Donor family time constraint
	Recovery team availability
	Transplant team or transplant facility availability
	Transportation availability
	Exceeded policy defined response time

HLA, Human leukocyte antigen; *PHS*, Public Health Service Guideline; *CPR*, cardiopulmonary resuscitation; *DCD*, donation after circulatory death; *VCA*, vascularized composite allotransplantation.