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Eligible DBD Donors Proceeding via the DCD Pathway: Incidence, Cause, and Outcomes in the United Kingdom

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Background. Eligible donation after brain death (DBD) donors may rarely proceed via the donation after circulatory death (DCD) pathway. The incidence, reasons for pathway divergence, and graft and recipient outcomes in the United Kingdom of this cohort are unknown. We aimed to establish the incidence of eligible DBD to DCD donors in the United Kingdom, the reasons for pathway divergence, organ donation and utilization rates, and the renal graft and recipient outcomes for this cohort. **Methods.** UK electronic and article records were reviewed for all eligible DBD donors proceeding via the DCD pathway from 2012 to 2022. Incidence and stated reasons for pathway divergence, including direct family quotations and time to mechanical asystole, were recorded. These data, in addition to organ donation and utilization rates and those pertaining to renal graft and recipient survival rates, were compared with "standard DCD" and "standard DBD" control groups. **Results.** One hundred twenty-three eligible DBD donors proceeded via the DCD pathway, overwhelmingly due to a familial desire to be present at mechanical asystole. Median time to asystole was comparable between the cohort and DCD control groups, but the range of times was considerably shorter in the cohort group. Donation and utilization rates were similar between all groups except for the notably lower rates in liver donation for DCD control. Graft and recipient survival rates were similar for all groups, but there was a nonsignificant reduction in delayed graft function (DGF) for the cohort versus DCD control and a significant reduction in DGF for the DBD versus DCD control groups. **Conclusions.** Eligible DBD donors proceeding via the DCD pathway is a rare event in the United Kingdom and overwhelmingly occurs due to a familial desire to witness asystole. This cohort proceeded to asystole more reliably within acceptable time periods for donation, have higher donation and utilization rates for liver grafts, and may show reduced rates of DGF for renal grafts versus "standard DCD" groups.

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Donation of solid organs after circulatory death (DCD) accounted for 23% of all global deceased organ donations in 2022 compared with 10% 10 y ago.[1] In comparison, UK DCD accounts for 46% of all deceased organ donations versus 41% 10 y ago.[2] This increase has been driven by both a rising unmet need between solid organ transplantation requirements and organ availability and a greater understanding of organ utilization rates and graft outcomes arising from DCD.

Controlled DCD (Maastricht III) is the most common pathway of DCD. Rarely, DCD may occur in a potential donor

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M.B. and D.G. conceived of and designed the study. L.S. and S.M. collected the donor cases from the database, including the time to asystole and use of NRP, and conducted statistical testing on the renal graft and recipient outcomes. J.D.S.L., S.T., J.T., S.M., R.H., K.H., M.Bo., R.P., and S.D. analyzed the database notes for the reasons for pathway divergence and pertinent quotations. M.B. and D.G. provided medical oversight for this analysis in cases of uncertainty. M.B., S.M., and L.C. wrote the article. All authors edited the article and also approved the final version.

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who has been diagnosed deceased using neurological criteria (DNC or brain death) rather than donation proceeding via the donation after brain death (DBD) pathway. This type of donation is categorized as Maastricht IV and typically follows a family request for donation to occur only after the heart has stopped beating or in situations of severe cardiovascular instability (eg, cardiac arrest), which prevents the usual DBD pathway from being followed. In this article, we refer to Maastricht IV donation as "DBD to DCD" and Maastricht III as "DCD." Last year in the United Kingdom, there were 21 cases of DBD to DCD compared with 762 DBD, a rate of 2.7%[3]

In the United Kingdom, 5-y graft survival after the first adult kidney transplant from a DBD donor is 87% and patient survival is 88% versus 84% and 85%, respectively, from a DCD donor.[4] United Network for Organ Sharing data have similarly shown no difference in patient or kidney graft survival at 5 y between DCD and DBD but has shown that the incidence of delayed graft function (DGF) is higher in DCD recipients (41%–51%) than in DBD recipients (24%).[5,6]

There is a paucity of data available worldwide about DBD to DCD, the reasons for it, and the outcomes. We sought to retrospectively explore and evaluate cases of DBD to DCD in the United Kingdom in more detail.

MATERIALS AND METHODS

We aimed to review all cases for a 10-y period in the United Kingdom where potential donors had been diagnosed with DNC and so were eligible to donate via the DBD pathway but proceeded to donate via DCD (DBD to DCD).

Specific aims were to establish:

1. The number of DBD to DCD cases.
2. The recorded reasons for diverging from the DBD to the DCD pathway.
3. The organ utilization rates for DCD and DBD during this time period as compared with our cohort group of DBD to DCD donors. (It was acknowledged a priori that this comparison was unlikely to reach statistical significance.)
4. A comparison of kidney transplant recipient survival and graft function between DBD, DCD, and DBD to DCD patient groups.

A study cohort of UK patients eligible for DBD who proceeded to DCD during a 10-y period was obtained from the UK Potential Donor Audit (PDA). Patients eligible for DBD are defined as those confirmed DNC with no absolute contraindications to organ donation.[3] Two comparative control groups were also obtained from the PDA for the same 10-y period. The first includes all "standard DCD" donors in this time period (controlled DCD, Maastricht III). Uncontrolled DCD (Maastricht II) is not practiced in the United Kingdom. Patients eligible for DCD are defined as those patients not confirmed DNC but expected to die within a suitable timeframe to allow organ donation to occur after withdrawal of life-sustaining treatment (WLST) and with no absolute contraindication to organ donation. The second control group includes all patients proceeding as "standard DBD" donors in this time period. The 10-y study period included all solid organ donors in these groups with a death date between April 1, 2012, and March 31, 2022.

The National Health Service Blood and Transplant donor records for all cases included in the DBD to DCD study cohort were clinically reviewed to identify, if possible, the reasons patients eligible for DBD proceeded to DCD. The donor record is completed by specialist nurses for organ donation (SNOD) as a routine part of the donation process. Cases deemed to have been incorrectly recorded were excluded from further review and records were corrected. Additionally, any meaningful verbal quotes recorded in the donor record from family members or by SNOD, which might provide further insight into the reason for divergence from the standard DBD pathway, were identified. "Family" is broadly defined to include family and friends of the potential donor present and involved in the donation approach when consent/authorization was taken for donation by a specialist nurse for organ donation.

Data on the organ outcome (whether the organ was offered, donated, and transplanted) of all proceeding donors in the study cohort and 2 control groups were obtained from the UK Transplant Registry (UKTR). Data on rates of normothermic regional perfusion (NRP) were also obtained for each of the cohort and control groups.

The standard DCD and DBD to DCD cohort groups were also compared with regards to time taken from WLST to the onset of mechanical asystole as recorded on the UKTR registry or PDA if incomplete on UKTR. WLST is increasingly occurring in operating theater complexes in the United Kingdom to facilitate rapid transfer to the operating room after the confirmation of death. This practice is not mandatory, and WLST does still frequently occur in the intensive care unit in approximately 50% of cases if it is geographically close to the operating theater complex. WLST in the United Kingdom usually involves extubation and cessation of all inotropic support. After the onset of mechanical asystole using an invasive arterial line, a 5-min observation period (stand-off) is required before death is confirmed. The standard UK wait time for kidney organ retrieval after WLST is 3 h.[7]

To further investigate the organ utilization and outcome of organs from donors in the study cohort, kidney transplant survival data were obtained from UKTR as well as relevant donor, recipient, and transplant risk factors that are associated with UK kidney transplant outcomes.[8] Analysis of transplant outcomes for other organs was not considered because of the expected small numbers of resulting transplants in the DBD to DCD study cohort.

A case-matched analysis was performed to compare kidney transplant outcomes across the cohort and control groups. Kidney outcomes were compared for adult recipients of first kidney transplant transplants. All cases in the study cohort were case matched to 2 equivalent cases in the 2 control groups, providing a 2:1 case match for the control-to-study cohort ratio. These matches will be referred to as the "matched DBD to DCD cohort." Case matching was performed on the risk factors included in the UK kidney patient survival model[8] as well as the transplant year due to the length of the study period. Exact case matching was not possible due to the small number of cases in the cohort and the number of risk factors included. The risk factors included were restricted to those considered most pertinent in kidney outcome analysis and cases were matched to factor groups for categorical variables and a range of values for

TABLE 1.

Stated reason for eligible DBD donors proceeding as DCD

Reason given for DBD-eligible patients proceeding as DCD (DBD to DCD)	Number (%)
Family requested to be present at the time of asystole	93 (75.6)
Family did not believe in/support DNC	8 (6.5)
Crash DCD[a] due to cardiac arrest before DBD could take place	14 (11.4)
Clinical uncertainty over the validity of DNC	2 (1.6)
No reason given	6 (4.9)

[a]Crash DCD represented cases of severe cardiovascular instability (eg, cardiac arrest) where the donor was no longer stable enough to allow DBD, and so donation proceeded as DCD.
DBD, donation after brain death; DCD, donation after circulatory death; DNC, deceased using neurological criteria.

continuous variables. To facilitate matching across all relevant risk factors, cases were matched on the basis of donor age (±10 y), time on the waiting list (grouped as 0–6 mo, 6–12 mo, 1–3 y, and ≥3 y), primary renal disease (grouped as diabetes, not diabetes and unknown), HLA group (levels 1: full match, 4: least favorable), cold ischemia time (grouped as 0–6 h, 6–12 h, 12–18 h, 18–24 h, and ≥24 h), and year of transplant (±2 y).

Those patients in the cohort where a match was not available were also reviewed to see whether any themes could be identified to ensure that there would be no bias by excluding these participants. This was done by comparing the distributions of those participants who had matches to those who did not; this indicated some differences. There were more younger donors, shorter waiting times, more extreme cold ischemia time values (low and high), and more level 1 HLA matches in the group where case matches were not available than in those where matches were available.

Several different measures of kidney transplant outcome were considered to ensure impacts were captured. Kaplan-Meier survival plots were produced for patient and graft survival at 3 and 12 mo posttransplant to compare outcomes for the study cohort and control groups. Where a participant in any of the groups had no survival data available (patient or graph), they were not included in the analysis.

Univariable logistic regression was used to compare the incidence of DGF and estimated glomerular filtration rate (eGFR) <30 mL/min/1.73 m^2 between the study cohort and control groups. To compare eGFR at 3 and 12 mo, recipients were considered to have a functioning graft if their eGFR was >30 mL/min/1.73 m^2 at the relevant time point. Recipients who had returned to dialysis within the time period were considered to have an eGFR of <30 mL/min/1.73 m^2. The onset of graft function posttransplant is recorded as immediate, delayed, or primary nonfunction (PNF). Any recipient without immediate graft function was recorded as having had DGF.

Furthermore, the incidence of DGF was compared across the study cohort, standard DCD, and standard DBD cohorts by selecting all recipients from the study cohort who had a match in both the standard DCD and standard DBD control group. Logistic regression was then performed on the incidence of DGF in the 3 groups.

RESULTS

There was a total of 130 recorded cases where eligible DBD cases proceeded via the DCD pathway (DBD to DCD) in the United Kingdom between April 1, 2012, and March 2022. Seven were discovered to have been recorded incorrectly and so were excluded from analysis and the records were corrected. Of all eligible DBDs proceeding to donation, 1.5% of cases proceed to DCD.

The stated reasons for eligible DBD cases proceeding as DCD are given in Table 1.

Examples of relevant verbal quotes from family members as recorded in the National Health Service Blood and Transplant donor record by SNOD, which give insight into reasons behind DBD to DCD, are shown in Figure 1.

Organ Utilization

Organ utilization data are summarized in Table 2

Overall organ utilization rates are similar between the cohort and standard DCD groups, 82.9% and 79.5%, respectively, and higher in the standard DBD group, 87.2%. Similar organ utilization rates can be seen between the cohort group and both control groups for the majority of organs, especially in kidney utilization (91.9% utilization in the DBD to DCD cohort compared with 84.7% in standard DCD and 91.6% in standard DBD groups). The biggest differences are seen in heart donation (66.7% utilization in the DBD to DCD cohort compared with 86.3% in standard DCD and 97.1% in standard DBD groups), although DBD to DCD numbers are small. There is also a notable difference in the donation of small bowel between the DBD to DCD cohort and standard DBD control, but this is expected as small bowel is not offered in DCD. Statistical analysis was not carried out owing to the expected small numbers in the DBD to DCD cohort.

Time to Mechanical Asystole

The time taken to reach mechanical asystole between the standard DCD control and the cohort group is shown in Table 3 and Figure 2. There is a higher proportion of missing time to mechanical asystole data in the cohort when compared with the standard DCD cohort (39% versus 1%). Before September 2020, PDA data collection was recorded for either potential DBD donors or potential DCD donors. Therefore, data regarding the time of treatment withdrawal were only captured for standard DCD donors and not for eligible DBDs proceeding to DCD.

Kidney Donation and Transplantation

There was a total of 213 kidney transplants within the DBD to DCD cohort group, 8515 in the standard DCD and 13 579 in the standard DBD groups. Factors associated with kidney transplant outcomes are summarized in **Table S1** (**SDC,** http://links.lww.com/TXD/A760). No statistical

Direct quotes from family members:

1. “Have been with him for his first breaths in the world and want to be with him when this ends.”

2. Mother – “I brought him into this world. I should be there at the end.”

3. “We have been married for over 30 years, and I want to be with my husband when his heart stops. I can't let him be taken away from me to theatre."

Quotes from a specialist nurse for organ donation summarising their impression of family reasons for DBD to DCD

4. "Mum doesn't think her daughter is dead and won't accept it until her heart stops and doesn't start again.”

5. “The child’s heart continuing to beat after the diagnosis of death made the father feel ‘uncomfortable.’”

6. “Whilst appreciating the significance of DBD, the family could not ‘let him go whilst the heart is beating.’”

7. “Family expressed “moral conflict” at going to theatre whilst their son’s heart was still beating.”

FIGURE 1. Examples of quotations from family members and specialist nurses for organ donation giving insight into the reasons behind DBD to DCD. DBD, donation after brain death; DCD, donation after circulatory death.

TABLE 2.

Organ utilization summary of organs donated from proceeding donors in cohort and comparative utilization rates of organs from standard DCD and DBD donors, 1 April 2012 to 31 March 2022

	DBD to DCD cohort			Standard DCD			Standard DBD		
Organ	Donation rate[a]	No. transplanted	Utilization rate[b]	Donation rate[a]	No. transplanted	Utilization rate[b]	Donation rate[a]	No. transplanted	Utilization rate[2]
Organ	67.6%	350	82.9%	63.7%	11 723	79.5%	64.1%	26 443	87.2%
Kidneys	95.9%	216[c]	91.9%	97.4%	8845	84.7%	94.3%	13746	91.6%
Pancreas	73.1%	32	56.1%	41.7%	445	47.3%	58.2%	1655	51.5%
Liver	79.8%	74	77.9%	48.5%	1673	68.5%	92.5%	6582	89.7%
Small bowel	0.0%	0	–	0.0%	0	–	9.7%	190	96.0%
Heart	21.4%	4	66.7%	31.6%	177	86.3%	33.6%	1624	97.1%
Lungs	19.6%	24	82.8%	16.2%	583	80.1%	26.4%	2646	92.0%

[a]Donation rate defined as proportion of organs donated of those offered.
[b]Utilization rate defined as proportion of organs transplanted from those donated.
[c]No. transplanted counts the number of organs transplanted which may differ from the total number of transplants where multiorgan transplants have been performed.
DBD, donation after brain death; DCD, donation after circulatory death.

TABLE 3.

Summary statistics for time to mechanical asystole, in minutes, for standard DCD and DBD to DCD cohort

Donation type	N	Median	Lower quartile	Upper quartile	Mean	Minimum	Maximum	SD	N missing data
Standard DCD	336	15	12	24	28	0	235	34	5
DBD to DCD cohort	107	13	10	17	14	0	25	5	42

DBD, donation after brain death; DCD, donation after circulatory death.

analysis was done on these data; however, the groups appear to have similar distributions across all of the factors observed. For categorical variables, similar proportions are seen at each level for each group, whereas for continuous variables, similar overlapping interquartile ranges are seen in each group.

Kidney outcomes were compared for adult recipients of first kidney transplants, leading to 182 transplants in the DBD to DCD cohort, 7487 in the standard DCD and 10 769 in the standard DBD groups.

Case matching resulted in 168 matched cases between the DBD to DCD cohort and standard DCD control group and 172

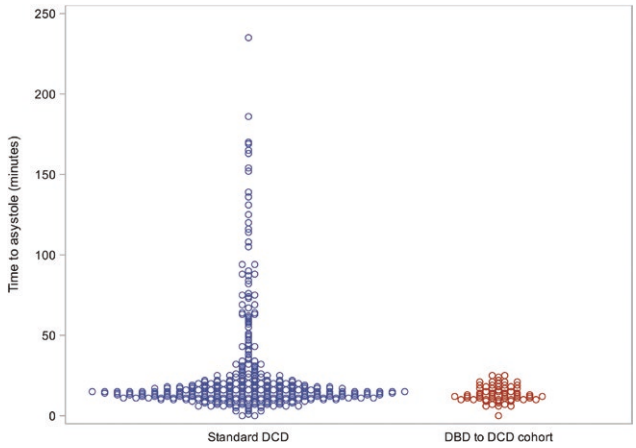


FIGURE 2. Dot plot time to asystole for standard DCD and DBD to DCD cohort. DBD, donation after brain death; DCD, donation after circulatory death.

matched between the cohort and standard DBD control group. The summaries of the DBD and DCD case-matched groups on the factors associated with kidney outcomes are given in **Tables S2** and **S3** (**SDC,** http://links.lww.com/TXD/A760); these show that the case matching was successful, distribution across all factors is similar, and balance was achieved.

DCD Retrieval Type

Although NRP usage increased 16-fold between the first and last year of the study, NRP was only used in a minority of cases (see Table 4). Usage among the matched standard DCD group was slightly higher than among the matched DBD to DCD cohort group for renal transplants, but this was not statistically significant. All other DCD retrieval types were via standard rapid recovery after the confirmation of death. Normothermic machine perfusion for kidney transplant was used only very rarely in the United Kingdom during the study period and has not been accounted for.

Regarding thoracoabdominal-NRP (TA-NRP), none of the 4 cohort donor hearts received TA-NRP and 24 of the 177 DCD control (13.6%) received TA-NRP. The remaining 153 (86.4%) donor hearts in the DCD control group were recovered via "standard rapid recovery".

TABLE 4.

NRP usage across groups

Donor type	NRP usage, n/N (%; 95% CI)
All DCD donors in study period	329/5457 (6.03%; 5.41-6.69)
All DCD donors in year 2012/2013	4/450 (0.89%; 0.24-2.26)
All DCD donors in year 2021/2022	86/603 (14.26%; 11.57-17.31)
Matched standard DCD donors	21/336 (6.25%; 3.91- 9.40)
Matched DBD to DCD cohort	8/168 (4.76%; 2.08-9.17)

CI, confidence interval; DBD, donation after brain death; DCD, donation after circulatory death; NRP, normothermic regional perfusion.

DGF and eGFR

Results from the univariate logistic regression models evaluating the risk of eGFR <30 mL/min/1.73 m^2 at 3 and 12 mo and the incidence of DGF are provided in Tables 5 and 6

None of these results were found to be statistically significant, but the point estimates for eGFR and DGF were lower in the DBD to DCD cohort than the standard DCD control group and lower in the DBD to DCD cohort than the standard DBD control group for eGFR at 12 mo but higher for eGFR at 3 mo and DGF.

Patient and Graft Survival

Patient and graft survival at 3 and 12 mo are shown in the Kaplan-Meier plots in Figures 3 and 4. None of these comparisons yielded significant differences in graft or patient survival.

The results of the additional logistic regression model of the incidence of DGF for all groups are given in Table 7. The results of this analysis were statistically significant ($P = 0.006$) and show that kidney transplantation from standard DBD donors has significantly lower rates of DGF than kidney transplantation from standard DCD donors, whereas for donors in the DBD to DCD cohort, the incidence of DGF is higher than that of a standard DBD donor and lower than that of a standard DCD donor, although not significantly so. However, the odds ratio for the study cohort was not significantly lower than that of the standard DCD donors, as seen by the upper

TABLE 5.

Logistic regression models and odds ratios for eGFR and DGF comparing standard DCD to control group

Outcome measure	DBD to DCD cohort	Standard DCD	Total
eGFR <30 mL/min/1.73 m^2 at 3 mo			
N/total N (%)	15/137 (10.9)	42/281 (14.9)	57/418 (13.6)
Odds ratio (95% CI)	0.70 (0.37-1.31)		
P	0.2558		
eGFR <30 mL/min/1.73 m^2 at 12 mo			
N/total N (%)	10/147 (6.8)	31/281 (11.0)	41/428 (9.6)
Odds ratio (95% CI)	0.59 (0.28-1.24)		
P	0.1475		
DGF			
N/total N (%)	37/163 (22.7)	87/305 (28.5)	124/468 (26.5)
Odds ratio (95% CI)	0.74 (0.47-1.15)		
P	0.1702		

eGFR at 3 mo was missing for 55 (16.4%) cases in the control group and 31 (18.5%) in the cohort. eGFR at 12 mo was missing for 55 (16.4%) cases in the control group and 21 (12.5%) in the cohort. DGF was missing for 31 (9.2%) cases in the control group and 5 (3.0%) in the cohort.
DBD, donation after brain death; DCD, donation after circulatory death; DGF, delayed graft function; eGFR, estimated glomerular filtration rate.

TABLE 6.

Logistic regression models and odds ratios for eGFR and DGF comparing standard DBD to control group

Outcome measure	DBD to DCD cohort	Standard DBD	Total
eGFR <30 mL/min/1.73 m^2 at 3 mo			
N/total N (%)	15/138 (10.9)	26/288 (9.0)	41/426 (9.6)
Odds ratio (95% CI)	1.23 (0.63-2.41)		
P	0.5501		
eGFR <30 mL/min/1.73 m^2 at 12 mo			
N/total N (%)	10/149 (6.7)	23/294 (7.8)	33/443 (7.4)
Odds ratio (95% CI)	0.85 (0.39-1.83)		
P	0.6713		
DGF			
N/total N (%)	38/166 (22.9)	57/310 (18.4)	95/476 (20.0)
Odds ratio (95% CI)	1.32 (0.83-2.09)		
P	0.2448		

eGFR at 3 mo was missing for 56 (16.3%) cases in the control group and 34 (19.8%) in the cohort. eGFR at 12 mo was missing for 50 (14.5%) cases in the control group and 23 (13.4%) in the cohort. DGF was missing for 34 (9.9%) cases in the control group and 6 (3.5%) in the cohort.
DBD, donation after brain death; DCD, donation after circulatory death; DGF, delayed graft function; eGFR, estimated glomerular filtration rate.

limit of (the) confidence being >1. These odds ratios are also presented graphically in Figure 5 for clarity.

DISCUSSION

There are approximately 12 cases per annum in the United Kingdom where eligible DBD donors proceed to donate via the DCD pathway. The vast majority of these cases proceed as DCD due to a desire by the family to be present at the point of mechanical asystole. We have illustrated this understandable stance with a series of unequivocal, poignant, and emotive quotations attributed to those families. In a minority of cases, this switch of donation pathway is either clinically necessary (eg, cardiopulmonary collapse immediately before planned DBD retrieval) or due to a failure to gain consent for DBD from the potential donor family. No consent to DBD may be rooted in a wide variety of cultural, religious, or spiritual beliefs or may reflect a lack of understanding of, or belief in, the concept of neurological death itself. Indeed, familial non-acceptance of brain death is a limiting factor for high consent rates for DBD in general.[9]

We know that some families remain unable to comprehend the notion that a loved one, physiologically maintained in an intensive care unit, who does not to them "look dead," has in fact died. Furthermore, the concept of neurological death is academically disputed or even rejected by some cultural or religious groups. We know that a myriad of religious, cultural, and ethnic considerations directly and significantly impact familial consent rates overall,[10] and so it is unsurprising that aspects of this can indirectly feed into a state of inadequate belief in neurological death. Reviewing this debate is beyond the scope of this article, but it remains incumbent on those who are approaching families for organ donation to seek to understand the individual ethnic, cultural, and religious opinions specific to DBD and facilitate the expressed wishes of the deceased to donate via whichever pathway is possible. In these circumstances, or indeed in any situation where consent for DBD in eligible DBD donors is not obtained, our study shows that the DCD pathway should be considered as a viable option to proceed upon. It might be the only path the families will accept.

Although family requests for DCD rather than DBD might suggest a preference for DCD in the United Kingdom, this is not representative. Consent from families for DCD is, on average, 11% lower than for DBD.[11] A retrospective study by Morgan et al[12] in the United Kingdom showed that families are 2.7 times more likely to override the expressed and registered wishes of a potential donor if the mode of donation is DCD as compared with DBD. The comprehensible desire to be present at the point the heart stops is undoubtedly a strong factor in many cases. A single-center study from the United Kingdom found that 36% of DBD families stay until the point of organ recovery compared with 80% of DCD families.[13] Unfortunately, we were not able to explore in any more detail in our evaluation the reasons families request DBD to DCD, and this is an area that requires further qualitative research.

Regarding the clinical impact of a DBD to DCD family request, we observed that the median time to mechanical asystole in the DBD to DCD versus standard DCD groups was a median of only 2 min quicker, whereas the mean difference was 14 min. It is clear from our results that withdrawing life-sustaining treatment on an eligible DBD donor with a view to proceeding via the DCD pathway removes the clinical uncertainty over whether there will be a very protracted period of warm ischemia or not, as is the case in some "standard" DCD scenarios. Given the clear association between the duration of warm ischemia time and graft and recipient outcomes,[14] the consequence of a shorter time to mechanical asystole should be an increase in solid organ donation and transplantation proportions and indeed improved graft and recipient outcomes. Furthermore, a more precise prediction of the time expected to reach asystole after withdrawal has secondary benefits in terms of family expectations and theater and retrieval team resource allocations.

In general, we observed a higher proportion of solid organs offered were both donated and then transplanted in the DBD to DCD cohort group as compared with the "standard DCD" control group. Although the numbers are small, so no statistical tests were carried out; this is particularly true for the deceased liver donation (48.5% and 68.5% donated and transplanted in standard DCD versus 79.8% and 77.9% in the DBD to DCD group). However, the respective proportions are higher in the DBD group than in the cohort group. The exception to this latter point is kidney donation, where

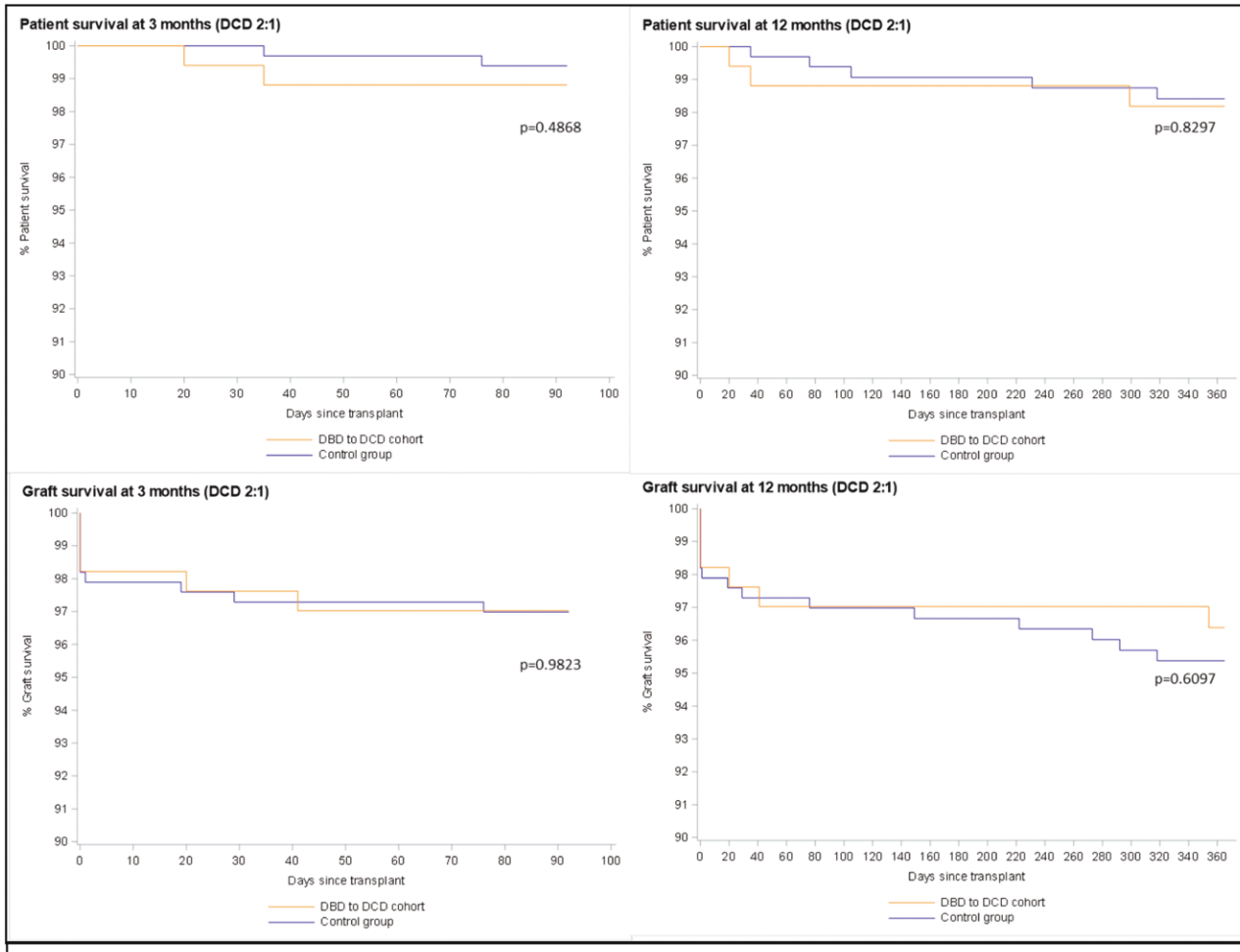
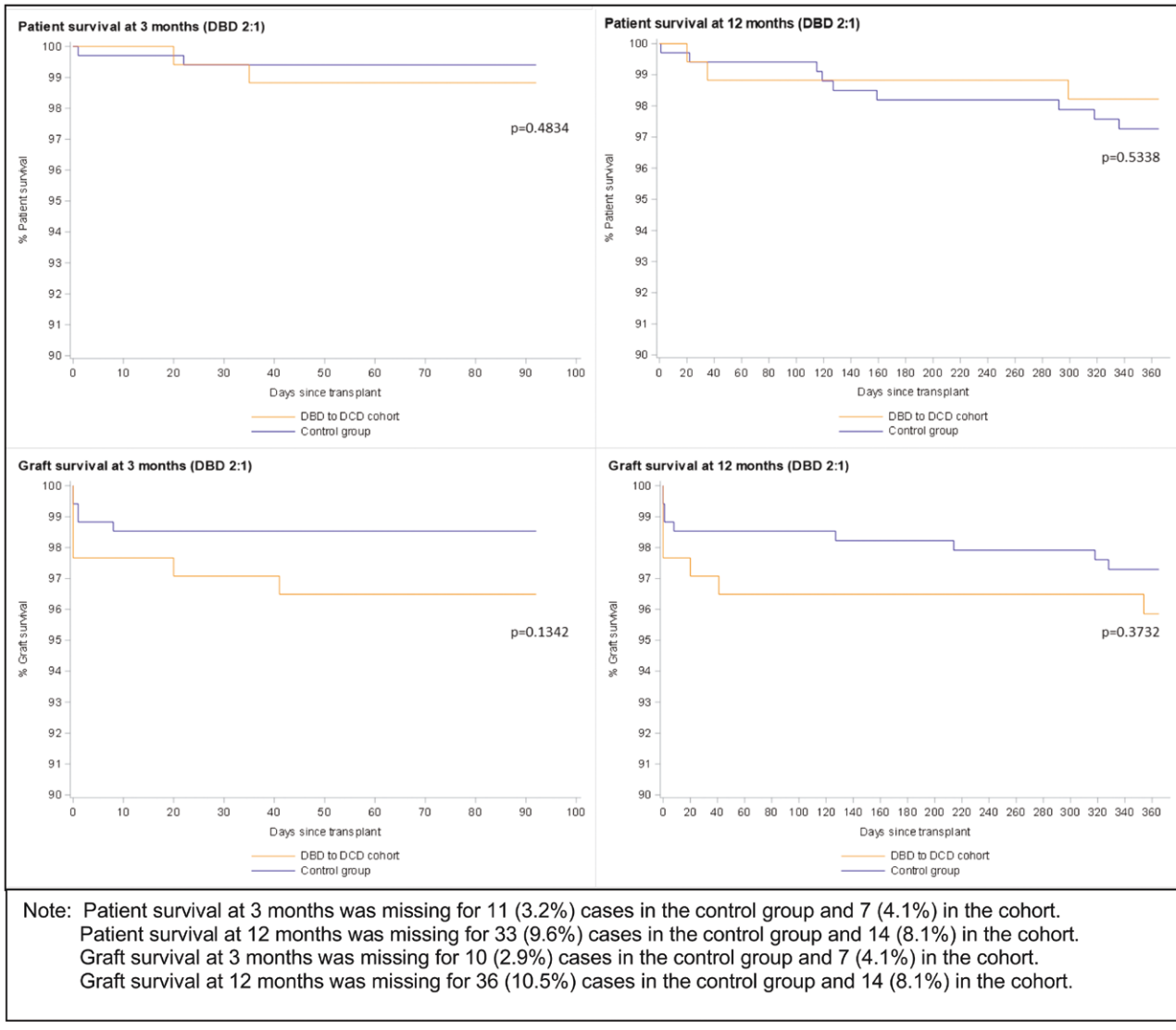


FIGURE 3. Three- and 12-mo patient and graft survival after first adult kidney transplant comparing DBD to DCD cohort to donors after circulatory death (April 1, 2012–March 31, 2022). DBD, donation after brain death; DCD, donation after circulatory death.

transplantation appears to be similar between DBD and the cohort group. The biggest difference was seen in heart donation (66.7% utilization in the DBD to DCD cohort compared with 86.3% in standard DCD and 97.1% in standard DBD groups). This might reflect complex acceptance criteria or bias that our study was unable to reveal due to the small numbers, as there should be no reason this should be the case. With the increased certainty of proceeding to donation and reduced warm ischemia time in DBD to DCD patients, there is good reason to think these patients would be favored by heart transplant teams over standard DCD.

Regarding our more detailed analysis of kidney outcomes, rates of DGF were significantly lower in the standard DBD group than the standard DCD group. Although of all the solid internal organs, kidneys are the most resistant to warm ischemic damage, the doubling of the mean time to mechanical asystole seen in standard DCD versus the DBD to DCD group correlates with the nonsignificant reduction in DGF observed. We have not been able to demonstrate a statistically significant reduction in DGF in the DBD to DCD group compared with standard DCD donors. It is very likely that the real-world outcomes in this group sit somewhere in between those of the standard DBD and standard DCD groups. Inferior recipient and graft outcomes in DCD is one factor believed to be limiting the more widespread roll-out of DCD programs globally, in addition to legislative, ethical, and cultural barriers.[15] With specific consideration to kidneys, it is widely believed that renal grafts from DCD donors have higher rates of DGF and PNF as to compared with DBD, with conflicting results shown for longer term graft and recipient survival.[16] A recent metanalysis by Rijkse et al[17] showed an increase in the risk of both PNF and DGF in DCD kidneys with risk ratios of 1.4 and 2, respectively. Similarly, a single-center retrospective study showed significantly increased rates of DGF, without any increase in overall graft and recipient loss.[18] Although DGF is thought not to impact on long-term patient and graft survival, the impact in terms of morbidity and resource implications should not be overlooked.

We have shown that in terms of kidney eGFR at 3 and 12 mo and rates of DGF, graft outcomes were similar between



Note: Patient survival at 3 months was missing for 11 (3.2%) cases in the control group and 7 (4.1%) in the cohort.
Patient survival at 12 months was missing for 33 (9.6%) cases in the control group and 14 (8.1%) in the cohort.
Graft survival at 3 months was missing for 10 (2.9%) cases in the control group and 7 (4.1%) in the cohort.
Graft survival at 12 months was missing for 36 (10.5%) cases in the control group and 14 (8.1%) in the cohort.

FIGURE 4. Three- and 12-mo patient and graft survival after first adult kidney transplant comparing DBD to DCD cohort to donors after brain death (April 1, 2012–March 31, 2022). DBD, donation after brain death; DCD, donation after circulatory death.

TABLE 7.

Logistic regression model of incidence of DGF for all groups

	Standard DCD	Standard DBD	DBD to DCD cohort	Total
DGF				
N/total N (%)	82/293 (28.0)	54/292 (18.5)	34/157 (21.7)	170/742 (22.9)
Odds ratio (95% CI)		0.58 (0.39-0.86)	0.71 (0.45-1.12)	
P		0.0058		

CI, confidence interval; DBD, donation after brain death; DCD, donation after circulatory death; DGF, delayed graft function.

the standard DCD, standard DBD, and the DBD to DCD cohort group. There was a trend toward improved outcomes in terms of eGFR and DGF with the cohort group compared with the standard DCD group, although none of these differences reached statistical significance. However, we have shown that grafts in the DBD to DCD cohort group functioned comparably to those in the standard DBD group, supporting the notion that, at least in terms of kidney donation, donating via the DCD pathway is a viable option for eligible DBD donors who cannot proceed via the DBD pathway.

Although we have not investigated graft and recipient outcomes in hepatic donation, the donor liver is most vulnerable to damage linked to the warm ischemia time in DCD. A meta-analysis by Ziogas et al[19] showed that although DCD liver donation was not associated with inferior patient survival, biliary complications, severe complications, length of stay, or acute renal failure when compared with outcomes after DBD, it was linked to increased risk of graft loss, retransplant, and PNF. Centers with high-volume experience in DCD liver donation may be able to demonstrate similar outcomes to

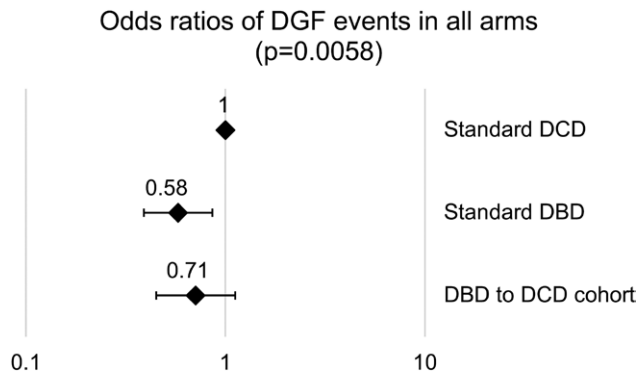


FIGURE 5. Odds ratios of DGF events in the cohort and 2 control groups. DGF, delayed graft function.

DBD liver donation in terms of graft survival.[20,21] However, DCD livers are more susceptible to ischemic cholangiopathy, and this remains an important cause of graft failure.[22] The advent of machine perfusion and NRP may negate the increased risk of posttransplant biliary complications in the future.[14] We have indeed shown that there has been a rapid increase in the usage of NRP over the decade that this study covers. However, regardless of whether NRP continues to be expanded within the United Kingdom and other countries, it is unavailable or illegal in many countries around the world, and so our data remain applicable also to these countries.

There is a paucity of available literature specifically addressing the issue of eligible DBD donors proceeding to donate via the DCD pathway. Maastricht IV DCD occurs when there is unexpected cardiac arrest in a patient who has been declared dead via neurological criteria.[23] In the absence of restoration of adequate perfusion, cessation of resuscitation and conversion to the DCD pathway can be considered, as was the case in a minority of cases in this study. Bahadır et al[24] described a successful Maastricht IV kidney donation and transplantation after unexpected cardiac arrest in an eligible DBD donor. Conversion to crash DCD must remain a viable option for organ donation given that in the United Kingdom, approximately 15% of consented eligible DBD donors are lost to uncontrollable hemodynamic instability, as shown in the PDA data. An alternative to "crash" DCD in eligible DBD donors is the so-called organ-preserving extra-corporeal membrane oxygenation , which is often not immediately available and raises a myriad of ethical and legal issues that render it unlikely to occur or be successful.[25]

The last group to consider are the potential donors who are likely "brain dead" but, for whatever reason, have not been or cannot be tested. Donors in this group may then proceed to DCD and are likely to deteriorate to mechanical asystole faster than the general DCD cohort, with the aforementioned reduction in warm ischemia time. However, these favorable outcomes should not be used in themselves as justification for not performing neurological death tests, particularly with regard to facilitating organ donation. Decisions over prognostication and end-of-life care should remain separate from decisions over potential organ donation.[26]

Limitations of our study were its retrospective nature, our reliance on what the specialist nurse recorded as the reason for a family request for DBD to DCD, the small number in this cohort group, and missing data.

We recommend that DCD be considered as a viable alternative to DBD in the event of failure to gain familial consent for DBD. However, DCD should not be promoted to families when consent for DBD can potentially be obtained because of a trend toward higher solid organ donation rates[4] and inferior outcomes for both grafts and recipients in DCD. Further qualitative research is required to better understand the reasons why some families request DBD to DCD.

CONCLUSIONS

Proceeding to donate via the DCD pathway in DBD-eligible donors is a rare event in the United Kingdom. It overwhelmingly occurs when there is no consent for DBD due to a request from the family to be present when the heart stops. These donors generally donate more solid organs, and a higher proportion of these organs are transplanted than with standard DCD. Outcomes from kidney donation in this cohort, in terms of DGF and graft and recipient survival, are comparable with those who donate via the DBD pathway, with a trend toward improved outcomes versus the standard DCD donors. This may be due, in part, to the reduced time from WLST to mechanical asystole, owing to the lack of brainstem reflexes, including the ability to breathe, in the DBD to DCD cohort group. Graft and recipient outcomes for other solid organs may show similarly encouraging results with the inevitable shorter warm ischemia times resulting from more rapid deterioration to mechanical asystole in comparison with standard DCD donors. More research is required with regard to graft and recipient outcomes for the other solid organs, specifically in this cohort, compared with standard DBD donors. There should be further qualitative research into the reasons why families request DBD to DCD, whether this request is modifiable, and even if it should be.

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