Article

Arch. Esp. Urol. 2022; 75(8): 720–728
https://doi.org/10.56434/j.arch.esp.urol.20227508.104

What Donation Features are Related to Complications in Donation after Circulatory Death Kidney Transplant? Analysis of Risk Factors for Complication after Circulatory Death Kidney Transplant

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Published: 28 October 2022

Objective: Complications in donation after circulatory death (DCD) kidney transplants (KT) are barely described, while in some urological complications the cause is unknown. The aim of this study is to describe surgical and urological complications and analyze what donation features could be involved.

Methods: A prospective, single center study was performed from 2016 to 2019 including all KT from controlled cardiac death donors (cDCD).

Results: A total of 86 cDCD KT were included in the study. Recipient BMI, residual urine output (RUO) <500 mL/day, delayed graft function (DGF), and wound complication were related to UTI ($p = 0.020$, $p = 0.008$, $p = 0.016$, and $p = 0.004$, respectively). Features related to early graft nephrectomy were recipient BMI and recipients with diabetes mellitus (DM) ($p = 0.025$ and $p = 0.036$, respectively). DM in recipients was significantly associated with hematuria ($p = 0.046$). Urinary leak (UL) was associated to vascular complication and ureteral stricture (US) ($p = 0.029$ both). UL and lymphocele were associated to US ($p = 0.029$ both). Features related to lymphocele were recipient BMI and US ($p = 0.028$ and $p = 0.029$, respectively). History of previous transplant, time from cardiac arrest (CA) to cold flush, and DGF, were associated to wound complication ($p = 0.040$, $p = 0.011$ and $p = 0.016$, respectively).

Conclusions: Surgical and urological complications after KT are an important issue to resolve. Our data revealed an association between RUO <500 mL/day, DGF, and wound complication with urinary infection, as well as between recipient DM and hematuria. Recipient BMI and DM were related to early graft nephrectomy. Vascular complications were associated with urinary leak, and lymphocele with US. Finally, wound complication was related to previous transplant, DGF, and time from CA to cold flush. This data revealed interesting associations between donor and recipient features and cDCD KT complications, providing more information to improve prevention and management.

Keywords: delayed graft function; diabetes mellitus; hematuria; lymphocele; nephrectomy

Introduction

Donation after circulatory death (DCD) is an essential source of organs to reduce kidney transplant (KT) waiting list. However, in contrast to donation after brain death (DBD), organs from DCD are submitted to warm ischemia, which is related to complications such as primary non-function, acute rejection, and delayed graft function (DGF) (1). Urological complications are the most frequent surgical complications after KT and cause significant morbidity, sometimes requiring surgical reintervention. Nowadays, vascular and urological complications in DCD KT have been scarcely described, and the origin of perigraft collections is not yet clear.

The purpose of this study is to describe the DCD KT complications encountered in our center and analyze what peritransplant features might be involved.

Material and Methods

A prospective study was performed including data regarding all KT from controlled DCD (Maastricht-III category) performed in Son Espases University Hospital from June 2016 to November 2019. Patient follow-up was from day of transplantation to August 2020. This study was approved by the Institutional Review Board.

Old donors were usually allocated to old recipients. There was not an age threshold in terms of age difference between donor and recipient. Antemortem canulation was

Table 1. Descriptive analysis.

DONORS (n 50)	
Age (median, IQR)	63 (56-68)
Gender:	
Male (n, %)	35 (75.6%)
Female (n, %)	15 (24.4%)
Expanded criteria (n, %)	34 (68%)
RECIPIENTS (n 86)	
Age (median, IQR)	61 (52-66.3)
Gender:	
Male (n, %)	67 (77.9%)
Female (n, %)	19 (22.1%)
Diabetes Mellitus (n, %)	32 (37.2%)
BMI (mean +/- SD)	27.1 +/- 4.5
Peritoneal dialysis (n, %)	24 (27.9%)
Hemodialysis (n, %)	50 (58.1%)
Pre-emptive (n, %)	12 (14%)
Previous transplant (n, %)	12 (14%)
Residual urine output (n, %, mL/day):	
<500	34 (39.5%)
>500	52 (60.5%)
ISCHEMIA TIMES (minutes) (median, IQR)	
WLST to CA	15 (11-18)
fWIT	19 (14-22)
CA to perfusion	9 (7.3-10.8)
CIT	540 (375-1125)

WLST: withdrawal of life-sustaining treatment; CA: cardiopulmonary arrest; fWIT: functional warm ischemia time; CIT: cold ischemia time.

Table 2. Outcomes and complications (n, %).

DGF	30 (37.5%)
Graft Survival	78 (97.5%)
Early graft nephrectomy	6 (6.9%)
Hematuria	19 (23.8%)
Transfusion	34 (42.5%)
Vascular complications	11 (12.8%)
UTI	20 (25%)
Urinary leak	5 (6.3%)
Ureteral stenosis	5 (6.3%)
Lymphocele	5 (6.3%)
Wound complication	11 (13.8%)

DGF: delayed graft function.

performed in 10 donationsin which the liver was extracted (extracorporeal membrane oxygenation) and multiple organs were donated in 13 cases. An ultrarapid technique was used for organ retrieval, the preservation method was cold storage, and the fluid preservation solution used was Wisconsin®. All KT were performed in adults, and none was performed simultaneously with pancreas or liver transplant. The ureteroneocystostomy performed was the modified Taguchi technique with two stiches, tutorized with a pediatric nasogastric tube which was exteriorized percutaneously. The nasogastric tube was usually removed on 5th day and the urethral catheter on 6th day after transplantation.

The immunosuppression induction protocol included anti-thymocyte globulin or basiliximab, whereas steroids, tacrolimus, and mycophenolate or everolimus were used during maintenance. No prophylaxis for viral diseases was implemented.

The expanded criteria donor (ECD) was defined as donor age ≥60 years or between 50-59 years with any of the following: stroke as cause of death, hypertension, or serum creatinine >1.5 mg/dL (2). The following ischemia times were recorded: time from withdrawal of life-sustaining therapies (WLST) to cardiopulmonary arrest (CA), functional warm ischemia time—time from systolic blood pressure <60 mm/Hg to cold organ flush—(fWIT), time from CA to perfusion, and cold ischemia time (CIT). DGF was defined as the need for dialysis within the first week after transplantation. Graft survival was defined as the current function of the graft without the need for hemodialysis.

Early complications registered were thrombosis, hemorrhagic shock, hematuria and urinary tract infection (UTI). Hematuria was considered when manual bladder washout or endoscopic surgery was needed. Urinary tract infection (UTI) was defined as asymptomatic bacteriuria as well as symptomatic infection.

Late complications considered were wound dehiscence, infection, and herniation or eventration, ureteral stricture (US), urine leak (UL) and arterial stenosis. US diagnosis was made when hydronephrosis was present on ultrasound examination and confirmed by a nephrostogram after insertion of a percutaneous nephrostomy tube. UL from the ureterovesical anastomosis was diagnosed by: (1) urine leak from the wound, (2) perigraft urine collection, and (3) leak on a nephrostogram. In cases 1 and 2, UL was confirmed with biochemical analysis. Ultrasounds and urine culture were performed protocolized during follow-up after KT. Qualitative variables are described in frequencies and percentages, and quantitative variables are shown with measures of central position and dispersion.

Numerical variables, except body mass index (BMI), present a non-normal distribution and are expressed with the median and interquartile range (IQR). BMI is expressed with the mean and typical deviation.

Quantitative and dichotomous variables were compared using U Mann-Whitney test (non-normality) or Student's *t*-test (normality), while qualitative variables were compared using Chi (2) or Fisher exact tests. A value of $p < 0.05$ was considered significantly different. Statistical software used was SPSS v.26.

Table 3. Influence of Donor and Recipient features and ischemia times on transplant complications I.

	HEMATURIA			BLOOD TRANSFUSION		
	No	**Yes**	***p***	**No**	**Yes**	***p***
Donor Age (median, IQR)	63.0 (53.0-68.0)	63.0 (56.0-68.0)	0.642	62.0 (51.0 – 68.0)	63.0 (56.0-68.0)	0.427
Donor Gender:						
Male (n, %)	46 (75.4%)	15 (78.9%)	1.000	35 (76.1%)	26 (76.5%)	0.968
Female (n, %)	15 (24.6%)	4 (21.1%)	1.000	11 (23.9%)	8 (23.5%)	0.968
Expanded criteria (n, %)	36 (60.0%)	11 (61.1%)	0.933	27 (60.0%)	20 (60.6%)	0.957
Recipient Age (median, IQR)	60.0 (51.0-66.0)	62.0 (52.0-67.0)	0.508	60.0 (49.0-65.0)	61.5 (53.0-67.0)	0.241
Recipient Gender:						
Male (n, %)	45 (73.8%)	16 (84.2%)	0.538	38 (82.6%)	23 (67.6%)	0.120
Female (n, %)	16 (26.2%)	3 (15.8%)	0.538	8 (17.4%)	11 (32.4%)	0.120
Diabetes Mellitus (n, %)	17 (27.9%)	10 (52.6%)	0.046	12 (26.1%)	15 (44.1%)	0.092
BMI (mean +/- SD)	26.7 ± 4.6	27.1 ± 4.3	0.753	27.7 ± 4.5	25.7 ± 4.4	0.054
Peritoneal dialysis (n, %)	16 (26.2%)	5 (26.3%)	N/A	12 (26.1%)	9 (26.5%)	0.394
Hemodialysis (n, %)	35 (57.4%)	12 (63.2%)	N/A	25 (54.3%)	22 (64.7%)	0.394
Pre-emptive (n, %)	10 (16.4%)	2 (10.5%)	N/A	9 (19.6%)	3 (8.8%)	0.394
Previous transplant (n, %)	8 (13.1%)	3 (15.8%)	0.717	6 (13.0%)	5 (14.7%)	1.000
Residual urine output (n, %, mL/day):						
<500	24 (39.3%)	8 (42.1%)	0.830	15 (32.6%)	17 (50.0%)	0.116
>500	37 (60.7%)	11 (57.9%)	0.830	31 (67.4%)	17 (50.0%)	0.116
WLST to CA (minutes) (median, IQR)	15.0 (11.0-18.0)	15.0 (11.0-16.0)	0.541	15.0 (11.0-20.0)	15.0 (10.0-17.0)	0.292
fWIT (minutes) (median, IQR)	19.0 (15.0-24.0)	17.0 (12.0-22.0)	0.318	19.0 (15.0-28.0)	19.0 (13.0-22.0)	0.472
CA to perfusion (minutes) (median, IQR)	9.0 (8.0-11.0)	9.0 (7.0-10.0)	0.2388	9.0 (7.0-10.0)	9.0 (7.0-12.0)	0.329
CIT (minutes) (median, IQR)	540.0 (360.0-1125.0)	900.0 (39.0-1140.0)	0.7301	540.0 (360.0-1125.0)	693.0 (382.0-1125.0)	0.6933
DGF	21 (34.4%)	9 (47.4%)	0.3089	14 (30.4%)	16 (47.1%)	0.1289
Hematuria	0 (0.0%)	19 (100.0%)	N/A	7 (15.2%)	12 (35.3%)	0.037
Blood Transfusion	22 (36.1%)	12 (63.2%)	0.037	0 (0.0%)	34 (100.0%)	N/A
UTI	13 (21.3%)	7 (36.8%)	N/A	8 (17.4%)	12 (35.3%)	N/A
Vascular complication	4 (6.6%)	1 (5.3%)	1	1 (2.2%)	4 (11.8%)	0.1573
Type of vascular complication						
Hemorrhagic shock	3 (75.0%)	0 (0.0%)	0.4	0 (0.0%)	3 (75.0%)	0.4
Thrombosis	0 (0.0%)	0 (0.0%)	0.4	0 (0.0%)	0 (0.0%)	0.4
Arterial stenosis	1 (25.0%)	1 (100.0%)	0.4	1 (100.0%)	1 (25.0%)	0.4
Early graft nephrectomy	0 (0.0%)	0 (0.0%)	N/A	0 (0.0%)	0 (0.0%)	N/A
Urinary leak	2 (3.3%)	3 (15.8%)	0.0841	3 (6.5%)	2 (5.9%)	1
Uretero-bladder stenosis	4 (6.6%)	1 (5,.3%)	1	2 (4.3%)	3 (8.8%)	0.6458
Lymphocele	3 (4.9%)	2 (10.5%)	0.5876	2 (4.3%)	3 (8.8%)	0.6458
Wound complication	8 (13.1%)	3 (15.8%)	0.717	7 (15.2%)	4 (11.8%)	0.7512

Table 4. Influence of Donor and Recipient features and ischemia times on transplant complications II.

	UTI			VASCULAR COMPLICATION		
	No	**Yes**	***p***	**No**	**Yes**	***p***
Donor Age (median, IQR)	62.5 (53.0-69.0)	63.5 (59.5-65.5)	0.846	63.0 (56.0- 68.0)	65.0 (61.0-71.0)	0.303
Donor Gender:						
Male (n, %)	46 (76.7%)	15 (75.0%)	1.000	57 (76.0%)	8 (72.7%)	1.000
Female (n, %)	14 (23.3%)	5 (25.0%)	1.000	18 (24.0%)	3 (27.3%)	1.000
Expanded criteria (n,%)	35 (60.3%)	12 (60.0%)	0.978	45 (61.6%)	8 (72.7%)	0.739
Recipient Age (median, IQR)	62.0 (52.5-67.0)	54.5 (48.5-61.5)	0.047	60.0 (52.0-66.0)	61.0 (59.0-70.0)	0.226
Recipient Gender:						
Male (n, %)	48 (80.0%)	13 (65.0%)	0.226	56 (74.7%)	11 (100.0%)	0.112
Female (n, %)	12 (20.0%)	7 (35.0%)	0.226	19 (25.3%)	0 (0.0%)	0.112
Diabetes Mellitus (n, %)	22 (36.7%)	5 (25.0%)	0.339	26 (34.7%)	6 (54.5%)	0.316
BMI (mean +/- SD)	27.5 ± 4.6	24.8 ± 3.7	0.020	27.0 ± 4.6	28.0 ± 4.3	0.481
Peritoneal dialysis (n, %)	17 (28.3%)	4 (20.0%)	0.493	21 (28.0%)	3 (27.3%)	N/A
Hemodialysis (n, %)	33 (55.0%)	14 (70.0%)	0.493	42 (56.0%)	8 (72.7%)	N/A
Pre-emptive (n, %)	10 (16.7%)	2 (10.0%)	0.493	12 (16.0%)	0 (0.0%)	N/A
Previous transplant (n, %)	7 (11.7%)	4 (20.0%)	0.454	10 (13.3%)	2 (18.2%)	0.648
Residual urine output (n, %, mL/day):						
<500	19 (31.7%)	13 (65.0%)	0.008	29 (38.7%)	5 (45.5%)	0.746
>500	41 (68.3%)	7 (35.0%)	0.008	46 (61.3%)	6 (54.5%)	0.746
WLST to CA (minutes) (median, IQR)	15.0 (11.0-20.0)	15.0 (11.0-16.0)	0.424	15.0 (11.0-18.0)	14.0 (12.0-16.0)	0.599
fWIT (minutes) (median, IQR)	19.0 (15.0-26.0)	19.0 (12.0-22.0)	0.585	19.0 (14.0-24.0)	20.0 (15.0-21.0)	0.977
CA to perfusion (minutes) (median, IQR)	9.0 (7.0-10.0)	9.0 (8.0-13.0)	0.361	9.0 (8.0-10.0)	9.5 (6.0-12.0)	0.836
CIT (minutes) (median, IQR)	490.5 (360.0-1020.0)	1045.5 (417.0-1185.0)	0.095438843	540.0 (360.0-1140.0)	470.0 (390.0-1020.0)	0.922716194
DGF	18 (30.0%)	12 (60.0%)	0.016395072	26 (34.7%)	4 (80.0%)	0.06292658
Hematuria	12 (20.0%)	7 (35.0%)	0.22572528	18 (24.0%)	1 (20.0%)	1
Blood Transfusion	22 (36.7%)	12 (60.0%)	0.067538285	30 (40.0%)	4 (80.0%)	0.157333756
UTI	0 (0.0%)	20 (100.0%)	N/A	17 (22.7%)	3 (60.0%)	N/A
Vascular complication	2 (3.3%)	3 (15.0%)	0.096672315	0 (0.0%)	11 (100.0%)	N/A
Type of vascular complication						
Hemorrhagic shock	1 (50.0%)	2 (66.7%)	1	0 (0.0%)	5 (45.5%)	N/A
Thrombosis	(0.0%)	(0.0%)	1	0 (0.0%)	4 (36.4%)	N/A
Arterial stenosis	1 (50.0%)	1 (33.3%)	1	0 (0.0%)	2 (18.2%)	N/A
Early graft nephrectomy	(0.0%)	(0.0%)	N/A	0 (0.0%)	6 (54.5%)	0.000
Urinary leak	3 (5.0%)	2 (10.0%)	0.594313914	3 (4.0%)	2 (40.0%)	0.02925855
Uretero-bladder stenosis	4 (6.7%)	1 (5.0%)	1	4 (5.3%)	1 (20.0%)	0.282055802
Lymphocele	4 (6.7%)	1 (5.0%)	1	4 (5.3%)	1 (20.0%)	0.282055802
Wound complication	4 (6.7%)	7 (35.0%)	0.004048674	10 (13.3%)	1 (20.0%)	0.53250809

Table 5. Influence of Donor and Recipient features and ischemia times on transplant complications III.

	EARLY GRAFT NEPHRECTOMY			Wound Complication		
	No	**Yes**	***p***	**No**	**Yes**	***p***
Donor Age (median, IQR)	63.0 (54.5-68.0)	68.5 (61.0-72.0)	0.082	62.0 (53.0- 68.0)	65.0 (63.0-70.0)	0.080
Donor Gender:						
Male (n, %)	61 (76.3%)	4 (66.7%)	0.631	50 (72.5%)	11 (100.0%)	0.058
Female (n, %)	19 (23.8%)	2 (33.3%)	0.631	19 (27.5%)	0 (0.0%)	0.058
Expanded criteria (n, %)	47 (60.3%)	6 (100.0%)	0.080	40 (59.7%)	7 (63.6%)	1.000
Recipient Age (median, IQR)	60.5 (52.0-66.0)	61.0 (59.0-69.0)	0.576	60.0 (51.0-66.0)	61.0 (53.0-63.0)	0.944
Recipient Gender:						
Male (n, %)	61 (76.3%)	6 (100.0%)	0.331	54 (78.3%)	7 (63.6%)	0.281
Female (n, %)	19 (23.8%)	0 (0.0%)	0.331	15 (21.7%)	4 (36.4%)	0.281
Diabetes Mellitus (n, %)	27 (33.8%)	5 (83.3%)	0.025	21 (30.4%)	6 (54.5%)	0.169
BMI (mean +/- SD)	26.8 ± 4.5	30.8 ± 3.4	0.036	27.0 ± 4.5	25.8 ± 4.5	0.409
Peritoneal dialysis (n, %)	21 (26.3%)	3 (50.0%)	N/A	19 (27.5%)	2 (18.2%)	N/A
Hemodialysis (n, %)	47 (58.8%)	3 (50.0%)	N/A	39 (56.5%)	8 (72.7%)	N/A
Pre-emptive (n, %)	12 (15.0%)	0 (0.0%)	N/A	11 (15.9%)	1 (9.1%)	N/A
Previous transplant (n, %)	11 (13.8%)	1 (16.7%)	1.000	7 (10.1%)	4 (36.4%)	0.040
Residual urine output (n, %, mL/day):						
<500	32 (40.0%)	2 (33.3%)	1.000	25 (36.2%)	7 (63.6%)	0.105
>500	48 (60.0%)	4 (66.7%)	1.000	44 (63.8%)	4 (36.4%)	0.105
WLST to CA (minutes) (median, IQR)	15.0 (11.0-18.0)	14.5 (12.0-17.0)	0.826	15.0 (11.0-18.0)	16.0 (10.0-22.0)	0.488
fWIT (minutes) (median, IQR)	19.0 (14.0-24.0)	21.0 (19.0-22.0)	0.481	19.0 (14.0-22.0)	19.0 (16.0-31.0)	0.460
CA to perfusion (minutes) (median, IQR)	9.0 (7.0-10.0)	10.0 (9.0-12.0)	0.521	9.0 (7.0-10.0)	13.0 (9.0-14.0)	0.011
CIT (minutes) (median, IQR)	540.0 (360.0-1125.0)	452.5 (390.0-580.0)	0.825517712	540.0 (360.0-1095.0)	900.0 (390.0-1211.0)	0.175
DGF	30 (37.5%)	0 (0.0%)	N/A	22 (31.9%)	8 (72.7%)	0.016335129
Hematuria	19 (23.8%)	0 (0.0%)	N/A	16 (23.2%)	3 (27.3%)	0.716975286
Blood Transfusion	34 (42.5%)	0 (0.0%)	N/A	30 (43.5%)	4 (36.4%)	0.751245093
UTI	20 (25.0%)	0 (0.0%)	N/A	13 (18.8%)	7 (63.6%)	N/A
Vascular complication	5 (6.3%)	6 (100.0%)	0.000	4 (5.8%)	1 (9.1%)	0.53250809
Type of vascular complication						
Hemorrhagic shock	3 (60.0%)	2 (33.3%)	N/A	2 (50.0%)	1 (100.0%)	1
Thrombosis	0 (0.0%)	4 (66.7%)	N/A	0 (0.0%)	0 (0.0%)	1
Arterial stenosis	2 (40.0%)	0 (0.0%)	N/A	2 (50.0%)	0 (0.0%)	1
Early graft nephrectomy	0 (0.0%)	6 (100.0%)	N/A	0 (0.0%)	0 (0.0%)	N/A
Urinary leak	5 (6.3%)	0 (0.0%)	N/A	3 (4.3%)	2 (18.2%)	0.136938012
Uretero-bladder stenosis	5 (6.3%)	0 (0.0%)	N/A	4 (5.8%)	1 (9.1%)	0.53250809
Lymphocele	5 (6.3%)	0 (0.0%)	N/A	5 (7.2%)	0 (0.0%)	1
Wound complication	11 (13.8%)	0 (0.0%)	N/A	0 (0.0%)	11 (100.0%)	N/A

Table 6. Influence of Donor and Recipient features and ischemia times on transplant complications IV.

	URINARY LEAK			Ureteral-bladder stenosis			Lymphocele		
	No	**Yes**	***p***	**No**	**Yes**	***p***	**No**	**Yes**	***p***
Donor Age (median, IQR)	63.0 (53.0-68.0)	65.0 (64.0-65.0)	0.819	63.0 (53.0- 68.0)	65.0 (65.0-65.0)	0.217	63.0 (53.0-68.0)	65.0 (65.0-65.0)	0.403
Donor Gender:									
Male (n, %)	56 (74.7%)	5 (100.0%)	0.332	57 (76.0%)	4 (80.0%)	1.000	58 (77.3%)	3 (60.0%)	0.588
Female (n, %)	19 (25.3%)	0 (0.0%)	0.332	18 (24.0%)	1 (20.0%)	1.000	17 (22.7%)	2 (40.0%)	0.588
Expanded criteria (n, %)	44 (60.3%)	3 (60.0%)	1.000	43 (58.9%)	4 (80.0%)	0.643	43 (58.9%)	4 (80.0%)	0.643
Recipient Age (median, IQR)	60.0 (52.0-66.0)	62.0 (61.0-67.0)	0.403	60.0 (51.0-66.0)	61.0 (60.0-66.0)	0.647	60.0 (52.0-66.0)	67.0 (66.0-67.0)	0.221
Recipient Gender:									
Male (n, %)	56 (74.7%)	5 (100.0%)	0.332	56 (74.7%)	5 (100.0%)	0.332	56 (74.7%)	5 (100.0%)	0.332
Female (n, %)	19 (25.3%)	0 (0.0%)	0.332	19 (25.3%)	0 (0.0%)	0.332	19 (25.3%)	0 (0.0%)	0.332
Diabetes Mellitus (n, %)	25 (33.3%)	2 (40.0%)	1.000	26 (34.7%)	1 (20.0%)	0.658	26 (34.7%)	1 (20.0%)	0.658
BMI (mean +/- SD)	26.8 ± 4.6	27.9 ± 1.5	0.220	26.6 ± 4.5	30.2 ± 2.8	0.087	26.5 ± 4.3	31.1 ± 6.0	0.028
Peritoneal dialysis (n, %)	20 (26.7%)	1 (20.0%)	N/A	18 (24.0%)	3 (60.0%)	N/A	18 (24.0%)	3 (60.0%)	N/A
Hemodialysis (n, %)	43 (57.3%)	4 (80.0%)	N/A	45 (60.0%)	2 (40.0%)	N/A	45 (60.0%)	2 (40.0%)	N/A
Pre-emptive (n, %)	12 (16.0%)	0 (0.0%)	N/A	12 (16.0%)	0 (0.0%)	N/A	12 (16.0%)	0 (0.0%)	N/A
Previous transplant (n, %)	10 (13.3%)	1 (20.0%)	0.533	11 (14.7%)	0 (0.0%)	1.000	11 (14.7%)	0 (0.0%)	1.000
Residual urine output (n, %, mL/day):									
<500	31 (41.3%)	1 (20.0%)	0.643	31 (41.3%)	1 (20.0%)	0.643	31 (41.3%)	1 (20.0%)	0.643
>500	44 (58.7%)	4 (80.0%)	0.643	44 (58.7%)	4 (80.0%)	0.643	44 (58.7%)	4 (80.0%)	0.643
WLST to CA (minutes) (median, IQR)	15.0 (11.0-18.0)	12.0 (11.0- 16.0)	0.658	15.0 (11.0-18.0)	16.0 (9.0-31.0)	0.779	15.0 (11.0-18.0)	24.0 (13.0-31.0)	0.196
fWIT (minutes) (median, IQR)	19.0 (14.0-24.0)	15.0 (15.0-19.0)	0.457	19.0 (14.0-22.0)	19.0 (15.0-31.0)	0.546	19.0 (14.0-22.0)	26.5 (17.5-31.0)	0.265
CA to perfusion (minutes) (median, IQR)	9.0 (8.0-10.0)	7.0 (7.0- 10.0)	0.511	9.0 (8.0-10.0)	7.0 (7.0-10.0)	0.511	9.0 (8.0-10.0)	8.0 (7.0-9.5)	0.473
CIT (minutes) (median, IQR)	540.0 (360.0-1125.0)	472.0 (420.0-1020.0)	0.952	575.0 (360.0-1125.0)	472.0 (420.0-540.0)	0.788	540.0 (360.0-1125.0)	1090.0 (930.0-1200.0)	0.095
DGF	26 (34.7%)	4 (80.0%)	0.06292658	28 (37.3%)	2 (40.0%)	1	26 (34.7%)	4 (80.0%)	0.06292658
Hematuria	16 (21.3%)	3 (60.0%)	0.084082057	18 (24.0%)	1 (20.0%)	1	17 (22.7%)	2 (40.0%)	0.587552479
Blood Transfusion	32 (42.7%)	2 (40.0%)	1	31 (41.3%)	3 (60.0%)	0.645758139	31 (41.3%)	3 (60.0%)	0.645758139
UTI	18 (24.0%)	2 (40.0%)	N/A	19 (25.3%)	1 (20.0%)	N/A	19 (25.3%)	1 (20.0%)	N/A
Vascular complication	3 (4.0%)	2 (40.0%)	0.02925855	4 (5.3%)	1 (20.0%)	0.282055802	4 (5.3%)	1 (20.0%)	0.282055802
Type of vascular complication									
Hemorrhagic shock	2 (66.7%)	1 (50.0%)	1	2 (50.0%)	1 (100.0%)	1	2 (50.0%)	1 (100.0%)	1
Thrombosis	0 (0.0%)	0 (0.0%)	1	0 (0.0%)	0 (0.0%)	1	0 (0.0%)	0 (0.0%)	1
Arterial stenosis	1 (33.3%)	1 (50.0%)	1	2 (50.0%)	0 (0.0%)	1	2 (50.0%)	0 (0.0%)	1
Early graft nephrectomy	0 (0.0%)	0 (0.0%)	N/A	0 (0.0%)	0 (0.0%)	N/A	0 (0.0%)	0 (0.0%)	N/A
Urinary leak	0 (0.0%)	5 (100.0%)	N/A	3 (4.0%)	2 (40.0%)	0.02925855	4 (5.3%)	1 (20.0%)	0.282055802
Uretero-bladder stenosis	3 (4.0%)	2 (40.0%)	0.02925855	0 (0.0%)	5 (100.0%)	N/A	3 (4.0%)	2 (40.0%)	0.02925855
Lymphocele	4 (5.3%)	1 (20.0%)	0.282055802	3 (4.0%)	2 (40.0%)	0.02925855	0 (0.0%)	5 (100.0%)	N/A
Wound complication	9 (12.0%)	2 (40.0%)	0.136938012	10 (13.3%)	1 (20.0%)	0.53250809	11 (14.7%)	0 (0.0%)	1

Results

In this study, 86 KT from controlled cardiac death donors (cDCD) were included. Six cases with early graft nephrectomy (6.9%) were excluded from further complication analyses. The median follow-up duration after transplantation was 2.3 years. Descriptive data from donors and recipients, as well as ischemia times, are described in Table 1.

DGF was present in 30 cases (37.5%) and current graft survival rate is 97.5%. Vascular complications were present in 12.8% while urinary complications were found in 12.6% of cases (Table 2). History of diabetes mellitus (DM) in recipients was significantly associated with hematuria (p = 0.046) (Table 3). Recipient BMI, residual urine output (RUO) <500 mL/day, DGF, and wound complication were related to UTI (p = 0.020, p = 0.008, p = 0.016, and p = 0.004, respectively) (Table 4). Features significantly related to early graft nephrectomy were: recipient with DM, recipient BMI, and vascular complication (p = 0.025, p = 0.036, and p = 0.000, respectively) (Table 5).

UL was associated to vascular complication and US (p = 0.029 both). Meanwhile, UL and lymphocele were associated to US (p = 0.029 both). Features related to lymphocele were recipient BMI and US (p = 0.028 and p = 0.029, respectively) (Table 6). Finally, history of previous transplant, time from CA to cold flush, and DGF, were associated to wound complication (p = 0.040, p = 0.011 and p = 0.016, respectively) (Table 5). ECD was not associated to any complication. Hypothermic machine perfusion was not used.

Discussion

Hardly any results have been published regarding surgical complications in DCD KT. Hematuria and UTI were the most common complications encountered in this study (23.8% and 25.0%, respectively). Hematuria was significantly associated to history of DM in the recipient (p = 0.046). No data have previously been published regarding this association.

Eleven vascular complications were recorded (12.8%). Six early graft nephrectomies occurred immediately in the postoperative period due to thrombosis (5 cases) and hemorrhagic shock. Thus, the main cause of graft loss was early vascular thrombosis.

Our data reveal an association between recipient BMI and DM and early graft nephrectomy (p = 0.036 and p = 0.025). These results may be explained by the surgical complexity added by the high BMI and poorer vascular status of DM recipients. Nevertheless, no literature is published concerning this relationship so no comparison or firm declarations can be made. Nevertheless, two cases (2.3%) developed arterial stenosis that was solved with angioplasty, which is comparable with other published results (3).

A European single-center retrospective study, which included 59 controlled DCD KT, reported one case of renal vein thrombosis (1.69%) (4), a lower rate than in our study (4.6%). It also reported five cases with hematuria and eleven cases with anemia (8.47% and 18.6%, respectively), lower rates as well (Table 2).

US and UL rates in DCD KT are scattered in the literature (3.5-15%) (5, 6) and our rate was comparable to these results (12.6%). However, perigraft collection rate in our study (urinary leak and lymphocele) was 12.6%, notably lower than another recent Spanish study (30.8%) (7).

Contradictory results have been published concerning DGF, in that some studies have revealed DGF as a risk factor for ureteral complications (4). In a prospective study in England with a sample of 198 DCD KT, incidence of US and UL was 7.5% and 0%, respectively, and was not related to CIT or DGF (3), as in our study (Table 4). On the other hand, the England study demonstrated a relationship between US and donor age and male recipient, whereas our data did not. However, in the latter association no differentiation was made between DCD and DBD KT. This is because incidence of ureteral complications in DCD or BDB KT are usually low, making it necessary for them to be considered together.

Our data did not reveal any association between ECD and urological complications. Neither did a large retrospective study in the UK reveal an association between ECD or CIT with urological complications. Once again, no differentiation was made between DCD, DBD, and live donors (4).

Our study revealed an association between vascular complications and US with UL. This association has not been previously analyzed. In our cohort, vascular complication always occurred before UL. In one case, vascular complication was arterial stenosis solved by placement of an arterial stent; while in the second case, vascular complication was hemorrhagic shock in which surgical reintervention was needed. In both cases, UL was diagnosed approximately two months after KT.

Further, our data show an association between lymphocele and US. In all cases the lymphocele was diagnosed first, and after resolution US was diagnosed. All cases were diagnosed approximately four months after KT and were obstructive, thereby requiring percutaneous drainage.

The causative factor of US and UL is unclear in most cases, but our results could be explained by compromised ureteral blood supply caused by vascular complications and inflammation and edema due to a lymphocele, as vascular/inflammation insult occurred before ureteral complication. Further, DCD KT usually need more dialysis due to DGF and this could also predispose to a poorer ureter blood supply (1). Finally, we cannot make any suggestion as to what came first, US or UL, because when both appeared in the same case, both diagnoses were made at the same time.

Our UTI rate was inferior to recently published data from a retrospective study in the Netherlands (1) which reported an UTI rate of 40.8%. Associations between UTI and urological complications have been reported previously (4). Nevertheless, US may lead to UTI too. In our study, no association was revealed between UTI and US or UL. However, our results did reveal that UTI was related to RUO lower than 500 mL/day and wound complication. No previous data have been published regarding this.

Another feature to take into account in ureteral complications is the ureteroneocystostomy technique. The most common is the Lich-Gregoir technique, which has been reported to have better results than other ones (8, 9). Our data come from a Taguchi technique, so comparison is not equal. However, the complication rate seems to be acceptable in this study.

Furthermore, the optimal time for removal of the ureteric stent is not clear and may play a role in ureteral complications, so these stents may predispose to UTI.

In regard to other analyses, no relationship was appreciated between fWIT and surgical complications. Finally, our data showed that wound complication was related to a previous transplant, DGF, and time from CA to cold flush. No similar analysis has been found regarding these associations.

This study has some limitations. It was a single center observational study with a relatively small sample. Furthermore, some confounding factors could be involved in KT complications and were not controlled in this study, which limits the statistical power of these results; BK nephropathy, for instance (10). This variable was not included because in our center we do not routinely perform BK virus screening. Also, established risk factors for complications as hypertension and peripheral vascular disease have not been analysed. Further, it is difficult to make solid comparisons and conclusions due to the fact that most studies about DCD KT complications include live donor and BDB as well, with no differentiation between different donors.

Nevertheless, despite these limitations, we present a prospective study of exclusively cDCD KT complications. Poor data is available about KT complications in this donor subgroup and no previous studies have been published regarding associations between donor and recipient features, and different ischemia times with DCD KT complications.

Conclusions

KT complications, especially surgical and urological ones, are not uncommon and can entail significant comorbidity due to infection and urinary obstruction. Our data on cDCD KT complications were reported, revealing some associations between donor and recipient features and KT complications: between RUO <500 mL/day, DGF, and wound complication and UTI, as well as between recipient DM and hematuria. Furthermore, recipient BMI and DM were related to early graft nephrectomy. Regarding urological complications, vascular complications were associated with UL, and lymphocele with US. Finally, wound complication was related to previous transplant, DGF, and time from CA to cold flush.

These data provide novel information to improve prevention and management of cDCD KT complications. Furthermore, these results support the use of DCD KT due to acceptable complication rates.

Author Contributions

IC—designed the analysis, collected and interpreted all data and wrote the paper; AM—designed the analysis, interpreted all data and wrote the paper; MP—contributed data and interpreted all data; LA—contributed data and interpreted all data; CV—contributed data and interpreted all data; MA—contributed data and interpreted all data; RG—contributed data and interpreted all data; JB—contributed data and interpreted all data; EP—interpreted all data and supervised the findings of this work.

Ethics Approval and Consent to Participate

Not applicable.

Acknowledgment

Authors would like to thank Ana Rosa Millán for statistical support.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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