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► **To cite this version:**

Quentin Dubourg, Emilie Savoye, Sarah Drouin, Camille Legeai, Benoit Barrou, et al.. Effect of Cardiac Arrest in Brain-dead Donors on Kidney Graft Function. *Transplantation*, 2023, 10.1097/TP.0000000000004825 . hal-04243044

HAL Id: hal-04243044

<https://hal.science/hal-04243044>

Submitted on 16 Oct 2023

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Effect of Cardiac Arrest in Brain-Dead Donors on Kidney Graft

Function

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Running title: Cardiac arrest in brain-dead donors.

Word count

abstract: 210

text (main text including abstract): 3181

Author contribution:

QD: conceptualization, data acquisition, data analysis, drafting of the manuscript

ES: methodology, data analysis, drafting of the manuscript

SD: conceptualization, data analysis, critical revision of the manuscript

CL: data analysis, critical revision of the manuscript

BB: conceptualization, critical revision of the manuscript

ER: conceptualization, critical revision of the manuscript

DB: conceptualization, critical revision of the manuscript

FK: data analysis, critical revision of the manuscript

RB: methodology, data analysis, critical revision of the manuscript

PG: conceptualization, data acquisition, data analysis, drafting and finalization of the manuscript

ABM study group: all members participated to the completion of the CRISTAL registry

Disclosures

All authors have completed the ICMJE uniform disclosure form at <http://www.icmje.org/disclosure-of-interest/> and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Funding :

This work was supported by INSERM (PG, 2019 ATIP Avenir grant), Societe Francophone de Nephrologie Dialyse et Transplantation (PG, 2020 grant), by Fondation pour la Recherche Médicale (PG, grant 40207) and by Société Francophone de Transplantation (QD, 2019 grant).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships

ABSTRACT

Background. Cardiac arrest causes renal ischemia in one third of brain-dead kidney donors before procurement. We hypothesized that the graft function depends on the time interval between cardiac arrest and organ procurement.

Methods. We conducted a retrospective population-based study on a prospectively curated database. We included 1469 kidney transplantations from donors with a history of resuscitated cardiac arrest in 2015-2017 in France. Cardiac arrest was the cause of death (primary cardiac arrest) or an intercurrent event (secondary cardiac arrest). The main outcome was the percentage of delayed graft function, defined by the use of renal replacement therapy within the first week post transplantation.

Results. Delayed graft function occurred in 31.7% of kidney transplantations and was associated with donor function, vasopressors, cardiovascular history, donor and recipient age and body mass index, cold ischemia time, and time to procurement after primary cardiac arrest. Short cold ischemia time, perfusion device use, and the absence of cardiovascular comorbidities were protective by multivariate analysis, whereas time less than 3 days from primary cardiac arrest to procurement was associated with delayed graft function (Odds Ratio 1.38).

Conclusion. This is the first description of time to procurement after a primary cardiac arrest as a risk factor for delayed graft function. Delaying procurement after cardiac arrest should be evaluated in interventional studies.

INTRODUCTION

Kidney transplantation is recognized as the best treatment for end-stage renal disease; it increases survival,^{1,2} improves quality of life,³ and reduces health care costs compared with hemodialysis.⁴ It is, however, limited by a global shortage of kidney donors.⁵ In response to this shortage, the procurement of kidneys from donors with acute kidney injury has proved to be a relatively safe strategy for increasing the number of available organs.⁶ Similar outcomes have been reported for acutely injured kidneys from brain-dead donors and those from BDD without AKI, on condition that the formers' characteristics are otherwise favorable. The impact of acute kidney injury in donors with comorbidities is, however, unknown, and long-term outcomes remain uncertain. Various comorbidities that might affect kidney quality are frequently found in brain-dead donors. About one third of donors have a history of resuscitated cardiac arrest before organ procurement.^{7,8} This cardiac arrest interrupts the blood flow and induces warm ischemia in the kidney.⁹ It can occur at different times during donor care, corresponding to different situations with various consequences on the circulation in terms of no flow (complete circulatory arrest) or low flow (partial circulatory restoration by resuscitation maneuvers). It can be either the primary event responsible for anoxic brain death (primary cardiac arrest) or be associated with brain death without being its cause (secondary cardiac arrest).¹⁰

Donors' renal function decreases after a resuscitated cardiac arrest.^{8,11} Other causes of warm ischemia during kidney transplantation, e.g., vascular anastomosis time, also lead to poorer functional results.^{12,13} Nonetheless, on average, resuscitated cardiac arrest does not impair allograft function in the recipient.^{8,11,14–18} The favorable characteristics of these donors selected despite their history of cardiac arrest might explain this result, as could the modification by other factors of the effects of ischemia

in this situation. For example, experimental models show that a first ischemic episode can provide time-limited protection against a second injury, a phenomenon called ischemic preconditioning.¹⁹ Conversely, epithelial cells undergo transient proliferation after injury,²⁰ which sensitizes them in case of a second injury.²¹ Thus, the interval between the two ischemic events — resuscitated cardiac arrest and organ procurement — is a variable that might either mitigate or aggravate the consequences of cardiac arrest on graft function.

The aim of this retrospective study was to assess potential risk factors for the occurrence of delayed graft function (DGF) in kidney transplants from brain-dead donors with resuscitated cardiac arrest, including the time from cardiac arrest to procurement.

METHODS

Study design and population

This retrospective cohort analysis of a prospectively maintained registry included all brain-dead donors with resuscitated cardiac arrest leading to a single kidney transplant in France in 2015 through 2018 (Figure 1). We identified 4077 brain-dead donors during this period, 1242 of whom had a history of resuscitated cardiac arrest. Cardiac arrest was identified as either the cause for brain death (death by anoxia: primary cardiac arrest) or an intercurrent event in brain-dead patients (secondary cardiac arrest).

Donors were excluded from this study when they had had multiple ischemic events, such as multiple cardiac arrests, defined by more than 2 cardiac arrests within a 30-minute interval or the use of extracorporeal membrane oxygenation (ECMO) during

cardiac resuscitation (description in Table S1 in the Supplementary Appendix). Preemptive transplants were excluded (143 transplants) because of the difficulty in observing delayed graft function (DGF) in these patients, as were recipients with DGF information missing (13 transplants).

The clinical and research activities being reported are consistent with the Principles of the Declaration of Istanbul as outlined in the 'Declaration of Istanbul on Organ Trafficking and Transplant Tourism.

Outcome measures

Our primary endpoint was DGF, defined as the need for dialysis during the first week after transplantation. It included primary nonfunction (PNF), defined as graft loss or recipient death with a nonfunctioning graft within 3 months after transplantation.

Secondary endpoints were

- Graft survival at 1 year with recipient death censored, graft survival at 1 year, and recipient survival at 1 year,
- Poor function at 1 year, defined by either an estimated glomerular filtration rate (eGFR) < 30 ml/min at 1 year or early graft loss (< 1 year) with exclusion of death.
- Estimated GFR at 1 year. We imputed a value of 10 mL/min/1.73m² to patients returned on chronic dialysis.

Data collection

The French national transplant registry (CRISTAL, Agence de la Biomédecine, Saint-Denis, France) prospectively collects demographic, clinical, and laboratory data for all organ transplant recipients and donors in France, as well as transplant outcomes. Data are recorded at registration (placement on a transplantation waiting list), procurement,

transplantation, and annually thereafter. Data collection is mandatory, and research technicians double-check its completeness and accuracy. The main parameter assessed was time from primary or secondary cardiac arrest to procurement (CA-P time), that is, the interval from the beginning of the cardiac arrest to the aortic clamping during organ procurement. We also considered donor acute kidney injury, defined as an increase in creatininemia of more than 50% or more than 26.5 $\mu\text{mol/l}$, and total or partial recovery from it, defined by diminution in serum creatinine between peak and procurement of more or less than 25%.²² Other donor-related parameters of interest were no-flow, cause of death, eGFR, high vasopressor levels, defined as more than 0.6 mg/h or use of multiple vasopressors, and diuresis.²³ Finally, we collected and considered the general characteristics of donors, recipients, and transplants, fully detailed in Table 1.

Exact times from cardiac arrest to procurement and the low-flow and no-flow durations were assessed from text comments in the database and double-checked by two different clinicians, blinded to the outcome. When data were missing for 5% or fewer of the values for any variable, they were imputed to the least risky and most frequent category when possible. If more than 5% of data were missing, a missing modality was created.

The French National Commission on Computing and Liberty approved the database. Written informed consent was not required for this non interventional registry study (methodological standard MR-004), and the Institutional Review Board authorized this study.

Statistical analysis

Data are expressed as means \pm SD, or as numbers (percentages). Differences between groups were assessed with Chi-2 and t-tests.

After the univariate analysis studied all the available variables known to be associated with DGF, graft survival at 1 year death censored or poor function at 1 year, we used a logistic regression model to perform a multivariate analysis, retaining potential confounders with $P < 0.20$ and those that were clinically significant to include all confounders between exposure and outcome. Odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. A directed acyclic graph for DGF occurrence was constructed (Figure S1 in the Supplementary Appendix) to interpret our multivariate analysis.²⁴ We examined the relation between continuous variables and the odds ratio for the outcome graphically with restricted cubic splines and then determined the cutoffs for continuous variables based on these graphs and clinical relevance. To determine a threshold for CA-P time, we analyzed the overall CA-P time distribution and its distribution according to DGF occurrence. We performed a restricted cubic spline logistic regression adjusted for donor and recipient age in the overall study cohort, in the primary cardiac arrest group, and in the secondary cardiac arrest group. A cubic spline regression model determined that a CA-P time threshold of 3 days optimized the discrimination between a high and low risk of DGF occurrence (Figure 2). Then, we categorized our exposure criteria (CA-P time) in two groups: less than 3 days, and 3 days or more, and studied the pre-specified secondary outcomes in these groups. We performed a sensitivity analysis on DGF occurrence and identified a significant interaction between CA-P time and cardiac arrest type (Figure 2 and data not shown). We thus identified donors with CA-P time less than 3 days after primary cardiac arrest as the high-risk group versus all other donors.

Since two kidneys of the same donor have been included in this analysis, we performed a sensitivity analysis, testing right kidney alone, followed by left kidney alone. We also performed sensitivity analyses on AKI status, KDPI >85, multiple organ procurement and vasopressor use at procurement.

Survival was estimated by the Kaplan–Meier method. Equality of survival curves was assessed with the log-rank test (P-value<0.05). Three versions of graft survival analysis — with death censored, without death censored, and overall recipient survival — were performed at 1 year. The observation end date was December 29, 2020.

Statistical analyses were performed with SAS guide 7.1 (SAS Institute, Cary, NC, USA). All P values were two-tailed and P<0.05 was considered significant.

RESULTS

The study included 1469 kidney transplantations: 836 (57%) from donors with primary cardiac arrest, and 633 (43%) from those with secondary cardiac arrest (Figure 1). In the overall study cohort, DGF occurred in 469 recipients (31.9%), 44 with primary nonfunction (3.0%) (Figure 1). DGF was associated with allograft loss at one year (both overall and censored on PNF) (Figure S2). The type of cardiac arrest was not associated with DGF, which occurred in 32.7% of donors with primary cardiac arrest and 31.0% of donors with secondary cardiac arrest (unadjusted OR 0.92, 95% CI 0.75 to 1.15, P=0.49, Table S2). Nonetheless, transplantations from primary cardiac arrest donors differed significantly from those from secondary cardiac arrest donors (Table 1). Donors with primary cardiac arrest were more often male (61.2% vs 51.0%, P<0.01) and had a lower Kidney Donor Profile Index (KDPI) score (59 vs 64%, P<0.01) and a less frequent history of hypertension (19.3% vs 26.9%, P<0.01). They more often had

diabetes (11.8% vs 5.5%, $P < 0.01$), a no-flow duration exceeding 15 minutes (21.4% vs 8.1%, $P < 0.01$), preserved diuresis (>50 ml/h) at procurement (91.4% vs 87.2%, $P = 0.01$), and fewer of them received vasopressors (36.0% vs 31.1%, $P = 0.05$). Both a CA-P time of at least 3 days (56.2% vs 27.2%, $p < 0.01$) and acute kidney injury were more frequent in the primary cardiac arrest group (62% vs 52%, $P < 0.01$), and the latter was not associated with DGF in recipients (unadjusted OR for no vs yes, 0.9, 95% CI 0.72 to 1.12, $P = 0.33$, Table S2). The median CA-P time was 3.4 (IQR: 2.0-4.8) days for donors with primary cardiac arrest and 2.0 (IQR: 1.4-3.2) for those with secondary cardiac arrest. A CA-P time of 3 days or longer was significantly associated with reduced DGF occurrence (29.1% vs 34.1%, unadjusted OR 0.79, 95% CI 0.64 to 0.99, $P = 0.043$, Table S2). We found an interaction between CA-P time and type of cardiac arrest (interaction term P -value = 0.112) and thus identified CA-P time after primary cardiac arrest as the variable of interest.

In the multivariate analysis (Figure 3), CA-P time less than 3 days in donors with primary cardiac arrest increased the risk of DGF (adjusted OR 1.38, 95% CI 1.07 to 1.79, $P = 0.014$), compared with others. Other variables significantly associated with DGF in multivariate analysis were higher vasopressor regimen in donors, right kidney donation, cold ischemia time, absence of hypothermic perfusion device, recipient cardiovascular comorbidity, and recipient diabetes. The effect of CA-P time remain even using vasopressor dose as a continuous covariate (Figure S3). A sensitivity analysis showing similar results for left and right kidneys ruled out a bias linked to the kidney side (Figure S4). CA-P time less than 3 days in donors with primary cardiac arrest was also associated with more unresolved acute kidney injury at procurement (33% vs 23%, $P = 0.002$, Table S3).

Sensitivity analysis showed that the effect of CA-P time was stronger in donors with KDPI>85, AKI, high vasopressor doses at procurement and donors of multiple organs (Figure S8).

The mean eGFR at 1 year was 53.0 ml/min/1.73m² (95%CI 51.8 to 54.2). At the same time point, CA-P time of less than 3 days after primary cardiac arrest was associated with death-censored graft loss (94.2% [95%CI 91.2 to 96.2] vs 97.3% [95%CI 96.1 to 98.1], P = 0.006, Figure 4), but not with eGFR (P = 0.29, Figure S5) nor with poor graft function defined as eGFR <30 ml/min/1.73m² or patient returned on dialysis (OR 1.34 [95%CI 0.96-1.88], Table S4). Also at 1 year, CA-P time after primary cardiac arrest was not associated with overall graft survival (Figure S6) or with recipient survival (Figure S7) (P=0.13 and P=0.22 respectively).

Among these kidney donors after resuscitated cardiac arrest, 77% also donated livers, 24% lungs, and 33% hearts (Table S1). CA-P time less than 3 days after primary cardiac arrest versus other donors was associated with fewer heart and liver transplants (Table S5).

DISCUSSION

We identified a new variable of interest that is predictive of DGF after primary cardiac arrest. DGF is an important outcome for morbidity and health cost and, even more importantly, it is a robust predictor of long-term renal allograft function and graft loss.²⁵⁻

²⁷ We chose DGF as a primary outcome to study procurement-related factors because it is a frequent event after transplantation, and because it is an early outcome (7 days after transplantation) that cannot be affected by later intercurrent events. As expected, loss of function at 1 year was a rare event, which limits the power of the statistical

analysis, although we found that it was more frequent when procurement was performed less than three days after cardiac arrest. After a severe cardiac arrest, time for recovery before procurement may be an important parameter for ensuring successful transplantation. The design of our study allowed us to assess the exact recovery time, or more precisely, the exact interval between two ischemic events (CA-P time), as both the cardiac arrest and the procurement procedure are traceable and monitored by standard donor management protocols.

One limitation of our study is the retrospective observational design. Causality cannot be established, and indirect association through confounders might bias our results. The use of a nationwide, systematic, and prospectively curated cohort nonetheless limits this bias. To further reduce the risk, every parameter included was assessed to identify possible confounders or mediators, and a Directed Acyclic Graph was constructed to help interpret our multivariate logistic analysis, based on our current knowledge of the pathophysiology of DGF. It must also be noted that although this study focused on kidney transplants, many donors in our cohort had other organs procured and transplanted. We found that organ procurement of the kidney within 3 days after resuscitated cardiac arrest is associated with less utilization of other organs from the same donor. This suggests that delaying organ procurement to more than 3 days after resuscitated cardiac arrest might increase the number and quality of other organs available for donation, but prospective studies are needed to provide definitive evidence of the effect of such a strategy on outcomes of solid organ transplantation.

Based on a careful review of the literature, this is the first study focusing on how the interval between resuscitated cardiac arrest in DBD and kidney graft procurement influences the graft's function in recipients. Other studies have focused on a different time interval — that between the diagnosis of brain death and organ procurement.²⁸

Eerola et al. recently showed that delaying organ procurement after a brain death diagnosis is acceptable, in contrast to the general belief that brain death is a detrimental condition that contributes to kidney injury in the donor.²⁹ This observational study in Finland and the USA found that a longer interval between the declaration of death and procurement was associated with less frequent DGF and thus suggests that extending the interval after brain death diagnosis might not be detrimental. In a multivariate model including CA-P time, we did not find that this parameter influenced DGF. The time interval between the diagnosis of brain death and organ procurement depends on the timing of the diagnosis (by brain angiography or electroencephalogram), not on when brain death actually happens. Calculation of the duration of brain death at any given time point is based on when the physicians decided to perform these diagnostic tests and is thus subjective. The synergistic effect of CA-P time < 3 days with primary cardiac arrest (associated with more severe ischemia with longer no flow and more AKI) suggests that it is indeed the recovery time after AKI before procurement that determines the risk of DGF.

Importantly, CA-P time is a potentially modifiable factor that could help to optimize the management of organ donors. In our study, the multivariate analysis identified CA-P time as an independent risk factor for DGF, even after adjustment for vasopressor drug use, and thus suggests that the association between increased DGF rates and shorter CA-P time is not related to a more unstable hemodynamic state in donors. Delaying procurement after a primary cardiac arrest would have as a disadvantage saturation of intensive care units where donors are managed, but decreasing DGF rates would reduce the recipients' morbidity and hospitalization time, and possibly improve the graft's long-term outcomes. Therapeutic hypothermia is another intervention that was reported to decrease delayed graft function in kidney allograft

recipients.³⁰ In this open-label study, patients were either randomized to normothermia or to hypothermia for at least 12 hours. Patients assigned to hypothermia had a better function at the time of procurement, shorter cold-ischemia time and less delayed graft function. Although it was interpreted as an effect of therapeutic hypothermia, it could also have been an effect of delaying procurement in patients assigned to hypothermia. Several clinical and experimental studies show that renal function starts recovering 72 hours after resuscitated cardiac arrest.³¹ Our data confirm that recovery from acute kidney injury after a primary cardiac arrest is less frequent within the first 3 days. We identified 3 days of recovery time as a cutoff for DGF risk after primary cardiac arrest. After an ischemic renal insult, the kidney undergoes ATP depletion, oxidative stress, and epithelial cell proliferation and differentiation — all factors that contribute to kidney allograft injury during procurement, cold ischemia, implantation, and reperfusion.

In conclusion, an interval of less than 3 days between a primary cardiac arrest and organ procurement from brain-dead donors is an independent and potentially modifiable factor of delayed graft function in kidney transplantation.

Acknowledgments

We would like to thank all members of organ recovery units, and transplantation units from clinical centers, the surgical supervisors of transplant units, and the technicians involved in the clinical studies and those who entered data into the database. We also thank Jo Ann Cahn for English editing.

Data Sharing

All data used in this study were extracted from the Cristal registry, coordinated and supported by the French Agence de la biomédecine. Access to national data is regulated by a scientific committee of the French Agence de la biomédecine, which analyzes each request.

Thus, data cannot be made publicly available due to legal restrictions. Data are available upon request. If readers need information about the data from the Cristal registry, they can contact Nicolas Chatauret (nicolas.chatauret@biomedecine.fr).

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Table 1. Comparison of Baseline Characteristics between Groups with Time from Cardiac Arrest to Procurement (CA-P Time) (less than 3 days, 3 days or more) and Between Types of Donor's Cardiac Arrest (Primary and Secondary)

Variable		Overall study cohort	CA-P time (days)			Donor's cardiac arrest		
			[0;3]*	[3;+]*	P Value	Primary	Secondary	P Value
Donor characteristics								
CA-P time (day)	[0;3[	827 (56.3)				366 (43.8)	461 (72.8)	<0.01
	[3;+]	642 (43.7)				470 (56.2)	172 (27.2)	
Type of cardiac arrest	Primary	836 (56.9)	366 (44.3)	470 (73.2)	<0.01			
	Secondary	633 (43.1)	461 (55.7)	172 (26.8)				
Gender	Male	835 (56.8)	417 (50.4)	418 (65.1)	<0.01	512 (61.2)	323 (51)	<0.01
	Female	634 (43.2)	410 (49.6)	224 (34.9)		324 (38.8)	310 (49)	
Age	18-39 years	348 (23.7)	183 (22.1)	165 (25.7)	0.04	199 (23.8)	149 (23.5)	0.48
	40-54 years	531 (36.1)	285 (34.5)	246 (38.3)		314 (37.6)	217 (34.3)	
	55-59 years	186 (12.7)	111 (13.4)	75 (11.7)		99 (11.8)	87 (13.7)	
	60 years and more	404 (27.5)	248 (30)	156 (24.3)		224 (26.8)	180 (28.4)	
Age (year)		50.6 (14.5)	51.5 (14.5)	49.4 (14.4)	0.01	50.3 (13.9)	50.9 (15.3)	0.43
Hypertension	No	1138 (77.5)	612 (74)	526 (81.9)	<0.01	675 (80.7)	463 (73.1)	<0.01
	Yes	331 (22.5)	215 (26)	116 (18.1)		161 (19.3)	170 (26.9)	
Diabetes	No	1335 (90.9)	751 (90.8)	584 (91)	0.92	737 (88.2)	598 (94.5)	<0.01
	Yes	134 (9.1)	76 (9.2)	58 (9)		99 (11.8)	35 (5.5)	
Coronary disease	No	1369 (93.2)	780 (94.3)	589 (91.7)	0.05	773 (92.5)	596 (94.2)	0.2
	Yes	100 (6.8)	47 (5.7)	53 (8.3)		63 (7.5)	37 (5.8)	
Body mass index (kg/m2)		26.2 (5.4)	26.4 (5.7)	26.1 (5)	0.29	26.1 (5.6)	26.4 (5.1)	0.28
KDPI (%)		61 (27)	65 (25)	56 (26)	<0.01	59 (26)	64 (27)	<0.01
No flow	< 15 min	895 (60.9)	554 (67)	341 (53.1)	<0.01	410 (49)	485 (76.6)	<0.01
	>= 15 min	230 (15.7)	119 (14.4)	111 (17.3)		179 (21.4)	51 (8.1)	
	Missing	344 (23.4)	154 (18.6)	190 (29.6)		247 (29.5)	97 (15.3)	
Death to procurement time (days)		0.65 (0.3)	0.61 (0.2)	0.70 (0.3)	<0.01	0.65 (0.2)	0.65 (0.3)	0.87
Last hourly diuresis	<50 ml/h	153 (10.4)	102 (12.3)	51 (7.9)	0.01	72 (8.6)	81 (12.8)	0.01
	>=50 ml/h	1316 (89.6)	725 (87.7)	591 (92.1)		764 (91.4)	552 (87.2)	
Last eGRF (ml/min/1.73 m2)		79.1 (44.7)	70.8 (35.9)	89.7 (52.1)	<0.01	78.9 (49.8)	79.4 (37)	0.83
Acute kidney injury**	No	622 (42.3)	393 (47.5)	229 (35.7)	<0.01	317 (37.9)	305 (48.2)	<0.001
	Yes	847 (57.7)	434 (52.5)	413 (64.3)		519 (62.1)	328 (51.8)	
Last mean arterial pressure	<65 mmHg	103 (7.0)	62 (7.5)	41 (6.4)	0.41	61 (7.3)	42 (6.6)	0.62
	>=65 mmHg	1366 (93.0)	765 (92.5)	601 (93.6)		775 (92.7)	591 (93.4)	
Vasopressors	<=1 and low dose	498 (33.9)	224 (27.1)	274 (42.7)	<0.01	301 (36)	197 (31.1)	0.05
	>1 or high dose	971 (66.1)	603 (72.9)	368 (57.3)		535 (64)	436 (68.9)	
Graft characteristics								
Graft type	Left	778 (53.0)	430 (52)	348 (54.2)	0.4	445 (53.2)	333 (52.6)	0.81
	Right	691 (47.0)	397 (48)	294 (45.8)		391 (46.8)	300 (47.4)	
Cold ischemia time (hour)		16.3 (6.2)	16.5 (6.2)	16.1 (6.1)	0.2	16.5 (6.3)	16.1 (5.9)	0.32
Hypothermic machine perfusion	No	1062 (72.3)	580 (70.1)	482 (75.1)	0.04	611 (73.1)	451 (71.2)	0.44
	Yes	407 (27.7)	247 (29.9)	160 (24.9)		225 (26.9)	182 (28.8)	
Recipient characteristics								
Gender	Male	945 (64.3)	523 (63.2)	422 (65.7)	0.32	547 (65.4)	398 (62.9)	0.31
	Female	524 (35.7)	304 (36.8)	220 (34.3)		289 (34.6)	235 (37.1)	

Variable		Overall study cohort	CA-P time (days)			Donor's cardiac arrest		
			[0;3]*	[3;+]*	P Value	Primary	Secondary	P Value
Age (year)		49.6 (13.3)	50.3 (13.2)	48.7 (13.4)	0.03	49.2 (13.1)	50.1 (13.5)	0.2
Body mass index (kg/m ²)		26.0 (5.2)	26 (5.4)	25.8 (5)	0.48	25.8 (5.4)	26.2 (4.9)	0.15
Duration on dialysis before transplantation	<2 years	534 (36.4)	307 (37.1)	227 (35.4)	0.27	314 (37.6)	220 (34.8)	0.5
	2-4 years	534 (36.4)	308 (37.2)	226 (35.2)		295 (35.3)	239 (37.8)	
	> 4 years	401 (27.3)	212 (25.6)	189 (29.4)		227 (27.2)	174 (27.5)	
Cardiovascular comorbidities	No	1290 (87.8)	732 (88.5)	558 (86.9)	0.35	727 (87)	563 (88.9)	0.25
	Yes	179 (12.2)	95 (11.5)	84 (13.1)		109 (13)	70 (11.1)	
Diabetes	No	1247 (84.9)	706 (85.4)	541 (84.3)	0.56	713 (85.3)	534 (84.4)	0.62
	Yes	222 (15.1)	121 (14.6)	101 (15.7)		123 (14.7)	99 (15.6)	
cPRA	0%	828 (56.4)	474 (57.3)	354 (55.1)	0.82	490 (58.6)	338 (53.4)	0.02
	1-24%	205 (14.0)	108 (13.1)	97 (15.1)		100 (12)	105 (16.6)	
	25-49%	148 (10.1)	82 (9.9)	66 (10.3)		90 (10.8)	58 (9.2)	
	50-84%	154 (10.5)	86 (10.4)	68 (10.6)		91 (10.9)	63 (10)	
	85-100%	134 (9.1)	77 (9.3)	57 (8.9)		65 (7.8)	69 (10.9)	

*Values are means (standard deviation) or frequencies (percentages)

**Acute kidney injury defined by an increase of 50% or 26.5 $\mu\text{mol/l}/88.4$ between the minimum and maximum values observed between cardiac arrest and procurement.

P-values were calculated with the use of Chi-2 test for categorical variables and the t-test for continuous variables to test the difference between the group and the rest of the study population

Glomerular filtration rate was estimated (eGFR) by using the Modification of Diet in Renal Disease (MDRD) formula ($186.3 \times (\text{creatinine last observed in } \mu\text{mol/l}/88.4)^{-1.154} \times \text{age}^{-0.203} (\times 0.742 \text{ for women})$)

KDPI: kidney donor profile index

cPRA: Calculated Panel Reactive Antibodies

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Table S1. Comparison of Baseline Characteristics between Included and Excluded Donors: Values are means (standard deviation), frequencies (percentages)

Variable		N	Donors included	Donors excluded	P value
Gender	Men	715	596 (56.7)	119 (62.6)	0.12
	Women	527	456 (43.3)	71 (37.4)	.
Age (year)		1242	49.9 (14.9)	49.4 (16.4)	0.72
Body mass index (kg/m ²)		1242	26.1 (5.4)	26 (5)	0.76
Hypertension	No	955	816 (77.6)	139 (73.2)	0.18
	Yes	287	236 (22.4)	51 (26.8)	.
Diabetes	No	1136	960 (91.3)	176 (92.6)	0.53
	Yes	106	92 (8.7)	14 (7.4)	.
Type of cardiac arrest	Primary	675	596 (56.7)	79 (41.6)	<0.01
	Secondary	567	456 (43.3)	111 (58.4)	.
Liver transplanted	No	311	246 (23.4)	65 (34.2)	<0.01
	Yes	931	806 (76.6)	125 (65.8)	.
Lung transplanted	No	963	805 (76.5)	158 (83.2)	0.04
	Yes	279	247 (23.5)	32 (16.8)	.
Heart transplanted	No	864	707 (67.2)	157 (82.6)	<0.01
	Yes	378	345 (32.8)	33 (17.4)	.
Pancreas transplanted	No	1181	1000 (95.1)	181 (95.3)	0.9
	Yes	61	52 (4.9)	9 (4.7)	.
eGRF (ml/min/1.73 m ²)		1242	62 (33.5)	61.4 (32.5)	0.82
KDPI		1242	0.6 (0.3)	0.6 (0.3)	0.83

P-values were calculated with the use of Chi-2 test for categorical variables and the t-test for continuous variables to test the difference between the group and the rest of the study population

Glomerular filtration rate was estimated (eGFR) by using the Modification of Diet in Renal Disease (MDRD) formula ($186.3 \times (\text{creatinine maximum observed in } \mu\text{mol/l} / 88.4)^{-1.154} \times \text{age}^{-0.203} (\times 0.742 \text{ for women})$)

KDPI : kidney donor profile index

Table S2. Univariate Logistic Model for Delayed Graft Function (DGF)

Variable		N	n	DGF %	OR	95% CI	P value
Donor characteristics							
CA-P time (day)	[0;3[	1469	827	34.10	1	-	0.043
	[3;+[		642	29.13	0.79	0.64 to 0.99	
Type of cardiac arrest	Primary		836	32.66	1	-	0.49
	Secondary	1469	633	30.96	0.92	0.74 to 1.15	
CA-P time (day) and CA type	[0;3[and primary CA	1469	366	37.70	1.50	1.12 to 2.01	0.043
	[3;+[and primary CA		470	28.72	1	-	
	[0;3[and secondary CA		461	31.24	1.13	0.85 to 1.49	
	[3;+[and secondary CA		172	30.23	1.08	0.73 to 1.58	
Death to procurement time (days)	Continuous	1469			0.74	0.48 to 1.15	0.18
Gender	Men	1469	835	31.50	1	-	0.69
	Women		634	32.49	1.05	0.84 to 1.31	
Age	18-39 years	1469	348	25.86	0.77	0.57 to 1.04	0.009
	40-54 years		531	31.26	1	-	
	55-59 years		186	33.33	1.10	0.77 to 1.57	
	60 years and more		404	37.38	1.31	1.00 to 1.72	
Age (year)	Continuous form	1469			1.01	1.01 to 1.02	0.0007
Body mass index (kg/m2)	Continuous form	1469			1.03	1.01 to 1.05	0.013
Hypertension	No	1469	1138	29.88	1	-	0.002
	Yes		331	38.97	1.50	1.16 to 1.93	
Diabetes	No	1469	1335	31.76	1	-	0.67
	Yes		134	33.58	1.09	0.75 to 1.58	
Coronary disease	No	1469	1369	31.26	1	-	0.045
	Yes		100	41.00	1.53	1.01 to 2.31	
KDPI	Continuous form	1469			2.67	1.75 to 4.09	<0.0001
No flow	< 15 min	1469	895	33.97	1	-	0.11
	>= 15 min		230	29.13	0.80	0.58 to 1.10	
	Missing		344	28.49	0.77	0.59 to 1.02	
Vasopressors	<=1 and low dose	1469	498	27.71	0.74	0.58 to 0.94	0.013
	>1 or high dose		971	34.09	1	-	
Acute kidney injury*	No	1469	622	30.55	0.90	0.72 to 1.12	0.33
	Yes		847	32.94	1	-	

Variable		N	n	DGF %	OR	95% CI	P value
Transplantation conditions							
Graft type	Left	1469	778	28.66	1	-	0.004
	Right		691	35.60	1.38	1.10 to 1.71	
Cold ischemia time (hour)	Continuous form	1469			1.05	1.03 to 1.06	<0.0001
Hypothermic machine perfusion	No	1469	1062	32.49	1	-	0.46
	Yes		407	30.47	0.91	0.71 to 1.17	
Recipient characteristics							
Gender	Men	1469	945	33.02	1	-	0.23
	Women		524	29.96	0.87	0.69 to 1.09	
Age (year)	Continuous form	1469			1.02	1.01 to 1.02	0.0004
Body mass index (kg/m2)	Continuous form	1469			1.03	1.01 to 1.05	0.007
Duration on dialysis before transplantation	Continuous form	1469			1.36	1.18 to 1.56	<0.0001
Cardiovascular comorbidities	Continuous form	1469			1.51	1.10 to 2.09	0.011
Diabetes	No	1469	1247	30.15	1	-	0.0006
	Yes		222	41.89	1.67	1.25 to 2.24	
cPRA	0%	1469	828	33.09	1	-	0.60
	1-24%		205	28.29	0.80	0.57 to 1.12	
	25-49%		148	32.43	0.97	0.67 to 1.41	
	50-84%		154	28.57	0.81	0.55 to 1.18	
	85-100%		134	33.58	1.02	0.69 to 1.50	

*Acute kidney injury defined by an increase of 50% or 26.5 $\mu\text{mol/l}$ /88.4 between the minimum and maximum values observed between cardiac arrest and procurement.

CI: confidence interval

CA-P time: time from cardiac arrest to procurement

CA: cardiac arrest

KDPI : kidney donor profile index

cPRA: Calculated Panel Reactive Antibodies

Table S3. Donor Acute Kidney Injury according to Time from Cardiac Arrest to Procurement (CA-P Time) and Type of Cardiac Arrest (CA)

		Primary CA		Secondary CA		P value
		[0;3[	[3;+[	[0;3[	[3;+[
Acute kidney injury (AKI)	No AKI	101 (40)	110 (35)	168 (53)	48 (41)	<0.001
	AKI	151 (60)	208 (65)	150 (47)	69 (59)	
Kidney recovery function	No recovery after AKI	84 (33)	74 (23)	76 (24)	25 (21)	0.016
	No AKI or AKI with recovery	168 (67)	244 (77)	242 (76)	92 (79)	

Donor frequencies (percentages)

P-values were calculated with the use of Chi-2 test

CA-P time: Time from cardiac arrest to procurement

CA: cardiac arrest

*Acute kidney injury (AKI) defined by an increase of 50% or 26.5 $\mu\text{mol/l}/88.4$ between the minimum and maximum values observed between cardiac arrest and procurement.

** No functional recovery after acute kidney injury defined by AKI with a creatinine decrease by >25% between maximum value and procurement

Table S4. Univariate Logistic Model for Poor Graft Function

Variable	Modalités	N	n	% d'evts	OR	IC (95%)	p-value	
CA-P time (day) - CA type	0	[0;3[and primary CA	1387	349	16,33	1,34	0,90 - 2,00	0,40
	1	[3;+[and primary CA		449	12,69	1	-	
	2	[0;3[and secondary CA		424	12,97	1,03	0,69 - 1,52	
	3	[3;+[and secondary CA		165	12,12	0,95	0,55 - 1,63	
Ca-P time (day) - Ca type	0	[0;3[and primary Ca	1387	349	16,33	1,34	0,96 - 1,88	0,09
	1	Other		1038	12,72	1	-	
CA-P time (day)	0	[0;3[	1387	773	14,49	1	-	0,29
	1	[3;+[		614	12,54	0,85	0,62 - 1,16	
Death to procurement time (days)		Continuous form	1387			0,60	0,31 - 1,16	0,13
Gender	0	Male	1387	787	11,56	1	-	0,011
	1	Female		600	16,33	1,49	1,10 - 2,03	
Age	1	18-39 years	1387	329	3,65	0,32	0,17 - 0,60	<0,0001
	2	40-54 years		505	10,69	1	-	
	3	55-59 years		172	12,79	1,22	0,72 - 2,08	
	4	60 years and more		381	26,51	3,01	2,10 - 4,33	
Age (year)		Continuous form	1387			1,06	1,04 - 1,07	<0,0001
Body mass index (kg/m2)		Continuous form	1387			1,02	0,99 - 1,05	0,20
Hypertension	0	No	1387	1081	11,10	1	-	<0,0001
	1	Yes		306	22,55	2,33	1,68 - 3,24	
Diabetes	0	No	1387	1259	12,79	1	-	0,005
	1	Yes		128	21,88	1,91	1,22 - 3,00	
Coronary disease	0	No	1387	1290	13,18	1	-	0,08
	1	Yes		97	19,59	1,60	0,95 - 2,72	
Cause of death: Anoxia	0	No	1387	589	12,73	0,88	0,64 - 1,20	0,41
	1	Yes		798	14,29	1	-	

Variable	Modalités	Format	N	n	% d'evts	OR	IC (95%)	p-value
KDPI		Continuous form	1387			24,15	11,7 - 50,0	<0,0001
No flow	0	< 15 min	1387	842	14,61	1	-	0,26
	1	>= 15 min		213	10,33	0,67	0,42 - 1,09	
	9	Missing		332	13,25	0,89	0,62 - 1,29	
Vasopressors	0	<=1 and low dose	1387	468	14,32	1,09	0,79 - 1,51	0,59
	1	>1 or high dose		919	13,28	1	-	
Graft type	0	Left	1387	743	11,57	1	-	0,017
	1	Right		644	15,99	1,45	1,07 - 1,98	
Cold ischemia time (hour)		Continuous form	1387			1,02	1,00 - 1,05	0,06
Hypothermic machine perfusion	0	No	1387	1011	11,37	1	-	<0,0001
	1	Yes		376	19,68	1,91	1,39 - 2,63	
Gender	0	Male	1387	892	13,34	1	-	0,68
	1	Female		495	14,14	1,07	0,78 - 1,47	
Age (year)		Continuous form	1387			1,05	1,03 - 1,06	<0,0001
Body mass index (kg/m2)		Continuous form	1387			1,02	0,99 - 1,05	0,16
Duration on dialysis before transplantation		Continuous form	1387			1,21	0,99 - 1,47	0,06
Cardiovascular comorbidities		Continuous form	1387			1,76	1,16 - 2,65	0,007
Diabetes	0	No	1387	1177	12,74	1	-	0,024
	1	Yes		210	18,57	1,56	1,06 - 2,30	
cPRA	0	0%	1387	781	14,08	1	-	0,84
	1	1-24%		198	14,65	1,05	0,67 - 1,63	
	2	25-49%		136	11,03	0,76	0,43 - 1,34	
	3	50-84%		150	12,00	0,83	0,49 - 1,42	
	4	85-100%		122	13,93	0,99	0,57 - 1,71	

Table S5. Organ Procurement According to Time to Cardiac Arrest to Procurement (CA-P Time) and to Type of Cardiac Arrest (CA)

		Overall study donors	[0;3[CA-P time and primary CA	Other donors	P-value
Liver transplanted	No	233 (23.2)	71 (28.2)	162 (21.5)	0.03
	Yes	772 (76.8)	181 (71.8)	591 (78.5)	
Lung transplanted	No	767 (76.3)	194 (77)	573 (76.1)	0.77
	Yes	238 (23.7)	58 (23)	180 (23.9)	
Heart transplanted	No	676 (67.3)	186 (73.8)	490 (65.1)	0.01
	Yes	329 (32.7)	66 (26.2)	263 (34.9)	

frequencies (percentages)

P-values were calculated with the use of Chi-2 test

CA: cardiac arrest

CA-P time: Time from cardiac arrest to procurement, in days

Table S6. Population description regarding kidney procurement only or with at least another organ procured

Variable		Overall study cohort	Kidney only	At least another organ	P-value
Donor characteristics					.
Gender	Male	835 (56.8)	143 (57.2)	692 (56.8)	0.9
	Female	634 (43.2)	107 (42.8)	527 (43.2)	.
Age	18-39 years	348 (23.7)	36 (14.4)	312 (25.6)	0.009
	40-54 years	531 (36.1)	70 (28)	461 (37.8)	.
	55-59 years	186 (12.7)	30 (12)	156 (12.8)	.
	60 years and more	404 (27.5)	114 (45.6)	290 (23.8)	.
Age (year)		1469 (100.0)	56.9 (13.4)	49.3 (14.4)	0.009
Hypertension	No	1138 (77.5)	160 (64)	978 (80.2)	0.009
	Yes	331 (22.5)	90 (36)	241 (19.8)	.
Diabetes	No	1335 (90.9)	200 (80)	1135 (93.1)	0.009
	Yes	134 (9.1)	50 (20)	84 (6.9)	.
Coronary disease	No	1369 (93.2)	220 (88)	1149 (94.3)	0.009
	Yes	100 (6.8)	30 (12)	70 (5.7)	.
Body mass index (kg/m2)		1469 (100.0)	28.9 (6.4)	25.7 (5)	0.009
Cause of death: Anoxia	No	633 (43.1)	123 (49.2)	510 (41.8)	0.03
	Yes	836 (56.9)	127 (50.8)	709 (58.2)	.
KDPI		1469 (100.0)	0.7 (0.2)	0.6 (0.3)	0.009
No flow	< 15 min	895 (60.9)	157 (62.8)	738 (60.5)	0.74
	>= 15 min	230 (15.7)	39 (15.6)	191 (15.7)	.
	Missing	344 (23.4)	54 (21.6)	290 (23.8)	.
Last hourly diuresis	<50ml/h	153 (10.4)	29 (11.6)	124 (10.2)	0.5
	>=50ml/h	1316 (89.6)	221 (88.4)	1095 (89.8)	.
Last eGRF (ml/min/1.73 m2)		1469 (100.0)	66.1 (38.8)	81.8 (45.4)	0.009
Last mean arterial pressure	<65 mmHg	103 (7.0)	28 (11.2)	75 (6.2)	0.009
	>=65 mmHg	1366 (93.0)	222 (88.8)	1144 (93.8)	.
Vasopressors	<=1 and low dose	498 (33.9)	63 (25.2)	435 (35.7)	0.009
	>1 or high dose	971 (66.1)	187 (74.8)	784 (64.3)	.
Graft characteristics					.
Graft type	Left	778 (53.0)	133 (53.2)	645 (52.9)	0.93
	Right	691 (47.0)	117 (46.8)	574 (47.1)	.
Cold ischemia time (hour)		1469 (100.0)	17.3 (6)	16.1 (6.2)	0.01
Hypothermic machine perfusion	No	1062 (72.3)	138 (55.2)	924 (75.8)	0.009
	Yes	407 (27.7)	112 (44.8)	295 (24.2)	.
receptient characteristics					.
Gender	Male	945 (64.3)	166 (66.4)	779 (63.9)	0.45
Age (year)		1469 (100.0)	55 (12.9)	48.5 (13.1)	0.009
Body mass index (kg/m2)		1469 (100.0)	27.8 (5.9)	25.6 (5)	0.009
Gender	Female	524 (35.7)	84 (33.6)	440 (36.1)	.
Duration on dialysis before transplantation	<2 years	534 (36.4)	90 (36)	444 (36.4)	0.71
	Between 2 and 4 years	534 (36.4)	96 (38.4)	438 (35.9)	.
	> 4 years	401 (27.3)	64 (25.6)	337 (27.6)	.
Cardiovascular comorbidities	No	1290 (87.8)	217 (86.8)	1073 (88)	0.59
	Yes	179 (12.2)	33 (13.2)	146 (12)	.
Diabetes	No	1247 (84.9)	211 (84.4)	1036 (85)	0.81
	Yes	222 (15.1)	39 (15.6)	183 (15)	.
cPRA	0%	828 (56.4)	160 (64)	668 (54.8)	0.01
	1-24%	205 (14.0)	26 (10.4)	179 (14.7)	.
	25-49%	148 (10.1)	30 (12)	118 (9.7)	.
	50-84%	154 (10.5)	14 (5.6)	140 (11.5)	.
	85-100%	134 (9.1)	20 (8)	114 (9.4)	.

Values are means (standard deviation) or frequencies (percentages)

P-values were calculated with the use of Chi-2 test for categorical variables and the t-test for continuous variables to test the difference between the group and the rest of the study population

Table S7. Population description regarding AKI in donors

Variable		Overall study cohort	AKI	Without AKI	P-value
Donor characteristics					.
Gender	Male	835 (56.8)	339 (54.5)	496 (58.6)	0.12
	Female	634 (43.2)	283 (45.5)	351 (41.4)	.
Age	18-39 years	348 (23.7)	128 (20.6)	220 (26)	0.009
	40-54 years	531 (36.1)	206 (33.1)	325 (38.4)	.
	55-59 years	186 (12.7)	91 (14.6)	95 (11.2)	.
	60 years and more	404 (27.5)	197 (31.7)	207 (24.4)	.
Age (year)		1469 (100.0)	52.4 (14.6)	49.3 (14.3)	0.009
Hypertension	No	1138 (77.5)	472 (75.9)	666 (78.6)	0.21
	Yes	331 (22.5)	150 (24.1)	181 (21.4)	.
Diabetes	No	1335 (90.9)	553 (88.9)	782 (92.3)	0.02
	Yes	134 (9.1)	69 (11.1)	65 (7.7)	.
Coronary disease	No	1369 (93.2)	579 (93.1)	790 (93.3)	0.89
	Yes	100 (6.8)	43 (6.9)	57 (6.7)	.
Body mass index (kg/m2)		1469 (100.0)	26.4 (5.2)	26.1 (5.5)	0.18
Cause of death: Anoxia	No	633 (43.1)	305 (49)	328 (38.7)	0.009
	Yes	836 (56.9)	317 (51)	519 (61.3)	.
KDPI		1469 (100.0)	0.6 (0.3)	0.6 (0.3)	0.38
No flow	< 15 min	895 (60.9)	399 (64.1)	496 (58.6)	0.08
	>= 15 min	230 (15.7)	86 (13.8)	144 (17)	.
	Missing	344 (23.4)	137 (22)	207 (24.4)	.
Last hourly diuresis	<50ml/h	153 (10.4)	62 (10)	91 (10.7)	0.63
	>=50ml/h	1316 (89.6)	560 (90)	756 (89.3)	.
Last eGRF (ml/min/1.73 m2)		1469 (100.0)	86.7 (33.2)	73.5 (50.8)	0.009
Last mean arterial pressure	<65 mmHg	103 (7.0)	48 (7.7)	55 (6.5)	0.36
	>=65 mmHg	1366 (93.0)	574 (92.3)	792 (93.5)	.
Vasopressors	<=1 and low dose	498 (33.9)	212 (34.1)	286 (33.8)	0.9
	>1 or high dose	971 (66.1)	410 (65.9)	561 (66.2)	.
Graft characteristics					.
Graft type	Left	778 (53.0)	328 (52.7)	450 (53.1)	0.88
	Right	691 (47.0)	294 (47.3)	397 (46.9)	.
Cold ischemia time (hour)		1469 (100.0)	16.4 (6.3)	16.3 (6)	0.65
Hypothermic machine perfusion	No	1062 (72.3)	456 (73.3)	606 (71.5)	0.46
	Yes	407 (27.7)	166 (26.7)	241 (28.5)	.
receptient characteristics					.
Gender	Male	945 (64.3)	397 (63.8)	548 (64.7)	0.73
Age (year)		1469 (100.0)	50.9 (13.3)	48.6 (13.3)	0.009
Body mass index (kg/m2)		1469 (100.0)	26.1 (5)	25.8 (5.4)	0.31
Gender	Female	524 (35.7)	225 (36.2)	299 (35.3)	.
Duration on dialysis before transplantation	<2 years	534 (36.4)	211 (33.9)	323 (38.1)	0.21
	Between 2 and 4 years	534 (36.4)	239 (38.4)	295 (34.8)	.
	> 4 years	401 (27.3)	172 (27.7)	229 (27)	.
Cardiovascular comorbidities	No	1290 (87.8)	542 (87.1)	748 (88.3)	0.5
	Yes	179 (12.2)	80 (12.9)	99 (11.7)	.
Diabetes	No	1247 (84.9)	526 (84.6)	721 (85.1)	0.77
	Yes	222 (15.1)	96 (15.4)	126 (14.9)	.
cPRA	0%	828 (56.4)	346 (55.6)	482 (56.9)	0.99
	1-24%	205 (14.0)	89 (14.3)	116 (13.7)	.
	25-49%	148 (10.1)	64 (10.3)	84 (9.9)	.
	50-84%	154 (10.5)	65 (10.5)	89 (10.5)	.
	85-100%	134 (9.1)	58 (9.3)	76 (9)	.

Acute kidney injury (AKI) defined by an increase of 50% or 26.5 $\mu\text{mol/l}$ /88.4 between the minimum and maximum values observed between cardiac arrest and procurement.

Values are means (standard deviation) or frequencies (percentages)

P-values were calculated with the use of Chi-2 test for categorical variables and the t-test for continuous variables to test the difference between the group and the rest of the study population

Table S8. Population description regarding KDPI

Variable		Overall study cohort	kdpi<85	kdpi>85	P-value
Donor characteristics					.
Gender	Male	835 (56.8)	662 (62.7)	173 (41.9)	0.009
	Female	634 (43.2)	394 (37.3)	240 (58.1)	.
Age	18-39 years	348 (23.7)	348 (33)	0 (0)	0.009
	40-54 years	531 (36.1)	515 (48.8)	16 (3.9)	.
	55-59 years	186 (12.7)	123 (11.6)	63 (15.3)	.
	60 years and more	404 (27.5)	70 (6.6)	334 (80.9)	.
Age (year)		1469 (100.0)	44.3 (11.6)	66.6 (7.1)	0.009
Hypertension	No	1138 (77.5)	951 (90.1)	187 (45.3)	0.009
	Yes	331 (22.5)	105 (9.9)	226 (54.7)	.
Diabetes	No	1335 (90.9)	1018 (96.4)	317 (76.8)	0.009
	Yes	134 (9.1)	38 (3.6)	96 (23.2)	.
Coronary disease	No	1369 (93.2)	1016 (96.2)	353 (85.5)	0.009
	Yes	100 (6.8)	40 (3.8)	60 (14.5)	.
Body mass index (kg/m2)		1469 (100.0)	25.6 (4.9)	27.7 (6.2)	0.009
Cause of death: Anoxia	No	633 (43.1)	423 (40.1)	210 (50.8)	0.009
	Yes	836 (56.9)	633 (59.9)	203 (49.2)	.
KDPI		1469 (100.0)	0.5 (0.2)	0.9 (0)	0.009
No flow	< 15 min	895 (60.9)	592 (56.1)	303 (73.4)	0.009
	>= 15 min	230 (15.7)	193 (18.3)	37 (9)	.
	Missing	344 (23.4)	271 (25.7)	73 (17.7)	.
Last hourly diuresis	<50ml/h	153 (10.4)	107 (10.1)	46 (11.1)	0.57
	>=50ml/h	1316 (89.6)	949 (89.9)	367 (88.9)	.
Last eGRF (ml/min/1.73 m2)		1469 (100.0)	83.4 (47.9)	68.2 (32.9)	0.009
Last mean arterial pressure	<65 mmHg	103 (7.0)	67 (6.3)	36 (8.7)	0.11
	>=65 mmHg	1366 (93.0)	989 (93.7)	377 (91.3)	.
Vasopressors	<=1 and low dose	498 (33.9)	355 (33.6)	143 (34.6)	0.71
	>1 or high dose	971 (66.1)	701 (66.4)	270 (65.4)	.
Graft characteristics					.
Graft type	Left	778 (53.0)	557 (52.7)	221 (53.5)	0.79
	Right	691 (47.0)	499 (47.3)	192 (46.5)	.
Cold ischemia time (hour)		1469 (100.0)	16.2 (6.1)	16.7 (6.4)	0.16
Hypothermic machine perfusion	No	1062 (72.3)	904 (85.6)	158 (38.3)	0.009
	Yes	407 (27.7)	152 (14.4)	255 (61.7)	.
receptient characteristics					.
Gender	Male	945 (64.3)	691 (65.4)	254 (61.5)	0.16
Age (year)		1469 (100.0)	44.7 (11.3)	62.1 (9.2)	0.009
Body mass index (kg/m2)		1469 (100.0)	25.5 (5)	27.1 (5.6)	0.009
Gender	Female	524 (35.7)	365 (34.6)	159 (38.5)	.
Duration on dialysis before transplantation	<2 years	534 (36.4)	411 (38.9)	123 (29.8)	0.009
	Between 2 and 4 years	534 (36.4)	365 (34.6)	169 (40.9)	.
	> 4 years	401 (27.3)	280 (26.5)	121 (29.3)	.
Cardiovascular comorbidities	No	1290 (87.8)	967 (91.6)	323 (78.2)	0.009
	Yes	179 (12.2)	89 (8.4)	90 (21.8)	.
Diabetes	No	1247 (84.9)	940 (89)	307 (74.3)	0.009
	Yes	222 (15.1)	116 (11)	106 (25.7)	.
cPRA	0%	828 (56.4)	599 (56.7)	229 (55.4)	0.73
	1-24%	205 (14.0)	144 (13.6)	61 (14.8)	.
	25-49%	148 (10.1)	107 (10.1)	41 (9.9)	.
	50-84%	154 (10.5)	115 (10.9)	39 (9.4)	.
	85-100%	134 (9.1)	91 (8.6)	43 (10.4)	.

Values are means (standard deviation) or frequencies (percentages)

P-values were calculated with the use of Chi-2 test for categorical variables and the t-test for continuous variables to test the difference between the group and the rest of the study population

Table S9. Population description regarding vasopressors use in donors

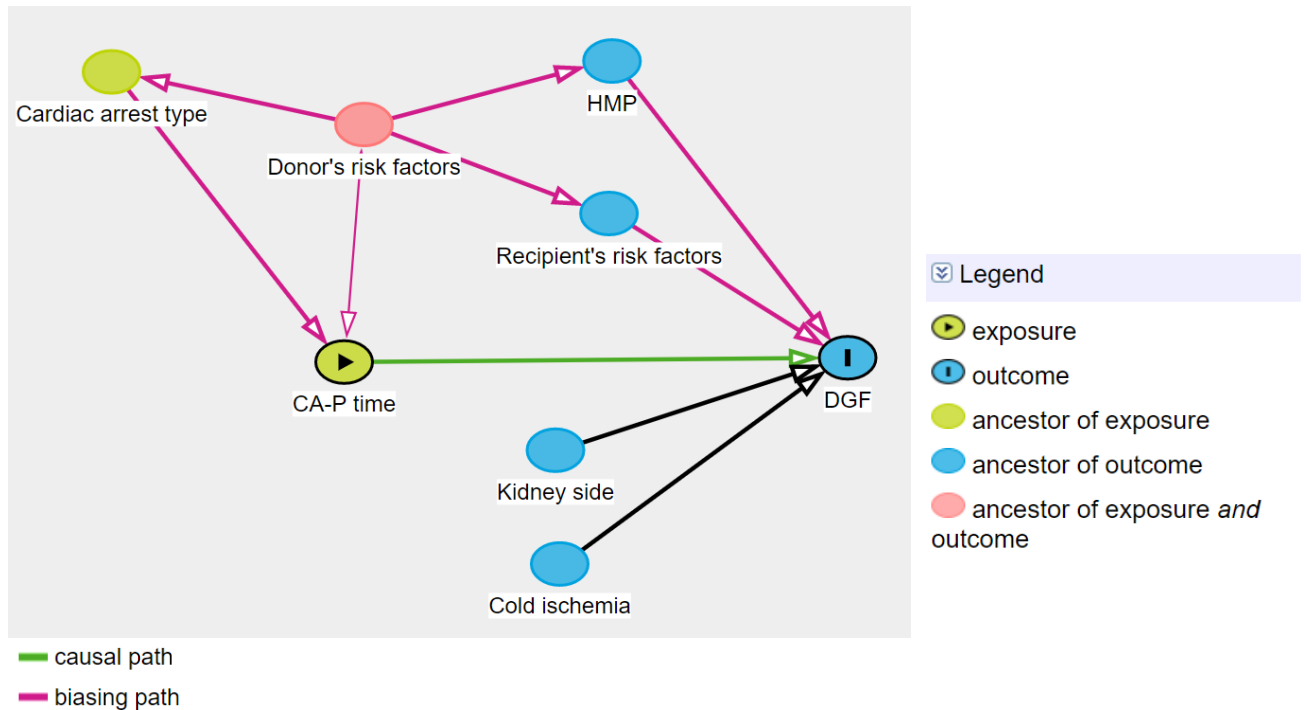
Variable		Overall study cohort	1 low	>1 high	P-value
Donor characteristics					
Gender	Male	835 (56.8)	298 (59.8)	537 (55.3)	0.1
	Female	634 (43.2)	200 (40.2)	434 (44.7)	.
Age	18-39 years	348 (23.7)	135 (27.1)	213 (21.9)	0.04
	40-54 years	531 (36.1)	168 (33.7)	363 (37.4)	.
	55-59 years	186 (12.7)	52 (10.4)	134 (13.8)	.
	60 years and more	404 (27.5)	143 (28.7)	261 (26.9)	.
Age (year)		1469 (100.0)	50 (15.3)	50.9 (14.1)	0.26
Hypertension	No	1138 (77.5)	379 (76.1)	759 (78.2)	0.37
	Yes	331 (22.5)	119 (23.9)	212 (21.8)	.
Diabetes	No	1335 (90.9)	436 (87.6)	899 (92.6)	0.009
	Yes	134 (9.1)	62 (12.4)	72 (7.4)	.
Coronary disease	No	1369 (93.2)	465 (93.4)	904 (93.1)	0.84
	Yes	100 (6.8)	33 (6.6)	67 (6.9)	.
Body mass index (kg/m2)		1469 (100.0)	26.5 (5.4)	26.1 (5.4)	0.19
Cause of death: Anoxia	No	633 (43.1)	197 (39.6)	436 (44.9)	0.05
	Yes	836 (56.9)	301 (60.4)	535 (55.1)	.
KDPI		1469 (100.0)	0.6 (0.3)	0.6 (0.3)	0.05
No flow	< 15 min	895 (60.9)	280 (56.2)	615 (63.3)	0.009
	>= 15 min	230 (15.7)	101 (20.3)	129 (13.3)	.
	Missing	344 (23.4)	117 (23.5)	227 (23.4)	.
Last hourly diuresis	<50ml/h	153 (10.4)	48 (9.6)	105 (10.8)	0.49
	>=50ml/h	1316 (89.6)	450 (90.4)	866 (89.2)	.
Last eGRF (ml/min/1.73 m2)		1469 (100.0)	87.4 (44.6)	74.9 (44.1)	0.009
Last mean arterial pressure	<65 mmHg	103 (7.0)	22 (4.4)	81 (8.3)	0.01
	>=65 mmHg	1366 (93.0)	476 (95.6)	890 (91.7)	.
Vasopressors	<=1 and low dose	498 (33.9)	498 (100)	0 (0)	0.009
	>1 or high dose	971 (66.1)	0 (0)	971 (100)	.
Graft characteristics					
Graft type	Left	778 (53.0)	260 (52.2)	518 (53.3)	0.68
	Right	691 (47.0)	238 (47.8)	453 (46.7)	.
Cold ischemia time (hour)		1469 (100.0)	16.1 (6)	16.4 (6.2)	0.39
Hypothermic machine perfusion	No	1062 (72.3)	357 (71.7)	705 (72.6)	0.71
	Yes	407 (27.7)	141 (28.3)	266 (27.4)	.
receptient characteristics					
Gender	Male	945 (64.3)	321 (64.5)	624 (64.3)	0.94
Age (year)		1469 (100.0)	48.9 (14)	49.9 (13)	0.18
Body mass index (kg/m2)		1469 (100.0)	26.1 (5.3)	25.9 (5.2)	0.38
Gender	Female	524 (35.7)	177 (35.5)	347 (35.7)	.
Duration on dialysis before transplantation	<2 years	534 (36.4)	200 (40.2)	334 (34.4)	0.09
	Between 2 and 4 years	534 (36.4)	173 (34.7)	361 (37.2)	.
	> 4 years	401 (27.3)	125 (25.1)	276 (28.4)	.
Cardiovascular comorbidities	No	1290 (87.8)	442 (88.8)	848 (87.3)	0.43
	Yes	179 (12.2)	56 (11.2)	123 (12.7)	.
Diabetes	No	1247 (84.9)	432 (86.7)	815 (83.9)	0.15
	Yes	222 (15.1)	66 (13.3)	156 (16.1)	.
cPRA	0%	828 (56.4)	288 (57.8)	540 (55.6)	0.75
	1-24%	205 (14.0)	67 (13.5)	138 (14.2)	.
	25-49%	148 (10.1)	52 (10.4)	96 (9.9)	.
	50-84%	154 (10.5)	52 (10.4)	102 (10.5)	.
	85-100%	134 (9.1)	39 (7.8)	95 (9.8)	.

high vasopressor levels, defined as more than 0.6 mg/h or use of multiple vasopressors

Values are means (standard deviation) or frequencies (percentages)

P-values were calculated with the use of Chi-2 test for categorical variables and the t-test for continuous variables to test the difference between the group and the rest of the study population

Figure S1. Directed Acyclic Graph (DAG) Showing the Hypothesized Causal Mechanisms between Time from Cardiac Arrest to Procurement (CA-P Time, Exposure) and Delayed Graft Function (DGF, Outcome) Taking into Account Potential Measured Confounders and Mediators. According to the DAG, CA-P time may be confounded by donor's risk factors.



Johannes Textor, Benito van der Zander, Mark S. Gilthorpe, Maciej Liskiewicz, and George TH Ellison. Robust causal inference using directed acyclic graphs: the R package 'dagitty'. *International Journal of Epidemiology*, 45(6):1887–1894, December 2016.

Figure S2 Graft Survival According to delayed graft function (DGF) (A) and delayed graft function with primary non function (PNF) censored (B) (Observation End Date: December 29, 2020, Survival Rate at 1 Year and 95% Confidence Interval)

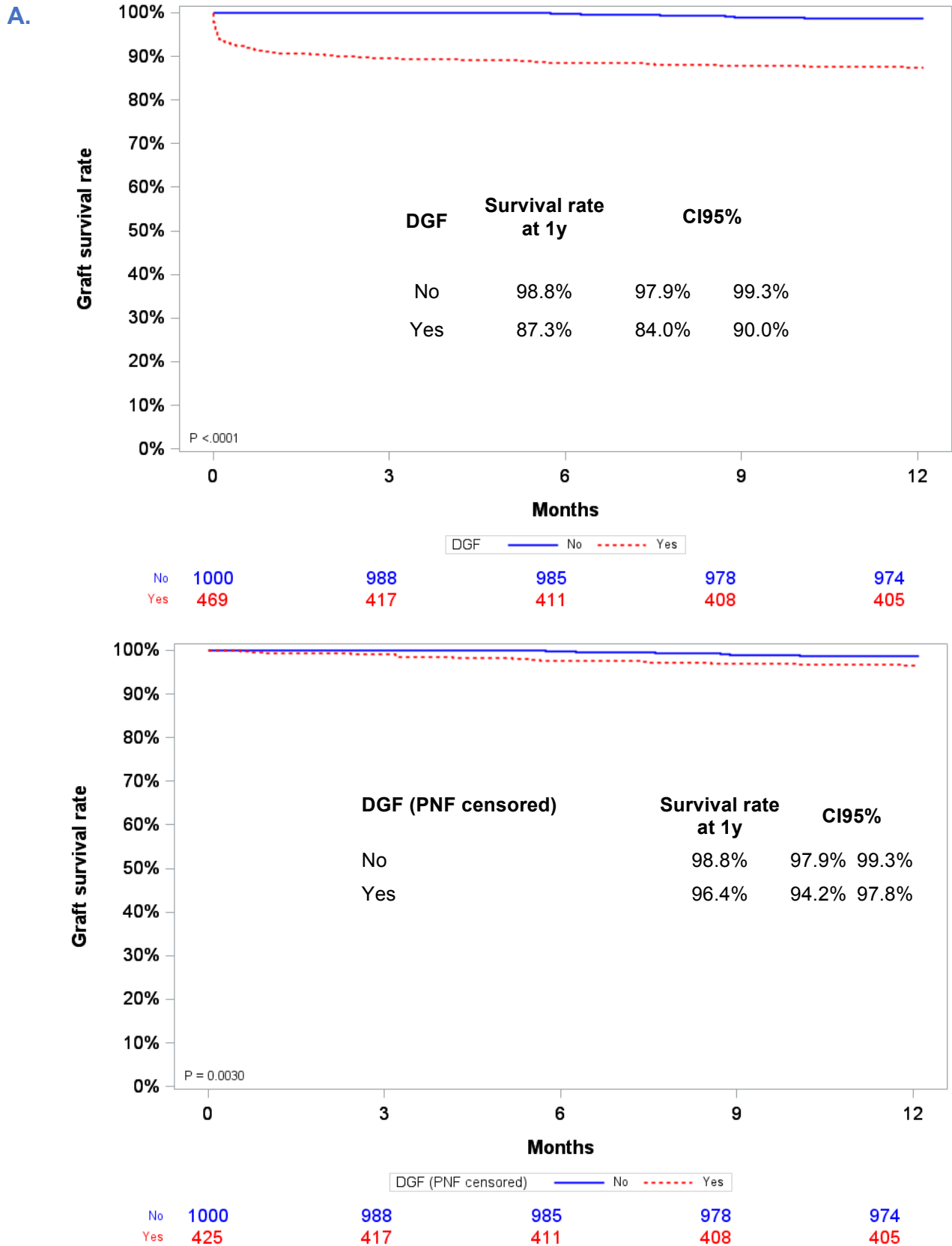


Figure S3. Forest Plot of the Multivariable Logistic Model for Delayed Graft Function including vasopressor dose as a continuous variable

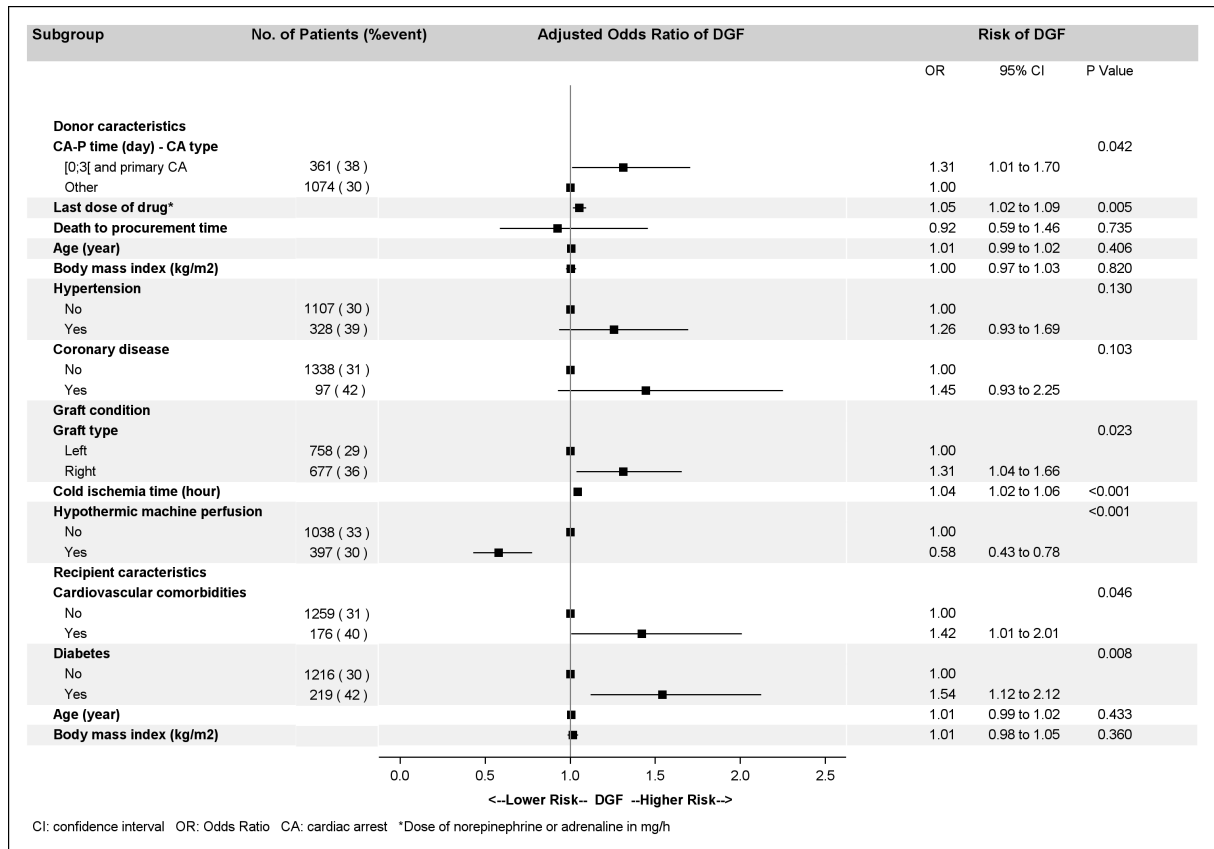
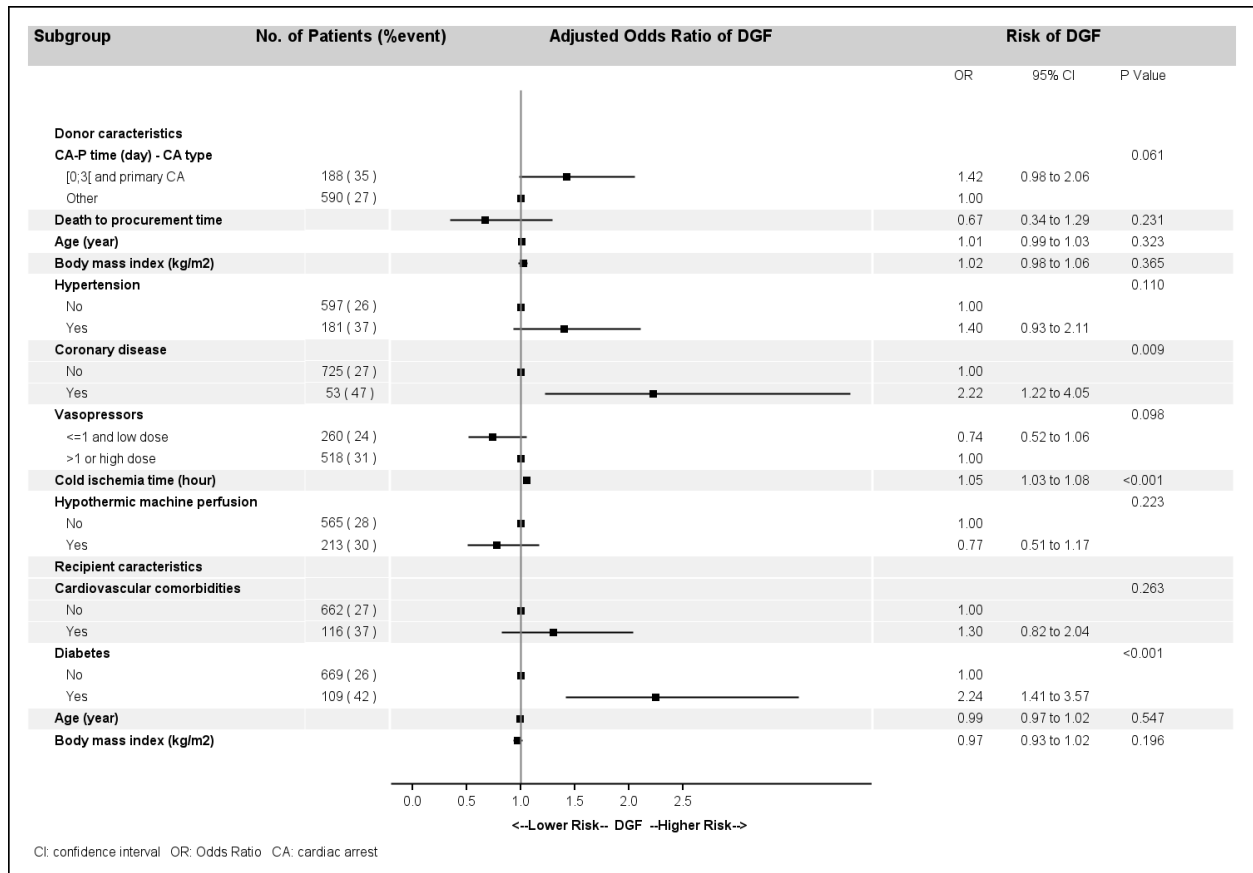


Figure S4. Forest Plot of the Multivariable Logistic Model for Delayed Graft Function (DGF) on subpopulation of left (A) and right (B) kidney

A.



B.

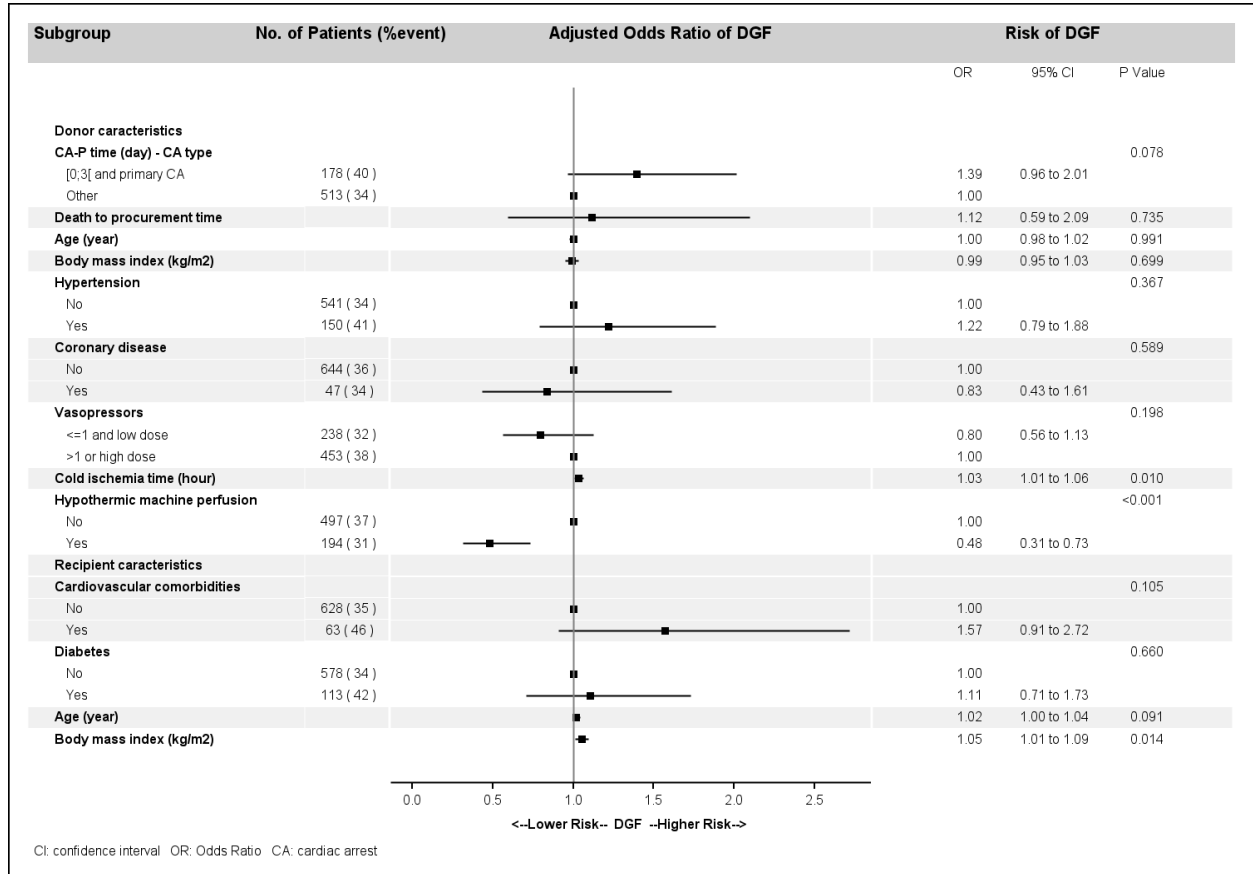


Figure S5. Boxplot of Recipient eGFR at 1-Year Post-Transplantation According to Time from Cardiac Arrest to Procurement Time (CA-P Time) and Type of Cardiac Arrest (CA) (Observation End Date: December 29, 2020)

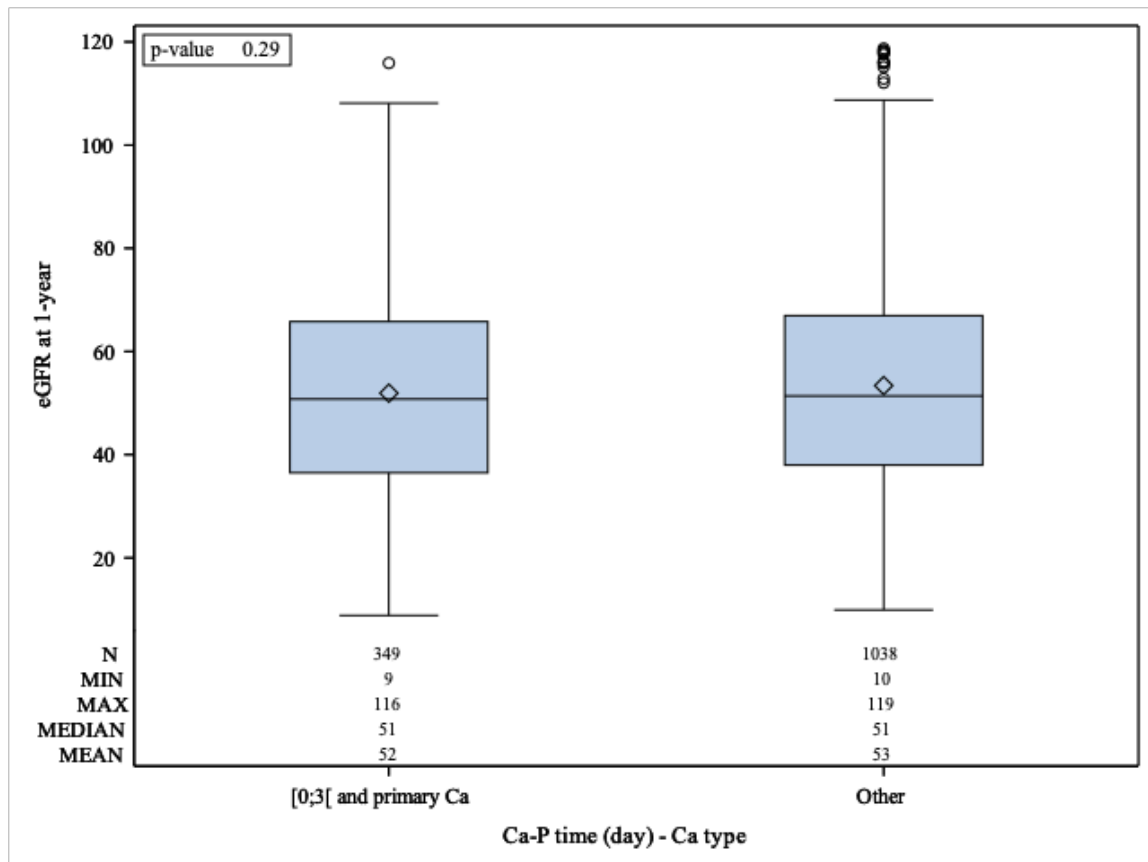


Figure S6. Graft Survival According to Time from Cardiac Arrest to Procurement (CA-P Time) and Type of Cardiac Arrest (CA) (Observation End Date: December 29, 2020, Survival Rate at 1 Year and 95% Confidence Interval)

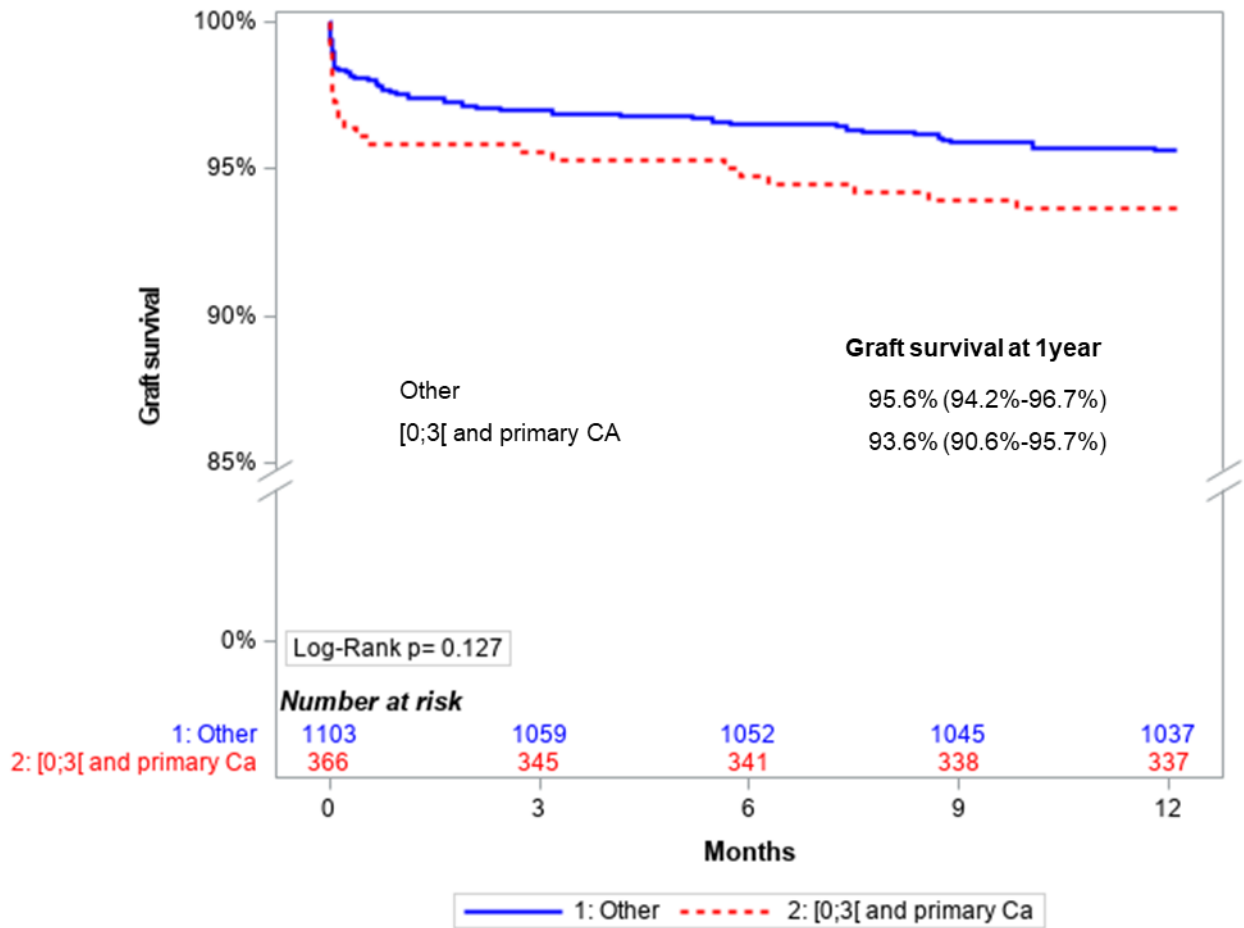


Figure S7. Patient Survival According to Time to Cardiac Arrest to Procurement (CA-P Time) and Type of Cardiac Arrest (CA) (Observation End Date: December 29, 2020, Survival Rate at 1 Year and 95% Confidence Interval)

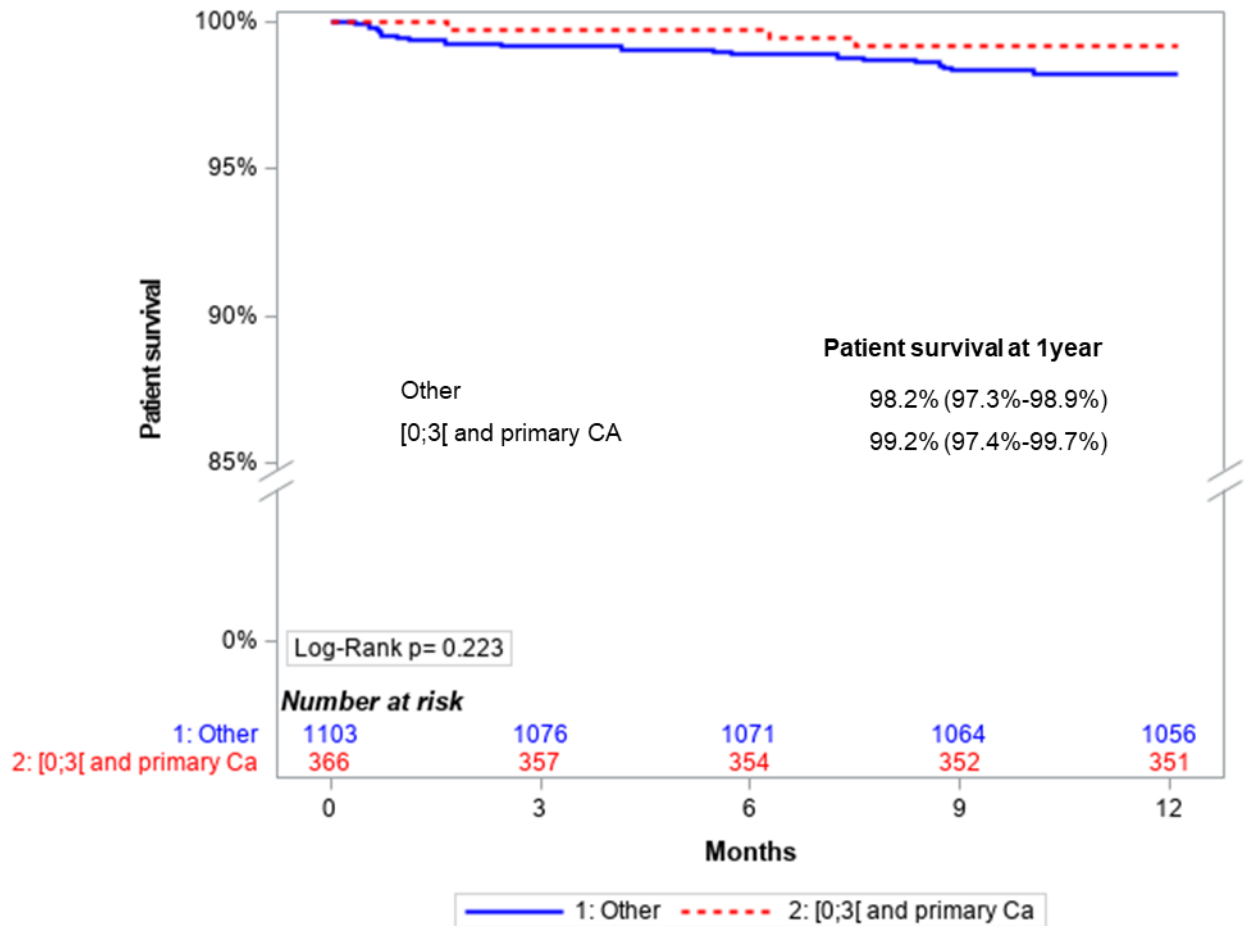
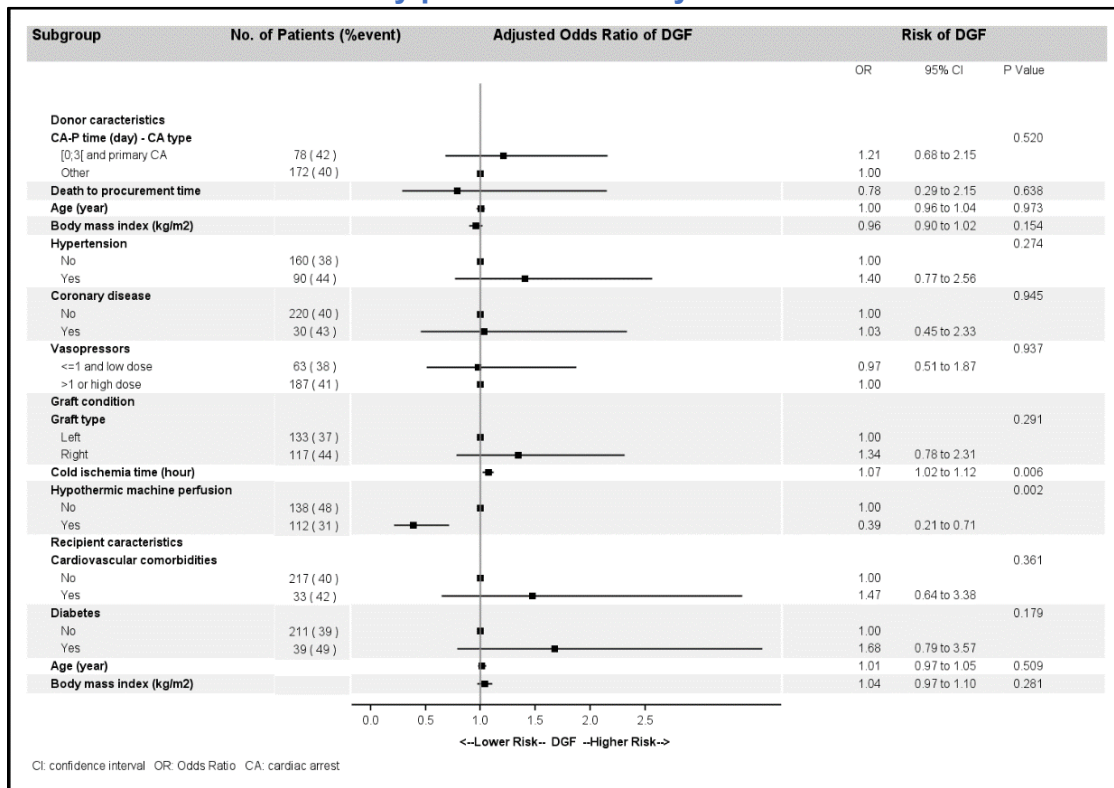
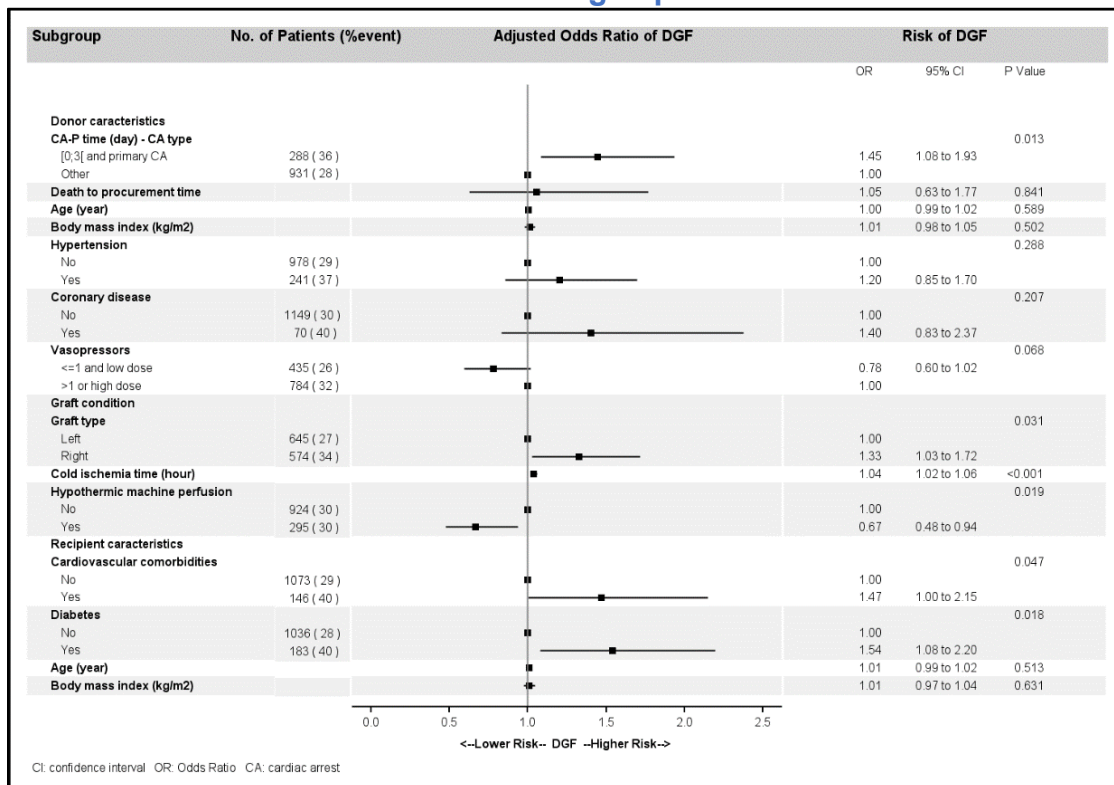


Figure S8. Sensitivity analyses. Forest Plot of the Multivariable Logistic Model for Delayed Graft Function (DGF)

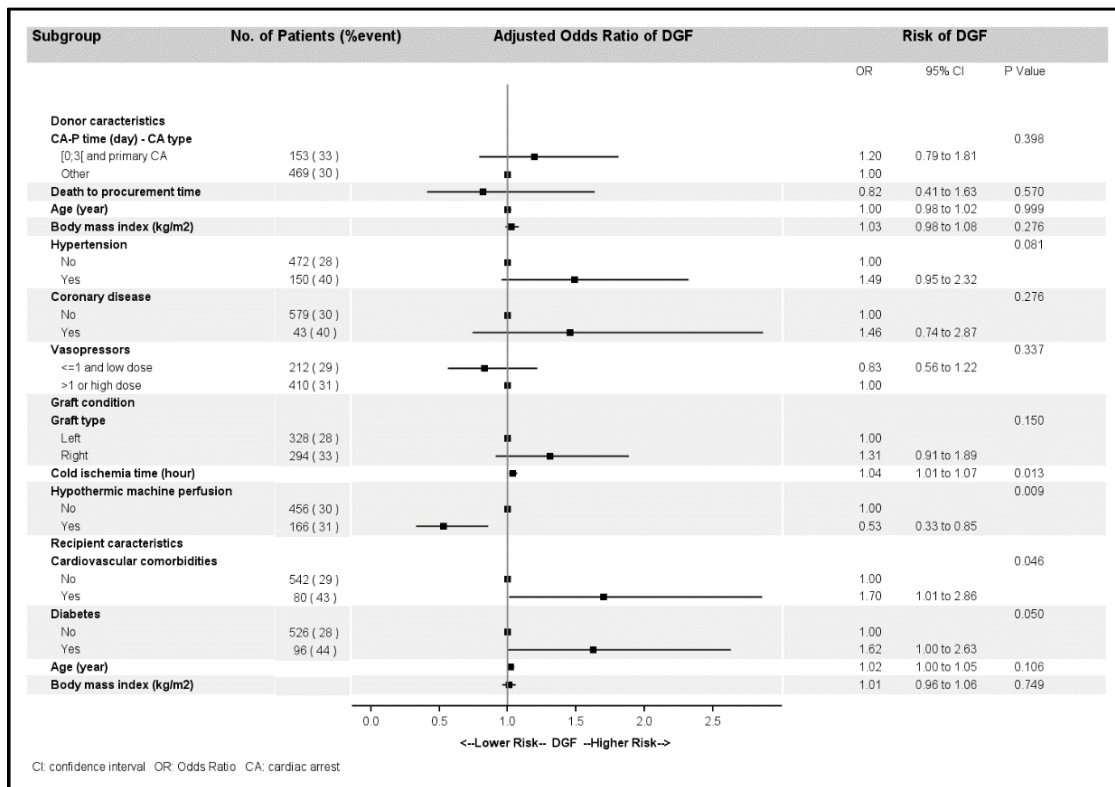
A. In donor with kidney procurement only



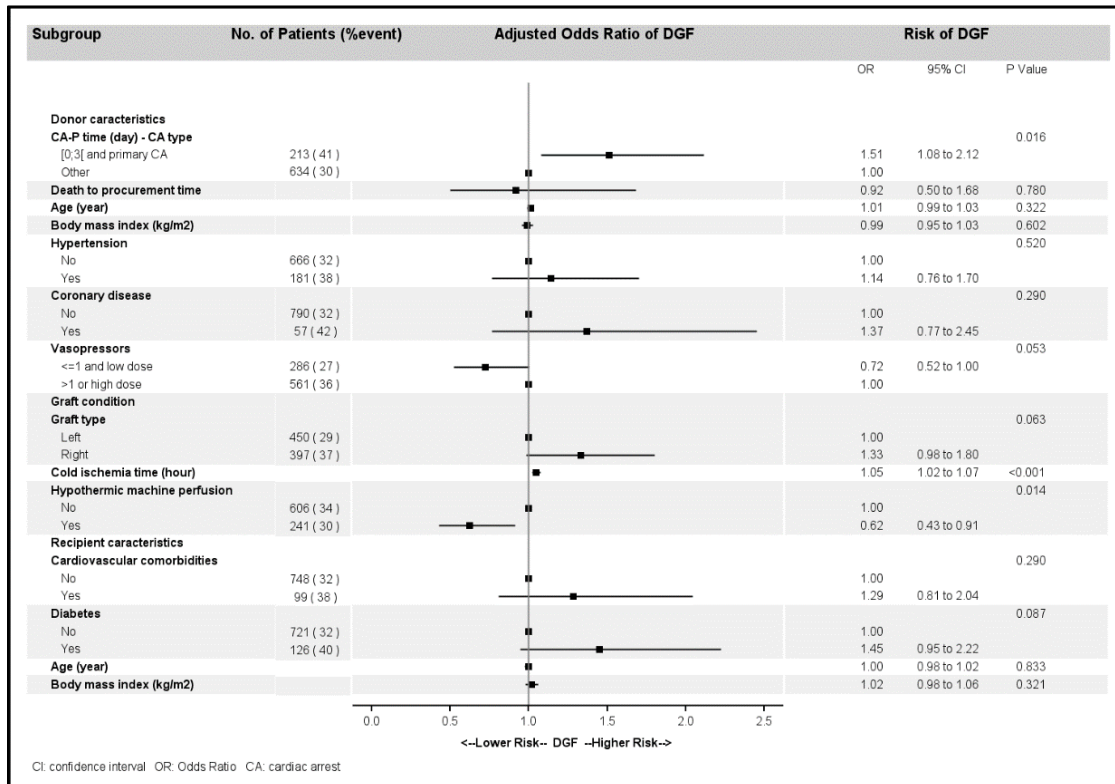
B. In donor with at least another organ procured



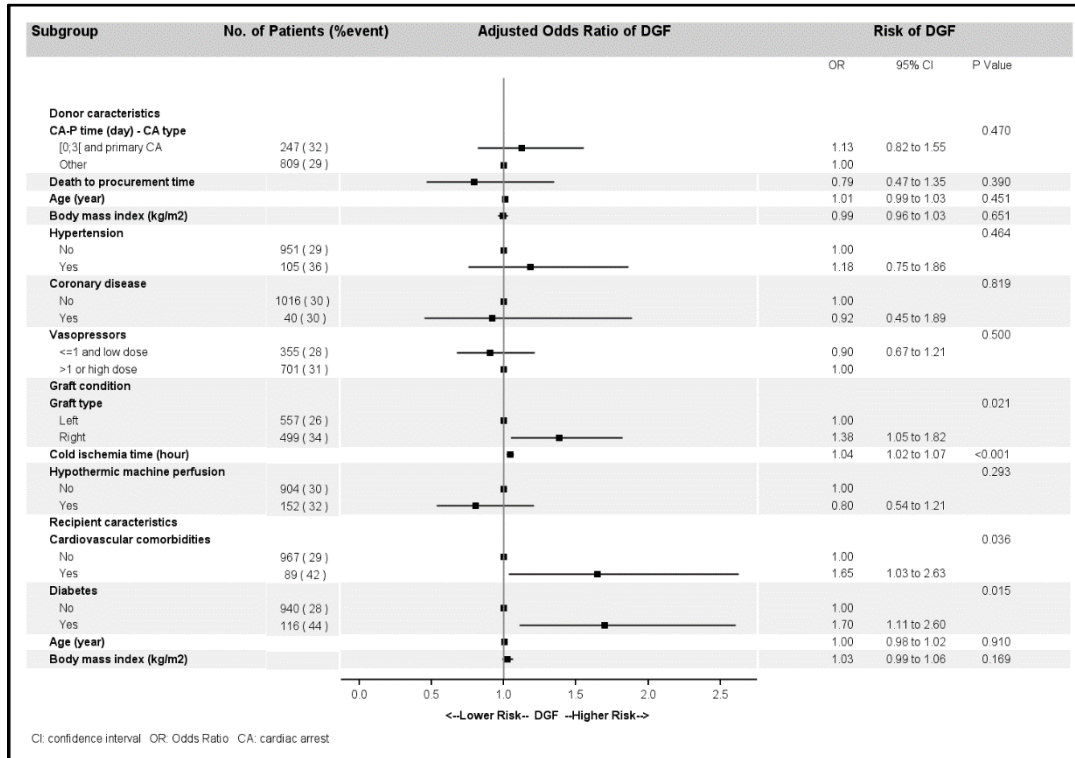
C. Donors without AKI



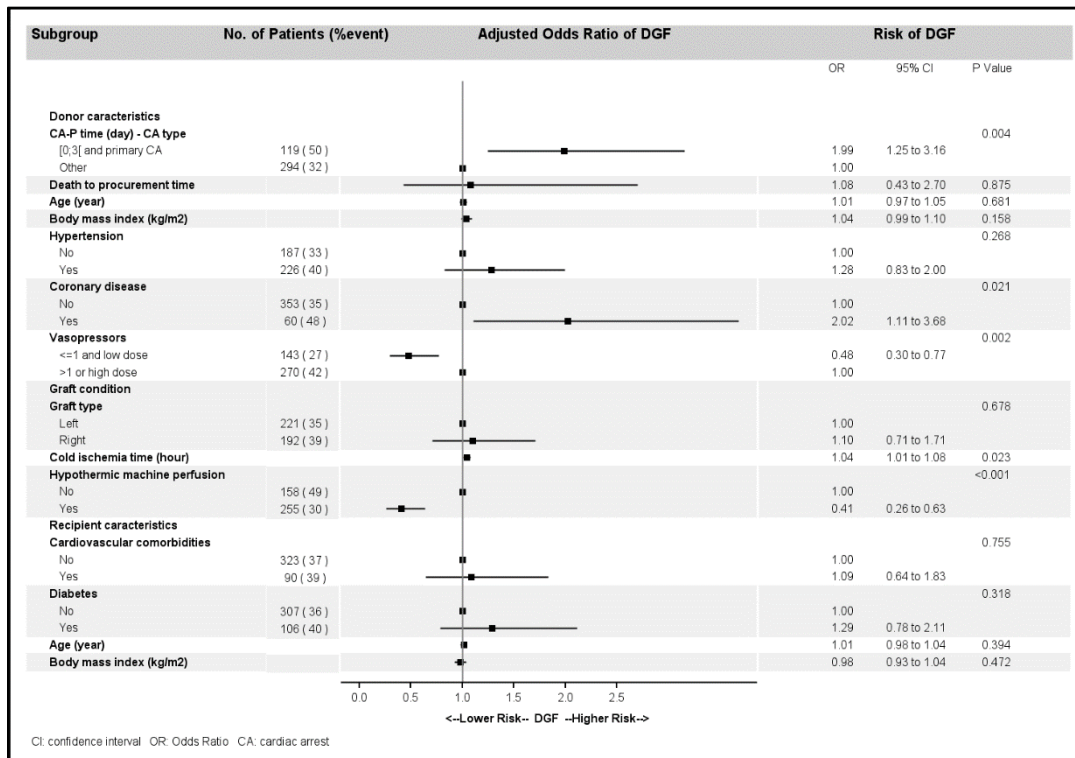
D. Donors with AKI



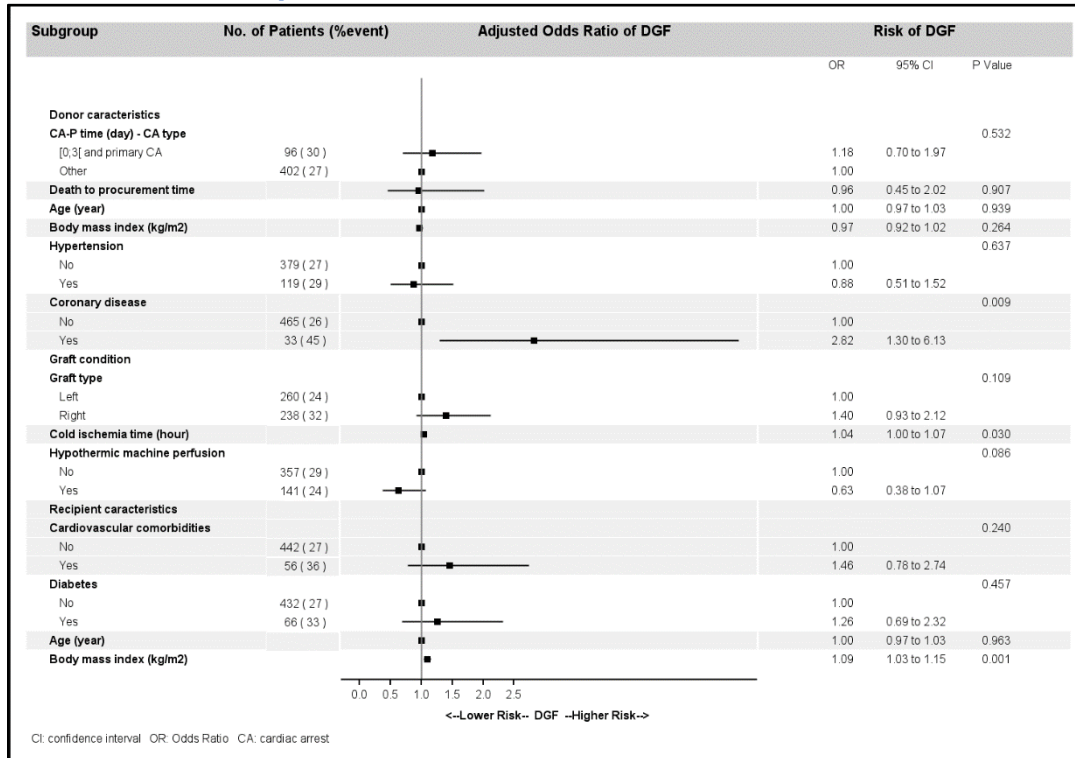
E. Donors with KDPI<85%



F. Donors with KDPI ≥ 85%



G. Donor vasopressors ≤1 and low dose



H. Donor vasopressors >1 or high dose

