Peritoneal dialysis catheter removal at the time of renal transplantation: Choosing the optimal candidate

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Abstract

Introduction: Concurrent peritoneal dialysis (PD) catheter removal during renal transplantation is controversial, with limited evidence supporting this practice. Our objective was to determine the rate of delayed graft function (DGF) in patients on preoperative PD. Additionally, we sought to identify which patients can safely have their PD catheter removed during transplantation due to a low risk of DGF.
Methods: We conducted a retrospective observational study between June 2011 and December 2015. The primary outcome was the diagnosis of DGF, defined as the need for dialysis within the first week of transplantation. Clinical and transplant factors, including graft type and donor criteria, were assessed for association with the primary outcome. Catheter-related complication rates were also compared between post-transplant PD and hemodialysis (HD).
Results: Of our cohort of 567 patients, 145 patients (25.6%) developed DGF. Obesity (odds ratio [OR] 1.06; 95% confidence interval [CI] 1.00–1.11; p=0.04) and increased perioperative blood loss (OR 1.002; 95% CI 1.000–1.003; p=0.03) were predictors of DGF. Protective factors included living donor (LD) grafts (OR 0.15; 95% CI 0.05–0.49; p=0.002) and intraoperative graft urine production (OR 0.39; 95% CI 0.23–0.65; p<0.001). In our PD cohort, only LD grafts demonstrated lower DGF rates (0 LD vs. 20.8% deceased donor; p=0.003). In terms of post-transplant renal replacement therapy, patients on PD and HD had similar duration of temporary dialysis (one day PD vs. two days HD; p=0.48) and catheter-related complication rates (4.5% PD vs. 2.6% HD; p=0.30).
Conclusions: Carefully selected patients, such as those receiving LD grafts, may benefit from concurrent PD catheter removal.

Introduction

Renal transplantation is the most definitive and cost-effective therapy for patients with end-stage renal disease (ESRD), offering significant improvements in quality of life and survival[1,2]. However, due to the shortage of available renal allografts, the majority of patients are put on renal replacement therapy (RRT), such as hemodialysis (HD) or peritoneal dialysis (PD), for several years prior to their transplant. At the time of transplantation for patients on pre-operative PD, a decision needs to be made on whether to remove the PD catheter concurrently or at a later date. The benefit of leaving the catheter *in situ* is the availability of temporizing dialysis in the event of post-transplant complications, such as acute rejection or delayed graft function (DGF) and avoiding the need for urgent placement of a HD access line. Reported rates of post-transplant PD catheter use range between 13-58%[3–7]. This is balanced by the inherent risks of leaving the foreign body *in situ*, namely peritonitis and catheter exit-site infections. Delayed removal of the catheter also exposes the patient to additional anesthesia, potentially more hospitalizations, and incurs additional costs to the health care system.

Several studies have investigated the optimal timing of PD catheter removal following renal transplantation. In pediatric populations, several groups have proposed to remove the PD catheter around one month post-transplantation[3,4,6]. In adult patients, Warren and colleagues have recommended PD catheter removal at the time of transplantation[7]. However, there are currently no evidence-based guidelines for selecting appropriate candidates for concurrent PD catheter removal. This decision is governed by several important considerations. Firstly, what patient and surgical factors, notably type of donor graft, may impact immediate graft function? Secondly, if the PD catheter is removed and there is DGF, what is the rate of complications from inserting a HD catheter? Thirdly, if the PD catheter is left *in situ* and there is DGF, will PD be enough due to risk of post-transplant peritoneal leak? Lastly, if the PD catheter is left *in situ* and there is immediate graft function, what is the rate of catheter-associated complications prior to the second procedure to remove it? Therefore, the purpose of this study was to examine these factors to identify patients who can safely have their PD catheter removed at the time of transplantation.

Methods

Study design and population

Following Research Ethics Board (REB) approval, we conducted a retrospective observational study of patients undergoing renal transplantation at St. Michael's Hospital, Toronto, Canada between June 2011 and December 2015. All renal transplant cases were included, regardless of donor type. Patients were stratified according to type of pre-operative RRT. The standard immunosuppression protocol at our institution includes induction with either basiliximab or thymoglobulin and intravenous immunoglobulin for low or high immunological risk, respectively, and maintenance therapy with tacrolimus, mycophenolate mofetil, and prednisone.

Outcomes
The primary outcome was the diagnosis of DGF. Although there are numerous definitions of DGF[8], we defined it as the need for dialysis within the first post-operative week. DGF was further stratified into RRT for a single session, <1 week, >1 week, or ongoing therapy.

Data collection
Patient demographic, clinical, and operative data including age, gender, body mass index (BMI), hypertension, diabetes, coronary artery disease, gout, pre-transplant urine production, previous abdominal surgeries, American Society of Anesthesiology (ASA) classification, pre-operative hemoglobin, etiology of ESRD, type of donor graft including living donor (LD), deceased donor (DD), donation after neurological death (NDD), donation after circulatory death (DCD), standard criteria donor (SCD), and expanded criteria donor (ECD), warm ischemia time, peri-operative blood loss, and intra-operative graft urine production (continuous fluid production from the transplant ureter at the time of ureterovesical anastomosis) were abstracted. For patients receiving pre-operative PD, we recorded whether the PD catheter was removed at the time of transplant.

Statistical analysis
Demographic, clinical, and operative data were compared between patients with or without DGF using ANOVA and T-tests. Mann-Whitney and Kruskall-Wallis tests were used when appropriate. Odds ratios (OR) with 95% confidence intervals (95% CI) for predictors of DGF were calculated using multivariable logistic regression models. All statistical analyses were performed using SPSS (Version 23), with a p-value of <0.05 used for statistical significance.

Results
A total of 567 patients underwent renal transplantation at our center between June 2011 and December 2015 (Table 1). Of these, 145 patients (25.6%) developed post-transplant DGF. The mean age of our cohort was 53.1 years and 224 patients (39.5%) were female. Diabetes was the most common cause of ESRD (22.0%), and most patients had at least one comorbid condition at the time of transplant, with hypertension being the most common (86.1%). Most patients received RRT (87.7%) and almost all of these patients were maintained on one form of dialysis prior to transplant. Only one patient simultaneously received HD and nocturnal PD. Over half of our cohort (55.6%) had intra-operative graft urine production, as assessed by the surgical team.

Within the PD group (n=110), 16 patients (14.5%) developed DGF (Table 2). No PD patients undergoing LD renal transplantation experienced DGF (p=0.003). A total of 18 patients (16.4%) had their PD catheter removed at the time of transplant (Figure). Only one patient (5.6%) in this subgroup developed DGF necessitating HD. No complications were observed from HD and only one session of dialysis was required prior to adequate graft function. Of the 92 patients who had their PD catheter left *in situ*, 15 patients (16.3%) developed DGF. PD was sufficient in most cases (80.0%) with a median PD duration of one day. However, 2 patients

(1.8%) required ongoing PD at discharge (Table 3). There were 5 cases of PD catheter-related complications (4.5%). Three patients required conversions to HD due to violation of the peritoneal cavity (2.7%). Median HD duration for these three patients was 6 days and there were no complications from placement of a HD access line. Other PD catheter-related complications included one case of peritonitis (0.9%) and exit-site infection (0.9%). No complications were reported from the second procedure to remove the PD catheter.

In contrast, 129 patients (33.3%) developed DGF in the HD group (n=387). Median duration of HD was 2 days and 32 patients (8.3%) required ongoing HD at discharge. HD catheter-related complications (n=10, 2.6%) included 7 cases of arteriovenous fistula thrombosis (1.8%), 1 case of "difficulty with cannulation" (0.3%), "poor functioning HD" (0.3%), and "significant leak from line upon removal" (0.3%).

In univariate analysis of the entire transplant cohort, patients with DGF of any duration were more likely to be older (52.3 vs 55.2 years, p=0.02), have higher BMI (26.2 vs 27.2 kg/m^2, p=0.05), diabetes (26.1 vs 39.2%, p=0.003), coronary artery disease (11.3 vs 18.2%, p=0.03), pre-operative anuria (8.0 vs 16.8%, p=0.003), diabetes as the etiology of ESRD (18.4 vs 31.0%, p=0.001), longer warm ischemia times (30.1 vs 33.1 mins, p<0.001), and increased peri-operative blood loss (289 vs 361 mL, p=0.001, Table 2). Patients on pre-operative PD were less likely to have DGF compared to those on HD (14.5 vs 33.3%, p<0.001). Patients receiving DCD grafts had worse graft outcomes than NDD grafts (42.7 vs 31.1%, p=0.03). Interestingly, higher pre-operative hemoglobin (112.4 vs 116.3 mL, p=0.01) was associated with increased need for dialysis while patients with polycystic kidney disease were less likely to develop DGF (12.9 vs 6.2%, p=0.03). Protective factors for immediate graft function included LD grafts (40.0 vs 5.5%, p<0.001) and intra-operative graft urine production (65.6 vs 29.0%, p<0.001).

Patients with prolonged duration of DGF were more likely to receive pre-operative HD (p=0.003) and DD grafts (p<0.001, Table 3). However, deceased donor graft type and donor criteria were not associated with prolonged DGF (p=0.14 and p=0.87, respectively). Notably, there were missing cases for both factors (59 cases, 15.1% for deceased donor graft type and 162 cases, 41.3% for deceased donor criteria).

In multivariate analysis of the entire transplant cohort, higher BMI (OR 1.06, 95% CI 1.00-1.11, p=0.04) and increased peri-operative blood loss (OR 1.002, 95% CI 1.000-1.003, p=0.03) were predictors of DGF (Table 4). LD grafts (OR 0.15, 95% CI 0.05-0.49, p=0.002) and intra-operative graft urine production (OR 0.39, 95% CI 0.23-0.65, p<0.001) were protective factors.

Since all PD patients receiving LD grafts had immediate graft function, a subset analysis of PD patients undergoing DD renal transplantation was performed. No clinical or operative factors were associated with increased risk of DGF (Table **5**). When stratified by deceased donor criteria (13 missing cases, 16.9%), SCD and ECD had comparable DGF rates (22.2 vs 17.9%, p=0.67). When stratified by deceased donor graft type (2 missing cases, 2.6%), DCD had

doubled the DGF rate as NDD (28.1 vs 14.0%), however this did not reach statistical significance (p=0.13).

Discussion

The decision for PD catheter removal during renal transplantation represents a double-edged sword in transplant care. Appropriate management of DGF is important as premature removal in the setting of DGF may impact short- and long-term graft survival as well as graft rejection[9–13]. However, leaving it *in situ* for too long increases the risk of PD catheter-related complications, the most common being infection. Warren *et al*. reported a 7% rate of peritonitis if PD catheters were left *in situ* versus 0% if removed (p<0.05)[7]. Other studies have reported complication rates as high as 43%[4]. In this study, we aimed to advance our understanding of predictors of DGF, post-transplant graft outcomes, and catheter-related complications to identify appropriate candidates for concurrent PD catheter removal.

Elevated BMI as an independent risk factor for DGF is well supported in the literature for both adult and pediatric populations[14,15]. A meta-analysis of 56 studies showed that patients with BMI >30 had a higher risk of delayed graft function (RR 1.52), mortality (RR 1.52), and acute rejection (RR 1.17)[16]. Increased peri-operative blood loss may be a surrogate marker of surgical complexity and indication for blood transfusion, which may be associated with DGF[17]. We found that intra-operative graft urine production was a protective factor and may have prognostic value during renal transplantation. Similar results were reported by Koning et al. (RR 0.12, 95% CI 0.07-0.21)[18]. Furthermore, healthy post-transplant urine production has been linked to more favourable graft outcomes[19,20]. However, according to our method of assessment of intra-operative graft urine production, we are unable to ascertain whether this represents true tubular function of the graft.

Patients on pre-operative PD seem to have better early post-transplant outcomes compared to HD patients, which may be best explained by the preservation of residual renal function (RRF). The rate of RRF decline in patients on HD has been shown to be double that of patients on PD (5.8 ± 0.4 vs 2.9 ± 0.3%, p<0.0001)[21]. Similarly, Moist et al. found that patients on PD had a 65% lower risk of RRF decline than those on HD (adjusted OR 0.35, p<0.001)[22].

The results of our study further support that LD transplants offer superior outcomes compared to DD transplants. Among our PD cohort, no DGF was observed in LD grafts. No statistically significant differences in DGF rates were identified based on deceased donor graft type and donor criteria. Therefore, we are unable to further risk stratify PD patients based on donor status. Michalak et al. reported similar DGF rates between SCD and ECD grafts (11.8 vs 19%, p=0.22)[23]. When comparing type of post-transplant RRT, median duration of dialysis (1 day PD vs 2 days HD, p=0.48) and catheter-related complication rates (4.5% PD vs 2.6% HD, p=0.30) were similar. Overall, we identified no additional benefits of post-transplant HD compared to PD other than the option of concurrent PD catheter removal at the time of transplantation to avoid a second procedure.

At our institution, we remove PD catheters at the time of transplantation in patients receiving LD grafts and our data supports this practice. Since the DGF and PD catheter-related complication rates in our PD cohort are 14.5 and 4.5%, respectively, the risks of concurrent removal during DD renal transplantation outweigh the benefits. For comparison, the current policy in Winnipeg, Manitoba, Canada is to routinely remove PD catheters in all transplant patients as temporary dialysis can be provided via a central line which is often already in place[24]. Similar protocols are used in London, Ontario, Canada with a 11.7% DGF rate, 10.9% rate of PD catheter-related complications, and no complications from urgent post-transplant HD placement in their PD cohort over a four year study period[7]. In contrast, the European Best Practice Guidelines recommends leaving the catheter *in situ* for up to 16 weeks[25]. These differences in removal policies may be attributed to the DGF and PD catheter-related complication rates at each institution.

Importantly, the results must be interpreted within the context of its limitations. As a single center study, patient populations, surgical techniques, and donor selection criteria may differ, therefore the risk factors may vary at other transplant centers. While there are several published DGF risk calculators[26–28], they perform poorly in external validations and lack predictive value to guide clinical decisions at the individual level[23]. This highlights the importance of understanding the patient population and donor selection criteria at each institution to develop meaningful risk calculators and algorithms for their patients. While strides have been made to examine the impact of clinical and transplant factors, including deceased donor graft type and donor criteria, on graft function specifically in PD patients, we have not explored the role of immunologic or pharmacologic factors on such outcomes. Since 42 patients, including 7 PD patients, developed DGF despite intra-operative urine output, additional work is needed to better characterize intra-operative graft urine production to differentiate true tubular function of the graft from other causes such as non-oliguric acute tubular necrosis. Furthermore, transplant outcomes and co-variates that were not documented in the electronic medical record may be missed in the analysis. For deceased donor criteria, there were 162 (41.3%) missing cases for the entire transplant cohort and 13 (16.9%) missing cases in the PD cohort. This limitation has several important implications in the results of our study. Firstly, the incidence of DGF and catheter-related complications could be an underestimation. Secondly, this may affect our ability to detect a statistically significant difference in graft function between SCD and ECD grafts. Future studies should aim to address these gaps.

Conclusions

Optimizing post-transplant care is critical is ensuring long-term graft function and survival, while reducing hospitalizations and anesthetic risks. We found that BMI, graft type (LD vs DD), peri-operative blood loss, and intra-operative graft urine production can be used to assess overall DGF risk. Concurrent PD catheter removal may offer significant benefits with minimal risks in carefully selected patients, such as those receiving LD grafts. However, DGF risk in PD patients

could not be further stratified based on other aspects of donor status, including deceased donor graft type and donor criteria.

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Figures and Tables

Fig. 1. Transplant outcomes and catheter-related complications for patients receiving preoperative peritoneal dialysis (PD). DD: deceased donor; DGF: delayed graft function; HD: hemodialysis.

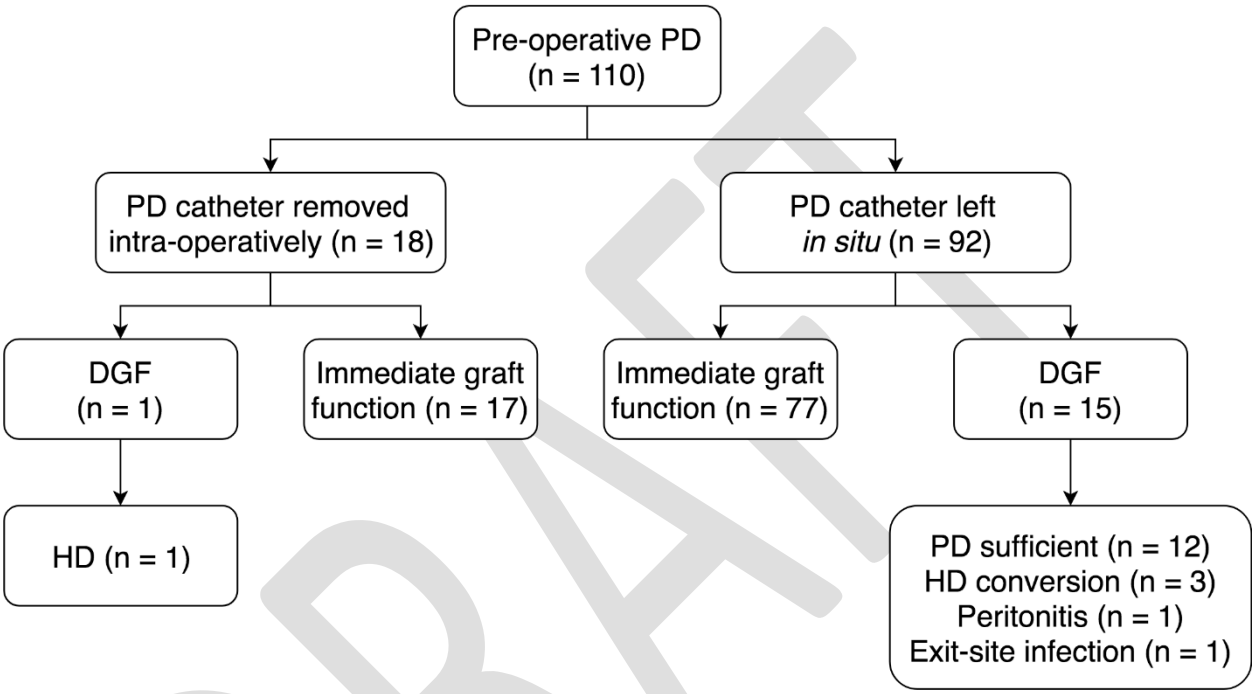

Table 1. Summary of patient demographics, clinical characteristics, and transplant outcomes	
	Overall cohort
Sample size, n	567
Age	53.1±13.0
Gender, n (% female)	224 (39.5)
BMI (kg/m^2)	26.5±5.1
Comorbidities, n (%)	
Hypertension	488 (86.1)
Diabetes	167 (29.5)
Coronary artery disease	74 (13.1)
Gout	48 (8.5)
Anuric	57 (10.1)
Previous abdominal surgery	246 (43.4)
ASA class, n (%)	
2	1 (0.2)
3	152 (26.8)
4	407 (71.8)
Preoperative hemoglobin	113.4±15.8
Graft type, n (%)	
LD	175 (30.9)
NDD	185 (32.6)
DCD	151 (26.6)
Unknown	56 (9.9)
Deceased donor criteria, n (%)	
SCD	100 (25.5)
ECD	131 (33.4)
Unknown	161 (41.1)
Etiology of end-stage renal disease, n (%)	
Diabetes	125 (22.0)
IgA nephropathy	99 (17.5)
Glomerulonephritis	70 (12.3)
Hypertension	64 (11.3)
Polycystic kidney disease	63 (11.1)
Focal segmental glomerulosclerosis	39 (6.9)
Reflux nephropathy	15 (2.6)
Kidney cancer	2 (0.4)
Other	108 (19.0)
Renal replacement therapy, n (%)	
Pre-emptive	70 (12.3)
PD	110 (19.4)
HD	387 (68.3)
Previous kidney transplant	38 (6.7)

Operative factors	
Warm ischemia time (mins)	31.0±8.7
Estimated blood loss (mL)	307±198
Intraoperative graft urine production (n, %)	315 (55.6)
DGF, n (%)	145 (25.6)

ASA: American Society of Anesthesiologists; BMI: body mass index; DCD: donation after circulatory death; DGF: delayed graft function; ECD: expanded donor criteria; HD: hemodialysis; LD: living donor; NDD: donation after neurological death; PD: peritoneal dialysis; SCD: standard donor criteria.

Table 2. Comparison of demographic and clinical characteristics in patients that developed delayed graft function in the entire transplant cohort

	No DGF	**DGF**	**p**
Sample size, n (%)	422 (74.4)	145 (25.6)	
Age	52.3±13.3	55.2±12.0	**0.02**[a]
Gender, n (% female)	172 (41.1)	50 (34.5)	0.16
BMI (kg/m^2)	26.2±5.0	27.2±5.2	**0.05**
Comorbidities, n (%)			
Hypertension	362 (86.8)	125 (86.2)	0.85
Diabetes	109 (26.1)	56 (39.2)	**0.003**
Coronary artery disease	47 (11.3)	26 (18.2)	**0.03**
Gout	34 (8.2)	14 (9.8)	0.55
Anuric	33 (8.0)	24 (16.8)	**0.003**
Previous abdominal surgery	187 (45.0)	57 (39.9)	0.29
ASA class, n (%)			
2	1 (0.2)	–	0.21
3	121 (29.0)	31 (21.8)	
4	295 (70.7)	111 (78.2)	
Preoperative hemoglobin	112.4±15.8	116.3±15.2	**0.01**
LD, n (%)	167 (40.0)	8 (5.5)	**<0.001**
Deceased donor graft type, n (%)[1]			
NDD	126 (68.9)	57 (31.1)	**0.03**
DCD	86 (57.3)	64 (42.7)	
Deceased donor criteria (n, %)[2]			
SCD	69 (69.0)	31 (31.0)	0.49
ECD	84 (64.6)	46 (35.4)	
Etiology of end-stage renal disease, n (%)			
Diabetes	77 (18.4)	45 (31.0)	**0.001**
IgA nephropathy	73 (17.5)	26 (17.9)	0.90
Glomerulonephritis	52 (12.4)	18 (12.4)	0.99
Hypertension	46 (11.0)	18 (12.4)	0.65
Polycystic kidney disease	54 (12.9)	9 (6.2)	**0.03**
Focal segmental glomerulosclerosis	33 (7.9)	6 (4.1)	0.13

Reflux nephropathy	14 (3.3)	1 (0.7)	0.13
Kidney cancer	2 (0.5)	–	1.00
Other	80 (19.1)	28 (19.3)	0.96
Renal replacement therapy (n, %)			
Pre-emptive	70 (16.7)	---	**<0.001**
PD	94 (85.5)	16 (14.5)	
HD	254 (66.7)	129 (33.3)	
Previous kidney transplant	25 (6.0)	13 (9.1)	
Operative factors			
Warm ischemia time (mins)	30.1±7.9	33.1±10.3	**<0.001**
Perioperative blood loss (mL)	289±152	361±289	**0.001**[a]
Intraoperative graft urine production (%)	273 (65.6)	42 (29.0)	**<0.001**

[a]Mann-Whitney U test used; [1]59 missing cases (15.1%); [2]162 missing cases (41.3%). ASA: American Society of Anesthesiologists; BMI: body mass index; DCD: donation after circulatory death; DGF: delayed graft function; ECD: expanded donor criteria; HD: hemodialysis; LD: living donor; NDD: donation after neurological death; PD: peritoneal dialysis; SCD: standard donor criteria.

Table 3. Impact of renal replacement therapy and graft type on duration of delayed graft function

	Total DGF	**DGF – RRT 1 session**	**DGF – RRT <1 week**	**DGF – RRT >1 week**	**DGF – RRT ongoing**	**p**
Renal replacement therapy	16 (14.5)	7 (6.4)	5 (4.5)	2 (1.8)	2 (1.8)	**0.003**
PD	129	42 (10.9)	42 (10.9)	15 (3.9)	32 (8.3)	
HD	(33.3)					
Donor type						
LD	8 (4.6)	2 (1.1)	3 (1.7)	2 (1.1)	1 (0.6)	**<0.001**
DD	137 (35.3)	47 (12.1)	44 (11.3)	14 (3.6)	32 (8.2)	
Deceased donor graft type[1]	57 (31.2)	23 (12.6)	19 (10.4)	5 (2.7)	10 (5.5)	0.14
NDD	64 (42.7)	19 (12.7)	21 (14.0)	7 (4.7)	17 (11.3)	
DCD						
Deceased donor criteria[2]	31 (31.0)	9 (9.0)	11 (11.0)	3 (3.0)	8 (8.0)	0.87
SCD	46 (35.4)	14 (10.8)	13 (10.0)	7 (5.4)	12 (9.2)	
ECD						

[1]59 missing cases (15.1%); [2]162 missing cases (41.3%). Estimated duration of RRT was calculated as follows: RRT for PD = no. of sessions of PD x 1 day, RRT for HD = (no. of sessions of PD – 1) x 2 days. These formulae were chosen since all PD patients with DGF

received continuous cycling PD, while HD patients with DGF typically received dialysis every other day (Monday/Wednesday/Friday or Tuesday/Thursday/Saturday). DCD: donation after cardiac death; DD: deceased donor; DGF: delayed graft function; ECD: extended criteria donor; HD: hemodialysis; LD: living donor; NDD: donation after neurological death; PD: peritoneal dialysis; RRT: renal replacement therapy; SCD: standard donor criteria.

Table 4. Multivariate logistic regression model to determine risk factors for delayed graft function in the entire transplant cohort

	Odds ratio	**95% confidence interval**	**p**
Age	1.00	0.98–1.02	0.90
BMI	1.06	1.00–1.11	**0.04**
Diabetes	1.41	0.56–3.56	0.47
Coronary artery disease	1.68	0.82–3.43	0.15
Anuria	1.53	0.71–3.31	0.28
Pre-operative hemoglobin	1.01	1.00–1.03	0.19
ESRD due to diabetes	0.95	0.35–2.57	0.92
ESRD due to polycystic kidney disease	0.74	0.31–1.80	0.51
Dialysis (PD)	0.65	0.36–1.17	0.15
LD	0.15	0.05–0.49	**0.002**
Deceased donor graft type (DCD)	1.26	0.74–2.12	0.39
Warm ischemia time	1.01	0.98–1.04	0.47
Perioperative blood loss	1.002	1.000–1.003	**0.03**
Intraoperative graft urine production	0.39	0.23–0.65	**<0.001**

BMI: body mass index; DCD: donation after circulatory death; ESRD: end-stage renal disease; LD: living donor; PD: peritoneal dialysis.

Table 5. Comparison of clinical, operative, and transplant factors for patients on preoperative peritoneal dialysis (PD) undergoing deceased donor renal transplantation			
	No DGF	**DGF**	**p**
Sample size, n (%)	61 (79.2)	16 (20.8)	
Age	57.4±11.4	54.6±10.4	0.37
Gender, n (% female)	30 (49.2)	8 (50.0)	0.95
BMI (kg/m^2)	25.7±4.4	26.7±5.4	0.47
Comorbidities, n (%)			
Hypertension	59 (96.7)	15 (93.8)	0.59
Diabetes	16 (26.2)	2 (12.5)	0.33
Coronary artery disease	4 (6.6)	2 (12.5)	0.60
Gout	6 (9.8)	3 (18.8)	0.38
Anuric	5 (8.2)	1 (6.3)	1.00
Previous abdominal surgery	48 (78.7)	14 (87.5)	0.43
ASA class (n, %)			
3	16 (26.2)	5 (31.3)	0.76
4	45 (73.8)	11 (68.8)	
Preoperative hemoglobin	108.2±11.5	109.5±13.1	0.70
Deceased donor graft type, n (%)[1]			
NDD	37 (86.0)	6 (14.0)	0.13
DCD	23 (71.9)	9 (28.1)	
Deceased donor criteria, n (%)[2]			
SCD	28 (77.8)	8 (22.2)	0.67
ECD	23 (82.1)	5 (17.9)	
Etiology of end-stage renal disease, n (%)	10 (16.4)	1 (6.3)	0.44
Diabetes	11 (18.0)	3 (18.8)	1.00
IgA nephropathy	12 (19.7)	4 (25.0)	0.73
Glomerulonephritis	6 (9.8)	4 (25.0)	0.20
Hypertension	6 (9.8)	2 (12.5)	0.67
Polycystic kidney disease	4 (6.6)	1 (6.3)	1.00
Focal segmental glomerulosclerosis	–	–	–
Reflux nephropathy	–	–	–
Kidney cancer	14 (23.0)	2 (12.5)	0.50
Other			
Previous kidney transplant, n (%)	1 (1.6)	1 (6.3)	0.38
Operative factors			
Warm ischemia time (mins)	30.6±9.6	29.1±7.0	0.57
Estimated blood loss (mL)	291±144	334±221	0.34
Intraoperative graft urine production, n (%)	27 (44.3)	7 (43.8)	0.97

No PD patients undergoing living donor renal transplantation experienced delayed graft function. [1]2 missing cases (2.6%); [2]13 missing cases (16.9%). ASA: American Society of Anesthesiologists; BMI: body mass index; DCD: donation after circulatory death; DGF: delayed

graft function; ECD: expanded donor criteria; NDD: donation after neurological death; SCD: standard donor criteria.