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Original contribution

Donor-related diabetic nephropathy: a comprehensive clinicopathological study

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Summary Knowledge on renal involvement in kidney donors with diabetes, that is, diabetic nephropathy (DN), is limited. During the 7 years (2010-2017), 921 postperfusion biopsies were performed for living donors (14%) or deceased donors (86%). The Renal Pathology Society classification schema for DN (class 0-IV) was used. Biopsies with light microscopic changes of DN (at least class IIa) were selected for study. Eleven biopsies (1.2%) showed DN, all from deceased donors (class IIa in 8, class IIb in 2, and class III in 1 biopsy). The glomerular basement membrane thickness ranged from 439 ± 52 to 725 ± 82 nm. These biopsies also displayed arterionephrosclerosis. They were from 9 deceased donors (fulfilling clinical criteria for acceptance in all, diabetes ;[>6 years] in 8, hypertension in 6, and proteinuria [1+] in all). Follow-up biopsies (5-342 weeks after transplant) showed DN of the same class (7 biopsies), probably progression (1), or progression (3). At follow-up (15-416 weeks), all recipients were alive. One graft was lost at 76 weeks because of progressive DN. The other 10 grafts were functioning, but the serum creatinine reached 2.0 to 2.7 mg/dL in 5 of them. Although diabetes is frequent in kidney donors, donor-related DN is unusual. It is observed only in deceased donors, but the risk factors for its development are not known. Donor-related DN may be stable or progress. Whether it resolves, especially for DN in early phase, remains unknown. It may adversely impact the graft outcome with a magnitude proportional to the severity of the tissue injury in the postperfusion biopsies.

1. Introduction

Criteria incorporating clinical, laboratory, and renal biopsy data have been developed to ensure that kidneys from living or deceased donors are suitable for transplantation [1,2]. These criteria have ensured that donor kidneys are free of diseases, which, if transplanted to a recipient, may impair graft function. Despite this effort, several donor-related renal diseases have been transplanted to the recipients, including IgA nephropathy [3,4], thin basement membrane disease, membranous glomerulonephritis, minimal change disease [4], disseminated intravascular coagulation [5], and myoglobin-induced acute kidney injury [6]. These diseases may be asymptomatic and thus escape clinical detection, such as IgA nephropathy or thin basement membrane disease [3,4]. Alternatively, some of

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Table 1 Donor DN: postperfusion and follow-up biopsies

Case no.	Types of biopsy	Weeks posttransplant	DN, RPS class (0-IV) [a]	GBM thickness (nm)	Sclerotic glomeruli: no./total (%)	IFTA (% of surface area) [a]	AN	Arterial intimal fibrosis (0-3) [a]	Arteriolar hyalinosis (0-3) [a]	Other diagnosis
1 [b]	Postperfusion Bx		IIa	Not done	0/25 (0)	20	Yes	2	3	None
	Follow-up Bx	16	IIb	489 ± 47	0/20 (0)	30	Yes	2	3	None
2 [b]	Postperfusion Bx		IIa	Not done	0/35 (0)	15	Yes	2	3	None
	Follow-up Bx	342	IIa	617 ± 89	3/18 (17)	15	Yes	2	3	None
3	Postperfusion Bx		IIa	439 ± 52	5/61 (8)	15	Yes	1	2	None
	Follow-up Bx	7	IIa	Not done	3/11 (3)	15	Yes	2	1	None
	Follow-up Bx	13	IIa	Not done	2/40 (5)	15	Yes	1	2	None
	Follow-up Bx	49	0	Not done	1/15 (7)	10	Yes	1	1	Glomerulitis; transplant glomerulopathy, early
	Follow-up Bx	57	0	375 ± 37	3/25 (12)	25	Yes	2	1	transplant glomerulopathy, severe
	Follow-up Bx	392	IIa	485 ± 38	3/20 (15)	20	Yes	3	3	transplant glomerulopathy, severe; acute antibody rejection
4	Postperfusion Bx		IIa	698 ± 82	1/18 (5)	5	Yes	1	3	ATN
	Follow-up Bx	17	IIa	628 ± 57	1/15 (7)	5	Yes	2	3	None
	Follow-up Bx	208	IIb	675 ± 68	9/24 (4)	60	Yes	3	3	None
5	Postperfusion Bx		IIa	550 ± 89	6/31 (19)	30	Yes	1	1	None
	Follow-up Bx	10	IIb/III	500 ± 36	0/36 (0)	10	Yes	1	1	Polyomavirus nephropathy
6	Postperfusion Bx		III	725 ± 82	2/26 (8)	40	Yes	1	1	None
	Follow-up Bx	5	III	812 ± 56	0/6 (0)	40	Yes	3	1	None
	Follow-up Bx	30	III	800 ± 62	14/26 (54)	75	Yes	3	3	None
7	Postperfusion Bx		IIb	583 ± 79	3/14 (21)	30	Yes	1	2	None
	Follow-up Bx	5	IIb	662 ± 64	3/25 (12)	50	Yes	2	2	None
	Follow-up Bx	52	IIb	604 ± 57	6/24 (25)	35	Yes	2	2	None
8	Postperfusion Bx		IIb	479 ± 102	6/106 (6)	50	Yes	3	3	FSGS, ATN
	Follow-up Bx	28	IIb	569 ± 31	4/15 (3)	25	Yes	3	3	FSGS
9 [b]	Postperfusion Bx		IIa	662 ± 57	6/108 (5)	15	Yes	2	0	None
	Follow-up Bx	4	IIa	638 ± 43	0/16 (0)	10	Yes	2	1	None
10 [b]	Postperfusion Bx		IIa	702 ± 48	0/120 (0)	20	Yes	2	1	None
	Follow-up Bx	4	IIa	Not done	3/26 (11)	40	Yes	2	1	None
	Follow-up Bx	14	IIa	612 ± 37	1/31 (3)	40	Yes	2	1	None
	Follow-up Bx	48	IIa	622 ± 48	0/25 (0)	40	Yes	1	1	Acute antibody rejection, early transplant glomerulopathy, glomerulitis
	Follow-up Bx	51	IIa	682 ± 71	1/35 (3)	30	Yes	1	2	Acute antibody rejection, early transplant glomerulopathy, glomerulitis
	Follow-up Bx	58	IIa	654 ± 69	0/12 (0)	50	Yes	1	1	Acute antibody rejection, early transplant glomerulopathy, glomerulitis
11	Postperfusion Bx		IIa	640 ± 109	0/26 (0)	20	Yes	2	3	ATN, FSGS
	Follow-up Bx	5	IIb	672 ± 86	1/20 (5)	15	Yes	2	3	None

Abbreviations: ; AN, arterionephrosclerosis; ATN, acute tubular necrosis; Bx, biopsy; ;FSGS, focal segmental glomerulosclerosis; ;IFTA, interstitial fibrosis and tubular atrophy Nm = Nanometer;.

[a] See Materials and Methods for description of grading scale.

[b] Kidneys from the same donor.

them may be recognized or suspected before transplantation, such as disseminated intravascular coagulation, but do not prohibit transplantation owing of their posttransplant resolution, leaving no adverse impact on the graft [1-4]. Although the frequency of these donor-related diseases is widely variable, ranging from up to 9% of all donors for IgA nephropathy, to

isolated cases report for many other diseases, their diagnosis, posttransplant evolution, and impact on graft outcome have been well defined [3-6]. This, however, is not the case for donor-related diabetic nephropathy (DN).

Diabetes, both diagnosed and undiagnosed, is noted in as many as 10% of the US adult population [7]. DN will develop in about a third of them [8,9]. Diabetes is considered a contraindication of kidney donation by living donors [2]. About 8% of deceased donors have diabetes, and up to 40% of kidneys from these donors were discarded [10]. The current kidney allocation system for deceased donor kidneys uses the Kidney Donor Profile Index based on 10 donor factors to assign a risk score for posttransplant graft survival [1]. Donor diabetes carries a heavy weight in this scoring. Against this background, very little is known on the donor-related DN. To the best of our knowledge, donor-related DN was characterized in only 2 *living* donors, but not described in the vast literature on preimplant donor biopsies, postperfusion donor biopsies, or outcome of kidney transplants from donor with diabetes [11-23]. The current study addresses this issue.

2. Materials and methods

All postperfusion biopsies of the transplanted kidneys accessioned in the Department of Pathology and Genomic Medicine, The Houston Methodist Hospital, from 2010 to 2017 were reviewed to identify those with DN. This study is approved by the institutional review board. In our transplant program, postperfusion biopsy of the transplanted kidney is in general performed to address concerns about the status of the transplanted kidneys, including abnormal renal function developing around the time of transplantation; technically complicated surgical procedures; abnormal intraoperative findings of the graft; or history of donor diseases that may impair renal function but by themselves not a cause donor rejection, such as hypertension or diabetes. During the 7 years from 2010 to 2017, 1544 kidney transplants were performed (living related [40%] and deceased donor [60%]), among which 921 postperfusion kidney biopsies were performed (living donors [14%] or deceased donors [86%]). Eleven biopsies with DN were identified among them. All of these biopsies were from deceased donors.

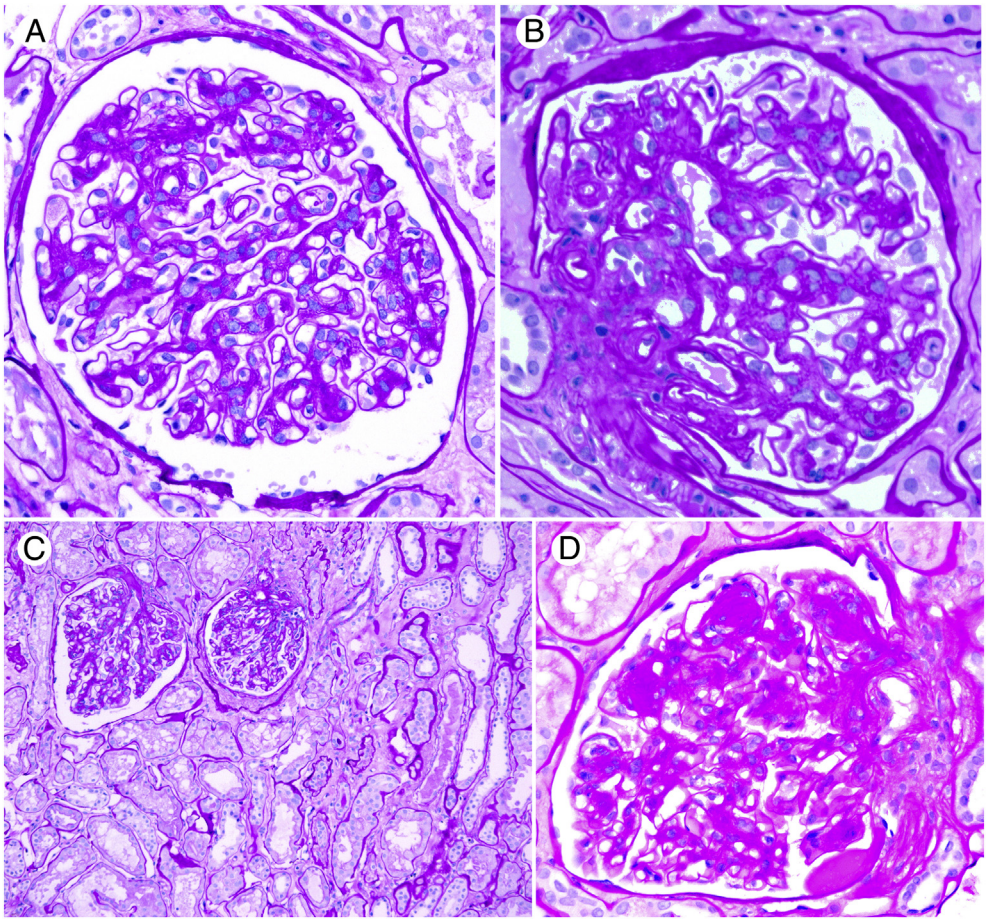

Fig. 1 Case 11. A-C, Postperfusion biopsy with DN, RPS class IIa. A, Mild/moderate mesangial expansion and hypercellularity. B, Segmental sclerosis noted at the vascular pole. C, Focal interstitial fibrosis and tubular atrophy. D, Follow-up biopsy 5 weeks later. DN, RPS class IIB: marked mesangial expansion (periodic acid–Schiff stain, original magnifications ×400 [A, B, and D ;] and ×200 [C]).

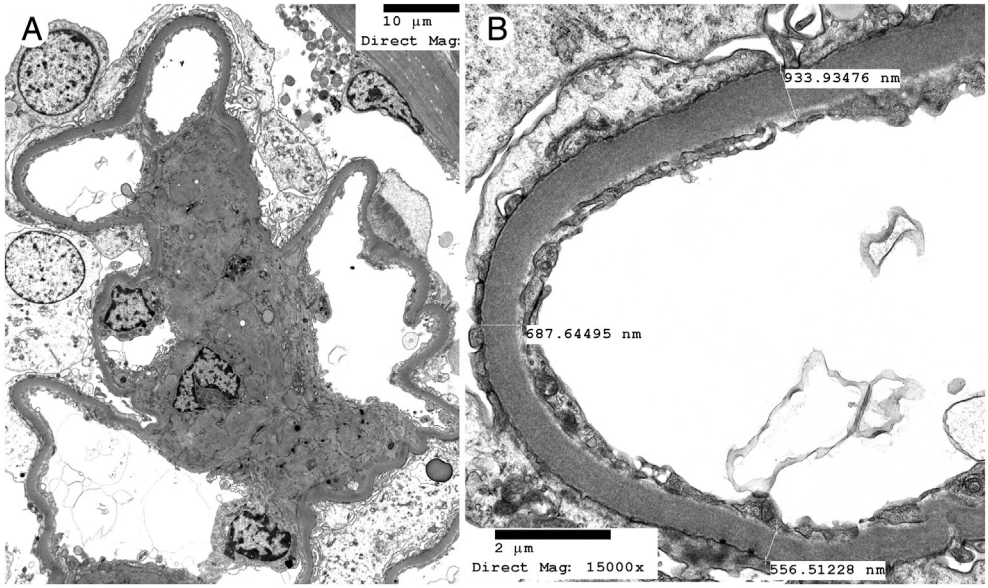

Fig. 2 Case 11. Postperfusion biopsy. A, Mesangial expansion and thickening of the GBM. Measurement of the thickness of the GBM is done for several capillaries, including the one marked by a rectangle. B, Uniformly thickened GBM (EM, original magnification ×5000 [A] and ×15,000 [B]).

The biopsies with DN were subjected to light microscopy (LM) including hematoxylin ;and eosin, periodic acid–Schiff, Masson trichome, and methenamine silver stains ;, and immunofluorescent stains including IgG, IgA, IgM, C3, C4, C1q, κ light chain, λ light chain, and C4d. Electron microscopy (EM) was done both prospectively and retrospectively on tissue samples originally fixed in glutaraldehyde. The thickness of the glomerular basement membrane (GBM) was determined, according to a method described by Haas [24]. Thickened GBM, a diagnostic change of DN, was defined as a thickness of more than 430 and 395 nm for male and female, respectively. The Renal Pathology Society (RPS) grading system

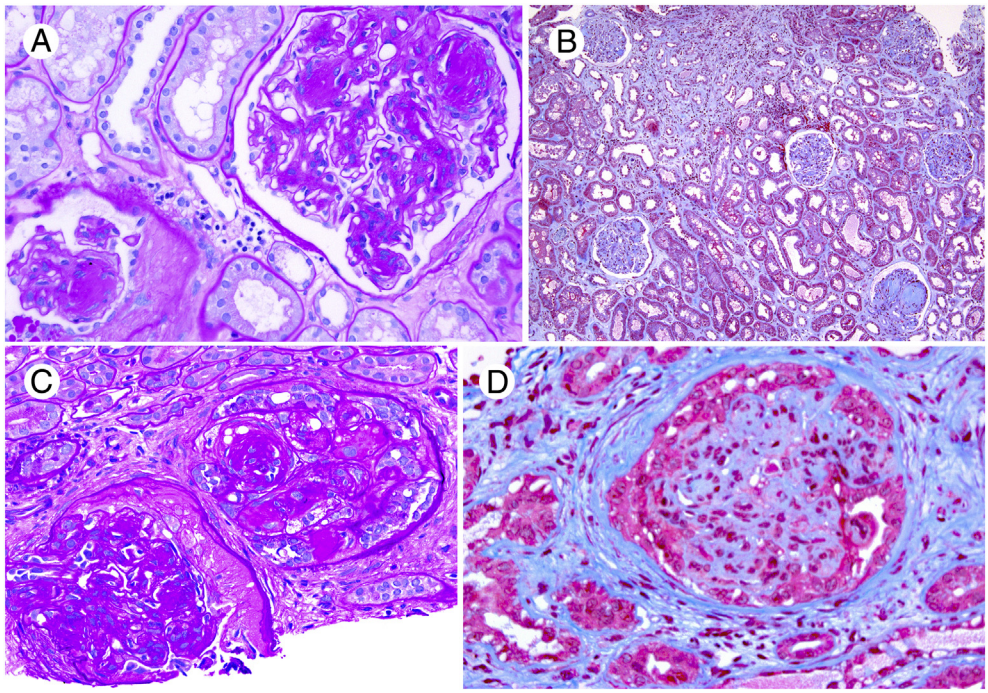

Fig. 3 Case 6. A and B, Postperfusion biopsy showing DN, RPS class III. A, Global diffuse marked mesangial expansion with some mesangial nodules (periodic acid–Schiff stain, original magnification ×400). B, Mesangial expansion with some mesangial nodules. Marked interstitial fibrosis and tubular atrophy (Masson trichome stain, ×100). C and D, Follow-up biopsy 30 weeks later: progression of DN. C, Progressive global diffuse diabetic sclerotic changes, with subcapsular fibrosis and podocyte proliferation (periodic acid–Schiff stain, ×400). D, Progressive diabetic sclerotic changes and podocyte proliferation, with severe interstitial fibrosis and tubular atrophy (Masson trichome stain, ×400).

(0-IV) is used [25]: class 0, no diabetic changes by LM or EM; class I, no obvious LM changes, but thickening of the GBM by EM; class IIa, mild mesangial expansion by LM; class IIb, marked mesangial expansion by LM; class III, nodular mesangial sclerosis; and class VI, advanced diabetic glomerulosclerosis with global sclerosis in more than 50% of glomeruli. This study does not include DN of class I. It is impractical to retrospectively perform EM study in all 921 postperfusion biopsies during the study period to identify these cases. More importantly, DN of class I is most often asymptomatic and is not progressive if the diabetogenic/hyperglycemic environment is eliminated [26-28]. Class I DN therefore is not expected to have any significant impact on the recipient and the graft outcome [26-28]. Other renal biopsy changes were also identified and scored, including sclerotic glomeruli (% of total glomeruli); interstitial fibrosis and tubular atrophy (% of affected cortical tissue at 5% increment ;), arterial intimal fibrous thickening (0, none; 1, 25% lumen narrow; 2, 26%-50%; 3, >50 ;%), arteriolar hyalinosis (0, none; 1, mild/moderate in at least 1 profile; 2, moderate/severe in several profiles; 3, severe in several profiles). The follow-up biopsies were evaluated in the same manner.

The profiles of donors and recipients and their clinical/laboratory information around the time of transplantation with special attention to those pertinent to the diabetic status were obtained from hospital medical records, United Network of Organ Sharing registry, and family members. Up-to-date follow-up including graft and recipient outcome was established.

3. Results

The postperfusion biopsy findings are summarized in Table 1. DN was of class IIa in 8, class IIb in 2, and class III in 1 biopsy (Figs. 1-5). The GBM thickness ranged from 439 ± 52 to 725 ± 82 nm. Sclerotic glomeruli were not identified in 4 biopsies but ranged from 5% to 21% in other biopsies. Interstitial fibrosis and tubular atrophy was noted in each of these biopsies (5%-50%; mean, 24%). Arterionephrosclerosis was noted in each biopsy, with a mean arterial intimal fibrosis score of 1.6/3 and a mean arteriolar hyalinosis score of 2/3. Other changes included acute tubular necrosis in 2 biopsies and focal segmental glomerulosclerosis also in these 2 biopsies.

The 11 postperfusion biopsies with DN were from 9 deceased donors (both kidneys from 2 donors transplanted locally). The donor profiles (Table 2) included the following:

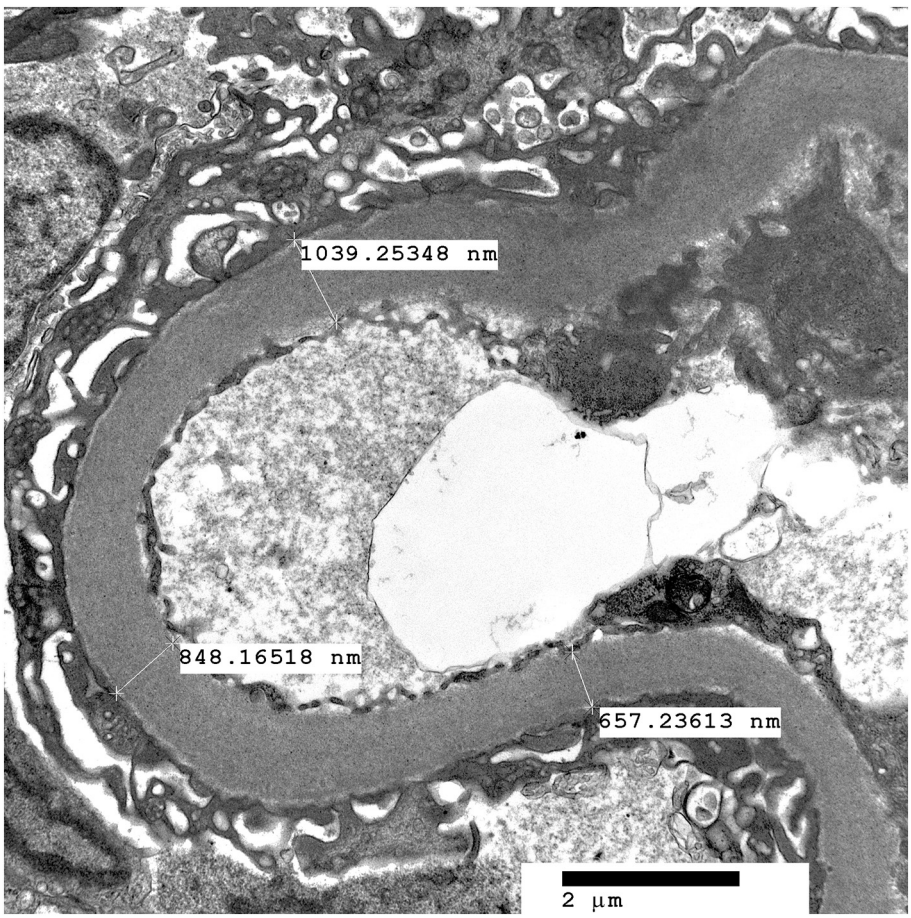

Fig. 4 Case 6. Postperfusion biopsy. Markedly thickened GBM (EM, original magnification ×15,000).

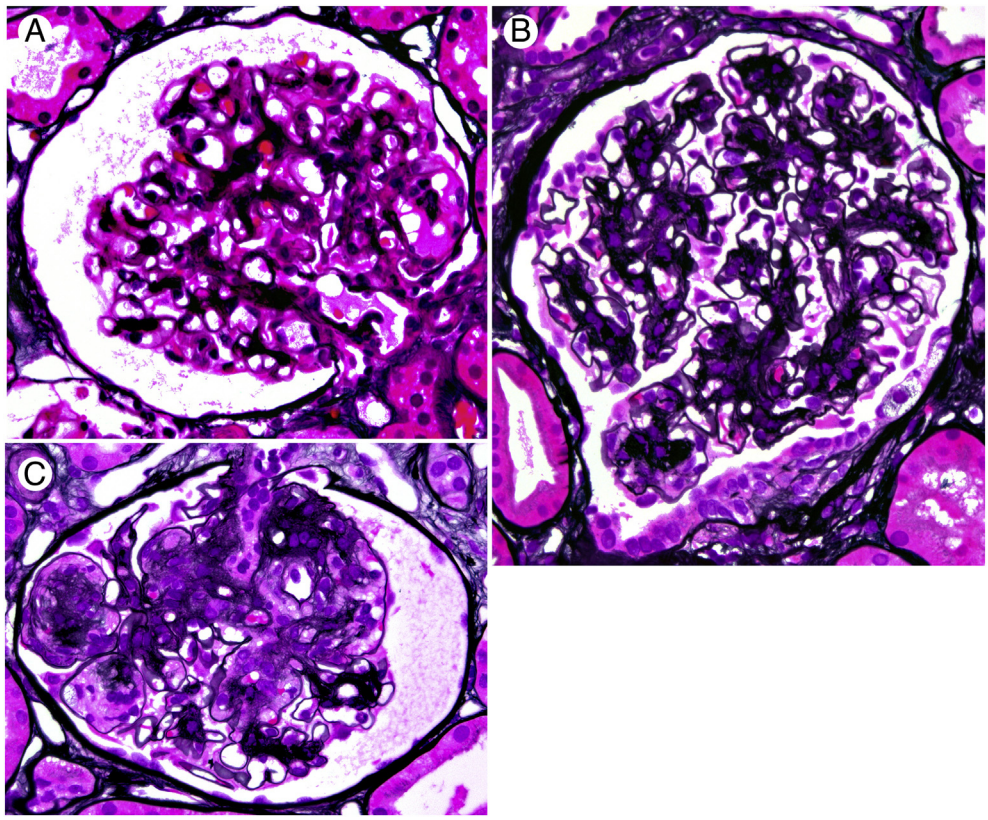

Fig. 5 Case 5. A, Postperfusion biopsy showing DN, RPS class IA: mild mesangial expansion. B and C, Follow-up biopsy 10 weeks later showing progression of DN. B, Marked mesangial expansion (RPS class IIB). C, Marked mesangial expansion with glomerular capillary aneurysms and early mesangial nodules (methenamine silver stain, original magnification ×400 for all panels).

age 47 to 65 years (mean, 48 years ;), race (4 white, 4 African American, and 1Hispanic ;), sex (6 male and 3 female ;), obesity (4 with body mass index >30 kg/m^2), and cause of death including cardiovascular accident/stroke (7), head trauma (2), and hypertension (6). History of diabetes was noted in 7 donors with a known duration of >10 years in 3. In 1 donor (cases 9 and 10), although "no diabetes" was recorded in organ transplant registry, retrospective study showed a blood glucose of 700 mg/dL and an hemoglobin A1C of 10.5% at the time of organ donation. History of diabetes could not be elicited in 1 donor (case 5). The terminal serum creatinine levels ranged from 1 to 1.4 mg/dL (<1 mg/dL in 6). Urine protein excretion (1+) was noted in every case when the results of urine analysis were available.

Follow-up biopsies (Table 1) were done in each case (1-5 biopsies, 5-342 weeks [mean, 59 weeks] after transplant). Focus was directed at the most recent follow-up biopsies.

DN persisted in each case. DN was of the same class in 7 cases (5 class IIa and 2 class IIb). In 1 case (case 3) of this group, DN (of class IIa in the postperfusion biopsy) was not seen in the follow-up biopsies at 49 and 57 weeks after transplant even by EM, but was noted again (class IIa) in the biopsy at 392 weeks. DN was more severe in 4 cases. Within this group, 2 cases showed progression from IIa to IIb (Fig. 1). One case showed progression from IIa to IIb, but a few glomerular capillary aneurysms were noted with early mesangial nodules, suggestive of impending class III (Fig. 5, case 5). In the remaining case (Fig. 3, case 6), although class III DN was noted in both postperfusion biopsy and most recent follow-up biopsy (at 30 weeks), there was progression of nodular lesions, sclerotic changes, podocyte proliferation, and interstitial fibrosis and tubular atrophy (40% versus 75%) in the latter, causing graft failure at 76 weeks after transplant.

The evolution of arterionephrosclerotic changes including interstitial fibrosis and tubular atrophy was variable, including minor changes, stability, or even improvement in 8; and progression in 3 biopsies. Other diagnoses included polyomavirus nephropathy (1 biopsy), antibody-mediated rejection, and transplant glomerulopathy in 2 biopsies. Cell-mediated rejection was not seen in any biopsies.

At follow-up (15-416 weeks after transplant), all recipients were alive. One graft was lost at 76 weeks after transplant (case 6) because of progressive DN and severe interstitial fibrosis and tubular atrophy, at which time the serum creatinine was 6.3 mg/dL and a daily protein excretion reached 16.5 g/d. The other 10 grafts were functioning, but the serum creatinine in these recipients reached 2.0 to 2.7 mg/dL in 5 of them, 1 of whom also developed heavy proteinuria (3.1 g/d).

Table 2 Donor profiles, recipient profiles, and graft outcome

Case no.	Donors						Recipients										Follow-up		
	Age (y)	Race	Sex	BMI (kg/m^2)	Cause of death	HBP	DM (y)	Creat (mg/dL)	Prot	Age (y)	Race	Sex	BMI (kg/m^2)	ESRD	DGF	HBP Pre-Tx	HBP Post-Tx	DM Pre-Tx	DM Post-Tx	HbA1C	Weeks post-Tx	Creat (mg/dL)	Prot (g/d)
1[a]	47	H	M	43.1	CVA	Yes	6-10	1	NA	36	As	F	36.1	DN	No	Yes	Yes	Yes	Yes	7.7	312	1.2	0.25
2[a]										53	His	M	28.2	HBP	No	Yes	Yes	No	Yes	7.1	416	1.5	0.05
3	44	AA	M	23.1	CVA	Yes	6-10	0.8	Neg	62	AA	M	21.4	HBP	No	Yes	Yes	No	Yes	8.8	404	2.3	0.13
4	44	W	M	25.8	CVA/stroke	Yes	>10	0,9	1+	52	W	F	22.7	Drugs	No	Yes	No	No	No	5.4	220	1.3	0.14
5	65	H	M	23.3	Head trauma	No	NA	1,4	NA	67	AA	F	28.4	HBP	No	Yes	No	No	No	NA	201	1.4	0.38
6	46	H	F	27.1	Anoxia	Yes	>10	0.9	1+	39	As	F	17.3	IgA	No	Yes	Yes	No	No	5.8	76	6.3	16.5
7	48	W	F	34.6	Head trauma	No	>10	0.6	1+	35	AA	F	29.9	HBP	Yes	Yes	Yes	No	No	5.5	72	2,5	0.36
8	48	W	M	26.4	CVA	Yes	6-10	1.2	1+	45	His	M	28.1	Cirrhosis	Yes	Yes	Yes	No	Yes	6.3	56	2	0,21
9[a]	39	W	M	38.6	CVA	Yes	Yes	1.13	1+	51	His	F	24.5	HBP	No	Yes	Yes	No	No	5.1	60	0.8	0.25
10[a]										44	W	M	25.8	IgA	No	No	Yes	No	No	5.7	58	2.7	0.17
11	50	H	F	30.9	Head trauma	No	6-10	0.72	1+	52	AA	M	39. 1	DN/HBP	Yes	Yes	Yes	Yes	Yes	NA	15	2.1	3.1

Abbreviations :; AA, African American; As, Asian; BMI, body mass index; Creat, serum creatinine; CVA, cardiovascular accident; DGF, delayed graft function; DM, diabetes; ;ESRD, end-stage renal disease; HbA1C, hemoglobin A1C; HBP, hypertension; His, Hispanic; IgA, IgA nephropathy; NA, not available; Neg, negative; Prot, proteinuria; Tx, transplant; W, white.

[a] Kidneys from the same donor.

4. Discussion

To the best of our knowledge, this is the first comprehensive study on DN in donor kidneys at the time of transplantation. Previous knowledge in this area is virtually limited to 2 case reports. In 1987, Abouna et al [29] reported DN in a deceased kidneys donor affected by diabetes for 17 years and resolution of DN documented by biopsy 7 months after transplant. Taking exception to the general guideline that diabetes is a contraindication for living kidney donation, Harada et al [30] reported in 2015 three living kidney donors with diabetes lasting 2 to 5 years, whose pretransplant kidney biopsies showed mild DN, which was no longer present in the follow-up biopsy 1 year after transplant.

The current study found that donor-related DN, at least for the cases that are diagnosed at the light microscopic level, is rare (1.2% of all postperfusion biopsies), almost always from donors with a history of diabetes, and noted in only in deceased donors. This low frequency contrasts with a higher incidence of diabetes in deceased donor ranging from 3.5% to 8% [11,13-15]. Although diabetes is common (10% of adult population in the United States), diabetes-induced kidney injury, that is, DN, develops in less than a third of these patients across the course of the disease and its clinical spectrum [7-9]. These observations in diabetic patients in general and the fact that kidney donors including those with diabetes must meet clinical criteria for elimination of symptomatic donors before donation account at least in part for the low frequency of donor-related DN. The absence of donor-related DN in living donors in this study not only reflects the guideline that diabetes is a contraindication for living kidney donation but also acknowledges the success of clinical screening applied to living donors [2].

We also retrospectively reviewed the clinical profiles of donors with donor-related DN to assess predictors of the renal lesions. Acceptance of these kidneys for transplantation was predicated at least in part from the normal or near-normal terminal serum creatinine in each donor; however, there was mild proteinuria (1+) in each of them. We could identify some potential risk factors including the presence of diabetes often of long duration, hypertension, and obesity.

Along the RPS 0-IV grading scale for DN, reflecting progressive severity of the glomerular lesion, most cases of donor-related DN are mild (IIa in 8, IIb in 2, and III in 1). However, within this small group of subjects, there seems to be no correlation of the known duration of diabetes and the severity of donor-related DN. Traditional teaching indicates that DN only develops after a long duration of clinical diabetes (at least 10-15 years), and there exists a rather predictable clinicopathological correlation along the course of the disease [31]. More recent studies, however, suggest a much more heterogeneous context, in which clinicopathological discrepancy is not unusual [8,9]. This discrepancy is also noted for the donor-related DN herein reported. Collectively, these observations indicate that DN will develop in a small percentage of diabetic kidney donors, and the disease may be transmitted to the recipients.

However, the risk factors for donor-related DN have not been established, and the current clinical screening may not help identify the disease before transplantation. The role of preimplant donor kidney biopsy within this context remains unknown.

Aside from DN, arterionephrosclerosis and interstitial fibrosis and tubular atrophy, often marked (20%-40% of cortical tissue area in 7 biopsies), are noted in each biopsy, perhaps reflecting the recognized frequent coexistence of DM and hypertension, which is also observed in the current study. This type of injury, which can be severe, can develop against the background of only mild DN and may be of more clinical significance than the DN itself. This type of change may also account at least in part for the heavy weight of donor diabetes in the Kidney Donor Profile Index risk score for graft survival, despite the observation that donor-related DN is both unusual and often mild [1].

The evolution of donor-related DN is not currently known. Reversibility of the renal changes characteristic for DN has been reported in experimental models, most notably for early changes [32-34]. Early DN in native kidney may not be progressive if the hyperglycemic environment is eliminated [26-28]. Isolated case reports suggest that donor-related DN in early stages transmitted to a kidney transplant recipient may be reversible, and this can materialize in a relatively short period of a few months [29,30]. Our study expands the current knowledge. It does not provide conclusive evidence on the reversibility of DN after transplantation, especially for DN in early phase, because these cases were indeed not included in the current study. It, however, suggests that established donor-related DN often stays the same, even after a rather long follow-up. Furthermore, in about a third of cases, DN does progress, even in a short period, in associated with more severe interstitial fibrosis and tubular atrophy. Such a morphologic evolution is perhaps multifactorial, including hemodynamic factors, implantation injury, immunosuppression regimens, or intercurrent diseases such as hypertension or cirrhosis. However, the diabetic status of the recipients seems to be a crucial factor. Diabetes was the cause of end-stage renal disease in only 2 recipients, which persisted after transplantation. In addition, diabetes developed de novo in 3 recipients. Thus diabetes, rather poorly controlled, was noted in 5 (45%) of the 11 recipients after transplant, and 2 of the 4 cases with progression of DN.

Despite a small number of cases, this study provides insights into the impact of donor DN on graft outcome. If the DN is severe (RPS class III), with marked interstitial fibrosis and tubular atrophy, the graft may not function well from the beginning and graft loss may develop rather quickly, as noted in 1 case (case 6). Although other factors contributing to this rapid progression, including hypertension in both donor and recipient, are possible, it is noted that only DN with progressive interstitial fibrosis and tubular atrophy is noted in both the postperfusion biopsy and the 2 follow-up biopsies in this case. For cases with milder postperfusion DN, graft dysfunction including heavy proteinuria (1/11 cases) and significant attenuation of graft function (serum creatinine >2 mg/dL, 5/11 cases) often develop even during a relatively short follow-up. In these latter cases, the pathogenetic role of postperfusion DN remains to be determined, and changes other than DN may also be important. Indeed, although only DN was noted in follow-up biopsies of 2 cases (cases 7 and 11), other lesions including transplant glomerulopathy, polyomavirus nephropathy, glomerulitis, focal segmental glomerulosclerosis, and rejection were also noted in the follow-up biopsies of other cases.

In summary, although diabetes is frequent in kidney donors, donor-related DN is unusual. It is observed only in deceased donors, but the risk factors for its development are not known. Donor-related DN may be stable or progress. Whether it resolves, especially for DN in early phase, remains unknown. It may adversely impact the graft outcome with a magnitude proportional to the severity of the tissue injury in the postperfusion biopsies.

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