Influence of renal transplantation and living kidney donation on large artery stiffness and peripheral vascular resistance

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Abstract

BACKGROUND: Vascular status following renal transplantation (RT) may improve while living kidney donation (LKD) is possibly associated with an increased cardiovascular risk.

METHODS: We prospectively assessed glomerular filtration rate (mGFR, ^{51}Chrome EDTA clearance) and intermediate vascular risk factors in terms of blood pressure (BP), pulse wave velocity (PWV), central augmentation index (AIx), excess pressure (P_{excess}) and forearm vascular resistance in donors (n=58, 45±13 years) and recipients (n=51, 50±12 years) before and one year following LKD or RT.

RESULTS: After kidney donation mGFR decreased by 33% to 65±11 ml/min/1.73m^2 while recipients obtained a mGFR of 55±9 ml/min/1.73m^2. Ambulatory 24-hour mean BP (MAP) remained unchanged in donors but decreased by 5 mmHg in recipients (P<0.05). Carotid-femoral PWV increased by 0.3 m/s in donors (P<0.05) but remained unchanged in recipients. AIx was unaltered after LKD but decreased following RT (P<0.01) while P_{excess} did not change in either group. Resting forearm resistance (R_{rest}), measured by venous occlusion plethysmography, increased after LKD (P<0.05) but was unaffected by RT, while no changes were seen in minimum resistance (R_{min}). ΔPWV showed a positive linear association to Δ24-hour MAP in both groups. Multiple linear regression analysis (adjusting for age, gender and the baseline value of the studied parameter) did not detect independent effects of graft function on 24-hour MAP, PWV, AIx, vascular resistance or P_{excess}, whereas low post-donation GFR was related to higher AIx and R_{rest}.

CONCLUSIONS: RT reduced BP and AIx without affecting PWV whereas LKD resulted in increased PVW and R_{rest}, despite unchanged BP.

Key words: Living kidney donation, Renal transplantation, Renal recipients, Blood pressure, Pulse wave velocity, Vascular resistance.

Introduction

Renal transplantation is the optimal treatment for end stage renal disease (ESRD), but after transplantation recipients still have markedly higher mortality rate due to cardiovascular diseases. Meanwhile, it is still uncertain whether the decline in renal function after kidney donation is associated with more cardiovascular disease.[1,2]

Accelerated vascular calcification is very frequent in ERSD and the increased vascular stiffness, usually assessed by pulse wave velocity (PWV), is an important predictor of cardiovascular events and mortality.[3] Endothelial dysfunction, elevated peripheral and central blood pressure (BP) and cardiac surplus work could contribute to this.[4,5] The latter can be assessed by the integral of aortic reservoir characteristics in terms of excess pressure (P_{excess}).[6] The resistance circulation may also be important and in essential hypertension small artery structural remodeling predicts cardiovascular events.[7,8] The structural design of the peripheral circulation affects central hemodynamics by impacting reflection of the forwarded pulse wave.[9] Despite this knowledge, effects of renal transplantation or kidney donation on peripheral resistance has never been examined.

Studies on vascular effects of kidney transplantation and donation have focused on large artery properties and central hemodynamics and PWV is reported to decrease following transplantation, partly due to improved BP regulation.[10-12] Data from living kidney donors are still sparse. One study suggested worsening of aortic stiffness and increased left ventricular mass,[13] whereas another did not detect changes.[14] To which degree renal function post-transplantation or post-donation influences these vascular parameters is unknown.

Our working hypothesis is that renal transplantation improves BP, PWV and central hemodynamics and possibly reduces vascular resistance, whereas kidney donation has the opposite effects. We also hypothesize that any changes in these parameters are determined by the renal

function achieved following transplantation or donation. In a prospective study we therefore

evaluated the effects of renal transplantation and living kidney donation on ambulatory BP, large artery stiffness, non-invasive central hemodymanic parameters and peripheral vascular resistance and analyzed to which degree these factors were influenced by the achieved glomerular filtration rate (GFR) after one year.

Methods and materials

Participants and study protocol

The study was approved the ethics committee for Central Denmark Region and all participants signed an approved consent form before entering the study. During a period of 33 months eligible recipients and their corresponding kidney donors were asked to take part in the study. Besides determination of GFR, the protocol consisted of ambulatory BP measurements (ABPM), determination of PWV, central BP, augmentation index (AIx) and excess pressure integral (P_{excess}) in addition to resting and minimal forearm vascular resistance as explained below (**Fig. 1**). Fifty-eight recipients and 52 of their donors participated in the baseline investigations as 6 donors declined to participate. One transplantation was cancelled due to improvement of renal function and one recipient died 6 months after the transplantation with a functioning graft. Another 5 recipients declined to take part in the one-year investigations leaving data from 51 recipients and 51 donors for follow-up.

Glomerular filtration rate

A standardized chromium 51-labelled EDTA (^{51}Cr-EDTA) plasma clearance was performed for GFR measurements (mGFR) in donors at baseline and follow-up and in recipients at follow-up. Three hours after injection of the tracer, venous blood samples were obtained 5 times with 30-minute intervals for subsequent measurement of radioactivity and calculation of ^{51}Cr-EDTA clearance.

Ambulatory blood pressure

Twenty-four-hour ABPM was performed with Spacelab Medical 90217 BP monitors (Spacelab Healthcare, Issaquah, WA, USA) every 20 min during daytime (0700-2300 h) and at night (2300-

0700 h). ABPM were accepted if at least 17 successful daytime and at least 7 night-time readings were available.

Pulse wave velocity

Carotid-femoral PWV was measured using arterial tonometry as previously described using the SphygmoCor equipment and software (version 8.2, AtCor Medical, Sydney, Australia) with assessment of the carotid-femoral path distance in accordance with current consensus.[5,15]

Estimated central blood pressure, augmentation index and excess pressure integral

Radial waveforms were also recorded using the SphygmoCor device and central BP and AIx was estimated by the generalized transfer function and based on calibration with the brachial cuff pressure measured with an automatic device (BP A100 PLUS; Microlife, Widnau, Switzerland). AIx was normalized to a heart rate of 75 beats per min (AIx_75). The central arterial waveforms were exported to Matlab for analysis and calculation of P_{excess} using customized programs as previously described in detail.[6]

Forearm blood flow and vascular resistance

Determination of forearm blood flow at rest and following maximal vasodilation after 10 min of hyperemia was done as explained previously using classic venous occlusion plethysmography.[16] In recipients with an arterio-venous dialysis fistula the measurements were conducted on the opposite extremity. Analysis of the plethysmography flow curves was performed using the software program NIVP3 Arterial Inflow Studies (Hokanson, Bellevue, WA, USA) with blinding of the status of the subject being analyzed (recipient or donor, baseline or follow-up). Vascular resistance at rest (R_{rest})

and at maximal hyperemia (R_{min}) was calculated as mean arterial pressure (MAP, diastolic BP plus one third of the pulse pressure) divided by forearm resting and hyperemic flow respectively.

Statistical evaluation

Data are given as means with standard deviations (SD) or median with 25 and 75% or 5 and 95% confidence intervals. R_{min} values were log transformed. First clinical characteristics of the recipients and donors were compared at baseline and within each group from baseline to follow-up using a paired *t*-test or the non-parametric Wilkinson rank-sum test as appropriate. Then the effect of transplantation or donation on the predefined primary study parameters (24-hour MAP, PWV, AIx_75, estimated central systolic BP, P_{excess}, R_{rest} and log R_{min}) was tested by comparing baseline and follow-up values. Next, we evaluated the influence of the achieved renal function (ie. mGFR at follow-up) on each of the primary study parameters at follow-up using multiple linear regression analysis adjusting for age, gender and the baseline value of the primary study parameter. In addition, PWV and P_{excess} was adjusted for 24-hour MAP. Furthermore, we adjusted for baseline mGFR in donors, but not in recipients as any residual renal function was not measured. A sensitivity analysis was done by further adjustments for diabetes, body mass index (BMI), number of antihypertensive drugs and blood tacrolimus concentration. Finally, results of linear associations were given by Pearson´s correlation coefficient. Analyses were performed using GraphPad Prism 5 (San Diego, CA, USA) and STATA 13 (StataCorp LP, Collage State, TX, USA).

Results

Characteristics of participants

Clinical characteristics, 24-hour ABPM and medication of recipients and donors at baseline and follow-up are shown in **Table 1**. Fifteen recipients received a kidney from their spouse, 14 from a sibling and 13 from a parent while the remaining kidneys were from more distant family or unrelated friends. All recipients examined at follow-up had a functioning graft.

Among the recipients approximately one third were pre-dialysis (2 of these had a renal graft) while the remaining received dialysis (7 of these with a non-functioning graft). Kidney transplantation did not significantly alter BMI but there was an improvement in 24-hour systolic and diastolic BP despite less antihypertensive medication. However, 63% still had hypertension when defined as daytime systolic BP ≥135 mmHg and/or diastolic BP≥85 mmHg. At follow-up all recipients received tacrolimus (mean trough blood concentration 6.4±2.0 μg/ml) and mycophenolate mofetil and only few had discontinued steroid treatment.

In donors, mGFR decreased on average by one third. A few of the donors received one antihypertensive medication at baseline and follow-up, but there was no change in ABPM one year after kidney donation. However, using the definition given above 32% of donors had mild hypertension.

mGFR

Fig. 2A depicts mGFR in recipients at follow-up divided into tertiles. Likewise, **Fig. 2B** shows mGFR at baseline and follow-up in donors divided into tertiles based on their follow-up mGFR. The reduction in mGFR was not significantly different between the 3 tertiles (***P***=0.33, one-way ANOVA). The corresponding age of the recipients and donors based on tertiles of mGFR at follow-

up is given in **Fig. 3**. The oldest donors achieved the lowest mGFR at follow-up ($P<0.01$), while there was no effect of recipient age on mGFR ($P=0.38$).

Primary endpoints

Table 2 gives absolute values and changes in the defined primary endpoints in recipients as well as donors. At baseline before transplantation 24-hour MAP, PWV and estimated central systolic BP were higher in recipients as compared to donors, while there were no differences in AIx_75, P_{excess}, R_{rest} or R_{min}.

Among the recipients there were significant reductions in 24-hour MAP, estimated central systolic BP and AIx_75, whereas PWV, P_{excess}, R_{rest} and R_{min} remained unchanged. In the donors, PWV and R_{rest} increased significantly, while 24-hour MAP, estimated central systolic BP, AIx_75, P_{excess} and R_{min} were unchanged. When comparing changes in the primary parameters, only the change in AIx_75 was significantly different between recipients and donors.

Primary endpoints in relation to mGFR at follow-up

Table 3 shows results from the multiple linear regression analysis relating mGFR at follow-up to the primary study parameters. After adjustment for age, gender and the baseline value, achieved graft function was not related to any of the parameters. In donors, however, renal function one year after donation significantly affected Aix_75 and R_{rest} which decreased with 2.1% and 11.9 R-units respectively for every 10 ml/min/1.73 m^2 increment in mGFR. Also 24-hour MAP after one year seemed dependent on renal function but with a small increase of 2 mmHg for every 10 ml/min/1.73 m^2 increment in mGFR. Sensitivity analyses were performed with both unadjusted and adjusted models. Further adjustments including the number of antihypertensive drugs, BMI, diabetes and blood tacrolimus concentrations did not change the results.

Correlations

Fig. 4 illustrates linear associations between changes in 24-hour MAP and changes in PWV from baseline to follow-up in recipients (**Fig. 4A**) and donors (**Fig. 4B**) and in both groups there was a significant positive correlation. The association between changes in 24-hour MAP and changes in AIx_75 is demonstrated for recipients in **Fig. 4C** and for donors in **Fig. 4D**. These parameters were significantly positively correlated in recipients, but with evidence for a negative correlation in donors.

A significant negative association was noticed between the blood tacrolimus concentration and mGFR (R^2=0.10, ***P***=0.03, data not shown). However, the tacrolimus concentration was not associated with either PWV, AIx_75, R_{rest}, R_{min} and excess pressure integral or with changes in these parameters from baseline to follow-up.

Discussion

This is the first study to report both on large artery stiffness and peripheral vascular resistance in renal transplant recipients as well as living kidney donors. The results confirmed our hypothesis of improved BP and lower AIx regulation following transplantation, but no significant alterations in PWV or forearm vascular resistance was observed. Despite unchanged BP in donors, PWV and R_{rest} increased. In recipients, arterial stiffness, central hemodynamics and vascular resistance at one year of follow-up did not seem to be influenced by the achieved graft function. In donors, a lower residual renal function at one year of follow-up was associated with higher AIx and R_{rest}.

Renal transplant recipients

Despite lowering of BP and achievement of good graft function we only detected a small and non-significant reduction in PWV which is different from some previous investigations demonstrating a decrease in vascular stiffness.[10,11,17-19] Direct comparisons of absolute carotid-femoral PWV values between studies are difficult, especially due to variations in measurements of the path length between the two probes but also due to the use of different devices. Using the same device and a similar calculation method for determination of carotid-femoral distance as a recent French study,[19] our recipients had considerably lower PWV values despite comparable age and BP levels. This suggests that the degree of improvement in PWV is dependent on the pre-transplantation level. Our finding is in agreement with the study by Ignace ***et al.*** showing that a decrease in PWV is most pronounced in recipients above 50 years of age.[11] Nevertheless, PWV continues to be an important prognostic factor for mortality, cardiovascular events and loss of graft function during the transplantation period.[20-23] A recent study pointed out that the initial BP-dependent de-stiffening of aorta following renal transplantation may later be counterbalanced by overactivation of the immune system.[12] Our finding that two thirds of recipients still had hypertension, and that reductions in

PWV and ambulatory BP are related, suggests more caution concerning withdrawal of antihypertensive medication and use of AMBP to secure optimal BP control.

Central AIx is often considered a marker of pulse wave reflection, but is influenced by many factors including gender, age, height, BP, cardiac output, PWV and peripheral resistance[24,25] and negative values of AIx should be interpreted with caution.[26] In addition, vasodilatory antihypertensive medications such as angiotensin converting enzyme inhibitors or calcium channel blockers tend to reduce heart rate-standardized AIx more than beta-blockers.[27,28]. The reduction in AIx following transplantation was associated with the decrease in ambulatory BP and in so far AIx is considered a predictor of cardiovascular events in ESRD patients[29] this finding further supports normalization of BP following transplantation. Although the recipients seemed to attain a central BP very similar to that of the donors this should be interpreted with caution as estimated central systolic BP in CKD patients may be substantially lower than the true invasively measured aortic systolic BP.[5] As this is partially explained by the CKD-related elevation of PWV, central BP could still be inappropriately high in the recipients as vascular stiffness remained elevated. Central BP waveform indices may independently predict end-organ damage and excess pressure (P_{excess}), an integral of aortic reservoir characteristics reflecting the surplus work performed by the heart in each cardiac cycle, has been associated with cardiovascular outcome in essential hypertension[6] and end stage renal disease,[30] but this parameter seemed unaffected by transplantation as well as donation.

Regardless of considerably increased BP before transplantation, the recipients did not have elevated forearm vascular resistance, either at rest or during maximal vasodilation. This finding is in accordance with another recent study from our department[31] but differs from findings in persons with untreated essential hypertension who display elevated R_{rest} and R_{min} due to structural resistance artery remodeling.[32,33] This discrepancy may be explained by ongoing extensive vasodilating antihypertensive therapy among the recipients in terms of renin-angiotensin and

calcium channel blockade inhibiting arterial inward structural narrowing.[34,35] But even with the reduction in vasodilatory treatment after transplantation R_{rest} and R_{min} remained unaltered. These observations suggest other factors than resistance artery vasoreactivity and structure are involved in hypertension of ESRD. Probably sodium and fluid retention increasing cardiac output are important factors and ultrafiltration during hemodialysis not only lowers BP and PWV, but also AIx.[36]

Graft function during the first year is influenced by numerous factors including perioperative circumstances, acute rejections and tacrolimus concentrations. These circumstances may explain why changes in PWV, and vascular resistance were not related to GFR in recipients after 12 months. Possibly many years of follow-up could detect beneficial effects of sustained good graft function on vascular parameters.

Living kidney donors

Despite unchanged ambulatory BP in the donor population, a slight increase in aortic stiffness was evident after one year. A reduction in aortic distensibility was also recently reported by Moody *et al.* in the Chronic Renal Impairment in Birmingham (CRIB)-Donor study,[13] whereas no significant changes were observed in another study.[14] Small reductions in aortic reservoir function together with higher peripheral resistance may partly explain the increase in left ventricular mass observed in the CRIB-Donor study.[13]

The positive association between Δ24-hour MAP and ΔAIx_75 in recipients and the tendency for a negative association in donors suggests that differential factors influence AIx in the 2 groups. This finding possibly reflects that elimination of excess fluid is an important cause of BP lowering and AIx reduction in recipients while this is not the case in donors.[36,37] P_{excess} has been associated with declining renal function among healthy individuals,[38] but among our donors P_{excess} was not associated with residual renal function after 1 year.

Our data show that donors with low post-donation GFR experience an increase in R_{rest}. Whether this warrants evaluation of peripheral vascular resistance in potential living kidney donors must await more studies. The large CRIB-Donor data set[13] as well as our results demonstrate worsening of intermediate risk factors such as left ventricular mass, large artery stiffness and peripheral vascular resistance without significant alterations in ambulatory BP implying that assessment of BP may not be a sufficient long-term monitoring parameter in living kidney donors. Further studies, including invasive measurements of aortic BP in living kidney donors are needed to elucidate which donors are at increased risk.

Strengths and limitations

Important strengths of the present study are use of 24-hour ABPM which are more reliable than office readings for diagnosing hypertension in renal transplant patients.[39,40] Furthermore, the use of ^{51}Cr-EDTA plasma clearance provides a better assessment of GFR as compared to estimated GFR as used in the majority of studies. Also, a sample size of about 50 in each group allow us to detect small changes in PWV. However, as most recipients were men the possibility to detect differences between gender is limited. As systematic echocardiography was not performed the impact of changes in PWV and vascular resistance on cardiac function remains unknown in the present study. Finally, we addressed multiple risk factors with multivariate analyses and therefore cannot exclude the possibility of false positive findings.

Conclusions

ESRD patients awaiting renal transplantation had increased ambulatory BP levels and carotid-femoral PWV but normal values of AIx, P_{excess} and peripheral vascular resistance. Successful renal transplantation with a living donor decreased AIx without significantly reducing PWV. However,

changes in both parameters were dependent on changes in ambulatory BP illustrating the importance of BP control after transplantation. Living kidney donors, on the other hand, had significant increases in PWV and forearm R_{rest} after donation which could potentially contribute to accelerated vascular damage.

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Text for figures

Figure 1

Flow chart describing the fate of the invited donor-recipient pairs and the investigations performed at baseline and after 12 months of follow-up. mGFR, measured glomerular filtration rate; ABPM, 24-hour ambulatory blood pressure measurement; PWV, pulse wave velocity; CBP, central blood pressure; AIx; augmentation index; P_{excess}, excess pressure integral; R_{rest} and R_{min}, forearm resting and minimum vascular resistance.

Figure 2

Tertiles (from low to high) of measured glomerular filtration rate (mGFR) at one-year follow-up in renal transplant recipients (**A**) and in living kidney donors (**B**). In donors the corresponding baseline mGFR and reduction from baseline (**C**) is also shown. ***P*<0.01 as compared to baseline. The reduction in mGFR was not significantly different between the 3 tertiles (*P*=0.33, one-way ANOVA).

Figure 3

Mean age of renal transplant recipients and living kidney donors according to tertiles of measured glomerular filtration rate (mGFR) at follow-up. The oldest donors achieved the lowest mGFR at follow-up (*P*<0.01, one-way ANOVA), while there was no effect of recipient age on mGFR (*P*=0.38).

Figure 4

Linear correlations between changes in 24-hour mean arterial blood pressure (MAP) and changes in carotid-femoral pulse wave velocity (PWV) and central augmentation index (AIx_75) from baseline and follow-up. In renal transplant recipients Δ24-MAP correlated significantly to ΔPWV (R^2=0.24, P<0.01) and ΔAIx_75 (R^2=0.28, P<0.01) (**A** and **C**). In living kidney donors Δ24-MAP correlated to ΔPWV (R^2=0.15, P<0.01) but not to AIx_75 (R^2=0.072, P=0.063) (**B** and **D**).

Disclosures

The authors have no disclosures.

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Table 1

Characteristics of kidney transplant recipients and living donors at baseline and follow-up.

	Recipients		**Donors**	
	Baseline	*Follow-up*	*Baseline*	*Follow-up*
N	58	51	52	51
Males (%)	76	76	46	45
Age (years)	44.7 ± 13.4	45.2 ± 12.8	49.5 ± 12.0	51.0 ± 11.6
BMI (kg/m^2)	24.3 ± 3.1	25.0 ± 3.7	25.8 ± 3.4	26.0 ± 3.8
Active smokers (%)	19	14	29	29
Diabetes (%)	12	12	0	0
CKD status (%)				
Pre-dialysis[a]	36	0	0	0
Dialysis (HD/PD)[b]	53 / 12	0	0	0
mGFR (ml/min/1.73 m^2)	n.d.	55.3 ± 15.4	100.6 ± 14.9	64.7 ± 10.6††
UAC (mg/g, median [range])	n.d.	20 [2; 3473]	0 [0; 52]	0 [0; 55]
P-cholesterol (mmol/l)	4.5 ± 1.1	n.d.	5.1 ± 0.8	n.d.
Ambulatory BP				
24-h systolic BP (mmHg)	139 ± 20**	131 ± 11††	120 ± 14	119 ± 13
24-h diastolic BP (mmHg)	85 ± 13**	81 ± 8††	74 ± 8	74 ± 8
24-h heart rate (min^{-1})	74 ± 10	74 ± 9	71 ± 8	70 ± 10
Antihypertensive drugs (%)				
ACE-I or ARB	71	24	6	6
Beta receptor blocker	57	45	2	2
Calcium channel blocker	67	47	4	6
Diuretics	48	14	4	4
Other	26	10	0	0
Immunosuppressive drugs (%)				
Calcineurin inhibitor	9	100	0	0
Antimetabolites	3	100	0	0

Steroids	9	90	0	0
Other	2	0	0	0

*P<0.05 and **P<0.01 *vs.* donors at baseline. †P<0.05 and ††P<0.01 *vs.* baseline.

ACE-I, angiotensin converting enzyme inhibitor; ARB, angiotensin II receptor blocker; HD, hemodialysis; PD, peritoneal dialysis; n.d.: not done.

[a)]estimated GFR < 15 ml/min/1.73 m^2 but not receiving dialysis; [b)]one recipient received both HD and PD.

Table 2

Primary study endpoints: 24-hour mean arterial blood pressure (MAP), carotid-femoral pulse wave velocity (PWV), estimated central systolic BP, central augmentation index (AIx_75), excess pressure integral and forearm resting (R_{rest}) and minimum (R_{min}) vascular resistance in kidney transplant recipients and donors at baseline and follow-up one year after transplantation.

	Recipients			**Donors**		
	Baseline	*Follow-up*	*Δ*	*Baseline*	*Follow-up*	*Δ*
24-hour MAP (mmHg)	102 ± 15‡	97 ± 8*	-5 [-9; 0]	90 ± 9	89 ± 8	-1 [-2; 1]
Carotid-femoral PWV (m/s)	8.7 ± 2.0‡	8.5 ± 2.2	-0.1 [-0.6; 0.4]	7.5 ± 1.3	7.8 ± 1.6*	0.3 [0.1; 0.6]
Central systolic BP (mmHg)	127 ± 21‡	118 ± 16*	-8 [-14; -2]	117 ± 15	115 ± 15	-2 [-5; 0]
AIx_75 (%)	16.1 ± 12.6	12.6 ± 14.4**	-3.5 [-6.0; -1.0]†	19.7 ± 12.8	19.8 ± 12.6	0.1 [-1.4; 1.6]
Excess pressure (mmHg s)	5.6 ± 3.1	5.1 ± 2.5	-0.5 [-1.3; 0.2]	5.0 ± 1.8	4.7 ± 1.8	-0.3 [-0.6; 0.04]
Forearm resistance (R units)	45 ± 18	47 ± 22	2 [-6; 10]	51 ± 21	63 ± 29*	12 [2; 21]
R_{rest}	0.51 ± 0.17	0.47 ± 0.12	-0.04 [-0.08; 0.01]	0.52 ± 0.15	0.54 ± 0.17	0.02 [-0.02; 0.06]
Log R_{min}						

Changes (Δ) are given as mean with 95% confidence intervals. Only the participants with measurements both at baseline and follow-up are included in the table. *P<0.05 and **P<0.01 follow-up compared to baseline. †P<0.05 change in recipients as compared to change in donors. ‡P<0.01, recipients at baseline compared to donors at baseline.

Table 3

Association between glomerular filtration rate (mGFR) at follow-up and primary study parameters in kidney transplant recipients and donors using multiple linear regression analysis.

	Recipients	**Donors**
24-hour MAP	-1 (-3; 2) (*P*=0.10)	2 (1; 4) (*P*=0.006)
(mmHg) Carotid-femoral PWV (m/s)	-0.2 (-0.5; 0.1) (*P*=0.21)	0.0 (-0.4; 0.3) (*P*=0.91)
Central systolic BP (mmHg)	1 (-1; 4) (*P*=0.31)	0 (-0.3; 3) (*P*=0.89)
AIx_75 (%)	0.1 (-1.6; 1.4) (*P*=0.92)	-2.1 (-4.0; -0.2) (*P*=0.03)
Excess pressure (mmHg s)	0.010 (-0.42; 0.44) (*P*=0.96)	0.16 (-0.20; 0.52) (*P*=0.38)
Forearm resistance (R units)	0.2 (-4.4; 4.9) (*P*=0.92)	-11.9 (-22.4; -1.4) (*P*=0.03)
R_{rest}	0.0006 (-0.02; 0.02) (*P*=0.96)	0.008 (-0.04; 0.05) (*P*=0.75)
Log R_{min}		

Adjustment was performed for age, gender and the baseline value of the study parameter. Values in donors were also adjusted for baseline mGFR and in addition PWV and excess pressure integral was adjusted for 24-hour MAP. The results are presented as β-coefficients (with 95% confidence intervals) per 10 ml/min/1.73 m^2 increase in mGFR. Only participants with relevant measurements both at baseline and follow-up are included in the table.

Figure 1

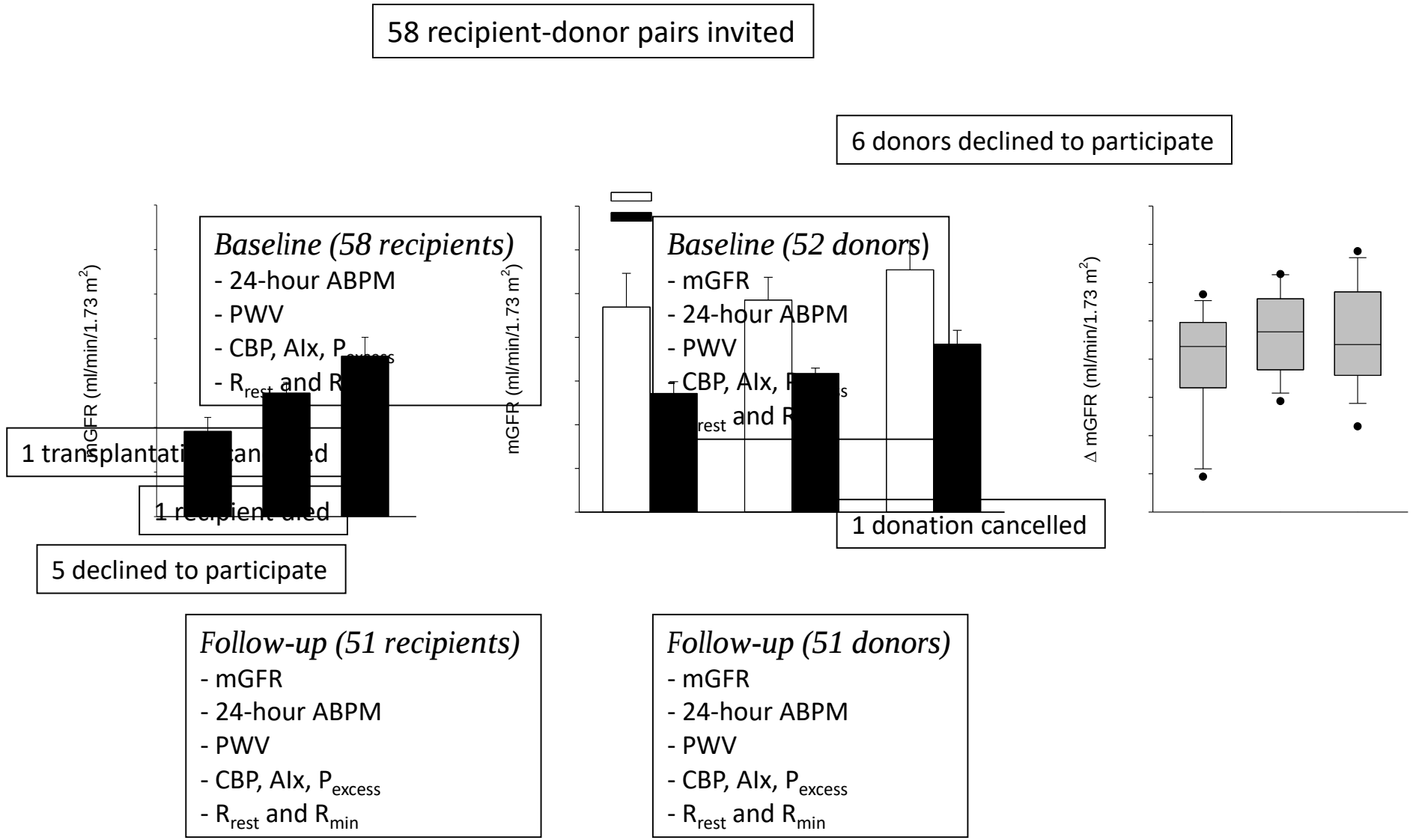


Figure 2

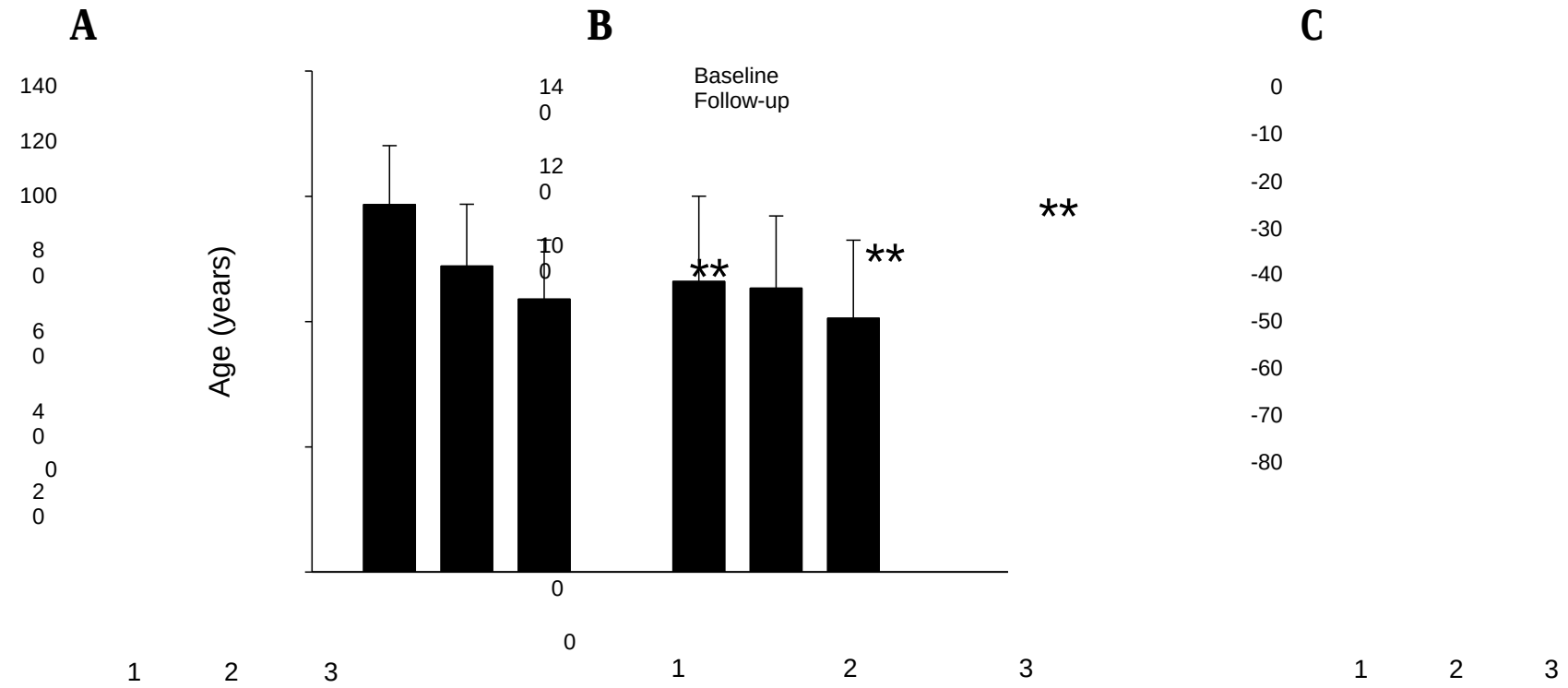


Figure 3

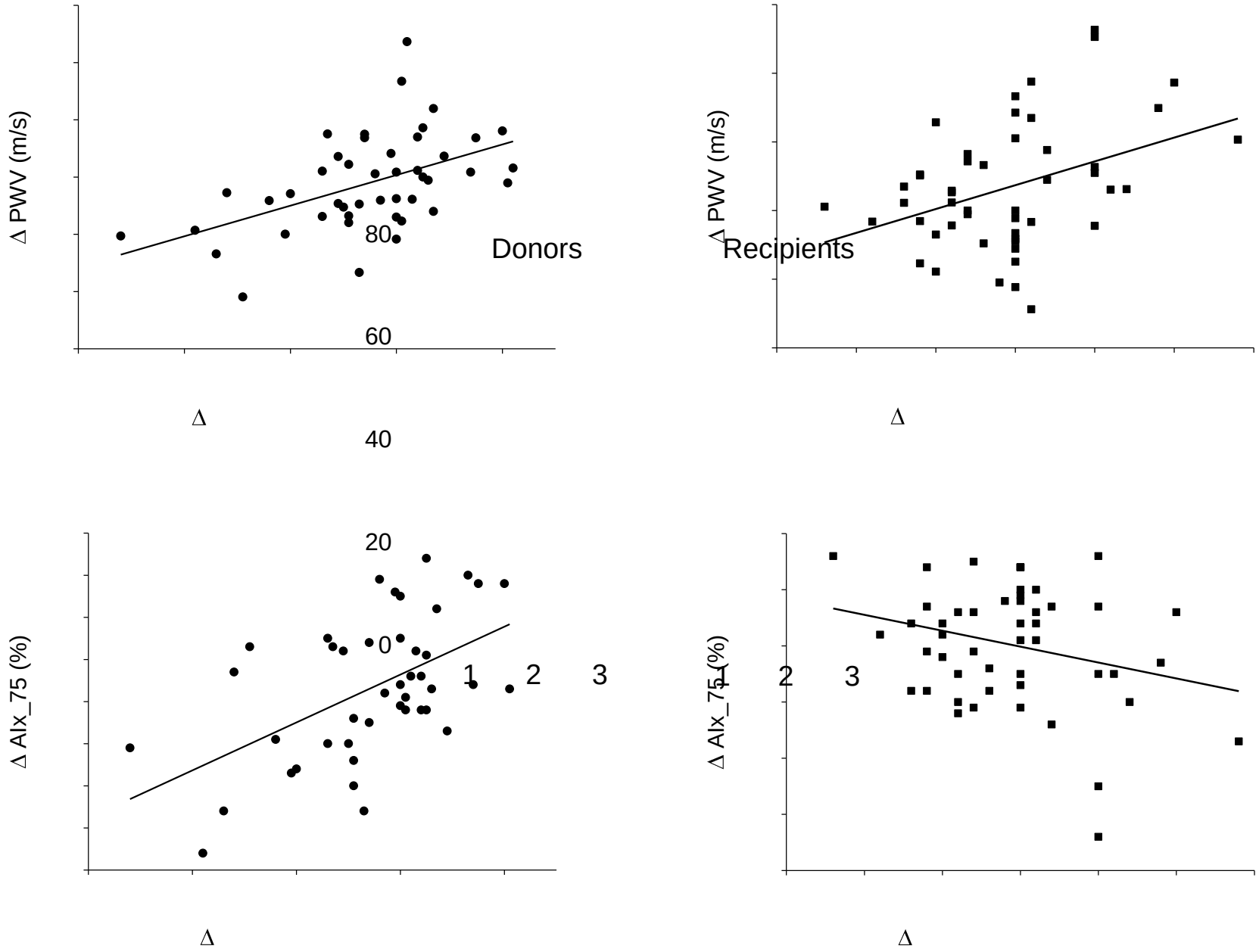


Figure 4

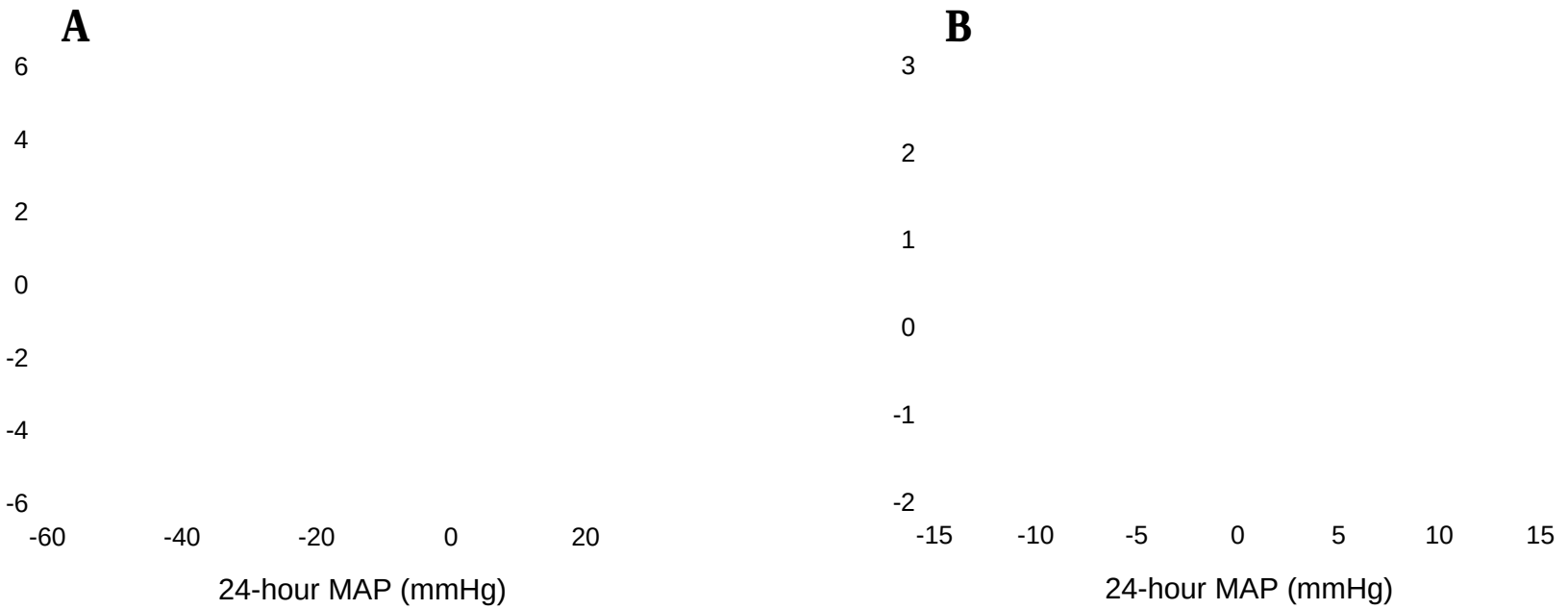
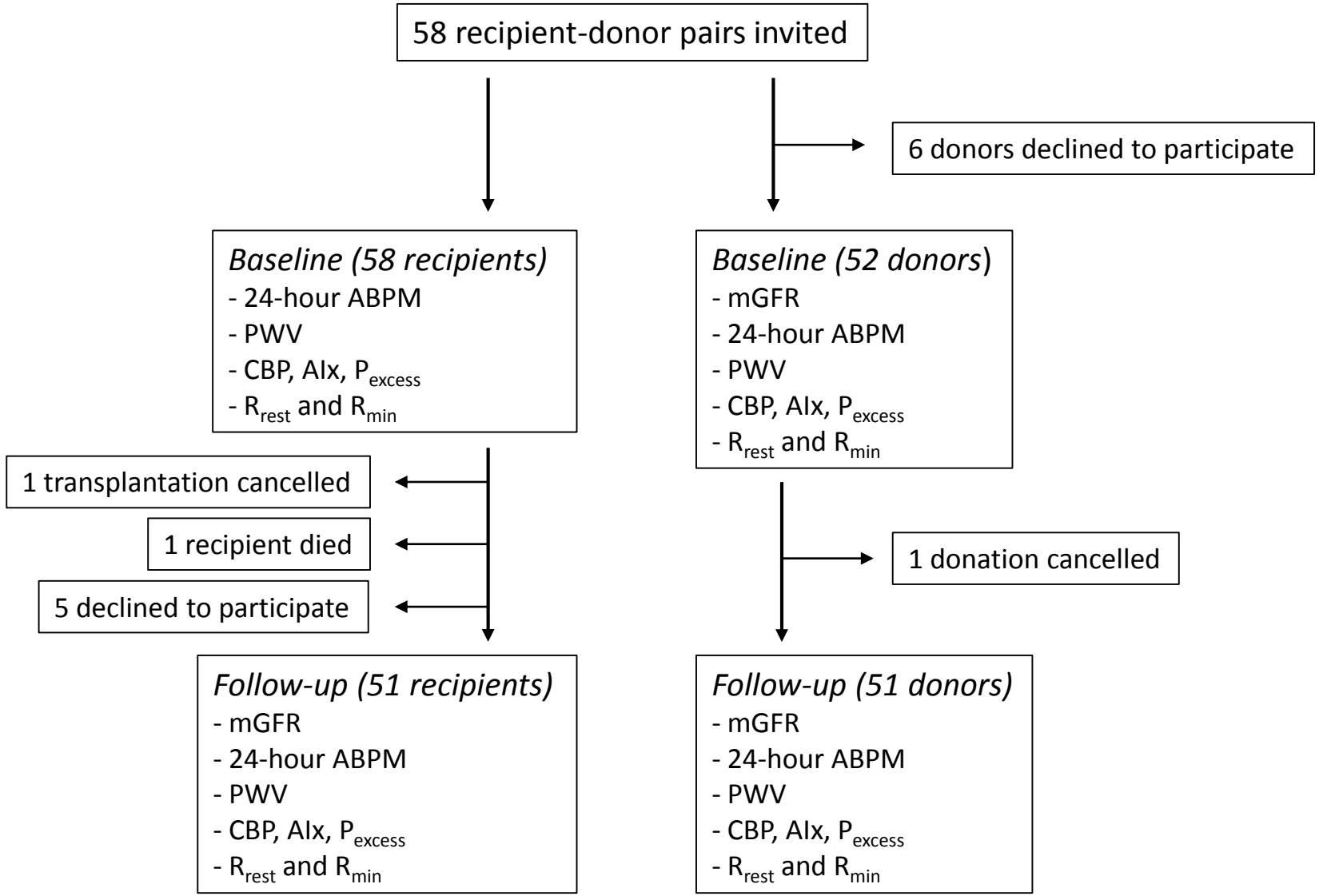

A
6
4
2
0
-2
-4
-6
-60
-40
-20
0
20
24-hour MAP (mmHg)
B
3
2
1
0
-1
-2
-15
-10
-5
0
5
10
15
24-hour MAP (mmHg)
C
15
10
5
0
-5
-10
-15
-20
-25
-60
-40
-20
0
20
24-hour MAP (mmHg)
D
10
5
0
-5
-10
-15
-20
-15
-10
-5
0
5
10
15
24-hour MAP (mmHg)

Figure 1



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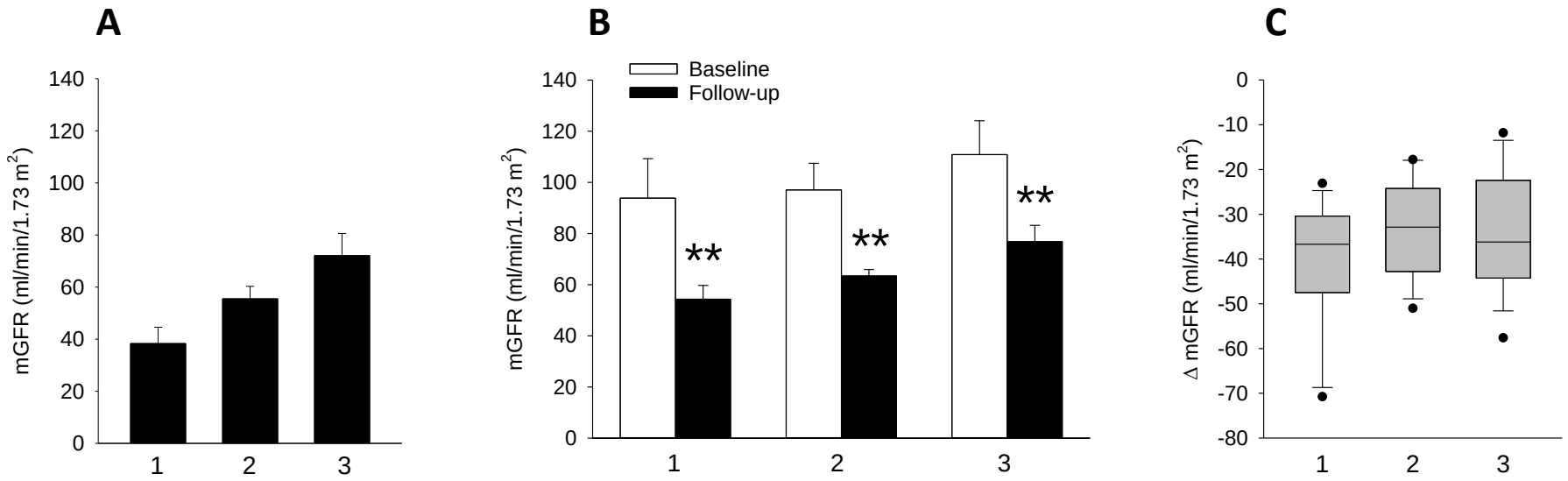

Figure 3

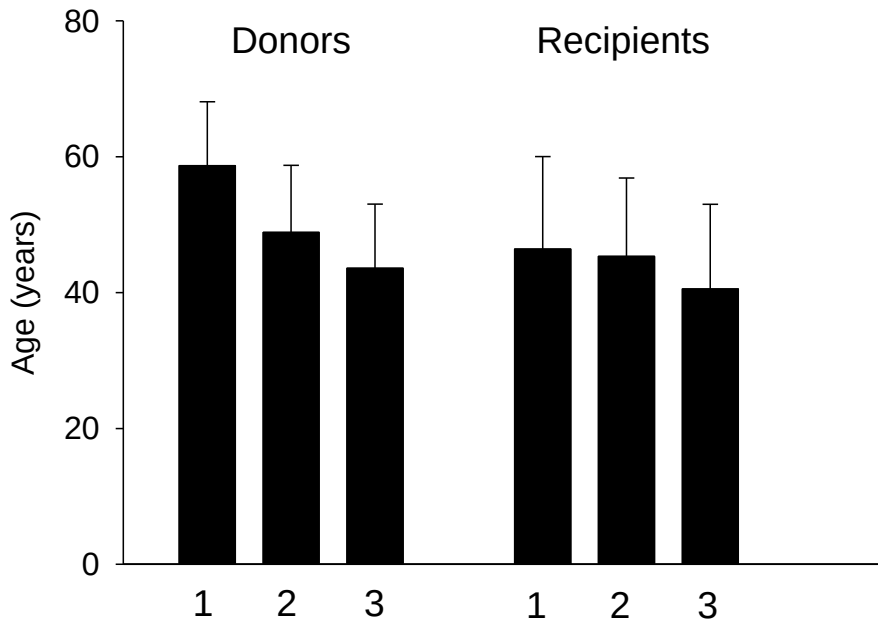

Figure 4