

# Outcomes of kidneys utilized from deceased donors with severe acute kidney injury

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## Summary

**Background:** Significant numbers of kidneys are discarded due to raised terminal creatinine of the donor.

**Aim:** To determine long-term outcomes of kidneys utilized from donors with severe acute kidney injury (AKI).

**Methods:** In this retrospective study, we included all patients who received kidneys from deceased donors between years 2000 and 2012. AKI was defined according to the acute kidney injury network (AKIN) classification. The primary outcomes were patient and graft survival and secondary outcomes were renal function at different time points, delayed graft function, acute rejection and length of hospital stay.

**Results:** Two hundred and eighty-four recipients received kidneys from 261 deceased donors. One hundred and fourteen patients (40%) received kidneys from the donors with AKI. Forty-two patients received kidneys from the donors with severe AKI

(AKIN-3 category). Mean age of the donor and recipient was 36 and 37 years, respectively. Main cause of death in donors was road traffic accident (34%) followed by cerebrovascular accident (33%). Terminal creatinine was 85 and 262  $\mu\text{mol/l}$  in non-AKI and AKI groups, respectively ( $P < 0.001$ ). Significantly more patients in the AKI group had delayed graft function ( $P = 0.006$ ), prolonged hospital stay ( $P < 0.001$ ) and high creatinine at discharge ( $P = 0.002$ ). However, acute rejection rates ( $P = 0.25$ ), 1-, 5- and 10-year graft survival ( $P = 0.57$ ) and patient survival ( $P = 0.77$ ) were not different between AKI and non-AKI groups. The outcomes in the AKIN-3 category were comparable with the non-AKI group.

**Conclusions:** This study has shown favorable long-term outcomes of kidneys utilized from donors with severe AKI. This study may encourage healthcare professionals to consider accepting such kidneys.

## Introduction

There remains a great disparity between demand and supply of the kidneys for patients with end stage renal disease (ESRD). The number of patients waiting for kidney transplant continues to rise<sup>1</sup> and unfortunately, many patients die on the waiting list.<sup>2</sup>

Significant number of kidneys from the deceased donors are discarded due to elevated terminal serum

creatinine.<sup>3</sup> A registry data analysis reported a 7-fold increase in the likelihood of kidney discard if terminal creatinine value was  $>2$  mg/dl compared to creatinine level of  $<1.5$  mg/dl.<sup>4</sup>

It has been shown in the literature that if underlying condition improves, the recovery of renal function from acute kidney injury (AKI) due to acute tubular necrosis (of native kidneys) exceeds 90%.<sup>5</sup>

Similar outcome would be expected from kidneys retrieved from donors with acute tubular necrosis (ATN). However, in the transplanted kidneys, other factors, e.g. cold ischemia time, immunological factors and ischemia reperfusion injury also play a role. Hence, recovery from AKI may not be as straightforward as in the native kidneys.

One small study has shown favorable<sup>6</sup> while the other has shown worse outcomes of using kidneys from donors with AKI.<sup>7</sup> Both these studies included donors with milder forms of AKI and number of patients with AKI was very small.

A larger study of 55 patients showed comparable outcomes at 3 years between the AKI and the non-AKI group.<sup>8</sup> A recent study showed good short-term outcomes by defining AKI by the Acute Kidney Injury Network (AKIN) criteria.<sup>9</sup> Of the 43 patients, only 1 was included in the AKIN-3 category. A large registry data analysis has shown that elevated donor creatinine is not a risk factor for graft loss, however, this study did not use standard AKI definition and there was no knowledge of the trend of renal function of the donors during their hospital admission.<sup>4</sup>

The available evidence mainly comes from small studies,<sup>7,8,10</sup> the majority of the donors in almost all studies had mild AKI or AKI of undetermined severity<sup>6,8,9,11</sup> and most studies looked at the short-term outcomes.<sup>11-14</sup> Only few small studies have used standard definition of AKI<sup>7,9,14,15</sup> and the others larger studies used different AKI definitions which makes it difficult to compare outcomes. The long-term outcomes of utilizing kidneys from the donors with severe AKI as defined by the AKIN system<sup>16</sup> are not known.

We aimed to determine the long-term outcomes of kidney recipients who received kidneys from donors with severe AKI as defined by the AKIN system.

## Methods

In this retrospective study, we include all deceased kidney donors from whom kidneys were utilized between 01 January 2000 and 30 December 2012. These patients received kidneys at King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia. In this center, ~170 kidney transplants are performed every year but the majority of the patients receive kidneys from the living or emotionally related donors. The deceased donor pool is extremely limited; hence, every effort is made to accept kidneys from the deceased donors. The Saudi Center of Organ Transplantation (SCOT)

organization in Saudi Arabia is responsible for deceased donor transplant program.

As we accept kidneys from suitable donors with AKI, we aimed to determine the outcomes of such kidneys in this study.

We interrogated all the medical records, laboratory data and electronic database for each donor and recipient.

## Definitions

### *AKI Group*

AKI was defined according to the AKIN staging system.<sup>16</sup> However, we used only serum creatinine criterion as urine output record was not complete.

Patients with AKI were assigned to one of the following categories of the AKIN staging system.

*AKIN 1:* Where serum creatinine had increased 1.5–1.9 times from the baseline

*AKIN 2:* Where serum creatinine had increased 2–2.9 times from the baseline

*AKIN 3:* Where serum creatinine had increased  $\geq 3$  times from the baseline or serum creatinine increased to  $\geq 354 \mu\text{mol/l}$  or initiation of dialysis.

### *Non-AKI group*

If patients did not fulfill the above criteria they were included in the non-AKI group.

### *Expanded criteria donors*

Expanded criteria donors (ECDs) were defined according to the UNOS definition: any brain-dead donor aged 60 years or older, or a donor aged between 50 and 59 years with two of the following features: history of hypertension, terminal serum creatinine value  $> 1.5 \text{ mg/dl}$  ( $133 \mu\text{mol/l}$ ) or death resulting from a cerebrovascular accident.<sup>17,18</sup>

### *Acute rejection*

Acute rejection was defined as biopsy proven rejection and pathologically categorized according to the Banff 97 classification.<sup>19</sup>

### *Baseline serum creatinine for the donors*

The first normal creatinine on admission ( $< 100 \mu\text{mol/l}$  for females and  $< 110 \mu\text{mol/l}$  for the male patients) was recorded as the baseline creatinine. In 24% of the donors, baseline creatinine was not available, in these patients baseline creatinine values were estimated according to the Kidney Disease Improving Global Outcomes (KDIGO) guidelines.<sup>20</sup>

### *Immunosuppression protocol*

Thymoglobulin (Sanofi) was the main induction agent in the majority (97%) of the patients. First dose was given immediately after implantation. Patients received three doses (1.5 mg/kg/day). After first three doses, subsequent doses were administered (until therapeutic tacrolimus was achieved) according to the absolute lymphocyte count or the CD3 count. All patients received intravenous methylprednisolone (5 mg/kg) at induction. This was followed by a further dose of 80 mg on the first day and then patients were commenced on oral prednisone. The dose was tapered from 80 to 20 mg in the first 7 days. The dose was gradually reduced to 5 mg/day within 6 weeks and continued in the long-term. Mycophenolate mofetil (93% of patients) was started prior to surgery (500 mg orally) upon admission followed by 500 mg twice daily. At discharge, dose was increased to 750 mg twice daily. Tacrolimus (93% of patients) was introduced within 12 h if patient had good urine output, its introduction was delayed for 4–7 days if patient developed delayed graft function.

### **Clinical information**

We recorded the following information for each donor:

Age, weight, cold ischemia time, comorbid conditions, cause of death, 'zero' time biopsy findings, serum creatinine values at various time points during hospital admission, and use of vasopressors.

We recorded the following information for all the recipients:

Patient demographic, comorbid conditions, cause of ESRD, Human leukocyte antigen (HLA) matching with the donor, dialysis modality prior to transplant, type of immunosuppressive agents and length of hospital stay.

### **Outcomes**

Primary outcomes were patient and graft survival (graft loss defined as development of ESRD requiring dialysis or retransplant). These outcomes were studied at 1, 3, 5 and 10 years posttransplantation.

The secondary outcomes were development of delayed graft function (dialysis in the first 7 days post-transplantation), acute rejection in the first year and renal function as determined by serum creatinine values. We recorded serum creatinine values at hospital discharge, 1 month, 6 months, 1 year and yearly thereafter up to 10 years.

### **Statistical analysis**

Data are reported as mean  $\pm$  standard deviation (SD) for continuous variables and as number and

proportion for categorical variables. For categorical variables, groups were compared using the  $\chi^2$  test or Fisher exact test when  $P$  value of  $< 0.05$  were reported significant. Student  $t$  test was used for the continuous variables. Bonferroni correction method was used to adjust for multiple comparisons. Patient and graft survival were estimated by Kaplan–Meier survival analysis.

### **Ethical consideration**

This study was approved by the institution's ethics committee.

### **Results**

A total of 284 recipients received kidneys from 261 donors. None of these kidneys were perfused with a pulsatile perfusion machine. One hundred and fourteen patients (40%) received kidneys from the donors with AKI, 36 recipients were in the AKIN-1, 36 in the AKIN-2 and 42 were included in the AKIN-3 category.

### **Donor characteristics**

#### *Cause of death*

The cause of death was road traffic accident in 34% patients, cerebrovascular accident (CVA) in 33% donors, trauma in 16% and the remainder (18%) died due to various other conditions (Table 1). Road traffic accident was most common cause of death (39%) in the non-AKI group ( $P=0.06$ ), while CVA in the AKI group ( $P<0.001$ ).

#### *Cardiac arrest prior to organ retrieval*

Kidneys were retrieved from 44 (17%) patients after sustaining a cardiac arrest and significantly greater number of them went on to develop AKI ( $P=0.03$ ) (Table 1). Similarly significantly higher number of donors with cardiac arrest were included in the AKIN-3 category ( $P=0.009$ ) compared with the non-AKI group. There was a trend of increasing number of patients with cardiac arrest included in the worsening category of the AKIN groups (12, 27 and 31%, respectively) (Table 1). However, this trend did not reach a statistical significance ( $P=0.21$ . Cochran–Armitage method).

#### *Terminal serum creatinine values*

Mean serum creatinine was 159  $\mu\text{mol/l}$  at the time of harvesting (range, 21–847  $\mu\text{mol/l}$ ) (Table 1). A total of 45 patients received kidneys from the donors with terminal creatinine of  $>250 \mu\text{mol/l}$ . There were 18 recipients who received kidneys from the donors

**Table 1** Donors' characteristics

	All	Non-AKI	AKI	<i>P</i> value	AKIN-1	AKIN-2	AKIN-3	<i>P</i> value*
<i>N</i>	261	160 (61.3)	101 (38.7)		33 (12.6)	33 (12.6)	35 (13.4)	
Mean age (years)	35.7 ± 12.3	35.0 ± 13.0	36.7 ± 11.0	0.18	35.8 ± 11.9	35.2 ± 12.1	39.0 ± 8.7	0.11
Male	229 (87.7)	146 (91.1)	83 (82.2)	0.03	28 (84.8)	25 (75.8)	30 (85.7)	0.35
Weight (kg)	65.2 ± 17.7	64.1 ± 18.3	67.0 ± 16.6	0.14	65.9 ± 16.5	63.3 ± 17.6	71.1 ± 14.9	0.03
Cause of death								
RTA	89 (34.1)	62 (38.8)	27 (26.7)	0.06	9 (27.3)	12 (36.4)	6 (17.1)	0.02
CVA	85 (32.6)	39 (24.4)	46 (45.5)	<0.001	15 (45.5)	12 (36.4)	19 (54.3)	<0.001
Trauma	41 (15.7)	30 (18.8)	11 (10.9)	0.11	4 (12.1)	2 (6.1)	5 (14.3)	0.63
Other	46 (17.6)	29 (18.1)	17 (16.8)	0.86	5 (15.2)	7 (21.2)	5 (14.3)	0.81
Cardiac arrest	44 (16.9)	20 (12.5)	24 (23.8)	0.03	4 (12.1)	9 (27.3)	11 (31.4)	0.009
Vasopressor use	97 (37.3)	59 (36.9)	38 (37.6)	1.00	11 (33.3)	14 (42.4)	13 (37.1)	1.00
ECD <sup>a</sup>	25 (9.6)	12 (7.5)	13 (12.9)	0.19	4 (12.1)	4 (12.1)	5 (14.3)	0.19
Creatinine <sup>b</sup>	159 ± 138	85 ± 28	269 ± 161	<0.001	145 ± 42	205 ± 51	431 ± 155	<0.001

Values in number (%) or mean ± SD. RTA, road traffic accident; CVA, cerebrovascular accident.

\**P* values for AKIN-3 vs. No AKI.

<sup>a</sup>Expanded criteria donor.

<sup>b</sup>Terminal creatinine (μmol/l).

with a terminal serum creatinine >400 μmol/l and 13 patients received kidneys from donors with a terminal creatinine of >500 μmol/l. Two patients received kidneys from dialysis-dependent donors.

### Zero time biopsy

Zero time biopsy data were available for 211 (81%) donors. A total of 55% biopsies showed no significant pathology and 30% showed ATN. Chronic structural changes were present in 15% biopsies. In the non-AKI donors, 66% biopsies were normal, 22% biopsies showed ATN and 12% biopsies showed chronic structural changes. In the AKI group, 37% biopsies were normal, ATN was the main feature in 42% biopsies and 22% biopsies showed chronic changes. Significantly more patients in the AKI group had features of ATN in the biopsies (*P*=0.003).

### Recipient characteristics

There were 284 recipients and the majority (58%) was male with a mean age of 37 years (Table 2). Glomerulonephritis was the leading cause of ESRD (20%), ESRD was due to diabetes in 18% patients and in 34% patient etiology for ESRD was not known. There was no significant difference in the etiology of ESRD between AKI and non-AKI groups and across the AKIN categories (Table 2).

### Outcomes

#### Delayed graft function

Delayed graft function (DGF) was observed in 90 (32%) patients (Table 3). Significantly more patients who received kidneys from donors from the AKI group developed DGF (*P*=0.006). The incidence of DGF was much higher in the AKIN-3 category donors whereby 60% of the patients had DGF (*P*<0.001) (Table 3).

#### Length of stay

The mean length of stay was 9 days in the non-AKI group compared with the AKI group of 12 days (*P*<0.001). The mean length of stay was 13 days in AKIN-3 category (*P*<0.001).

#### Acute rejection

In the first year, 16% of patients developed acute rejection (AR; Table 3). There was no difference in the AR rates between AKI and non-AKI groups (*P*=0.25). A higher number of patients in the AKIN-1 category developed AR (31%) but AR rates in the AKIN-2 and AKIN-3 were low at 11 and 17%, respectively (Table 3).

#### Mean serum creatinine values at follow-up

At the time of discharge, mean serum creatinine in the non-AKI group was lower at 233 μmol/l compared with 306 μmol/l in the AKI group (*P*=0.002) (Table 3). There was trend of higher creatinine values across the AKIN categories with the highest



**Table 2** Recipients' characteristics

	All	Non-AKI	AKI	<i>P</i> value	AKIN-1	AKIN-2	AKIN-3	<i>P</i> value*
Total patient	284	170 (59.9)	114 (40.1)		36 (12.7)	36 (12.7)	42 (14.8)	
Age (years)	36.7 ± 13.8	35.8 ± 13.3	37.9 ± 14.3	0.20	33.6 ± 13.5	39.0 ± 13.6	40.7 ± 14.9	0.03
Male	166 (58.4)	105 (61.7)	61 (53.5)	0.17	17 (47.2)	20 (55.5)	24 (57.1)	0.60
Weight (kg)	63.1 ± 16.3	62.3 ± 17.0	64.2 ± 15.2	0.35	63.2 ± 16.4	63.8 ± 14.9	65.4 ± 14.4	0.30
RRT <sup>a</sup>								
Hemodialysis	219 (77.1)	136 (80.0)	83 (72.8)	0.19	25 (69.4)	28 (77.8)	30 (71.4)	0.29
Peritoneal	41 (14.4)	20 (11.8)	21 (18.4)	0.12	7 (19.4)	7 (19.4)	7 (16.7)	0.43
No dialysis	21 (7.3)	12 (7.1)	9 (7.9)	0.81	4 (11.1)	1 (2.8)	4 (9.5)	0.52
ESRD <sup>b</sup> cause								
Unknown	97 (34.1)	60 (35.3)	37 (32.4)	0.70	11 (30.6)	17 (47.2)	9 (21.4)	0.09
GN <sup>c</sup>	58 (20.4)	35 (20.5)	23 (20.1)	1.00	9 (25.0)	4 (11.1)	10 (23.8)	0.67
Diabetes	51 (17.9)	30 (17.6)	21 (18.4)	0.87	3 (8.3)	5 (13.9)	13 (31)	0.08
Previous transplant	38 (13.4)	26 (15.3)	12 (10.5)	0.28	5 (13.9)	5 (13.9)	2 (4.8)	0.08
Mismatches	5.1 ± 0.9	5.1 ± 0.9	5.1 ± 1.0	0.76	5.1 ± 1.0	5.2 ± 1.1	5.1 ± 1.0	0.97
Cold ischemia ( <i>h</i> )	14.7 ± 7.2	14.2 ± 7.3	15.3 ± 7.1	0.23	15.6 ± 8.7	15.4 ± 6.5	14.9 ± 5.9	0.58
Kidney weight (g)	156.5 ± 35.5	151.0 ± 31.6	164.0 ± 39.1	0.006	165.0 ± 37.5	156.8 ± 50.9	168.9 ± 28.3	0.002

Results shown in numbers and (%) or mean ± SD where appropriate.

\**P* values for AKIN-3 vs. no AKI.

<sup>a</sup>Renal replacement therapy (pre transplant): three missing values.

<sup>b</sup>End-stage renal disease: three top causes.

<sup>c</sup>Glomerulonephritis.

creatinine (380 μmol/l) in the AKIN-3 group ( $P < 0.001$ ). At 1 month, the mean creatinine was higher in the AKI group as well as in the AKIN categories compared with the non-AKI group but this trend did not reach a statistical significance ( $P = 0.23$ ). The mean creatinine level did not differ between AKI and non-AKI groups or across the AKIN categories at 6 months or yearly thereafter up to 10 years of follow-up (Table 3).

### Patient and graft survival (Figures 1–3)

Patient survival in the non-AKI group at 1, 5 and 10 years was 99, 95 and 85%, respectively. Patient survival in the AKI group at these time points were 98, 94 and 94% respectively (Figure 1).

Graft survival at 1, 5 and 10 years in the non-AKI group was 94, 86 and 68%, respectively. The corresponding rates for the AKI group were 98, 85 and 75%, respectively (Figure 2).

### Causes of patient and graft loss

In the 10 years follow-up period, 14 patients had died (11 patients died with a functioning graft). A total of 6 patients died due to cardiac reasons, 3 due to malignancy, 1 due to septic shock, 1 due to pancreatitis and 1 due to liver failure. In 2 patients, cause of death was unknown.

A total of 41 grafts were lost during 10 years follow-up (excluding 11 grafts lost due to patients' death). 10 grafts were lost due to chronic allograft nephropathy, 10 due to acute rejection, 6 due to recurrent/*de novo* glomerulonephritis, 5 due to surgical causes and 2 due to recurrent UTI. Another 8 patients lost their grafts due to variety of other reasons.

### Trends of renal function in the donors and outcomes

In the AKI group, 76% patients had stable AKI and 24% had some recovery of AKI (drop of creatinine >0.5 mg/dl, i.e. 44 μmol/l from the maximum value) at the time of harvest but remained in one of the AKIN stages. There was no difference in the outcomes of the recipients who received kidneys from the donors with stable AKI or recovering AKI groups (serum creatinine 128 vs. 126 μmol/l at the last follow-up, 5 years patient and graft survival of 87 vs. 86%, respectively).

### Discussion

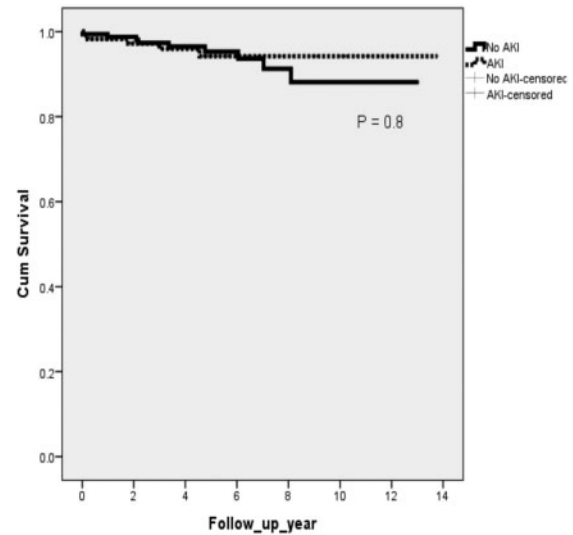
This long follow-up study of kidney transplantation from donors with severe AKI has shown favorable long-term outcomes. The deceased donor pool is very limited and living donation is not sufficient to

**Table 3** Outcomes

	Total	Non-AKI	AKI	P value	AKIN-1	AKIN-2	AKIN-3	P value*
Total	284	170	114		36	36	42	
Delayed graft function	90 (31.6)	43 (25.2)	47 (41.2)	0.006	13 (36.1)	9 (25.0)	25 (59.5)	<0.001
Length of hospital stay (days)	10.4 ± 6.3	9.3 ± 5.2	12.1 ± 7.4	<0.001	13.4 ± 10.7	10.0 ± 4.4	12.9 ± 5.1	<0.001
Acute rejection+ Creatinine (µmol/l)	46 (16.2)	24 (14.1)	22 (19.3)	0.25	11 (30.6)	4 (11.1)	7 (16.7)	0.63
At discharge	262 ± 199	233 ± 189	306 ± 206	0.002	242 ± 162	284 ± 216	380 ± 208	<0.001
1 month	163 ± 134	155 ± 132	174 ± 136	0.23	153 ± 68	193 ± 199	176 ± 107	0.33
6 month	126 ± 59	120 ± 42	129 ± 52	0.12	132 ± 51	129 ± 65	127 ± 39	0.37
1 year	124 ± 51	123 ± 52	125 ± 49	0.78	128 ± 49	117 ± 46	128 ± 50	0.58
3 years	135 ± 98	129 ± 75	128 ± 60	0.69	125 ± 38	125 ± 60	133 ± 73	0.81
5 years	126 ± 67	123 ± 55	120 ± 43	0.81	122 ± 21	114 ± 50	129 ± 50	0.70
10 years	113 ± 41	107 ± 46	122 ± 30	0.37	136 ± 31	116 ± 18	110 ± 31	0.92

Results shown in numbers and (%) or mean ± SD where appropriate.

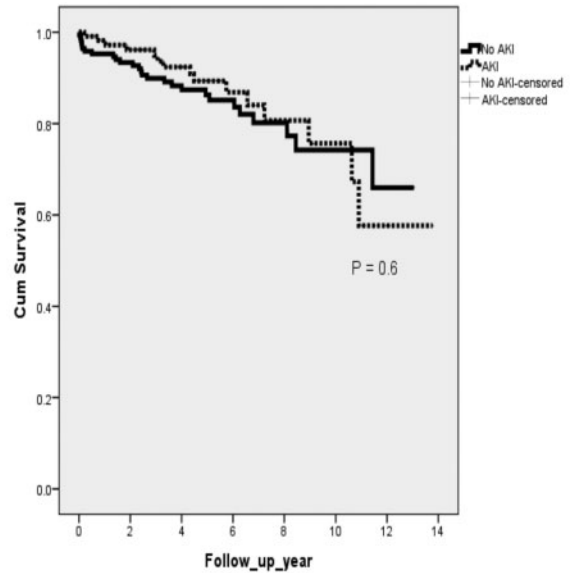
\*P value AKIN-3 vs. Non-AKI+ biopsy proven acute rejection in the first year.



**Patient at risk**

	1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	10Y
Non-AKI	170	141	122	99	78	57	40	31	21	15
AKI	114	88	76	65	48	34	26	19	15	12

**Figure 1.** Patient survival.



**Patient at risk**

	1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	10Y
Non-AKI	170	141	122	99	78	57	40	31	21	15
AKI	114	88	76	65	48	34	26	19	15	12

**Figure 2.** Graft survival.

meet the demand. Two recent publications have raised some concerns on the safety of living donation,<sup>21,22</sup> which may have further impact on living donation. It is thus very important to avoid unnecessary discard of organs from the deceased donors.

Studies of AKI have shown that if underlying condition improves then the majority of patients recover from AKI.<sup>5,23</sup> However, kidney transplantation from

donors with AKI is more complex as other factors such as surgical issues, hemodynamic compromise, immunological issues and ischemia reperfusion injury<sup>24</sup> also play a role. Unfortunately, donors with AKI are either not considered for donation or kidneys from such donors are discarded during multi-organ harvest.<sup>8</sup> A study using Scientific Registry of Transplant Recipients (SRTR) data has shown that terminal creatinine of >2 mg/dl was associated with a 7-fold higher likelihood of discard compared to donors with terminal creatinine levels <1.5 mg/dl.<sup>4</sup> In this study, we determined the long-term outcomes of kidneys utilized from donors with AKI. Our findings are encouraging and hopefully would help in reducing the discard rate of kidneys from donors with AKI.

In our study, DGF rates were higher in the AKI group and about 60% patients developed DGF if they were in the AKIN-3 category. The mean serum creatinine was highest at the time of discharge in the AKIN-3 category. However, serum creatinine in the AKI group was comparable to the non-AKI at 1 month. Patients in the AKIN-3 stayed in the hospital significantly longer (13 days vs. 9 days in the non-AKI category;  $P < 0.001$ ). A previous study showed that DGF had no impact on graft survival in the AKI group.<sup>25</sup> Our study also confirms that DGF and higher creatinine in the initial phase has no impact on the long-term outcomes.

Kumar et al. reported a 15% incidence of acute rejection in the AKI group.<sup>8</sup> A smaller study reported rejection rate of 21%.<sup>14</sup> We observed unexpectedly high rejection rates in the AKIN-1 category (31%). However, in the AKIN-2 and AKIN-3 categories the rejection rates were similar to the non-AKI groups. In this study the acute rejection rate of 16% are comparable to the international literature and no significant difference was observed between AKI and non-AKI groups.

This is a long follow-up study and has shown survival data of up to 10 years (Figures 1 and 2). We have shown that the long-term patient and graft survival is comparable between the AKI and the non-AKI groups. The long-term outcomes in the AKIN-3 category are also comparable to the non-AKI group (Figure 3). A previous study has shown comparable outcomes in a 3 years follow-up.<sup>8</sup> The other studies also reported on the short-term outcomes.<sup>11-14</sup> Hence, the findings in the present study are reassuring that the long-term outcomes of kidneys from the donors with AKI are good and comparable to the non-AKI group.

The AKIN staging system is designed to define AKI<sup>16</sup> and new classification system has shown to predict outcomes.<sup>26</sup> A recently published study has utilized AKIN classification and has shown good short-term

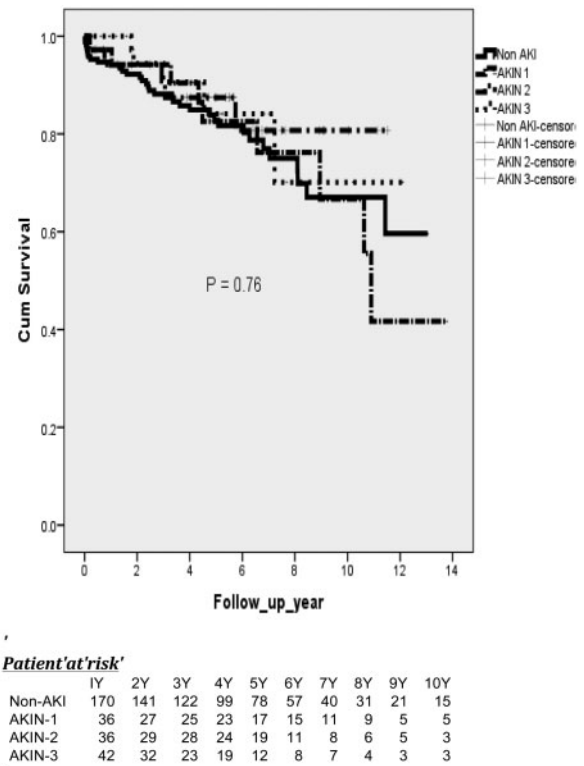


Figure 3. AKIN categories: patient and graft survival.

outcomes of the kidneys transplanted from the donors with AKI.<sup>9</sup> However, only one patient was included in the AKIN-3 category. In the present study, this classification predicted some of the short-term outcomes (DGF rates, length of hospital stay and creatinine level at discharge) but not the long-term outcomes. The strength of our study is that we used a standard definition and classification of AKI for the deceased kidney donors. The other feature of this study is that we tested the ability of AKIN staging system to predict the short- and the long-term outcomes (up to 10 years follow-up) in the context of kidneys utilization from the deceased donors.

Both the donors and recipients in this study were of young age (36 and 37 years, respectively). A previous small study has shown poor outcomes of patients who received kidneys from donors with AKI.<sup>7</sup> The author concluded that kidneys from donors with AKI should not be offered to young recipients. However, our study has shown that the long-term outcomes of utilizing such kidneys are good even in the young recipients and these kidneys can be transplanted in the young recipients, especially from the young donors.

The utilization of pulsatile perfusion machines has shown to reduce the incidence of DGF and perhaps the outcomes.<sup>27</sup> A previous study has shown that with the use of pulsatile perfusion machines the DGF rates were 48 and 88% in the non-AKI and

AKI groups, respectively.<sup>8</sup> In our center, we did not use these machines to perfuse kidneys but still had acceptable rates of DGF (32% in the non-AKI and 60% in the AKIN-3 category). The cold ischemia time in our unit is not that long and perhaps perfusion machine would be valuable where cold ischemia time is long.

There are certain limitations of this study, this is a retrospective analysis but our case notes and electronic database review was comprehensive. The sample size was small, hence we did not report on the multivariate analysis. Unfortunately, the urine volume data was not comprehensive so we could not apply the urine criterion for the AKIN staging system. Both the donors and recipients were of young age but 51 recipients (17.9%) were above the age of 50 years with good clinical outcomes (data not shown). The age factor may differ in the different population as in some areas the donors and recipients are older than our study population. Most of the contralateral kidneys were sent to other areas in the country. Unfortunately outcome data of these kidneys were not available due to lack of a central system. This study was conducted only in one center and further multicenter prospective studies are required to confirm our findings.

Our study has shown high DGF rates, prolonged hospital stay and high creatinine level at discharge in recipients who received kidneys from the donors with AKI in comparison to the non-AKI group. However, rejection rates, long-term kidney function, short- and long-term patient and graft survival is similar in the AKI and non-AKI groups. The severity of AKI had no negative impact on the outcomes.

In conclusion, this study has shown favorable long-term outcomes of kidneys utilized from donors with severe AKI. This study may encourage healthcare professionals to consider accepting such kidneys, which will help in expanding the limited donor pool.

*Conflict of interest:* None declared.

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