A Nationwide Analysis of Kidney Autotransplantation

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There are limited data regarding outcomes of patients underwent kidney autotransplantation. This study aims to investigate outcomes of such patients. The nationwide inpatient sample database was used to identify patients underwent kidney autotransplantation during 2002 to 2012. Multivariate analyses using logistic regression were performed to investigate morbidity predictors. A total of 817 patients underwent kidney autotransplantation from 2002 to 2012. The most common indication of surgery was renal artery pathology (22.7%) followed by ureter pathology (17%). Overall, 97.7 per cent of operations were performed in urban teaching hospitals. The number of procedures from 2008 to 2012 were significantly higher compared with the number of them from 2002 to 2007 (473 vs 345, P < 0.01). The overall mortality and morbidity of patients were 1.3 and 46.2 per cent, respectively. The most common postoperative complications were transplanted kidney failure (10.7%) followed by hemorrhagic complications (9.7%). Obesity [adjusted odds ratio (AOR): 9.62, P < 0.01], fluid and electrolyte disorders (AOR: 3.67, P < 0.01), and preoperative chronic kidney disease (AOR: 1.80, P 5 0.03) were predictors of morbidity in patients. In conclusion, Kidney autotransplantation is associated with low mortality but a high morbidity rate. The most common indications of kidney autotransplantation are renal artery and ureter pathologies, respectively. A kidney transplant failure rate of 10.7 per cent was observed in patients with kidney autotransplantation. The most common postoperative complication was hemorrhagic in nature.

Since the early 1960s, when the kidney auto-transplant procedure was introduced by Hardy,[1] kidney auto-transplant has been performed for multiple indications such as renal vessel pathologies, ureteral avulsion, urothelial malignancy, and renal trauma.[1–6] Successful renal autotransplantation while retaining kidney function has been reported in 94 per cent of cases.[7] Recently published articles have reinforced the role of kidney autotransplantation as an effective method to avoid nephrectomy or complex ureteral reconstructions and preserve the renal unit.[2, 8] Investigating indications, outcomes, and postoperative complications of kidney autotransplantation can help to delineate the value of the procedure as an alternative option in selected cases. There are currently limited data regarding outcomes of patients who underwent kidney autotransplantation.

A successful kidney autotransplant with retention of kidney function has been reported.[7, 8] Overall, postoperative mortality has been reported as low as 4 per cent.[7] Although the feasibility and safety of kidney auto-transplant have been well established, use of the procedure by surgeons is very limited. Previous studies on kidney donors suggested that heminephrectomy is a safe procedure that does not increase long-term morbidity or mortality.[9] However, even a slight decrease in kidney function has been linked to cardiovascular disease and higher mortality,[10] and recent studies have suggested that even carefully selected kidney donors are indeed at long-term risk of end-stage renal disease and premature death.[11, 12] When the remaining kidney in a patient who has undergone heminephrectomy fails, dialysis treatment is

associated with high medical costs, low quality of life, and high mortality.13 Autotransplantation could therefore be valuable to prevent these conditions when a medical situation requires consideration of heminephrectomy. This is especially true for young patients or high-risk patients with pre-existing comorbidities such as cardiovascular disease, diabetes, and chronic kidney disease.

Even though there are advancements in surgical techniques such as bench surgery and minimally invasive approaches to kidney autotransplantation,14–18 the surgical literature regarding kidney autotransplant remains limited, and most published studies have reported on the limited number of cases. More information is needed to define the role of kidney autotransplantation. Using a large national database, this study aims to report the most common indications, short-term outcomes, and predictors of morbidity in patients who underwent kidney autotransplant in the United States.

Methods

A retrospective analysis of the nationwide inpatient sample (NIS) database from 2002 to 2012 was performed for this study. NIS is the largest inpatient care database in the United States maintained by the Agency for Healthcare Research. It is an annually compiled database which contains information on more than eight million hospital admissions each year which represents 20 per cent of all U.S. hospital discharges to calculate population estimates.19 The informed consent was obtained from individual patients within the individual hospitals' patient consent forms by NIS. This study evaluated patients who underwent kidney autotransplantation according to the ICD-9-CM procedure code of 55.61 from 2002 to 2012. We excluded patients from the study, who had a history of kidney transplantation. Patients' diagnoses of surgery were extracted using ICD-9-CM diagnosis codes from the database. Variables of interest were inherent variables of the NIS database, which include demographic data (age, sex, and race), comorbidities (such as hypertension, hypertension, and diabetes mellitus), hospitalization length, and admission type (elective versus nonelective). The primary endpoints were mortality and postoperative complications according to the ICD-9 diagnosis codes, which were reported as the second to 25th diagnosis of patients in the database. A risk adjusted analysis was performed to investigate morbidity predictors.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Sciences software, version 22 (SPSS Inc., Chicago, IL). The main analysis was multivariate analysis using logistic regression. The associations of morbidity with the variable of interest were examined using a multivariable logistic regression model. We included all the potential confounder variables in the model as covariates which were all variables of the study. The estimated adjusted odds ratio (AOR) with a 95 per cent confidence interval (CI) was calculated. The level of significance was set at $P < 0.05$.

Results

We identified 817 patients who underwent kidney autotransplantation between 2002 and 2012. Overall, 97.7 per cent of kidney autotransplantation was performed in urban teaching hospitals. The median patient age was 44; the majority of the patients were white (67.5%) and

female (58.3%). Overall, 85.4 per cent of patients were operated electively. The most common comorbidity was hypertension (35.5%). Also, 12.5 per cent of patients had preoperative chronic kidney disease. The most common indication of kidney autotransplant was renal artery pathology (22.7%) followed by ureter pathology (17%) and aortic pathology (14.9%). The mean hospitalization length of patients was six days. Demographics and clinical characteristics of patients are shown in Table 1.

There was a steady increase in the number of patients who underwent kidney autotransplantation between 2002 and 2012 (Fig. 1). The number of patients increased from 67 in 2002 to 100 cases in 2012. Also, the number of procedures was significantly higher during 2008 to 2012 compared with 2002 to 2007 (473 vs 345, $P < 0.01$). The overall mortality and morbidity of patients who underwent kidney autotransplantation was 1.3 per cent and 46.2 per cent, respectively (Table 2). Patients who underwent transplantation for a complication of another procedure had the highest mortality and morbidity rates and risks (7.8% and 92%, respectively, $P < 0.01$). However, patients who were operated for ureter pathology had the lowest morbidity rate and risk (29.5%, $P < 0.01$; Table 3).

Risk adjusted analysis of factors associated with morbidity of patients is reported in Table 4. Patients with obesity (AOR: 9.62. $P < 0.01$), preoperative fluid and electrolyte disorders (AOR: 3.67, $P < 0.01$), and preoperative chronic kidney disease (AOR: 1.80, P 4 0.03) had significantly higher morbidity. Also, although only 5.7 per cent of patients had laparoscopicnephrectomy, such patients had a significantly lower morbidity (AOR: 0.39, $P < 0.01$).

TABLE 1. *Demographics and Clinical Characteristics of Patients Uunderwent Kidney Autotransplantation*

Variables		Kidney Autotransplantation (Sample Size = 817)
Age	Mean ± SD (year)	42 ± 17
	Median (year)	44
Sex	Female	473 (58.3%)
Race	White	420 (67.5%)
	Black or African-American	84 (13.5%)
	Hispanic	66 (10.7%)
	Asian	13 (2.1%)
	Other	38 (6.2%)
Comorbidity	Hypertension	288 (35.5%)
	Diabetes mellitus	81 (9.9%)
	Chronic pulmonary disease	64 (7.8%)
	Obesity	40 (4.9%)
	Drug abuse	20 (2.4%)
Admission type	Elective	693 (85.4%)
	Nonelective	110 (14.6%)
Patient diagnosis/indication of surgery	Renal artery pathology*	185 (22.7%)
	Ureter pathology§	139 (17%)
	Malignant tumor†	122 (14.9%)
	Complications of other procedures	65 (7.9%)
	Stone or cystic kidney disease	39 (4.8%)
	Aortic pathology‡	25 (3.1%)
	Trauma	26 (3.1%)
	Congenital anomalies	15 (1.8%)
	Other diagnosis	202 (24.7%)
Other factors	Preoperative fluid and electrolyte disorders	215 (26.4%)
	Preoperative chronic kidney disease	102 (12.5%)

* Atherosclerosis, aneurism, dissection, or hyperplasia of renal artery.
† Malignant tumor of kidney or adjuvant structures.
‡ Aneurism or structure of aorta.
§ Stricture or fistula of ureters.

The overall rate of transplanted kidney failure was 10.7 per cent. After multivariate analysis, patients who had preoperative chronic kidney disease had a significantly higher rate of transplanted kidney failure (AOR: 3.27, CI: 1.59–6.74, P < 0.01).
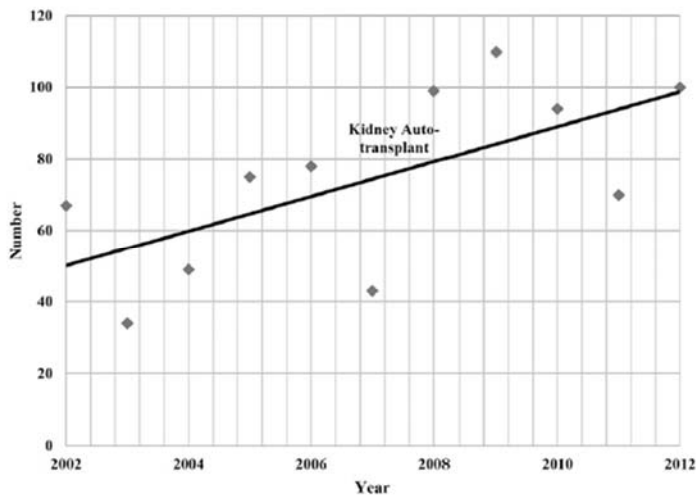

FIG. 1. Number of kidney autotransplant cases by year in United State.

The most common postoperative complication was hemorrhagic complications (9.7%) followed by prolonged ileus (9.2%). Factors of obesity (AOR: 12.52, CI: 4.48–34. 95, P < 0.01) and preoperative chronic kidney disease (AOR: 4.51, CI: 2.12–9.61, P < 0.01) were significantly associated with postoperative hemorrhagic complications.

TABLE 2. *Postoperative Complications of Patients Who Underwent Kidney Autotransplantation by Pathology*

Complications	Overall Rate (%)	Patients with Malignancy (%)	Patients with Trauma (%)	Patient with Complication of Another Procedure (%)	Patients with Ureter Pathology (%)	Patients with Arterial Pathology (%)
Mortality	11(1.3)	0	0	7.8	0	0
Overall morbidity	378(46.2)	47.5	38.5	92.2	29.5	41.6
Overall transplanted kidney failure	88(10.7)	12.3	0	7.7	7.2	2.2
Hemorrhagic complications	80(9.7)	3.3	19.2	7.8	7.2	13.4
Prolonged ileus	75(9.2)	3.3	0	0	10.9	11.9
Urinary tract infection	73(8.9)	7.4	19.2	15.4	3.6	10.8
Stricture or kinking of ureter	65(7.9)	0	19.2	60	7.9	0
Wound infection	35(4.2)	11.6	19.2	9.2	0	2.7
Thrombosis of renal vein	26(3.2)	4.1	0	7.8	3.6	0
Pneumonia	25(3.1)	12.4	0	0	0	0
Hospitalization >30 days	24(3)	16.4	0	0	0	0
Acute myocardial infarction	15(1.9)	0	19.2	7.7	0	0
Acute respiratory failure	20(2.4)	4.1	0	0	3.6	2.7
Wound disruption	20(2.4)	7.4	0	0	0	3.2
Intra-abdominal abscess	11(1.2)	4.1	19.2	0	0	0
Deep vein thrombosis	*	0	0	0	0	0
Arterial thrombosis	*	0	0	0	0	0

* Too small to report.

TABLE 3. *Mortality and Morbidity of Patients by Patients' Diagnosis/Indication of Surgery (Univariate Analysis)*

Diagnosis/Indication of Surgery	Mortality (%)	OR (95%CI)	*P* Value	Morbidity (%)	OR (95%CI)	*P* value
Complications of other procedures	7.8	12.66 (3.56–44.97)	<0.01	92	16.05 (6.37–40.45)	<0.01
Stone or cystic kidney disease	0	0.95 (0.93–0.96)	0.45	48.7	1.10 (0.58–2.11)	0.75
Malignant tumor†	0	0.84 (0.82–0.87)	0.16	47.5	1.06 (0.72–1.56)	0.74
Renal artery pathology*	0	0.77 (0.74–0.80)	0.07	41.6	0.78 (0.56–1.09)	0.15
Aortic pathology‡	0	0.96 (0.95–0.98)	0.55	40	0.76 (0.34–1.73)	0.52
Trauma	0	0.96 (0.95–0.98)	0.54	38.5	0.72 (0.32–1.60)	0.42
Congenital anomalies	0	0.98 (0.97–0.99)	0.64	33.3	0.57 (0.19–1.69)	0.31
Ureter pathology§	0	0.82 (0.80–0.85)	0.13	29.5	0.42 (0.28–0.63)	<0.01
Other diagnosis	2.5	3.11 (0.89–10.86)	0.06	48.8	1.14 (0.83–1.57)	0.41

* Atherosclerosis, aneurism, dissection, or hyperplasia of renal artery.
† Malignant tumor of kidney or adjuvant structures.
‡ Aneurism or structure of aorta.
§ Stricture or fistula of ureters.

Among patients who were admitted nonelectively, the most common reasons of admission were injury to ureter without mention of open wound into cavity (41%), injury to ureter with open wound into cavity (39.2%), and injury to renal artery (19.7%). The morbidity of patients who were admitted nonelectively and were operated for injury to renal artery was 100 per cent.

Postoperative complications by the type of admission were reported in Table 5. Patients who were admitted nonelectively had significantly higher mortality, pneumonia, deep vein thrombosis, and prolonged hospitalization.

Discussion

Kidney autotransplant is a safe procedure that can be used for the treatment of a variety of vascular, urologic, and other diseases with an acceptable functional result. Our study shows mortality and morbidity of patients who underwent kidney autotransplant are 1.3 per cent and 46.2 per cent, respectively. Except for patients who need autotransplant due to a complication of another procedure, which is associated with a high mortality and morbidity rates, we found acceptable mortality and morbidity in kidney autotransplantation as the treatment of a variety of diseases. Also, our results show that the failure of transplantation occurs in a relatively small percentage of patients (10.7%). Although this is higher than most single institution reported results (3.6–10%), it reflects national outcomes with different hospital settings and surgeons expertise.[7, 8] Besides decreasing the risk of nephrectomy, kidney autotransplant is used as an alternative option for complex kidney diseases requiring surgical interventions such as in situ renal artery bypasses or reconstruction, which cause the substantial kidney damage due to the prolonged warm ischemia. We found kidney autotransplantation is a practical treatment for resuming kidney function. However, use of kidney autotransplant in clinical practice is very limited and there are barriers needed to investigate. Due to the considerable morbidity associated with kidney autotransplantation candidates for the procedure should be referred to tertiary centers where adequate staffing and surgical experience may be more readily available.

TABLE 4. *Risk Adjusted Analysis of Morbidity Predictors of Patients Who Underwent Kidney Autotransplantation (Multivariate Analysis)*

Variables		AOR	95% CI	P Value
Age	Age	1.01	1.01–1.02	<0.01
Sex	Female	0.92	0.65–1.31	0.67
Comorbidity	Obesity	9.62	3.94–23.50	<0.01
	Hypertension	0.82	0.55–1.23	0.35
	Diabetes mellitus	0.65	0.35–1.17	0.15
	Chronic lung disease	0.57	0.30–1.05	0.07
	Drug abuse	1.49	0.51–4.34	0.45
Admission Type	Nonelective	Reference	Reference	Reference
	Elective	0.83	0.50–1.37	0.47
Other Factors	Preoperative fluid and electrolyte disorders	3.67	2.49–5.39	<0.01
	Laparoscopic nephrectomy *vs* open nephrectomy	0.39	0.18–0.83	0.01
	Preoperative chronic kidney disease	1.80	1.04–3.10	0.03

TABLE 5. *Risk Adjusted Analysis of Complications of Patients Who Underwent Kidney Autotransplantation by Admission Type (Multivariate Analysis)*

Complications	Patients with Elective Admission (Rate, %)	Patients without Elective Admission (Rate, %)	AOR (95% CI)	P Value
Mortality	0.7	4.2	6.03 (1.72–21.17)	<0.01
Overall morbidity	45.8	50.4	1.20 (0.73–1.97)	0.46
Overall transplanted kidney failure	10.4	13.4	0.61 (0.31–1.23)	0.17
Hemorrhagic complications	10.1	8.4	0.64 (0.26–1.56)	0.33
Prolonged ileus	9.5	8.4	1.19 (0.55–2.59)	0.65
Urinary tract infection	9.1	7.6	0.98 (0.45–2.13)	0.96
Stricture or kinking of ureter	7.1	12.7	2.59 (1.29–5.20)	<0.01
Wound infection	4.3	4.2	0.99 (0.32–3.01)	0.98
Thrombosis of renal vein	3	4.2	1.40 (0.52–3.80)	0.50
Pneumonia	2.2	8.4	4.66 (1.65–13.13)	<0.01
Hospitalization >30 days	1.4	12.6	9.85 (4.31–22.50)	<0.01
Acute myocardial infarction	1.4	4.2	2.39 (0.72–7.94)	0.15
Acute respiratory failure	2.9	0	0.97 (0.95–1)	0.06
Wound disruption	1.4	7.6	5.63 (2.24–14.19)	<0.01
Intra-abdominal abscess	0	8.4	1.09 (1.03–1.15)	<0.01
Deep vein thrombosis	0	4.2	1.04 (1.005–1.84)	<0.01
Arterial thrombosis	0.7	0	0.99 (0.98–1)	0.35

Our results demonstrate that kidney autotransplant is performed for the treatment of a variety of benign and malignant conditions such as renal vascular disease, aortic disease, malignant tumors, ureter pathology, and trauma. As expected, renal artery pathologies are the most common indications of kidney autotransplant in our study. Renal artery pathologies were previously reported as the most common indication of kidney autotransplant.[7] Although currently renal artery pathologies are often treated with interventional radiologic approaches,[20, 21] in cases where there is a need for open vascular treatment of renal artery pathologies, kidney autotransplantation has been reported as a superior technique compared to conventional bypass surgery.[22] However, there are limited data on this topic. Kidney autotransplantation as an alternative treatment of complex renal vascular procedures needs more investigations.

We found ureter pathologies as the second most common indication of kidney autotransplantion. A number of ureter pathologies such as tuberculosis, fibrosis, trauma, and tumors have been reported to result in extensive ureteral loss which may benefit from kidney autotransplant with restoration of continuity of ureter to bladder when simpler reconstruction methods are not possible.[7, 23, 24] Our results show kidney autotransplant for these patients has the lowest postoperative morbidity rate among indications of kidney autotransplantation. This is in line with previously reported excellent results for kidney autotransplantation for patients who require ureteral replacement.[25] We suggest kidney autotransplantation as an alternative method

for complex ureter reconstruction. However, outcomes of kidney autotransplantation with complex ureter reconstruction need to be further investigated.

The third most common indication of kidney autotransplantation was malignant tumors of the kidney or adjacent structures in our study. Feasibility and advantages of kidney autotransplantation after resection of malignant tumors have been previously reported. 26, 27 Our study shows almost half of the patients (47.5%) will develop a complication in this group. Also, such patients had the highest rate of transplanted kidney failure (12.3%) in our study. This may be related to the complexity of procedure. Safety and long-term outcomes of kidney autotransplant after resection of malignancy need for further investigations.

Although the number of patients who underwent kidney autotransplant in the United States increased during the last decade, the overall number of patients is still low. The main reason for such a low number may be the lack of expertise in nonurban or nonacademic hospitals as we found 97.7 per cent of kidney autotransplantations were performed in urban teaching hospitals. Considering our findings of acceptable mortality and functional results for kidney autotransplantation, this treatment option should be taken into consideration.

Although kidney autotransplant has an overall low mortality rate, morbidity of patients is high in most cases. When including minor complications such as prolonged ileus and urinary tract infections, we found an overall morbidity rate of 46.2 per cent. We found hemorrhagic complications as the most common complication of kidney autotransplant. Intensive perioperative care for patients undergoing kidney autotransplantation is needed. Due to the considerable morbidity, candidates for kidney autotransplant should be referred to tertiary centers where more perioperative care is readily available. Also, patients undergoing kidney autotransplant may benefit from minimally invasive approaches. Recently published papers have reported on the safety and feasibility of minimally invasive approaches to kidney autotransplant.16–18 Although in our study only a limited number of patient were operated laparoscopically for nephrectomy, we found significantly lower morbidity for such patients. However, there is limited data on this topic.

Our study shows kidney autotransplant has acceptable short-term outcomes in both elective and emergent situations. Although we found the risks of complications including pneumonia, DVT, and prolonged hospitalization significantly increased in nonelective settings, overall risk of graft failure does not significantly increase in nonelective settings. In nonelective settings, it is reasonable to decide about kidney autotransplant according to preoperative comorbid conditions and mortality risk of patients. However, further studies are indicated to evaluate benefits of kidney autotransplant in patients with multiple comorbid conditions who underwent nonelective kidney autotransplant.

Kidney autotransplant due to a complication of other procedures is associated with a high mortality and morbidity rates. We found mortality and morbidity rates of 7.8 and 92 per cent when kidney autotransplant was done for a complication of another procedure. However, there are limited data on this topic. Further studies are indicated to check alternative treatments in such patients and see if intensive perioperative care can decrease mortality and morbidity of patients.

Among comorbid conditions we found obesity as a factor which has the strongest association with morbidity of patients who underwent kidney autotransplant. In addition, we

found obese patients have an over 12 times higher risk of hemorrhagic complications. The association between obesity and postoperative complications has long been established.28 In kidney allotransplantation there is a controversy regarding benefits of kidney transplant in obese patients, especially in African American patients with body mass index more than 40.29 Obese patients undergoing kidney autotransplant may benefit from minimally invasive approaches. However, kidney transplantation in obese patients needs further investigation. In patients without the comorbidity of obesity, correcting the fluid and electrolyte disorders preoperatively, as well as using minimally invasive approaches for kidney autotransplant may decrease postoperative complications.

Preoperative kidney function can predict the risk of postoperative kidney failure in kidney autotransplant. Our results show patients who had chronic kidney dysfunction preoperatively have a more than three times higher risk of postoperative transplanted kidney failure. Potential benefits of kidney autotransplantation in the presence of chronic kidney disease need more investigations.

Study Limitations

The main limitation of the study was its retrospective nature, which makes any definitive conclusion difficult. The number of transplanted patients was limited in our study, therefore the power of the study was very small. Although we used multivariate analysis in the study, statistically significant results were obtained only in presence of huge differences in outcomes between two compared groups of patients. Also, for morbidity and mortality predictors we could only use the univariate analysis. There were a great number of indications of kidney autotransplant with a limited number of patients in our study and 24.7 per cent of patients were classified into other diagnosis and we could not adjust our results with all indications of operation. NIS did not provide information regarding long-term outcomes of patients and the reasons of kidney transplant failure. Also, due to the limitations of the database we compared outcomes of electively and nonelectively admitted patients and we did not have any information regarding the type of surgery (elective versus nonelective). NIS did not provide any information on the percentage of patients who were transferred from other hospitals for kidney autotransplant. Also, the information regarding warm and cold ischemia times was not provided. Some patients may have had other major concomitant procedures with kidney auto transplantation such as abdominal aortic aneurism repair which can affect outcomes of patients. Despite these limitations, this study is one of the first studies reporting outcomes of patients who underwent kidney autotransplant using a nationwide database.

Conclusion

Kidney autotransplant is a safe and feasible procedure with satisfactory short-term functional results. The most common indication of kidney autotransplant is renal artery pathologies followed by ureter pathologies. Although mortality of kidney autotransplant is low, morbidity of patients is significantly high. Patients who underwent kidney autotransplantation for ureter pathologies and those who did for a complication of other procedures have the lowest and highest morbidity rates respectively. Obesity, preoperative fluid and electrolyte disorders, and preoperative chronic renal failure are morbidity predictors of patients. Controlling fluid and electrolyte disorders, perioperative intensive care, and minimally invasive approaches to kidney autotransplant may all decrease postoperative morbidity of patients.

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