Original Article

Ex vivo removal of stones in donor kidneys by pyelotomy prior to renal transplantation: a single-center case series

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Background: Donors with incidentally discovered asymptomatic renal stones was considered a relative contraindication to the kidney donation because of a potential increased morbidity risk for renal transplant recipients. Stone clearance from the donors should be done before donation to ensure safety of the recipient. This study aimed to observe the safety and efficacy of kidney transplantation from donors with nephrolithiasis who received pyelolithotomy before transplantation.

Methods: Between January 2015 and March 2021, 14 deceased organ donors at The Second Affiliated Hospital of Guangzhou Medical University were found to have kidney stones during predonation evaluation. After donor kidney repair, all of the donor kidneys underwent *ex vivo* pyelolithotomy. Then the organs were transplanted to the right iliac fossa of 17 patients with end-stage renal failure. Data were analyzed for technical feasibility, intraoperative and postoperative complications, and stone clearance. Ultrasonography and urinal routine were followed at the 1-, 3-, and 6-month postoperatively.

Results: The stones were successfully removed *ex vivo* by pyelotomy with an average time of 41.0± 12.8 minutes. Seventeen recipients successfully underwent renal transplantation, and their renal function recovered well. Slight gross hematuria occurred in 12 cases after operation, and hematuria disappeared after conservative treatment. Ureteral stents were removed within two months after the procedure. There were no complications such as delayed recovery of renal function, acute rejection, ureteral necrosis, and urinary fistula. The serum creatinine of 17 patients 1 month after the operation was 136.8±26.7 μmol/L. None of the 17 patients included in the study suffered from stone recurrence or graft dysfunction in the follow-up period.

Conclusions: *Ex vivo* removal of stones by pyelotomy was a technically feasible means of safely and efficiency rendering a stone-bearing donor kidney stone-free. The procedure obtained good early-middle outcomes in kidney transplantation and is therefore worthy of clinical application.

Keywords: Renal transplant; kidney stone; kidney donor; pyelotomy; case series

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Introduction

Kidney transplantation remains an effective means to treat end-stage renal disease. However, while transplantation of organs from deceased donors has been rapidly developing in China, a shortage of donor organs is still a core problem. The presence of kidney stones in the urinary system is common, and the number of cases of kidney stones is gradually increasing. However, with the development of endoscopic urology, kidney stones in living relatives are no longer a contraindication for surgery, and satisfactory results have been achieved (1,2). There have been few clinical studies on the treatment of kidney stones in deceased organ donors, and it is particularly important to use such donor kidneys safely and effectively.

Few guidelines have addressed the issue of donors with renal calculi. *Ex-vivo* pyelotomy that is eventually sutured after the procedure have made it possible to obtain stone clearance in the kidney donors. Potential complications include inadvertent mucosal injury and/or failure to address the stones because of narrow caliceal neck. Nonetheless, there was no reported harmful impact on the graft during the postoperative period. In this article, we evaluated the safety and efficacy of *ex-vivo* pyelolithotomy in renal transplant recipients. From January 2015 to March 2021, our center adopted pyelotomy to treat isolated deceased donor kidney stones, with all recipients obtaining good short-term survival and renal function. We present the following article in accordance with the STROBE and AME Case Series reporting checklists (available at https://tau.amegroups.com/article/view/10.21037/tau-22-335/rc).

Methods

Study population

Between January 2015 and March 2021, the Organ Transplantation Department of The Second Affiliated Hospital of Guangzhou Medical University completed 580 kidney transplants from deceased donors. After institutional review board approval, a retrospective chart review of all donors who had urolithiasis was done. All prospective renal donors with asymptomatic non-obstructive subcentimeter calculi (<20 mm) in one kidney included in the study. Preoperative examination imaging data indicated that 14 donors had kidney stones. Among them, there were 12 males and 2 females, and the average age was 47.5± 8.1 years. There were 11 cases of unilateral kidney stones, 3 cases of bilateral kidney stones, and 7 cases of multiple stones. The number of stones was 2–5, and the maximum diameter of the stones was 8–12 mm. There were 7 cases of single stones, with a diameter of about 4–7 mm. Serum creatinine ranged from 97–195 μmol/L. Donor details are shown in *Table 1*.

Ethical statement

This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Institutional Review Board of The Second Affiliated Hospital of Guangzhou Medical University (No. 2017-XJS-Y-06). Informed consent was taken from all individual participants.

Evaluation of deceased donors

All deceased donors were Chinese Class III standard donors, which refers to donors whose life support was withdrawn and the donation implemented after the heart stopped beating. The donors were all well-identified, under the age of 65, without malignant tumor or active infection, and had relatively stable hemodynamics before kidney donation. The acceptance criteria were in line with the China Heart Death Organ Donation Guidelines (Second Edition). Informed consent was provided by the donor's relatives and relevant approvals were obtained for all organ donations (3).

Surgical methods

Donor kidney harvesting and trimming

All donor kidneys were routinely harvested in large cross pieces and fully perfused with 0–4 ℃ hypertonic citrate purine solution. After the left and right kidneys were separated, they were placed in a mixture of ice and water at 0–4 ℃ for trimming.

Incision of the renal pelvis for stone removal

After the donor kidney was trimmed, the fat of the renal hilum was freed to expose the renal pelvis, and an incision of about 0.5–1.0 cm was made along the running direction of the ureter at the outer side of the ureteral root, near the junction of the renal pelvis and ureter. Both ends of the incision were suspended with wire to expose the incision, after which the assistant held the kidney, and the surgeon used a F8.0/9.0 ureteroscope to enter from the incision. Based on the results of preoperative computed tomography (CT) examination, the location of the stone was roughly

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Table 1 Baseline data of donors

Donor number	Gender	Age (year)	Cause of death	Stone location	Number of stones	Serum creatinine level before organ procurement (μmol/L)	Maximum diameter of stone (mm)	Time of stone removal (min)
1	Male	50	Cerebral trauma	Left kidney	Multiple	100	8	45
2	Male	41	Cerebral trauma	Both kidneys	Multiple	110	9	65
3	Male	55	Cerebral hemorrhage	Left kidney	Single	150	6	25
4	Male	36	Cerebral hemorrhage	Right kidney	Single	103	5	30
5	Male	54	Cerebral hemorrhage	Right kidney	Single	107	7	35
6	Male	54	Cerebral hemorrhage	Left kidney	Single	100	5	28
7	Female	56	Cerebral hemorrhage	Left kidney	Single	105	6	28
8	Male	38	Cerebral hemorrhage	Both kidneys	Multiple	195	10	60
9	Female	51	Cerebral trauma	Right kidney	Single	97	6	30
10	Male	33	Cerebral hemorrhage	Left kidney	Multiple	169	12	45
11	Male	56	Cerebral infarction	Left kidney	Multiple	103	8	50
12	Male	55	Cerebral hemorrhage	Right kidney	Multiple	128	10	40
13	Male	47	Cerebral trauma	Left kidney	Single	102	4	38
14	Male	39	Cerebral hemorrhage	Both kidneys	Multiple	179	9	55

judged, and the shape, size and location of the stone were determined by rotating the kidney and adjusting the angle of the ureteroscope. In the ureteroscopy process of entering and searching for stones, ice saline irrigation was used to keep the kidneys at a low temperature state while maintaining a small irrigation flow rate.

After determining the location of the stone, lithotripsy forceps were used to grasp the stone and remove it completely without injuring or tearing the calyx during the clamping process. If the stone was too large to be clamped out, the ureteroscope was used to crush the stone with a lithotripsy rod into 2 or 3 pieces, and then stone forceps were used to completely remove the small stones. Care was taken to avoid powdering any crushed stone during the procedure as it causes stone fragments to adhere to the renal pelvis mucosa or scatter to renal calyces, which eventually leads to stone residues or even stone recurrence. The ureteroscope was withdrawn after checking that there were no stones in any of the calyces of the kidney. If any were found, a 10-gauge small urinary catheter was inserted into the renal pelvis and the stones were flushed out with a 50 mL syringe with ice water. Finally, 5-0 absorbable suture was used to suture the renal pelvis incision. After suturing was completed, a double-J tube was inserted along the end of the ureter to observe whether there was stenosis at the incision. The donor kidney was then placed in an ice pack for transplantation (*Figure 1*).

Perioperative and postoperative follow-up data of recipients

For kidney transplantation, an arc-shaped incision next to the rectus abdominis on the right side of the lower abdomen was selected. The artery and vein of the donor kidney were then anastomosed with the external iliac artery and vein of the recipient end-to-side, and the ureter was anastomosed using the bladder-type Lich technique. A 6-F indwelling double-J tube was placed in the ureter and removed after 2 months. A corresponding immune induction program was provided during the perioperative period, and a triple antirejection program of tacrolimus + mycophenolate mofetil + methylprednisolone was routinely given after surgery.

Seventeen renal transplant recipients were included in the analysis. All patients were counseled regarding follow-up. They were explained the possibility of residual stones and the steps to be taken in the event of urinary fistula or ureteral obstruction. The transplanted kidney was checked regularly by color Doppler ultrasound for urine

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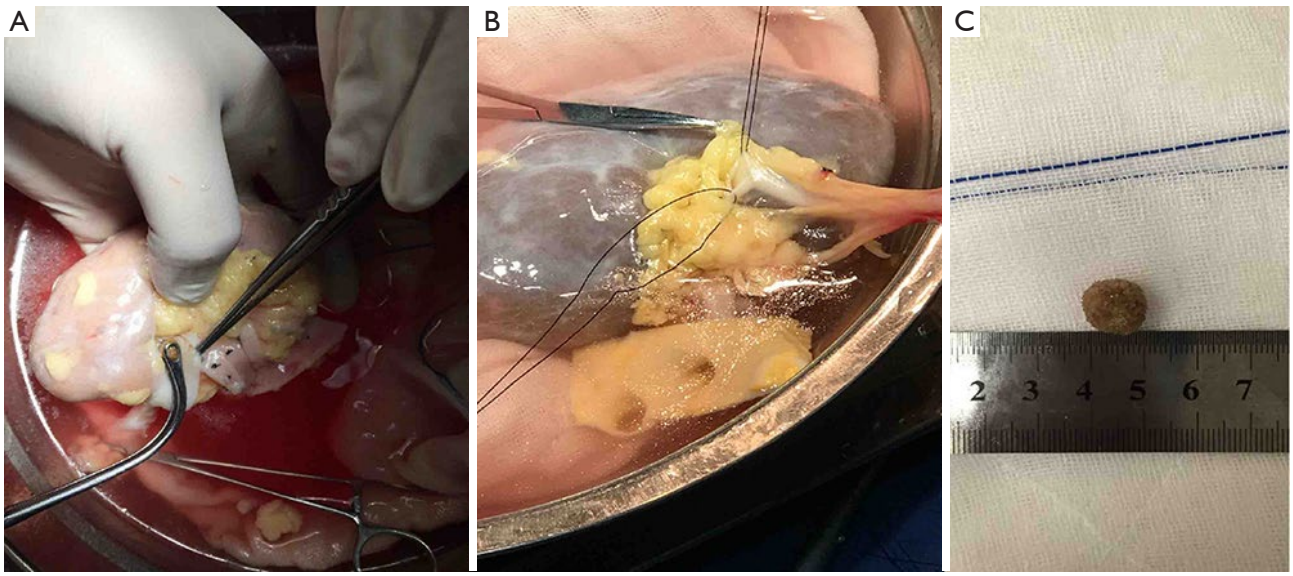

Figure 1 Removal of stones in donor kidney by pyelotomy. (A) Kidney stones were clamped with lithotripsy forceps. (B) The renal pelvis longitudinal incision was intermittently sutured. (C) The stone was completely removed.

leakage or obstruction. After the surgery carried out on patients followed up including clinical examination, blood routine examination kidney function, urinal routine and ultrasonography at the 1-, 3-, and 6-month.

Statistical methods

The data were entered into an EXCEL database and analyzed using SPSS 19.0 software (IBM Co., Armonk, NY, USA). The results are expressed as the means + standard deviation (SD). This study did not utilize statistical tests due to the observational and summative nature of this study.

Results

In this study, 17 recipients successfully underwent kidney transplantation. The recipients included 9 males and 8 females, aged 38.7±11.5 years, and 82.4% (14/17) of the patients had chronic primary glomerulonephritis (*Table 2*).

The warm ischemia time for the 17 cases was 3–10 minutes and cold ischemia time was 2–3.5 hours. The average time for stone removal was 41.0±12.8 minutes, and no stones remained in the renal calyces and renal pelvis. Twelve patients had slight gross hematuria after surgery, which disappeared within 3 days postoperation, and 1 patient had blood clots in the renal pelvis and ureter of the donor kidney. Four weeks after the routine operation, the recipients had the renal ureter stents removed, and there were no complications such as urinary tract infection, urinary fistula, and ureteral obstruction. The serum creatinine of the 17 recipients remained at 136.8± 26.7 μmol/L 1 month after surgery.

After discharge, the recipients were instructed to drink more water, maintain a 24-hour urine output of 2,000–3,000 mL, and limit the intake of sodium, animal-derived protein, and oxalic acid in the diet to prevent the recurrence of stones. At the 1-, 3-, and 6-month postoperative ultrasound examinations, there were no recurrences of stones and expansion of the collecting system in the transplanted kidneys, and kidney function was recovering well.

Discussion

Nephrolithiasis is a common urologic disease, and there are obvious regional differences in its incidence in China. The cross-sectional survey results of Zeng *et al.* (4) on the prevalence of urolithiasis among Chinese adults showed that among 7 provinces and municipalities, the highest incidence rate (11.63%) was found in Guangdong Province. Further, incidence was higher in males than females, rural areas than urban areas, and southern areas than northern areas. Since 2015, China has been transplanting organs from deceased donors. As people's awareness of organ donation

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Table 2 The characteristics and perioperative parameters of recipients

Recipients	Age (year)	Gender	Pathology	Preoperative creatinine (μmol/L)	Postoperative creatinine (μmol/L)	Postoperative complications				
						Acute rejection reaction	Delayed graft function	Stone recurrence	Urinary fistula	Ureteral obstruction
1	43	Male	Chronic nephritis	1,002	107	No	No	No	No	No
2	27	Male	Chronic nephritis	951	155	No	No	No	No	No
3	50	Female	Lupus nephritis	805	104	No	No	No	No	No
4	53	Male	Chronic nephritis	783	134	No	No	No	No	No
5	40	Female	Chronic nephritis	910	92	No	No	No	No	No
6	31	Female	Chronic nephritis	921	114	No	No	No	No	No
7	41	Female	Chronic nephritis	744	87	No	No	No	No	No
8	35	Female	Chronic nephritis	787	146	No	No	No	No	No
9	21	Male	Chronic nephritis	979	125	Yes	Yes	No	No	No
10	55	Male	Diabetic nephropathy	908	168	No	No	No	No	No
11	25	Male	Chronic nephritis	1,609	143	No	No	No	No	No
12	37	Male	Polycystic kidney	568	168	No	No	No	No	No
13	40	Female	Chronic nephritis	974	189	No	Yes	No	No	No
14	28	Male	Chronic nephritis	970	172	Yes	No	No	No	No
15	49	Male	Chronic nephritis	1,166	141	No	No	No	No	No
16	52	Female	Chronic nephritis	568	135	No	No	No	No	No
17	23	Female	Chronic nephritis	766	140	No	Yes	No	No	No

has improved, the number of donations has been increasing year by year, as are the number of kidney donations with stones. The criteria for whether kidneys with calculi can be used are inconsistent. Donors with calculi belong to a category for marginal donors, and they were considered a contraindication to kidney transplantation in the past. An urgent problem and challenge for organ transplant physicians is how to maximize the use of organs available for transplantation.

Many transplant centers have reported success using a kidney with stones as a donor kidney, and all have achieved good results (5,6). A previous study has shown that minimally invasive treatment of kidney stones *in vitro* can minimize the damage to the donor kidney, and donor kidney stones are no longer an absolute contraindication for kidney transplantation (7). This study showed that stone removal with forceps through the renal pelvis resulted in good clinical outcomes without the complications of increased urinary fistula or obstruction. We found that the key step of this method was exposure of the renal pelvis incision. For an extrarenal pelvis, dissociation is relatively simple, with the incision position about 1 cm above the ureteropelvic junction and in the lateral direction. For an intrarenal pelvis, it is necessary to dissociate into the renal hilum during exposure and select a renal pelvis incision above the ureteropelvic junction. When exposing the renal pelvis, the tissue around it should not be freed too much, and blunt dissection of the adjacent renal pelvis can be used. After stone removal is completed and no residual stones are found, the renal pelvis incision should be tightly sutured, and the severed pararenal pelvis tissue can be rewrapped with 5-0 absorbable sutures to the ureter.

Schade *et al.* (8) reported a method of changing the angle of the ureteropelvis by rotating the isolated kidney. In this center, the assistant holds the kidney during the exploration of the renal calyx and lithotripsy, and the assistant rotates

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the kidney so that the rigid ureteroscope can reach any renal calyx. Stone removal forceps can be used to remove stones after the size and location of the stones are determined. The operation is simple and performed in a short period of time, which avoids damage to the renal pelvis and calyceal mucosa during the process of laser lithotripsy or pneumatic ballistic lithotripsy.

The advantages of this method include: (I) the size and position of the stones in the renal pelvis and each renal calyx can be clearly observed by entering the ureteroscope through the renal pelvis incision; (II) for larger stones, ureteroscope ballistic lithotripsy can be used to crush the stones into 2 or 3 pieces, and then stone forceps can be used to clip the stones out, while traditional "powdered" lithotripsy is prone to residual small calculi or small rubble adhering to the renal pelvis mucosa, which is difficult to discharge; and (III) after stone extraction, brine ice can be used for irrigation through the incision, which can reduce residual stone debris or small stones in the renal pelvis. There are a number of points to note concerning this method. First, the incision site should be where the root of the ureter is close to the renal pelvis; it must be along the lateral direction of the ureter, and the length of the incision should generally not exceed 1 cm to avoid affecting the blood supply of the ureter. Second, sutures along the longitudinal direction of the ureter is beneficial for reducing the occurrence of obstruction, and at the same time, attention should be paid to the full-thickness suture of the ureter to avoid postoperative urinary fistula. Third, when using stone-removing forceps, it should be noted that if the angle of the calyx or the neck of the calyx is small, the stone should not be forcefully removed to avoid tearing the renal pelvis or renal pelvis mucosa. Lastly, 2 months after the operation, the double-J tube should be removed. The color Doppler ultrasound of the transplanted kidney should be reviewed before and after the double-J tube removal to assess the possibility of urine leakage, ureteral obstruction, and recurrence of stones in order to facilitate early intervention.

At present, the treatment of renal pelvis stones before kidney transplantation mainly involves living donor kidneys, and there are not many reports on deceased donor kidney stone extraction. The most commonly used method in China is holmium laser lithotripsy under ureteroscope in an isolated state (9,10). Song *et al.* (10) used flexible ureteroscopy combined with holmium laser lithotripsy to treat 4 cases of isolated kidney stones. Two patients had delayed recovery of transplanted kidney function after surgery but no complications such as hydronephrosis or stone recurrence occurred. The J tube was in place for 4 weeks, and B-scan ultrasound was performed during follow-up for 24–36 months after the operation. All patients recovered well. Zhu *et al.* (11) reported the experience of ureteroscopic stone removal before kidney transplantation. Donor kidney trimming was routinely performed followed by extracorporeal endoscopic lithotripsy on the same operating table. The diameter of calculi in 7 cases was 1.2±0.5 cm, and the operation time was 23.0±6.1 minutes. No severe hematuria occurred in 7 recipients after the operation, and renal function recovered well. Zhu *et al.* (12) used ureteroscopic lithotripsy through the renal pelvis incision to treat 10 cases of living donor kidney stones in relatives. The recipients healed well after surgery, and the function of the transplanted kidney was not affected.

The overall effect of treating isolated kidney calculi through renal pelvis incision is effective, but in the process of incision and extraction, care should be taken to protect the renal pelvis blood vessels to avoid damage to the renal pelvis and renal calyx mucosa in order to reduce the occurrence of complications such as postoperative hemorrhage and urinary fistula. Proficient clinical application of our method can expand the donor pool and improve the utilization rate of kidney stones. A total of 17 recipients were included in this study, all of whom achieved good clinical outcomes. Nephrolithotomy through renal pelvis incision has good clinical application prospects and is a surgical method worthy of promotion.

The study has several limitations. First, its retrospective nature is a shortcoming, and may cause some bias. Second, the small samples were obtained from a single center. Third, information about long-term prognosis after ex-vivo pyelotomy in such patients is limited.

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Footnote

Reporting Checklist: The authors have completed the STROBE and AME Case Series reporting checklists. Available at https://tau.amegroups.com/article/view/10.21037/tau-22-335/rc

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Data Sharing Statement: Available at https://tau.amegroups.com/article/view/10.21037/tau-22-335/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-22-335/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Institutional Review Board of The Second Affiliated Hospital of Guangzhou Medical University (No. 2017-XJS-Y-06). Informed consent was taken from all individual participants.

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