CASE REPORTS / CASE SERIES

The perioperative management of simultaneous bilateral nephrectomy with renal transplantation: a case series

Prise en charge périopératoire des néphrectomies bilatérales réalisées simultanément avec une transplantation rénale : une série de cas

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Abstract

Purpose *Bilateral nephrectomy is performed at times with renal transplantation. Though surgical indications and timing of these two procedures have been described, there are no large case series describing the anesthetic management of these cases. We sought to describe our experience.*

Methods *We performed a historical cohort study on 54 consecutive cases of simultaneous bilateral nephrectomy with renal transplantation at a single, tertiary-care medical centre. Descriptive statistics were used.*

Results *The most common etiology of kidney disease involved was autosomal dominant polycystic kidney disease at 52/54 (96%) cases. All patients received grafts from living donors. An arterial line was placed in 44 (81%) and a central venous catheter in 16 (30%) subjects. At least one vasopressor infusion was used in 44 (81%) cases and 37 (69%) patients required admission to the intensive care unit (ICU). Of this subset, 30 (81%) were admitted for ongoing vasopressor support and six (16%) for hemodynamic monitoring. All patients were extubated in the operating room upon completion of the procedure. Median [interquartile range (IQR)] ICU length of stay (LOS) was 0.9 [0.7–1.4] days and total hospital LOS was 4.4 [4.3–5.4] days. There were no cases of mortality at 30 days or of postoperative dialysis.*

Conclusions *Adult patients undergoing simultaneous bilateral nephrectomy with renal transplantation often developed perioperative hypotension requiring vasopressor infusions and postoperative transfer to the ICU. This is possibly due to a temporary loss of the renin-angiotensin system. Despite this, patients most commonly were transferred to the floor on postoperative day 1 and had successful outcomes with no mortality at 30 days.*

Résumé

Objectif *La néphrectomie bilatérale est parfois réalisée en même temps qu'une transplantation rénale. Bien que les indications chirurgicales et le moment de ces deux interventions aient été décrits, il n'existe aucune grande série de cas décrivant la prise en charge anesthésique de ces procédures. Notre objectif était de décrire notre expérience.*

Méthode *Nous avons réalisé une étude de cohorte historique sur 54 cas consécutifs de néphrectomie bilatérale avec transplantation rénale simultanée dans un seul centre médical de soins tertiaires. Des statistiques descriptives ont été utilisées.*

Résultats *La maladie polykystique des reins autosomique dominante constituait l'étiologie de la maladie rénale la plus fréquente, représentant 52/54 (96 %) des cas. Tous les patients ont reçu des greffes de donneurs vivants. Une ligne artérielle a été installée chez 44 (81 %) patients et un cathéter veineux central chez 16 (30 %) patients. Au moins une perfusion de vasopresseurs a été utilisée chez 44 (81 %) patients, et 37 (69 %) patients ont dû être admis à l'unité de soins intensifs (USI). De ce sous-ensemble, 30 (81 %) patients ont été admis pour recevoir un soutien continu de vasopresseurs et six (16 %) pour un monitorage hémodynamique. Tous les patients ont été extubés en salle*

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d'opération à la fin de l'intervention. La durée médiane [écart interquartile (ÉIQ)] de séjour aux soins intensifs était de 0,9 [0,7 à 1,4] jour, et la durée totale de séjour à l'hôpital était de 4,4 [4,3 à 5,4] jours. Il n'y a eu aucun cas de mortalité à 30 jours ou de dialyse postopératoire.

Conclusion *Les patients adultes subissant une néphrectomie bilatérale et une transplantation rénale simultanées ont souvent souffert d'hypotension périopératoire exigeant des perfusions de vasopresseurs et un transfert postopératoire aux soins intensifs. Ceci est probablement dû à une perte temporaire du système rénine-angiotensine. Malgré cela, les patients étaient en général transférés à l'étage au jour postopératoire 1 et ont eu des devenirs favorables sans mortalité à 30 jours.*

Bilateral nephrectomy is a procedure performed at times with renal transplantation. The most common etiology involved is autosomal dominant polycystic kidney disease (ADPKD) associated end-stage renal disease (ESRD) though various disease states can be involved, including vesicoureteral reflux, nephrolithiasis, glomerulonephritis, hypertension, and vasculitis.[1] Autosomal dominant polycystic kidney disease is the most common etiology of inherited renal failure with a prevalence estimated at one in 400 to one per 4,000.[2,3] It is characterized by renal cyst development and an exponential increase in kidney and cyst volume with an associated decrease in glomerular filtration rate.[1,4] Approximately half of patients will progress to ESRD and nearly all patients will develop hypertension.[1,5] The renin-angiotensin system (RAS) can fall into a state of dysregulation and has been implicated as a cause of this hypertension.[6,7] Patients' most common complaint is pain (60% of adult patients) although they can additionally report hematuria, renal stones, early satiety, hepatic cysts, intracranial aneurysms, mitral valve prolapse, and diverticular disease.[1] Nephrectomy indications for patients with ADPKD include symptomatic patients, infected cysts, and frequent bleeding.[1] In the most recently available US data, over 36,000 patients received renal replacement therapy for ADPKD in 2017.[1,5,8]

Timing of bilateral nephrectomy in relation to renal transplantation has been under investigation for several years.[9-13] Concerns had arisen that pretransplant nephrectomy exposes the patient unnecessarily to complications associated with an anephric state, including the initiation of dialysis for patients who would have otherwise received pre-emptive transplantation.[14] On the other hand, concomitant bilateral nephrectomy with renal transplantation was originally thought to create conditions that would put the renal allograft at risk. This included extended time under general anesthesia, large fluid shifts, and a possible increased risk of transfusion.[9] Nevertheless, more recent studies have shown that bilateral nephrectomies can be safely performed concomitantly with renal transplantation.[9,10] Though safety of this concomitant procedure has been established, there are limited data available describing the anesthetic management and early postoperative outcomes in these cases.

At our institution, we have been performing combined bilateral nephrectomies and renal transplantation since 2012. Here, we describe the anesthetic management and outcomes of a case series of adult patients undergoing simultaneous bilateral nephrectomy with renal transplantation. To our knowledge, no descriptive case series is available that reports in detail the perioperative management of these cases.

Methods

We performed a historical cohort study at a single medical centre with approval by the Mayo Clinic Institutional Review Board (protocol # 19-011590). Dataset assembly occurred after the protocol design was completed. Any patient who did not consent to research authorization was excluded from this study, in accordance with Minnesota Statute 144.295. As applicable, guidelines from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) were followed.

Fifty-four consecutive bilateral nephrectomies performed in conjunction with renal transplantation in adult patients at Mayo Clinic Hospital in Rochester, MN between 12 January 2012 and 25 October 2019 were included. No patients were excluded. Perioperative management of each case was at the discretion of the anesthesia team lead by a supervising anesthesiologist who was part of the Solid Organ Transplant anesthesia group. Fluid administration and hemodynamic goals for the transplant portion of the procedure were in accordance with institutional protocols. For cases involving grafts from living donors, this includes administration of at least 3,000 mL of a balanced salt solution prior to kidney perfusion and a goal systolic blood pressure of at least 130 mmHg when requested by the transplant surgeon. The nephrectomies and the transplant were performed by members of the same surgical team led by a transplant surgeon. The decisions of the indications for and timing of the bilateral nephrectomies in relation to the renal transplantation are described elsewhere.[15] All patients

requiring intensive care unit (ICU)-level postoperative care were managed in the same ICU with protocolized volume management.

An institutional data warehouse, the Perioperative Data Mart, was used to abstract patient demographic, surgical, medical, laboratory, anesthetic, and outcome data.[16] The incorporation of a second database, the Advanced Cohort Explorer, allowed for additional data to be obtained.[17] The accuracy of these two databases is reported to exceed that of manual extraction and both are periodically validated.[18,19]

Extracted variables included demographic characteristics (age, sex, American Society of Anesthesiologists [ASA] Physical Status Classification score, and select comorbidities). Laboratory data included select preoperative electrolytes and hemoglobin. Anesthetic data included duration, fluid administration (crystalloid, colloid, blood product transfusion), presence of invasive lines, lowest intraoperative hemoglobin, and data on vasoactive infusions. Finally, postoperative data included hospital length of stay (LOS), ICU admission and LOS, 30-day mortality, and select complications.

We used descriptive statistics for data analysis. Continuous variables were summarized as median and interquartile range. Categorical variables were summarized as frequency and proportion.

Results

Of the 54 cases, 32 (59%) were male, the median [interquartile range (IQR)] age was 51.50 [43.00–58.25] years, and 44 (82%) had an ASA Physical Status score of III. The median [IQR] Charlson comorbidity score was 4.[3-5] The most common etiology of kidney disease was ADPKD at 52/54 (96%). Five of 54 patients (9%) had undergone a dialysis procedure in the six months prior to transplantation. All received grafts from living donors. Only 14 (26%) cases were completed between 2012 and 2016, with 40 (74%) of cases occurring during 2017–2019. Additional baseline patient characteristics can be found in Table 1.

All procedures were conducted under general endotracheal anesthesia using a volatile-based balanced technique. Thirty (56%) patients were also administered a dose of preoperative intrathecal opioid. An arterial line was placed in 44 (82%) and a central venous catheter in 16 (30%) individuals. Three of these 16 included the use of thymoglobulin as an immunosuppressive induction agent, which is given centrally in our institution. In fifty-three (98%) cases, a hand-assisted, laparoscopic approach was used for the bilateral nephrectomies followed by renal transplantation. In the remaining case, an open approach

Table 1 Baseline patient demographic, clinical, and laboratory characteristics

Patient demographics	N = 54
Male	32 (59%)
Age (yr)	51.50 [43.00–58.25]
BMI (mg·kg^{-2})	28.3 [25.6–32.3]
ASA physical status	
II	3 (6%)
III	44 (81%)
IV	7 (13%)
Comorbidities	
Any smoking history	6 (11%)
Charlson comorbidity score	4 [3-5]
Hypertension	37 (69%)
Number of home antihypertensive medications	2 [1-3]
Polycystic liver disease	11 (20%)
Intracranial aneurysm	7 (13%)
Coronary artery disease	5 (9%)
Nephrolithiasis	7 (13%)
Home antihypertensive medication	
Angiotensin II receptor blocker	13 (24%)
Angiotensin converting enzyme inhibitor	20 (37%)
Beta blocker	26 (48%)
Calcium channel blocker	24 (44%)
Diuretic	11 (20%)
Other	3 (6%)
Kidney disease	
ADPKD	52 (96%)
Mantle zone B-cell lymphoma	1 (2%)
Bilateral papillary renal cell carcinoma	1 (2%)
Dialysis procedure in 6 months prior to transplant	5 (9%)
Laboratory data	
Preoperative potassium (mmol·L^{-1})	4.6 [4.3–4.9]
Preoperative sodium (mmol·L^{-1})	141 [140–143]
Preoperative creatinine (mg·dl^{-1})	4.2 [3.2–5.3]
Preoperative GFR (mL·min^{-1}BSA^{-1})	14.8 [9.4–17.6]
Preoperative hemoglobin (g·dL^{-1})	11.6 [10.3–12.7]

ADPKD = autosomal dominant polycystic kidney disease; ASA = American Society of Anesthesiologists; BMI = body mass index; GFR = glomerular filtration rate. Continuous variables are presented as median [interquartile range] and categorical variables as *n* (%)

via midline incision was used for both the bilateral nephrectomies and the renal transplantation. The median [IQR] surgical duration was 315 [296–354] min. One surgeon performed 52 (96%) of cases and a second surgeon performed two (4%).

Median crystalloid administration was 5,179 [4,608–6,225] mL and median estimated blood loss

(EBL) was 200 [125–400] mL. Five (9%) patients received intraoperative transfusion of packed red blood cells (RBC). Of these five, three received one unit of RBC. A fourth patient received four units of RBC and a fifth received three units of RBC along with two units of fresh frozen plasma (FFP). No other transfusions of FFP, platelets, or cryoprecipitate were given in this case series.

Forty-five (83%) patients had a mean blood pressure < 60 mmHg for at least four contiguous minutes and the median cumulative time with mean blood pressure below 60 mmHg was 14.00 [8.00–29.50] min. At least one vasopressor infusion was used in 44 (82%) cases and four (7%) required more than one vasopressor infusion used concomitantly. Intraoperative data can be found in Table 2.

Postoperatively, all patients were extubated in the operating room upon completion of the procedure and transported to the postanesthesia care unit. Subsequently, thirty-seven (69%) patients required admission to the ICU. Of this subset, 30 (81%) were admitted for continued need of vasopressor infusion, six (16%) for blood pressure monitoring in the absence of a vasopressor infusion, and one (2%) for monitoring of urine output/graft function. Median ICU LOS was 0.9 [0.7–1.4] days and total hospital LOS was 4.4 [4.3–5.4] days. One of 54 (2%) patients had to return to the operating room for exploratory laparotomy for lysis of adhesions. This patient was readmitted on postoperative day (POD) 5 for treatment of a small bowel obstruction that could not be managed conservatively. Although three (6%) patients did initially show signs of graft rejection, there were no cases of mortality at 30 days, postoperative dialysis, postoperative bleed, surgical site infection, myocardial infarction, or cerebrovascular accident. Median days alive and out of hospital at 30 days was 25.6 [24.6–25.7] days. Postoperative data can be found in Table 3.

Discussion

To our knowledge, this is the largest case series of the perioperative management of simultaneous nephrectomy with renal transplantation. Our main findings were that: 1) most cases involved ADPKD; 2) perioperative hypotension requiring vasoconstrictive medications was common; and 3) most patients required a short ICU stay.

As expected, the most common etiology of renal disease was ADPKD. Regardless of the operation, this disease state can create its own unique set of circumstances. Patients can have a myriad of conditions that require specific approaches for successful perioperative management, including hematuria, renal stones, hepatic cysts, intracranial aneurysms, and mitral valve prolapse.

Table 2 Intraoperative characteristics

Surgical data	N = 54
Living donor	54 (100%)
Surgical duration, min	315 [296–354]
Anesthetic duration, min	416 [387–456]
Intraoperative volume	
Crystalloid, mL	5,179 [4,608–6,225]
-Any normal saline	30 (56%)
-Normal saline, mL	5,941 [4,706–6,913]
-Any lactated Ringer's	28 (52%)
-Lactated Ringer's, mL	4,852 [3,925–6,575]
-Any Plasma-Lyte	6 (11%)
-Plasma-Lyte, mL	4,300 [3,025–5,300]
Colloid, mL	500 [0–1,000]
UOP, mL	200 [0–389]
EBL, mL	200 [125–400]
Intraoperative blood product administration	
Any RBC	5 (9%)
RBC, units	1.00 [1.00–3.50]
Any FFP	1 (1.9)
FFP, units	2 [2]
Any platelets	0 (0%)
Any cryoprecipitate	0 (0%)
Lowest intraoperative hemoglobin, $g \cdot dL^{-1}$	9.5 [8.5–11.2]
Invasive monitors/procedures	
Arterial line	44 (81%)
Central venous line	16 (30%)
Intrathecal narcotic administration	30 (56%)
Hemodynamics	
Mean blood pressure < 60 mm Hg for 4 contiguous min	45 (83%)
Cumulative time with mean blood pressure below 60 mm Hg, min	14.00 [8.00–29.50]
Infusions	
Any vasopressor infusion	44 (81%)
Two or more vasopressor infusion	4 (7%)
Ephedrine bolus	47 (87%)
Total ephedrine dose, mg	50 [28–50]
Total phenylephrine dose, μg	2,469 [0–9,925]
Phenylephrine infusion	34 (63%)
Total norepinephrine dose, μg	804 [356–1,059]
Norepinephrine infusion	7 (13%)
Total vasopressin dose, units	0 [0–2]
Vasopressin infusion	5 (9%)
Total epinephrine dose, μg	0 [0–0]

EBL = estimated blood loss; FFP = fresh frozen plasma; RBC = red blood cells; UOP = urine output. Continuous variables are presented as median [interquartile range] and categorical variables as n (%).

Table 3 Patient outcomes

Outcomes	N = 54
30-day mortality	0 (05)
Days alive and out of hospital at 30 days, days	25.6 [24.6–25.7]
ICU admission	37 (69%)
ICU length of stay, days	0.9 [0.7–1.4]
Invasive ventilator use	0 (0%)
Complications	
Postoperative hemorrhage	0 (0%)
Postoperative surgical infection	0 (0%)
Postoperative graft failure	1 (2%)
Postoperative graft rejection	3 (6%)
Delayed graft function	1 (2%)
Return to OR	1 (2%)
New postoperative dialysis	0 (0%)
Postoperative MI	0 (0%)
Postoperative acute stroke	0 (0%)

ICU = intensive care unit; MI = myocardial infarction; OR = operating room. Continuous variables are presented as median [interquartile range] and categorical variables as n (%).

In this case series, perioperative hypotension was common, as was the use of vasopressor medications. A likely contributor is that bilateral nephrectomy results in the loss of the RAS. After secretion by the kidneys, renin will hydrolyze angiotensinogen into angiotensin I, which is further cleaved by angiotensin-converting enzyme into angiotensin II.[20,21] Angiotensin II is a potent vasoconstrictor and also increases secretion of antidiuretic hormone (vasopressin) and aldosterone.[22-24] Together, this leads to an increase in arterial blood pressure and blood volume. Renin, of which the kidneys appear to be the only major source, will fall below baseline levels after bilateral nephrectomy.[25] The loss of the RAS initiator renin via bilateral nephrectomy could explain this decrease in blood pressure.

Over two-thirds of patients were admitted to the ICU postoperatively, as is the required level of care at our institution when vasoactive medications are used. Nearly this entire group was admitted for pharmacologic blood pressure support or close blood pressure monitoring. Though speculative, a possible etiology is the loss of the RAS system. Consistently, the stay in the ICU was brief. Most patients spent a single night in the ICU and were discharged to the floor on POD 1. This time course follows the new kidney graft resuming function and the resultant elevated renin levels in the immediate post-transplant period.[26,27]

The argument can be made that this requirement for perioperative vasopressor medications is a reason to stage the procedure. Nevertheless, our data show that the vasopressor requirements and ICU stay were brief. This would likely be a lower risk and less of an inconvenience to

patients than requiring a period of repeated dialysis during a temporary anephric state for pre-emptive patients.

With over 80% of patients requiring an intraoperative vasopressor infusion and two-thirds requiring ICU-level care for management related to blood pressure control, strong consideration should be made for obtaining central venous access for administration of vasopressor medications. Nevertheless, phenylephrine was the most commonly used infusion (63% of patients) as this is the first-line vasopressor drug used at our institution. Only four of 54 patients (7%) required two or more vasopressor infusions intraoperatively. These two points do allow for an argument that central access is not required as most cases could be adequately managed with a peripherally administered phenylephrine infusion. If the uncommon situation arises that a second vasopressor infusion is needed, vasopressin could be added peripherally. Taking this approach would still allow for safe management of patient hemodynamics without exposing the patient to the risk of central line placement. Invasive arterial blood pressure monitoring is highly recommended given the high frequency of hypotension and need for vasopressor infusion in this case series.

There are several limitations of this study. First, this study has all the inherent limitations of a historical cohort study design including charting errors and ambiguous rationales for decision-making. Secondly, the need for blood pressure support or monitoring requiring ICU-level care could be requested by either the attending anesthesiologist or attending surgeon. Due to limitations of the medical record database, it was not possible to determine absolute vasopressor indications for treatment of sustained hypotension vs surgeon blood pressure preference for graft perfusion. Third, this procedure is not common and our study contained a relatively small number of cases. Fourth, a limited protocol was used that applied to all renal transplantation cases but was not specific for cases of concomitant bilateral nephrectomy with renal transplantation. Fifth, all patients received kidneys from living donors and deceased donors were not involved in this case series.

Additional studies are required to better risk-stratify patients that do develop perioperative hypotension and/or require ICU-level care for blood pressure management. This would assist in determining vascular access needs and planning for the most appropriate postoperative level of care. One particular area of interest would be measuring plasma renin levels in the perioperative period as a potential cause of hypotension. Investigating arterial waveform-measured cardiac output would also help with the management of hemodynamics in this patient population. Finally, a large review incorporating the data

mentioned in this study could serve to create a protocol for the management of these cases.

In conclusion, we found that adult patients undergoing simultaneous bilateral nephrectomy with renal transplantation often developed perioperative hypotension requiring vasopressor infusions continuing into the postoperative period and thus required postoperative transfer to the ICU. Despite this, patients most commonly were transferred to the floor on POD 1 and had successful outcomes. In planning for these cases, appropriate monitoring and venous access for vasopressor infusions should be obtained and resources made available for postoperative transfer to an appropriately monitored setting.

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