Effect of Intraoperative Division of the Left Renal Vein on the Fate of Renal Function and Left Renal Volume After Open Repair of Para- and Juxtarenal Aortic Aneurysm

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Background: The effect of left renal vein division (LRVD) during open surgery (OS) for pararenal and juxtarenal abdominal aortic aneurysm (P/JRAA) on postoperative renal function remains controversial, so we focused on chronic renal decline (CRD) and separately examined renal volume as a surrogate index of split renal function.

Methods and Results: The 115 patients with P/JRAA treated with OS from June 2007 to January 2017 were reviewed: 26 patients without LRVD were matched to 27 patients with LRVD according to preoperative chronic kidney disease (CKD) stage and proximal clamp sites. The effect of LRVD on CRD was investigated by a time-to-event analysis. During a median follow-up of 23.5 months, CRD occurred in 5 patients with LRVD and in 4 patients without LRVD. Comparison of freedom from CRD showed no significant difference between the matched groups ($P=0.870$). The separate renal volumes were evaluated before surgery and at 1 and 2 years of follow-up using CT images from 18 patients with LRVD. At 2 years, the mean renal volume had decreased by 15% in the left kidney and by 9% in the right kidney ($P=0.052$ and 0.148 , respectively), but the left-to-right renal volume ratio showed no significant change ($P=0.647$).

Conclusions: LRVD had no significant effect on CRD or left renal volume relative to the right renal volume for up to 2 years.

Key Words: Chronic renal decline; Juxtarenal abdominal aortic aneurysm; Left renal vein; Separate renal function

A juxtarenal abdominal aortic aneurysm (AAA) is defined as an aneurysm requiring suprarenal or inter-renal proximal clamping for open surgery (OS) with infrarenal reconstruction. A pararenal AAA also necessitates suprarenal, and occasionally supraceliac, clamping but requires additional revascularization of the renal artery by definition.¹

Despite the continuing evolution of endovascular technologies, pararenal and juxtarenal AAA (P/JRAA) have not been recommended as suitable for standard endovascular aneurysm repair (EVAR) because of inadequate proximal sealing. Thus, OS persists as the gold standard for P/JRAA.

During OS for P/JRAA, left renal vein division (LRVD) is occasionally imperative for better access to the suprarenal aorta. Although half a century has passed since this technique was first reported as a feasible adjunct during AAA repair in 1967, its effect on postoperative renal function remains controversial.²

Although several prior studies suggested the safety of LRVD based on single-center series, those studies mostly referred to the effect on acute kidney injury (AKI) and rarely evaluated longer-term renal decline.^{3–8}

Recently, we reviewed a series of P/JRAA procedures using

a time-to-event analysis to show that preoperative renal function is a predictor of chronic renal decline (CRD) after OS for P/JRAA.⁹ Although we suggested that LRVD had no effect on CRD in that study, patients with LRVD tended to require suprarenal clamping more frequently than those without LRVD, which might have distorted the results. The position of the aortic cross-clamp in relation to the renal arteries is an important factor to consider because it might determine the laterality of renal ischemia and subsequent renal damage.^{7,10}

Another topic that has not been discussed in prior studies is split renal function after LRVD. Intuitively, LRVD is expected to have a greater influence on the left kidney than on the right kidney. However, to the best of our knowledge, no clinical study has evaluated split renal function to date.

In the present study, we retrospectively reviewed a series of P/JRAA patients treated with OS and compared patient groups with and without LRVD using a risk-adjusted analysis, in which proximal clamp sites and preoperative renal function were matched. The primary major goal was to analyze the effect of LRVD on renal function during longitudinal follow-up. Additionally, renal volume changes after LRVD were evaluated separately for each kidney to

Received May 8, 2019; accepted June 17, 2019; J-STAGE Advance Publication released online July 17, 2019 Time for primary review: 40 days

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assess the influence on the left kidney over time.

Methods

Study Population

Between June 2007 and January 2017, 1,085 patients underwent elective AAA repair, including 616 who underwent EVAR and 469 who were treated with OS, at the Division of Vascular Surgery, Nagoya University Hospital. Among OS patients, those who underwent elective OS with supra-renal or inter-renal clamping were included in the present study. Patients for whom supraceliac clamping was applied for the proximal clamp were also included as long as neither the superior mesenteric artery nor the celiac artery was involved in the aneurysm. Patients with thoracoabdominal aortic aneurysm or simultaneous endovascular repair for thoracic aortic aneurysm were excluded. In the present study, aneurysms fulfilling these criteria were defined as P/JRAA. Patients on hemodialysis at the time of surgery were excluded.

The study was performed in accordance with the principles of the Declaration of Helsinki. All patients gave informed consent to participate, and the Institutional Review Board of the Nagoya University Graduate School of Medicine approved and registered this study.

Surgical Procedures and Surveillance Protocol

Details of the perioperative management, surgical techniques, and follow-up surveillance have been described previously.^{9,11} Briefly, OS was performed under general anesthesia in combination with epidural anesthesia. The surgical approach was transperitoneal from a midline incision. The positions of the proximal clamps were decided based on the anatomy of the aneurysmal neck. Preoperative computed tomography (CT) images were carefully reviewed in advance to avoid embolization to the renal arteries by the mural thrombus. If necessary for approaching the proximal neck, the left renal vein (LRV) was divided adjacent to the inferior vena cava, preserving collateral tributaries for drainage of the left kidney. None of the divided LRVs was reconstructed.

Straight or bifurcated knitted Dacron grafts were used for in situ repair. If reconstruction of the renal artery was expected, renal perfusion with chilled Ringer's solution was performed. Warm arterial blood perfusion via a passive shunt from the brachial sheath was applied only in early, limited cases.

Similar to our previous study, the "renal ischemia time" was defined as the duration of time when at least the unilateral renal artery had been clamped and the normal blood supply had been affected.⁹

Enhanced CT with contrast was routinely performed in patients without renal impairment prior to discharge. Periodic follow-up examinations that included obtaining plain or enhanced CT and laboratory data were performed at 3, 6, and 12 months and annually thereafter according to our conventional practice.

Data Collection and Analysis of Renal Function

The patients' medical records were reviewed to retrospectively collect preoperative and intraoperative clinical parameters. Follow-up data concerning clinical outcomes were assembled into the database prospectively.

The estimated glomerular filtration rate (eGFR) was calculated based on the serum creatinine (Cr) level according to the following formula: $\text{eGFR (mL/min/1.73 m}^2\text{)} = 194 \times \text{Cr}^{-1.094} \times \text{age}^{-0.287} \times 0.739$ (if female).¹²

The eGFR was measured at pre- and postoperative time points and repeatedly evaluated during follow-up. Available follow-up eGFR data evaluated by other divisions of the institution were also included in the present study dataset.

Preoperative renal function was estimated using the chronic kidney disease (CKD) staging system and stratified as normal (stages 1 and 2, $\text{eGFR} \geq 60 \text{ mL/min/1.73 m}^2$) and abnormal (stage ≥ 3 , $\text{eGFR} < 60 \text{ mL/min/1.73 m}^2$).¹³ Patients in stage 5 ($\text{eGFR} < 15 \text{ mL/min/1.73 m}^2$ or dependent on renal replacement therapy) were excluded from this study.

Postoperative renal function during hospital stay was evaluated using the risk, injury, failure, loss of function, endstage renal disease (RIFLE) criteria.¹⁴

AKI was defined as an eGFR decrease $>50\%$ or a 2-fold increase in serum Cr level at the nadir of the patient's renal function. If the decrease in eGFR improved by $\leq 50\%$ or the serum Cr level increased by less than a 2-fold decrease compared with basal renal function, the patient was deemed to have recovered from AKI.

CRD was defined according to the same method used in previous studies.^{9,15,16} In patients with normal preoperative renal function (CKD stages 1 and 2), postoperative CRD was defined as a progression in CKD stage, namely, a sustained reduction in eGFR to $<60 \text{ mL/min/1.73 m}^2$ during follow-up. In patients with abnormal function (stages 3 and 4) preoperatively, postoperative CRD was defined as an eGFR reduction $>20\%$ or de novo dependence on permanent renal replacement therapy.

Renal Volume Measurements

Renal volume was measured in the patients who underwent LRVD using a method similar to that used in previous studies.^{17–20} All measurements were performed using a 3D-enabled workstation with AquariusNET software (TeraRecon Inc., Foster City, CA, USA). CT data were imported into the workstation to measure the volume of each kidney. On the workstation, the renal parenchyma was semi-automatically selected as the area of interest in enhanced CT images, and renal cysts and the pelvicalyceal system were manually excluded. If enhanced CT images were not available, the renal parenchyma was selected by integration of the manually included area in each of the axial view slices. The parenchymal volume was calculated using an algorithm available in the AquariusNET software. The renal volume before the operation and at 1 year and 2 years of follow-up was estimated. Because all measurements were performed by a single author (MS), the interobserver variability was not a consideration. To minimize the intraobserver variability, measurements were performed 3 times, and the data were averaged.

Statistical Analysis

Continuous data with normal distributions are expressed as the mean $\pm$ standard deviation (SD). Medians and interquartile ranges (IQRs) were used for other continuous data. Categorical data are presented as percentages. Student's t-test or the Mann-Whitney U-test was used for univariate analysis of continuous variables. The chi-square test or Fisher's exact test was used for univariate analysis of categorical variables. Kaplan-Meier analysis was performed to compare late survival rates and freedom-from-CRD rates. The significance of the differences was estimated by log-rank tests. A P-value <0.05 was considered significant for all analyses. For the propensity-matched analysis, patients without LRVD were matched to patients with LRVD accord-

Table 1. Comparison of the Groups With and Without LRV Division

Variable	LRV division (+)	LRV division (–)			
	(n=27)	Original (n=88)	P value	Matched (n=26)	P value
Age (years)	72.0±7.5	71.7±6.1	0.868	70.7±6.3	0.519
Male	22 (81.5)	77 (87.5)	0.525	21 (80.8)	1.000
COPD	6 (22.2)	10 (11.5)	0.372	10 (38.5)	0.229
Hypertension	24 (88.9)	69 (79.3)	0.395	21 (80.8)	0.409
Coronary artery disease	9 (33.3)	35 (40.2)	0.652	14 (53.8)	0.219
Diabetes	2 (7.4)	12 (13.8)	0.513	1 (3.8)	1.000
Stroke	2 (7.4)	6 (6.9)	1.000	0 (0)	0.491
Dyslipidemia	12 (44.4)	49 (56.3)	0.377	13 (50.0)	0.685
CKD			0.995		0.983
Stage 3	10 (37.0)	32 (36.8)		9 (34.6)	
Stage 4	2 (7.4)	6 (6.9)		2 (7.7)	
Proximal clamp site			0.087		0.854
Supraceliac	2 (7.4)	3 (3.4)		1 (3.8)	
Suprarenal	13 (48.1)	25 (28.7)		13 (50.0)	
Inter-renal	12 (44.4)	60 (67.8)		12 (46.6)	
Operation time (min)	320 [272–364]	245 [212–295]	<0.001	251 [211–290]	0.002
Blood loss (mL)	2,301 [1,401–3,157]	1,823 [1,149–2,627]	0.074	1,641 [982–2,329]	0.044
Renal ischemia time (min)	33 [28–40]	33 [25–45]	0.916	33 [25–40]	0.855
RA reconstruction	4 (14.8)	10 (11.5)	0.738	5 (19.2)	0.669
RA perfusion			0.129		0.144
Shunt from brachial artery	2 (7.4)	1 (1.1)		0 (0)	
Cold Ringer perfusion	1 (3.7)	9 (10.3)		4 (15.4)	

Categorical data are expressed as a number (%). Continuous data are expressed as the mean±SD or the median [interquartile range]. COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; LRV, left renal vein; RA, renal artery.

ing to proximal clamp sites and preoperative CKD stage.

All statistical analyses were performed using IBM Statistics Statistical Package for Social Science version 24 (IBM Corp., Armonk, NY, USA).

Results

Among the 469 elective OS cases, 119 patients underwent repair for P/JRAA; 3 with preoperative hemodialysis and 1 patient who died in hospital were excluded from the analysis. Consequently, 115 patients were enrolled in the present study, including 27 patients with LRVD (23.5%; LRVD group) and 88 patients without LRVD (76.5%; non-LRVD group).

Comparative Analysis With the Original Cohort

Patients' demographics and operative details are summarized in **Table 1**. Between the LRVD group and the original (unmatched) non-LRVD group, there were no significant differences in the patients' backgrounds, including preoperative CKD stages.

Concerning operative factors, patients with LRVD tended to need higher proximal clamping sites ($P=0.087$) and required a significantly longer operation time ($P<0.001$) than those without LRVD. On the other hand, the median renal ischemic time was not significantly different between the groups ($P=0.916$).

The clinical outcomes are shown in **Table 2**. AKI appeared to be more common in the LRVD group, but this difference was not significant ($P=0.103$). Because 1 patient with LRVD required postoperative temporary renal replacement therapy, the postoperative duration of hospital stay

was significantly longer in the LRVD group ($P=0.001$). However, this patient recovered and was free from hemodialysis at the time of discharge. At discharge, 1 patient in the LRVD group and 2 in the non-LRVD group had not recovered from AKI.

With respect to late outcomes, late survival rates were not significantly different between the groups ($P=0.371$, log-rank test). No aneurysm-related death has been confirmed.

During a median renal function follow-up of 29 months (IQR, 6.0–49.9) in the LRVD group and 22.7 months (4.8–42.3) in the original non-LRVD group, CRD occurred in 5 (18.5%) and 14 (16.1%) patients, respectively; 1 patient in the original non-LRVD group required hemodialysis 5 years after surgery.

Comparative Analysis of Matched Cohorts

The demographics and operative details of the patients matched using propensity scores are also presented in **Table 1**. The 26 patients in the original non-LRVD group were matched to 27 patients in the LRVD group according to preoperative CKD stage and proximal clamp sites. After this matching, there were no significant differences in other preoperative factors.

The proximal clamp sites were matched to be similar between the groups ($P=0.854$). In the matched non-LRVD group, suprarenal clamping was more dominant (50.5%) than in the original group (28.7%). That is, suprarenal cases were matched more frequently, and inter-renal clamp cases were adopted less, indicating that the more challenging cases were extracted into the matched non-LRVD group. Despite this matching, operation time and blood loss remained significantly longer and greater in the LRVD group ($P=0.002$

Table 2. Postoperative Renal Outcomes

Variable	LRV division (+)	Original (n=88)	LRV division (-)		
	(n=27)		P value	Matched (n=26)	P value
Early outcomes					
Postoperative hospital stay (days)	18 [13–32]	12 [10–15]	0.001	12 [10–15]	0.022
AKI during hospital stay	9 (33.3)	15 (17.2)	0.103	5 (19.2)	0.244
Temporary renal replacement therapy	1 (3.7)	0 (0)	0.237	0 (0)	0.322
Persistent AKI at discharge	1 (3.7)	2 (2.3)	0.599	2 (7.7)	0.610
Late outcomes					
Median follow-up (months)	33.0 [18.1–67.0]	34.1 [14.8–54.3]	0.271	36.2 [15.5–42.4]	0.302
Death during follow-up	4 (14.8)	5 (5.7)	–0.371 ^a	2 (7.7)	0.904 ^a
Aneurysm-related death	0 (0)	0 (0)	1.000	0 (0)	1.000
Renal function follow-up (months)	29.0 [6.0–49.9]	22.7 [4.8–42.3]	0.432	20.6 [10.4–40.8]	0.715
CRD	5 (18.5)	14 (16.1)	0.805 ^a	4 (15.4)	0.870 ^a
Permanent hemodialysis	0 (0)	1 (0.01)	0.576	0 (0)	1.000

Categorical data are expressed as a number (%). Continuous data are expressed as the median [interquartile range]. ^aTime-to-event analysis with the Kaplan-Meier method. AKI, acute kidney injury; CRD, chronic renal decline. Other abbreviations as in Table 1.

and 0.044, respectively), reflecting the absolute complexity of LRVD.

The clinical outcomes of the matched cohort are shown in **Table 2**. After matching, postoperative stay remained longer in the LRVD group ($P=0.022$). With respect to early renal outcomes, there was no significant difference between the groups.

Late survival rates were similar between the matched cohorts ($P=0.904$, log-rank test). The rates of freedom from CRD were also comparable between the LRVD group and the matched non-LRVD group ($P=0.870$, log-rank test) (**Figure 1**).

Renal Volume Change After LRVD

In the LRVD group, 1- and 2-year follow-up CT images were available for 18 patients. The results of renal volume measurement in these 18 patients are shown in **Table 3** and **Figure 2**.

The mean left renal volume decreased during follow-up, resulting in a 15% decrease at 2 years after surgery, although this change was marginally significant ($P=0.052$) (**Figure 2A**). Additionally, the mean right renal volume had decreased by 9% at 2 years after surgery ($P=0.148$) (**Figure 2B**). As a result, the ratio of left-to-right renal volume, which indicates the relative volume of the left kidney, showed no significant change for up to 2 years ($P=0.647$) (**Figure 2C**).

Discussion

With the advent of EVAR followed by the development of anatomical indications with new devices, the majority of infrarenal AAA cases have been treated with EVAR at Nagoya University Hospital.²¹ However, challenging proximal aneurysmal necks are still a contraindication for standard EVAR, and OS has been the gold standard, especially in countries such as Japan where the introduction of

Table 3. Renal Volume After LRV Division

	LRV division (+) (n=18)		
	Preoperative	1 year	2 years
Left renal volume (cm ³)	141.9±19.0	131.7±29.2	120.5±29.2
Right renal volume (cm ³)	130.8±20.1	124.1±19.7	119.1±22.9
Left/right renal volume ratio	1.09±0.11	1.08±0.27	1.04±0.31

Data are expressed as mean±SD. Abbreviations as in Table 1.

Figure 2. Mean±standard error of left renal volume (A), right renal volume (B), and the left-to-right renal volume ratio (C) during follow-up in 18 patients with left renal vein division.

advanced armamentarium, such as fenestrated or branched EVAR, is delayed. Thus, the proportion of P/JRAA in OS has been increasing at our hospital. The proportion was 25.3% (119/469) during the present study period, a significant increase compared with the 2-year period in the pre-EVAR era before this study (6%; 7/113; $P<0.01$).

When tackling the anatomically challenging necks of P/JRAA, LRVD is occasionally necessary for better access to the suprarenal aorta to allow surgeons to administer a secure proximal clamp and perform anastomosis with an improved view. Although this technique was first reported as a feasible adjunct during OS for AAA in 1967, postoperative renal function after LRVD has remained controversial.²

Some previous studies suggested that renal hypertension caused by LRVD could result in a reduction in renal blood flow and subsequent renal impairment.^{4,22,23}

According to West et al,⁴ LRVD without reconstruction was significantly associated with acute renal impairment. In their 247 patients with pararenal AAA, LRVD was associated with acute renal failure (defined as postoperative Cr elevation ≥ 0.5 mg/dL) in multivariable logistic regression ($P=0.04$). On the other hand, Marrocco-Trischitta et al²² analyzed their series of AAA repair with LRVD followed by reconstruction, and advocated that the LRV should be routinely reconstructed after temporary division for maintenance of renal function. They also claimed that this strategy did not increase operation time or postoperative complications.

Another strategy is selective reconstruction of the divided LRV. Calligaro et al²³ found that LRV pressure elevation caused by LRVD could diminish left renal glomerular and tubular function at pressures ≥ 50 –60 cmH₂O in a canine model. Based on this finding, they recommended selective reconstruction according to the LRV stump pressure.

Although these strategies seem to be acceptable to some extent, there is no strong evidence supporting their ability to contribute to preventing postoperative left renal impairment, especially in the longer term.

By contrast, there are other studies suggesting the safety of LRVD without reconstruction. Theoretically, the stump pressure will remain low as long as the tributaries (gonadal, adrenal, and lumbar veins) are well preserved to function as collateral drainage.

Mehta et al⁶ reported that LRVD without reconstruction led to an initial drop in renal function, followed by an improvement over 2–6 weeks. At each stage, the eGFR was comparable between the 49 patients with LRVD and 212 patients without LRVD.

Samson et al⁵ also reported results for 56 patients with LRVD. The suprarenal clamp was used in 51 patients. In 36 patients who were followed for >1 year, only 2 patients with preoperative Cr >1.5 mg/dL had chronic renal dysfunction, defined as Cr >2.0 mg/dL, and these elevations of Cr were deemed to be caused by the progression of intrinsic nephrosclerosis and thus irrelevant to the LRVD.

Consistent with those studies, our results supported the safety of LRVD without reconstruction during OS for P/JRAA in which renal artery clamping was required. Compared with previous studies, however, the present study has 3 distinctive features.

The first is the definition of late renal impairment. Because patients with preoperative CKD are expected to progress to the advanced stage in the natural course of CKD, a systematic definition of CRD that stratifies patients by preoperative CKD stages is considered rational. Thus, the present study adopted the methodology used in other studies that analyzed long-term renal function after open and/

Figure 3. A 3D reconstructed image of a representative case 2 years after left renal vein division. The large arrow indicates the stump of the left renal vein. The small arrows indicate developed collaterals that run from the left renal vein to the inferior vena cava via the lumbar vein.

or endovascular AAA repair.^{15,16} In this method, preoperative renal function is stratified as normal (CKD stages 1 and 2) or abnormal (CKD stages 3 and 4). During long-term follow-up, postoperative CRD was defined differently for each subgroup: in the normal preoperative renal function group, it was defined as a sustained reduction of eGFR to $<60 \text{ mL/min/1.73 m}^2$; in the abnormal group, it was defined as an eGFR reduction $>20\%$ (more rapid than expected for CKD patients as a group) or de novo dependence on permanent renal replacement therapy. Additionally, this method enabled us to compare the rates of freedom from CRD between the groups in a time-to-event analysis, which is also unique to the present study.

The second feature is the risk-adjusted analysis. We previously suggested that LRVD had no effect on CRD.⁹ However, in that study, patients were not matched, and patients who underwent LRVD tended to require suprarenal clamping more frequently than those without LRVD. Notably, a previous study suggested that LRVD was not a genuine predictor of postoperative renal function but was a surrogate indicator of challenging aneurysm repair in which more proximal clamping was required.⁷ Moreover, the mode of the proximal clamp, namely, bilateral vs. unilateral renal transient ischemia, was considered to affect gross renal function.^{7,10} To avoid these problems, another previous study chose to exclude patients with suprarenal clamping and limited their study population to those with inter-renal clamping.⁸ As an alternative to this exclusion, we conducted a risk-adjusted comparison matching the original non-LRVD group to the LRVD group. Because the preoperative CKD stage was shown to be a significant predictor for CRD in our previous publication, it must be matched as well.⁹

Similar to our recent publication, suprarenal clamping seemed to be less frequent in the original non-LRVD group than in the LRVD group ($P=0.087$), indicating that LRVD tended to be required for more anatomically challenging aneurysms. This factor became similar after matching ($P=0.854$). Even in the matched comparison, LRVD was related to longer operation times and greater blood loss. Because LRVD itself is inevitably time consuming, this finding is acceptable. Notwithstanding this larger intraoperative invasion, LRVD did not correlate with poorer early outcomes in our results, and the subsequent analysis con-

cluded that LRVD had no significant effect on CRD for up to 2 years during longitudinal follow-up.

The third feature is separate measurement of renal volumes. As discussed earlier, several studies have suggested that LRVD, especially without reconstruction, might be detrimental to the left kidney. However, previous studies, including ours, evaluated postoperative renal function using the creatinine level and/or eGFR, which reflects the sum of bilateral renal function.^{1,3,5–10,23} Although the gross renal function is emphasized in common clinical practice, split renal function is also of great interest after LRVD. Because the right kidney potentially compensates for disorders of the other kidney, unilateral impairment of the left kidney does not necessarily lead to deterioration of gross renal function. However, this is not true in patients whose right kidney has very little reserve. If LRVD without reconstruction will be detrimental to the left kidney, intraoperative reconstruction is mandatory for those patients.

In this context, the present study separately measured renal volumes as a surrogate index of split renal function. Renal volume measurements on CT images have been shown to be a reliable alternative to a Tc-99m-mercaptoacetyltriglycine (MAG3) scintigraphy for evaluating split renal function.^{19,20} To the best of our knowledge, the present study is the first to evaluate split renal function after LRVD. Among 18 patients who underwent LRVD without reconstruction, the left renal volume decreased by 15% at 2 years after surgery ($P=0.052$). However, the right renal volume also decreased by 9% during this period ($P=0.148$). A previous study reported that bilateral renal volumes, which are indicators of absolute renal function, are expected to diminish over time after OS for AAA.¹⁷ Therefore, the present study calculated the ratio of the left-to-right renal volumes to evaluate relative renal function. Our results demonstrated that left renal function remained relatively constant compared with right renal function for up to 2 years after LRVD, even without reconstruction. We speculate that our operative technique to preserve the tributary vein might have contributed to the development of sufficient collateral drainage during follow-up, resulting in the prevention of renal hypertension and subsequent renal injury (Figure 3).

Study Limitations

Because of the nature of a retrospective analysis, our results are subject to bias. In the present study, complete data sets covering the medical management of comorbidities during follow-up were lacking. Thus, the association between CRD and medical management was not adequately clarified.

Although the risk-adjusted analysis is one of the features of the study, it led to a smaller sample size and lower statistical power. In addition, the number of events was limited during the study period. Although the present study is a valuable consecutive series of LRVD with longitudinal renal function follow-up, a larger population might be necessary to construct stronger evidence to support the safety of LRVD.

Conclusions

According to a risk-adjusted comparison with matching for preoperative CKD stage and proximal clamp sites, LRVD had no significant effect on CRD for up to 2 years of follow-up after OS for P/JRAA. Even without reconstruction, LRVD was not detrimental to the left kidney relative to the right kidney. Our results supported the safety of LRVD in terms of midterm outcomes.

Disclosures

None to declare.

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