Left Renal Vein Division During Open Surgery of Abdominal Aortic Disease: A Propensity Score-Matched Case—Control Study

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WHAT THIS PAPER ADDS
As management of the left renal vein in abdominal aortic surgery is still controversial, we conducted a propensity score-matched case—control study to evaluate the effect of left renal vein division, and concluded that left renal vein division did not increase the risks of early or late mortality and morbidity in patients who underwent open surgery of the abdominal aorta.

Objective: To investigate the impact of left renal vein division (LRVD) on the postoperative renal function of abdominal aortic aneurysm (AAA) or aortic occlusive disease (AOD).

Methods: Between January 2000 and January 2012, 238 patients, including 179 AAAs and 59 AODs underwent open surgery in our institution (patients who required suprarenal aortic clamping were excluded). 49 patients (38 AAAs, 11 AODs) required LRVD during the operation. Patients in the LRVD and non-LRVD groups were matched using propensity score method in a 1:2 ratio. Pre- and postoperative renal function, major complications, in-hospital mortality and long-term renal function were compared. Late survival rate was estimated using the Kaplan—Meier method.

Results: Overall, the LRVD group had a significantly higher male/female ratio (39/10 vs. 122/67, \( p = .045 \)), higher ruptured AAA ratio (36.7% vs. 20.1%, \( p = .014 \)), higher American Society of Anesthesiologists (ASA) classification 3 (53.1% vs. 30.2%, \( p = .003 \)), higher co-morbidities of coronary artery disease (51.0% vs. 33.3%, \( p = .022 \)), higher preoperative shock (22.4% vs. 8.5%, \( p = .006 \)) and longer operative time (164.2 ± 43 vs. 150.1 ± 41 min, \( p = .035 \)). With propensity score matching (PSM), 48 patients in the LRVD group and 96 in the non-LRVD group were enrolled in this study. The baseline characteristics were well balanced in the groups (\( p < .05 \)) after PSM. There were no statistically significant differences in preoperative glomerular filtration rate (GFR, expressed as mL/min/1.73 m²) (62.0 ± 13.1 vs. 62.9 ± 12.9, \( p = .695 \)), and postoperative GFR on day 1 (60.3 ± 13.7 vs. 61.3 ± 13.1, \( p = .671 \)), day 3 (54.6 ± 16.8 vs. 58.8 ± 14.3, \( p = .120 \)), day 7 (62.1 ± 16.8 vs. 63.7 ± 13.4 \( p = .537 \)) and in the long term (>12 months) (62.4 ± 14.0 vs. 64.7 ± 11.8 \( p = .302 \)). There were no statistically significant differences in in-hospital mortality (6.3% vs. 9.2%, \( p = .522 \)) and late survival rate estimated by the Kaplan—Meier method (\( p = .96 \)).

Conclusion: LRVD may be a safe maneuver during abdominal aortic surgery as it did not increase the risks of early or late mortality and morbidity.

INTRODUCTION
To gain adequate exposure of the infrarenal aorta during surgery for abdominal aortic aneurysm (AAA) or aortic occlusive disease (AOD), left renal vein division (LRVD) is often required. According to the literature, LRVD rate ranges from 1.3% to 18.8%.1,2 This adjunctive maneuver could facilitate the operation and sometimes save time during a bleeding situation. On the other hand, LRVD may also lead to venous hypertension and dysfunction of the left kidney. There are several published studies giving conflicting results on the safety of LRVD.2–8

More clinical data need to be accumulated, but it is difficult to perform a large sample study in a single centre. And, because of the ethical problem, we cannot collect evidence from a randomized clinical trial (RCT). In this study, we made some amelioration in methodology. A propensity score-matched (PSM) method, which could replicate some of the characteristics of a RCT,9 was used to control confounding factors and selective bias between LRVD patients and non-LRVD patients who underwent abdominal aortic surgery. Both the early and long-term renal function were compared.
PATIENTS AND METHODS

A retrospective review was carried out of all patients diagnosed as AAA or AOD treated with open surgery at First Hospital of China Medical University between January 2000 and January 2012. To avoid the confounding factors of renal ischemia impact on the postoperative renal function, patients requiring suprarenal aortic clamping were excluded from this study. Two-hundred and thirty-eight (238) patients, including 123 stable AAAs (sAAA) (51.7%), 56 ruptured AAAs (rAAA) (23.5%) and 59 AODs (24.8%), were eligible. Patients with CT and laparotomic findings of retroperitoneal hematoma or free peritoneal blood were diagnosed as rAAA. All rAAAs were treated urgently.

A transperitoneal midline incision was used in all cases. Blood flow was reconstructed with a bifurcated PTFE graft in the form of end-to-end anastomosis in proximal aorta and end-to-side anastomosis in distal iliac arteries or femoral arteries. To improve the exposure of proximal neck, LRVD was performed in 49 patients (20.6%), including 20 sAAA, 18 rAAA and 11 AOD. All left renal veins were ligated and divided near the inferior vena cava to preserve collateral tributaries for drainage of the left kidney. There was no left renal vein reconstruction in this group.

Theoretically, patients who needed LRVD may have had worse baseline characteristics and surgical complexity compared with non-LRVD patients. In order to attenuate confounding variables, we conducted a propensity score-matched case-control study.

Pre- and postoperative (day 1, 3 and 7) renal function, major complications, in-hospital mortality, late survival rate and long-term renal function were compared. For renal function evaluation, both serum creatinine (sCr) and glomerular filtration rate (GFR) were used. GFR was estimated by the Cockcroft-Gault equation: \[ \frac{140 \text{ (age)} - \text{weight/72} \times \text{sCr}}{1.73} \] (age is in years, weight is in kg and sCr is in mg/dL; the equation is multiplied by 0.85 in women). The GFR values are expressed as mL/min/1.73 m².

Major complications include myocardial infarction (MI), pulmonary embolism (PE), respiratory failure, renal dysfunction, major amputation, cerebral infarction and ileus. MI was diagnosed by electrocardiographic change and elevated cardiac enzymes. Respiratory failure was defined as a patient who could not be independent from a ventilator >72 hours, or required postoperative reintubation or tracheostomy. The diagnosis of PE or cerebral infarction was made using radiographic evidence and consultation of a senior specialist. Major amputation indicated below- or above-knee amputation for severe lower limb ischemia. Renal dysfunction was defined as a rise in sCr >0.5 mg/dL or an absolute sCr level >2.0 mg/dL. Ileus was considered if the gut motility did not recover till 72 hours after surgery.

We used the propensity score-matched method to balance the confounding factors between the LRVD and non-LRVD groups. For each patient, propensity score was calculated using a multivariable logistic regression model with the end point of LRVD (non-LRVD coded as 0, LRVD coded as 1). Theoretically, matched pairs of patients were selected from the eligible population to compare major complications, late survival rate and longitudinal renal function. Patients were matched by age, weight, diabetes mellitus, chronic obstructive pulmonary disease (COPD), hypertension, coronary artery disease (CAD), end-stage renal disease (ESRD), global ischemic time and operative time. Values >2.0 mg/dL were considered abnormal. Preoperative and postoperative serum creatinine and GFR were used to calculate the glomerular filtration rate (GFR) with the Cockcroft-Gault equation: \[ \frac{140 \text{ (age)} - \text{weight/72} \times \text{sCr}}{1.73} \] (age is in years, weight is in kg and sCr is in mg/dL; the equation is multiplied by 0.85 in women). The GFR values are expressed as mL/min/1.73 m².

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RESULTS
A total of 144 patients were included in our study (48 in the LRVD group and 96 in the non-LRVD group). One rAAA patient in the LRVD group was not matched. Prior to matching, LRVD had significantly higher male/female ratio, ruptured AAA ratio, ASA classification, comorbidities of coronary artery disease, preoperative shock rate and longer operative time. After matching, these variations were well balanced between groups. Detailed patient demographics are shown in Table 1.

Both preoperative sCr and GFR showed no significant difference. We found a compromised renal function on postoperative day 1 and 3, which recovered to the baseline on day 7. However, there was still no significant difference on postoperative renal function. In 115 patients (37 in the LRVD group, 78 in the non-LRVD group) survived more than 12 months, long-term renal function was obtained in an average of 31 months after surgery (13–78 months). Renal functions of six patients (four in the LRVD group, two in the non-LRVD group) were failed to be evaluated. Data available also showed no significant difference. Details of sCr and GFR are shown in Tables 2 and 3.

No significant difference was observed between groups in major complications (Table 4). Total in-hospital mortality was 8.3% (12 patients), all of these patients were rAAA except for one sAAA who died from PE in the non-LRVD group. In-hospital mortality (%)

<table>
<thead>
<tr>
<th>Value</th>
<th>LRVD group</th>
<th>Non-LRVD group</th>
<th>p Value</th>
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<tr>
<td>MI</td>
<td>2 (4.2%)</td>
<td>1 (1.0%)</td>
<td>.216</td>
</tr>
<tr>
<td>PE</td>
<td>0 (0%)</td>
<td>1 (1.0%)</td>
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<td>3 (6.3%)</td>
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DISCUSSION
Although the incidence of abdominal aortic disease is increasing with the aging of Chinese population, the amount of open surgery is decreasing. This is because of a widely accepted endovascular therapy for AAA or AOD. However, increased complexity of open aortic surgery had been noticed.12 Cases left to open surgery were often in emergency or with unfavorable anatomy, especially the short proximal neck. Thus, more LRVD was needed to improve the exposure of the aorta. In our series, the ratio of LRVD was 20.6% in all and 21.2% in AAA patients, which was higher than previous reports.1,2

Renal hypertension caused by LRVD resulted in a reduction of renal blood flow and GFR. The activation of the renin—angiotensin—aldosterone system may further reduce GFR.13 These pathophysiological changes were similar to the nutcracker syndrome, which was characterized by impeded outflow from the LRV into the inferior vena cava as a result of extrinsic compression.14 To preserve venous collaterals and reduce the risk of stump thrombosis, all left renal veins were divided close to the inferior vena cava. Some early reports described complications of bleeding, renal edema or renal rupture caused by division near the left kidney.15–17 In our series, no patient experienced any symptoms of nutcracker syndrome, such as left flank pain or massive hematuria,14 both in-hospital and follow-up. There

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LRVD = left renal vein division; MI = myocardial infarction; PE = pulmonary embolism.

Table 2. Pre- and postoperative sCr (mean ± SD), expressed as mg/dL.

<table>
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<tr>
<td>Preoperative sCr</td>
<td>.92 ± .27</td>
<td>.94 ± .25</td>
<td>.660</td>
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<tr>
<td>Postoperative day 1 sCr</td>
<td>1.06 ± .25</td>
<td>1.05 ± .26</td>
<td>.826</td>
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<tr>
<td>Postoperative day 3 sCr</td>
<td>1.14 ± .34</td>
<td>1.07 ± .32</td>
<td>.228</td>
</tr>
<tr>
<td>Postoperative day 7 sCr</td>
<td>.97 ± .37</td>
<td>.96 ± .28</td>
<td>.857</td>
</tr>
<tr>
<td>Long-term sCr</td>
<td>.95 ± .29</td>
<td>.93 ± .23</td>
<td>.653</td>
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LRVD = left renal vein division.
was also no symptomatic PE in the LRVD group. Re-
anastomosis of the left renal vein might be necessary 
when the collaterals, especially inferior adrenal and gonadal 
veins, are in absence.

So far, the safety of LRVD without re-anastomosis is still 
controversial. Some studies showed that the LRVD did not 
influence the in-hospital renal function or associated com-
lications of aortic surgery. Samson and colleagues investigated the long-term renal function of 36 LRVD pa-
tients, and found that all patients had a stable sCr and GFR level except for two, who had insufficient preoperative renal function and experienced deterioration more than a year after surgery. These findings demonstrated that LRVD was a safe adjunct for aortic surgery.

Some other reports gave a conflicting conclusion, in that increased in-hospital sCr and decreased GFR after LRVD were observed. AbuRahma reported that two of 13 LRVD patients had no left renal function six months after surgery. In a multivariate analysis for open surgery of pararenal AAA, West et al. demonstrated that LRVD was a significant predictor of pulmonary complications, post-
operative renal insufficiency and prolonged hospital stay.

Marrocco-Trischitta et al., reporting on a group of AAAs who underwent LRVD and reconstruction during open repair, concluded that left renal vein reconstruction main-
tained renal function and was not associated with length-
ening operative time and increasing complications. However, re-anastomosis of the vein can only be completed safely and quickly by a well-trained surgeon. It was difficult to promote the reconstruction in all hospitals.

Available reports could not fully answer whether LRVD was a marker of complexity of surgical procedure or whether LRVD itself led to those complications. Obviously, a RCT design would be unethical for this issue. Suprarenal aortic clamping might be another impact factor on renal function. Hence, in our retrospective study, patients requiring suprarenal aortic clamping were excluded, and the LRVD group was matched using the propensity score method to make the two groups more comparable.

There are still some limitations of this study. Post-
operative imaging of computed tomography angiography or ultrasonography may help us better understand the physi-
ological and pathological changes in the left kidney after LRVD. Further determination of split renal function is recommended to reveal the direct impact of LRVD on the left kidney.

In conclusion, LRVD does not adversely affect the post-
operative renal function, complications and early or late survival rate of patients undergoing abdominal aortic surgery. It is a safe procedure for complex or emergency aortic surgery. Reconstruction of the left renal vein may be un-
necessary when the collaterals are preserved.

CONFLICT OF INTEREST
None.

FUNDING
None.

REFERENCES