Comparison of Renal Artery vs Renal Artery-Vein Clamping During Partial Nephrectomy: A System Review and Meta-Analysis

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Abstract

Background: Although artery-only (AO) clamping has been proposed to minimize ischemic renal damage compared with artery-vein (AV) clamping, the benefit of AO clamping during laparoscopic partial nephrectomy (LPN) is still controversial. We performed a systematic review and meta-analysis to test the difference between AO clamping and AV clamping in partial nephrectomy (PN).

Materials and Methods: A systematic review of the literature on PubMed, Web of Science, the Cochrane Library, and Embase was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement to search-related studies. Data were extracted using a reporting checklist proposed by the Meta-analysis of Observational Studies in Epidemiology Group. RevMan 5.3 software and Stata 12.0 were used to do meta-analysis.

Results: The present meta-analysis included 2 retrospective and 3 prospective studies, including 242 patients who underwent AO clamping and 369 patients who underwent AV clamping, which compared AO and AV clamping in LPN for renal cell carcinoma. At baseline, no statistically significant differences were detected between AO and AV clamping groups in terms of body mass index ($p=0.23$), tumor size ($p=0.95$), but AO clamping group had significantly lower RENAL Score (fixed effects [FE]: weighted mean difference [WMD]: 0.36, $p=0.007$). For surgical outcomes analysis, no significant difference was detected regarding to warm ischemia ($p=0.58$), operating time ($p=0.40$), transfusion rate ($p=0.58$), and estimated blood loss ($p=0.35$) between two groups. The assessment of renal function by creatinine value both at the early postoperative ($p=0.36$) and at last follow-up ($p=0.38$) revealed no difference. There was no significant difference in estimated glomerular filtration rate (eGFR) ($p=0.62$), and at the early postoperative percentage decrease of eGFR ($p=0.79$). However, a higher percentage decrease of eGFR decrease at last follow-up was demonstrated for the AV clamping group (FE: WMD: 2.42, $p<0.00001$).

Conclusion: These results suggest that AO clamping might be a better choice for PN in long term. Randomized controlled trial studies with larger sample numbers and long-term follow-up and split renal function assessment should be conducted in the future to confirm our conclusion.

Keywords: renal artery clamping, renal artery-vein clamping, partial nephrectomy

Introduction

PARTIAL NEPHRECTOMY (PN) has been gaining popularity in the last decade and become the gold standard treatment for patients with small renal tumors.¹ Renal artery clamping techniques is a key point in PN for renal function preservation, and renal artery with or without renal vein clamping during PN is one of these techniques. Theoretically, artery-only (AO) clamping may minimize ischemic renal

damage compared with artery-vein (AV) clamping because of retrograde venous perfusion during AO clamping. On the contrary, AV clamping blocks venous backflow during tumor resection, allowing better visualization of the renal tumor margins control and subsequent renal reconstruction.^{2–4}

Several animal studies have shown that AO clamping resulted in increased tolerance to ischemic damage compared with AV clamping during PN.^{3–5} However, most of recent studies among human subjects undergoing PN show no

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benefit of retrograde venous perfusion associated with AO vs AV clamping during PN.^{2,3,6,7} However, a retrospective study by Gong suggested that AO occlusion may provide superior renal preservation during laparoscopic partial nephrectomy (LPN).⁸ These studies yield inconsistent results and thus fail to provide a general consensus on the renoprotective effect of AO vs AV clamping during PN. In an effort to elucidate any surgical and renal function benefit from AO vs AV clamping, we conducted a systematic review and meta-analysis of the available literature to compare AO vs AV clamping on the clinical characteristics and surgical and functional outcomes of renal cell carcinoma (RCC) patients who underwent PN.

Materials and Methods

Literature search strategy

Systematic literature searches of PubMed (through May 2019), EMBASE (through May 2019), Web of Science (1950 to May 2019), and the Cochrane Library (through May 2019) were conducted to retrieve potentially relevant studies, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines.⁹ We used the keywords as follows: (“partial nephrectomy” OR “nephron sparing surgery”) AND (“renal artery only clamping” OR “renal artery and vein clamping”) AND (“comparative studies”). No restriction was applied. We also manually searched the references of related articles for additional studies. Two reviewers conducted the searching independently, and all divergences were diminished through group discussion, and consensus were reached.

Inclusion criteria and exclusion criteria

Two authors reviewed all candidate studies (J.C. and S.Z.), and divergences were solved by focus groups. Studies fulfilling the following criteria were selected for the meta-analysis: patients who were diagnosed with RCC and received PN treatment; the study that directly compared AO vs AV clamping; and sufficient original data for comparison could be extracted or calculated. We excluded noncomparable studies, such as reviews, letters, case reports, and nonhuman studies; studies without sufficient data to analyze AO and AV clamping; and studies not in English language were excluded as well.

Data extraction

The reporting checklist proposed by the Meta-analysis of Observational Studies in Epidemiology (MOOSE) Group was applied to extracted related data.¹⁰ Data extraction was performed independently by two authors, and any discrepancies were resolved by group discussion. The first author, publication year, country, study design, age of patients, patients numbers, and baseline clinical characteristics were extracted from related studies. The main surgical and functional parameters of interest included warm ischemia time, operating time (OT), estimated blood loss (EBL), transfusion rate (TR), tumor size (TS), RENAL Score, creatinine, postoperative estimated glomerular filtration rate (eGFR), and percentage decrease in baseline eGFR (% eGFR).

Statistical analysis

Inverse variance test was used to pool weighted mean differences (WMDs) for continuous variables, and dichotomous variables were pooled as odds ratios and 95% confidence intervals (95% CIs) using Mantel-Haenszel (M-H) test. The Cochrane Q statistic and I^2 statistic were applied to assess statistical heterogeneity among studies. The value of $p < 0.10$ or $I^2 > 50\%$ was used to account for substantial heterogeneity among studies. If there was no evidence of heterogeneity among studies, a fixed effects (FE) model was used; otherwise a random-effects (RE) model was used. The “leave-one-out” cross-validation procedure was applied to evaluate sensitivity among studies. Publication bias of studies was analyzed via the Begg’s funnel plot and the Egger’s linear regression test. Review Manager Version 5.0 (The Cochrane Collaboration, Oxford, London, UK) and STATA 12.0 software (Stata Corporation, College Station, TX) were used to conduct statistical analyses. Two-tailed $p < 0.05$ was considered statistically significant.

Quality assessment

The quality assessment of included studies was conducted following the Newcastle Ottawa scale (NOS)¹¹ for non-randomized controlled trials (RCTs). Each study was evaluated by eight methodology items with a score ranging from 0 to 9. Studies with scores ≤ 5 were considered as low quality, 6–7 considered as intermediate quality, and 8–9 as high quality.

Results

Clinical characteristics and quality assessment of eligible studies

The flow chart of the literature search is shown in Figure 1. From a total of 337 potentially relevant abstracts initially retrieved, 197 records were removed after review of title/abstract if there were case reports, letters, review, meta-analysis, or nonhuman studies; 30 studies were excluded because of data deficiencies and surgical technique on off-clamping or artery selective clamping. At last five studies that complied with the inclusion criteria were included in the meta-analysis.^{2,6–8,12} The clinical characteristics of all five included studies are shown in Table 1. A total of 611 patients with RCC patients received PN were included in this meta-analysis, of whom 242 applied AO clamping and 369 used AV clamping during PN. All of these studies were non-RCTs (level of evidence 3b), revealing a high risk of selection bias for all the studies. For quality evaluated by the NOS, all included studies were of intermediate quality (score 6 for one and score 7 for four) (Table 1).

Meta-analysis of clinical characteristics

At baseline, no statistically significant differences were detected between AO and AV clamping groups in terms of body mass index (BMI) (RE: WMD: -0.44 , 95% CI: $[-1.15, 0.27]$, $p = 0.23$; $I^2 = 54\%$), TS (RE: WMD: -0.01 , 95% CI: $[-0.47, 0.44]$, $p = 0.95$; $I^2 = 71\%$). However, patients in the AO clamping group had significantly lower RENAL Score than the AV clamping group (FE: WMD: 0.36 , 95% CI: $[0.10, 0.62]$, $p = 0.007$; $I^2 = 43\%$) (Fig. 2A–C, Table 2).

FIG. 1. PRISMA 2009 flow diagram. Data from: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi: 10.1371/journal.pmed1000097. For more information, visit www.prisma-statement.org. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analysis.

Meta-analysis of surgical outcomes

Pooled analysis of surgical outcomes revealed no significant difference regarding warm ischemia (RE: WMD: 1.97, 95% CI: [-4.93, 8.88], $p=0.58$; $I^2=97\%$), OT (FE: WMD: 3.20, 95% CI: [-4.32, 10.71], $p=0.40$; $I^2=0\%$), TR (FE: weighted odds ratio: 1.34, 95% CI: [-0.48, 3.78], $p=0.58$; $I^2=0\%$), and EBL (RE: WMD: 33.26, 95% CI: [-35.88, 102.40], $p=0.35$; $I^2=79\%$) between two groups (Fig. 3A-D, Table 2).

Meta-analysis of functional outcomes

The assessment of renal function by creatinine value both at the early postoperative (RE: WMD: -0.18, 95% CI: [-0.56, 0.2], $p=0.36$; $I^2=85\%$) and at last follow-up (RE: WMD: -0.11, 95% CI: [-0.36, 0.14], $p=0.38$; $I^2=50\%$) revealed no

difference. There was no significant difference in eGFR (FE: WMD: -1.36, 95% CI: [-6.67, 4.04], $p=0.62$; $I^2=0\%$), and at the early postoperative %eGFR (RE: WMD: -0.40, 95% CI: [-3.29, 2.5], $p=0.79$; $I^2=91\%$). However, a higher %eGFR decrease at last follow-up was demonstrated for the AV clamping group (FE: WMD: 2.42, 95% CI: [1.66, 3.18], $p<0.00001$; $I^2=0\%$) (Fig. 4A-E, Table 2).

The meta-analysis was conducted with STATA 12.0 software as well and the results were consistent with Review Manager Version 5.0 software (Supplementary Fig. S1)

Sensitivity analysis and publication bias

The pooled data in sensitivity analysis were similar to those of the original analysis, indicating that the findings

TABLE 1. MAIN CHARACTERISTICS OF THE STUDIES INCLUDED IN THE META-ANALYSIS

First author	Year	Country	Study design	Age (year)		Sample size (n)		Tumor size (cm)		RENAL Score		NOS Score
				AO	AV	AO	AV	AO	AV	AO	AV	
Edward	2008	USA	Retrospective	63.1	57.9	25	53	2.4	2.9	—	—	6
Kyle	2016	USA	Retrospective	61.0	60.0	70	163	2.9	3.0	6.5	6.0	6
Zhuo-Wei	2013	USA	Prospective	58.1	58.0	12	25	4.6	3.6	8.0	8.0	7
Annie	2012	USA	Prospective	59.9	59.4	103	102	3.2	3.4	—	—	7
Yasuhito	2013	Japan	Prospective	63.6	60.1	32	26	2.8	3.0	5.5	5.6	7

AV = artery-vein; AO = artery-only; NOS = Newcastle Ottawa scale.

FIG. 2. Forest plots of clinical characteristics. (A) BMI: (B) TS: (C) RENAL Score.

were reliable and robust (Supplementary Fig. S2). The Begg funnel plot and Egger funnel plot showed no statistically significant publication bias in outcomes of interest (Table 2).

Discussion

As the population of patients growing with older age, hypertension, or diabetes, PN with better surgical and functional recovery would become a more common choice for patients of RCC. However, WI injury during renal occlusion limited

the use of PN. One proposed way to reduce the detrimental effect of WI is renal AO clamping during PN, which has been demonstrated effectively in animal models. Colli et al. compared the ischemic damage of AO vs AV clamping in two animal models, and they demonstrated that oxygen saturation was picking up two times faster, and mean postclamp 8-isoprostane level, which was a biomarker to quantitate renal reperfusion injury, was a 1.54-fold decrease with clamping renal artery alone compared to clamping artery/vein together.³ Orvieto and colleagues evaluated the impact of laparoscopic vs open surgery on the recovery of renal function

TABLE 2. SUMMARY OF ALL THE META-ANALYSIS AND PUBLICATION BIAS

Analysis	No. of studies	Effect model	Study heterogeneity		Pooled WMD/OR [95% CI]	p	Begg test	
			I ² (%)	p			t	p
BMI	3	Random	54	0.11	-0.44 [-1.15, 0.27]	0.23	1.04	0.30
TS	4	Random	71	0.02	-0.01 [-0.47, 0.44]	0.95	1.02	0.31
RENAL Score	3	Fixed	43	0.18 0.36	[0.10, 0.62]	0.007	0.00	1.00
WI	5	Random	97	<0.001	1.97 [-4.93, 8.88]	0.58	-0.24	1.00
OT	3	Fixed	0	0.54	3.20 [-4.32, 10.71]	0.40	0.00	1.00
TR	2	Fixed	0	0.75	1.34 [-0.48, 3.78]	0.58	0.00	1.00
EBL	5	Random	79	0.0008	33.26 [-35.88, 102.40]	0.35	0.24	0.81
E-creatinine	2	Random	85	0.009	-0.18 [-0.56, 0.2]	0.36	0.00	1.00
L-creatinine	2	Random	50	0.16	-0.11 [-0.36, 0.14]	0.38	0.00	1.00
eGFR	2	Fixed	0	0.46	-1.36 [-6.67, 4.04]	0.62	0.00	1.00
E-%eGFR	3	Random	91	<0.0001	-0.40 [-3.29, 2.5]	0.79	0.00	1.00
L-%eGFR	4	Fixed	0	0.51	2.42 [1.66, 3.18]	<0.00001	0.34	0.73

p value in bold represents statistical significance.

95% CI=95% confidence interval; BMI=body mass index; EBL=estimated blood loss; eGFR=estimated glomerular filtration rate; OR=odds ratio; OT=operating time; TR=transfusion rate; TS=tumor size; WI=warm ischemia; WMD=weighted mean difference.

FIG. 3. Forest plots of surgical outcomes. (A) WI: (B) OT: (C) TR: (D) EBL.

after AO and AV clamping in a solitary kidney porcine model. They found that clamping of the artery alone during open surgery had better effect on protecting the kidney function from WI compared to AV occlusion. However, this benefit was not found during laparoscopic porcine surgery, perhaps because of pneumoperitoneum limited renal vein backflow, which might provide some level of oxygen for renal parenchyma.⁴

On the contrary, the results in human studies which had more complicated clinical settings were not consistent with animal studies. Gong and coworkers conducted a retrospective study and concluded that AO clamping might provide superior renal preservation during LPN.⁸ Some other studies reached different conclusions under more complicated clinical settings. Funahashi et al. reported that ischemic renal injury of AO clamping during LPN was smaller compared with AV clamping when the ischemic time was prolonged to 25 minutes.² Liu et al. assessed renal oxygenation profiles

during PN using digital light processing-hyperspectral imaging and found that there was also no significant retrograde venous oxygen delivery and renal functional advantage for AO clamping in patients of difficult PN where prolonged ischemia time might have mitigated any benefits.¹² Blum et al. and Imbeault and coworkers had similar conclusions and believed that AV and AO techniques were associated with similar renal function recovery in patients of LPN.^{6,7}

Conventionally, the renal function recovery after PN was based on assessments of the serum creatinine level, eGFR, or percentage change of eGFR. However, these parameters evaluated the overall renal function, without considering the compensation by the functioning of contralateral kidney. Therefore, quantification of split renal function is preferable for the precise evaluation of renal functional changes. Imbeault and coworkers used renal mercaptoacetyltriglycine-Lasix scintigraphy to assess the split renal function.⁶ Furthermore, the volume of resected nephron and ischemic

FIG. 4. Forest plots of functional outcomes. (A) E-Creatinine: (B) L-Creatinine: (C) eGFR: (D) E-%eGFR: (E) L-%eGFR.

injury in the preserved renal tissue was associated with renal function after PN, and conventional parameters cannot reflect these factors. A more specific method was applied in Funahashi et al.'s study. They assessed effective renal plasma flow by regional ^{99m}Tc -mercaptoacetyltriglycine (^{99m}Tc -MAG3) uptake, which could assess only of the ischemic damage to the surgically preserved renal tissue after PN without being affected by tumor or patient characteristics.² In addition, renal oxygenation was used as a new parameter to measure instant renal function, and percent renal parenchymal oxyhemoglobin (%HbO₂) during AO vs AV occlusion was evaluated by DLP-HSI. The results showed that %HbO₂ profiles during PN were similar for AO vs AV clamping, although in the AV group, but not the AO group, a

lower mean ischemic %HbO₂ was associated with lower eGFR at the last follow-up and remained significant on multivariable analysis.¹²

Although the relationship between these two clamping techniques on renal function recovery is not clear, it seems that WI is a strong predictor of decrease in renal function. In an animal model, the %HbO₂ of AO clamping were significantly higher than AV clamping between 16 and 24 minutes after vascular occlusion, and it became similar after ~36 minutes, indicating a possible "ischemic window" in which AO occlusion may provide benefit over AV occlusion.¹³ Similarly, in a human study by Funahashi et al., they used regional ^{99m}Tc -MAG3 uptake to assess the operated kidney and found that longer WI was correlated with more decrease

in renal function in both groups, but this decrease was significantly less in the AO group when the ischemic time was more than 25 minutes.² In another study by Liu et al., the value of %HbO₂ quickly reached an “ischemic plateau” in both groups after vascular occlusion time within 45 minutes, with no significant difference between the groups; however, when the vascular clamping time went beyond 45 minutes, the %HbO₂ in both groups dropped sharply from plateau levels, indicating a possible “ischemic window” as well.¹² As a result, the vascular occlusion time during LPN should not be longer than 45 minutes, no matter which clamping technique was applied.

The present meta-analysis included two retrospective and three prospective studies, including 242 patients who underwent AO clamping and 369 patients who underwent AV clamping, which compared AO and AV clamping in PN for RCC. The analysis consists of three main parts: meta-analysis of clinical characteristics, surgical outcomes, and functional outcomes. The first part has shown that patients in the AO clamping group had significantly lower RENAL Score (WMD: 0.36, $p=0.007$) and have similar BMI and TS. The complexity of renal masses in AV clamping group was higher than AO clamping group and the reason may be that AV clamping which blocked venous backflow could provide clearer visualization of the renal tumor margins during operations. The analysis of surgical outcomes showed similar WI, OT, TR, and EBL between two groups. These results suggested that AO clamping would not increase the difficulty of operation, which was commonly thought to be caused by venous backflow bleeding, and that AV clamping could not shorten the WI time to preserve more renal function. Finally, in the functional assessment, when the renal function was valued by creatinine, the two techniques were equivalent both at short and long term and no significant differences were detected in the eGFR variations and the early postoperative percentage change of eGFR as well. Interestingly, the AV clamping technique had a significant higher postoperative percentage change of eGFR decrease at last follow-up (WMD: 2.42, $p<0.00001$). When the renal function was estimated by postoperative percentage change of eGFR decrease, which was more accurate than creatinine and eGFR, the results proposed that AO clamping might produce less ischemic damage in the long term compared to clamping renal artery and vein together.

The present study has the following limitations that should be taken into consideration. First, no prospective RCT studies were included, indicating potential risk of bias of our findings. Second, obvious heterogeneity was identified in some analyses possibly because of the differences in parameters, such as study design, follow-up duration, and the patients' baseline characteristics, in the included studies. Third, the assessment parameters of renal function are not the same and not referred to as split renal function. Finally, oncologic outcomes are not observed between these two groups in all selected studies.

Conclusion

AO clamping would not increase the difficulty of LPN for the similar surgical results between AO and AV clamping. Although there is no significant difference in renal function preservation in short term after operations, AO clamping

might produce less ischemic damage in the long term. These results suggest that AO clamping might be a better choice for LPN in long term. RCT studies with larger sample numbers, and long-term follow-up and split renal function assessment should be conducted in the future to confirm our conclusion.

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Supplementary Material

Supplementary Figure S1
Supplementary Figure S2

References

1. Klatte T, Vincenzo Ficarra, Christian Gratzke, et al. A literature review of renal surgical anatomy and surgical strategies for partial nephrectomy. *Eur Urol* 2015;68:980–992.
2. Funahashi Y, Kato M, Yoshino Y, Fujita T, Sassa N, Gotoh M. Comparison of renal ischemic damage during laparoscopic partial nephrectomy with artery-vein and artery-only clamping. *J Endourol* 2013;28:306–311.
3. Colli JL, Wang Z, Johnsen N, Grossman L, Lee BR. Clamping renal artery alone produces less ischemic damage compared to clamping renal artery and vein together in two animal models: Near-infrared tissue oximetry and quantitation of 8-isoprostane levels. *Int Urol Nephrol* 2013;45:421–428.
4. Orvieto MA, Zorn KC, Mendiola F, Lyon MB, Mikhail AA, Gofrit ON, Shalhav AL. Recovery of renal function after complete renal hilar versus artery alone clamping during open and laparoscopic surgery. *J Urol* 2007;177:2371–2374.
5. McLoughlin GA, Heal MR, Tyrell IM. An evaluation of techniques used for the production of temporary renal ischaemia. *Br J Urol* 1978;50:371–375.
6. Imbeault A, Pouliot F, Finley DS, Shuch B, Dujardin T. Prospective study comparing two techniques of renal clamping in laparoscopic partial nephrectomy: Impact on perioperative parameters. *J Endourol* 2012;26:509–514.
7. Blum KA, Paulucci DJ, Abaza R, et al. Main renal artery clamping with or without renal vein clamping during robotic partial nephrectomy for clinical T1 renal masses: Perioperative and long-term functional outcomes. *Urology* 2016;97:118–123.
8. Gong EM, Zorn KC, Orvieto MA, Lucioni A, Msezane LP, Shalhav AL. Artery-only occlusion may provide superior renal preservation during laparoscopic partial nephrectomy. *Urology* 2008;72:843–846.
9. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *J Clin Epidemiol* 2009;62:1006–1012.
10. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: A proposal for reporting. *JAMA* 2000;283:2008–2012.
11. Zeng X, Zhang Y, Kwong JS, Zhang C, Li S, Sun F, Niu Y, Du L. The methodological quality assessment tools for

- preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: A systematic review. *J Evid Based Med* 2015;8:2–10.
12. Liu Z-W, Faddegon S, Olweny EO, Best SL, Jackson N, Raj GV, Zuzak KJ, Cadeddu JA. Renal oxygenation during partial nephrectomy: A comparison between artery-only occlusion versus artery and vein occlusion. *J Endourol* 2013;27:470–474.
 13. Tracy CR, Terrell JD, Francis RP, et al. First Prize: Characterization of renal ischemia using DLP[®] hyperspectral imaging: A pilot study comparing artery-only occlusion versus artery and vein occlusion. *J Endourol* 2010;24:321–325.

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Abbreviations Used

95% CIs = 95% confidence intervals

AO = artery-only

AV = artery-vein

BMI = body mass index

DLP-HSI = digital light processing-hyperspectral imaging

EBL = estimated blood loss

eGFR = estimated glomerular filtration rate

FE = fixed effects

LPN = laparoscopic partial nephrectomy

MOOSE = Meta-analysis of Observational Studies
in Epidemiology

NOS = Newcastle Ottawa scale

ORs = odds ratios

OT = operating time

PN = partial nephrectomy

PRISMA = Preferred Reporting Items for Systematic
Reviews and Meta-Analyses

RCC = renal cell carcinoma

RCT = randomized controlled trials

RE = random-effects

TR = transfusion rate

TS = tumor size

WI = warm ischemia

WIT = warm ischemia time

WMDs = weighted mean differences

WOR = weighted odds ratio