

Original Article



A comparison of renal functional outcomes after partial nephrectomy with and without pedicle clamping

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Received: 25 May 2020

Accepted: 24 Jan. 2020

e-Published: 19 Mar. 2021

Keywords:

- Partial nephrectomy
- Pedicle clamping
- Kidney cancer

Abstract**Introduction:** Considering the mixed results reported about partial nephrectomy with and without pedicle clamping, this study aimed to compare the impacts of these two techniques on renal functional outcomes.**Methods:** This was descriptive-analytical study. Patients included in the investigation were randomly assigned to pedicle clamping and non-clamping groups. The day before surgery, the routine tests, as well as diethylene triamine pentaacetic acid (DTPA) scan were carried out for all of the patients, and some questions were asked from them. During the surgery, the amount of blood loss and the duration of pedicle clamping were measured, and after the surgery, the required tests were performed for all patients. Also, three months after hospital discharge, DTPA scan was carried out for all patients once again. Finally, required statistical analyses were performed on the obtained data, using SPSS v. 18.**Results:** The present study was conducted on 40 patients with renal cancer who underwent partial nephrectomy with (20 patients) and without (20 patients) pedicle clamping. The amount of operative blood loss ($P=0.000$) and blood transfusion ($P=0.001$) in the non-pedicle clamping group were higher than those in the pedicle clamping group. The mean duration of surgery for patients in the pedicle clamping group was 139.2 minutes, and for those in the non-pedicle clamping group was 149 minutes ($P=0.258$). The mean duration of pedicle clamping was also calculated to be 20.65 minutes. The results of renal scans 3 months after the surgery indicated that the level of renal function decline in the pedicle clamping group was significantly higher than that in the non-pedicle clamping group ($P=0.000$).**Conclusion:** The results of this study indicated that partial nephrectomy without pedicle clamping could lead to a better renal function in the short run. However, the level of blood loss, as well as the need for blood transfusion in patients, increases as a result of using this technique.**Introduction**

Renal cell carcinoma accounts for 2%-3% of all cancers in adults and is the third most prevalent cancer in the genitourinary system.¹ Due to medical radiography developments, the diagnosis of cancers with lower grades and in the early stages (less than 4 cm) has become increasingly feasible.² Small renal masses account for 48-66% of all diagnosed renal cancers and 38% of the tumors resected from the kidney.³

Open partial nephrectomy (OPN) is an alternative surgery performed instead of the radical nephrectomy in the treatment of small renal masses, with the aim of preserving renal function. However, this surgery can bring about complications such as blood loss, acute kidney injury, etc, in patients.^{4,5}

The purpose of performing a partial nephrectomy is to completely remove the focal lesions and preserve

the maximum renal function. Partial nephrectomy is usually performed with vascular pedicle clamping so that tumor resection can be conducted easily and with less blood loss. This method of renal artery clamping, poses a big challenge for many surgeons in terms of surgery technique, duration of the surgery, and duration of ischemia.⁶ Therefore, clamping renal arteries can lead to ischemic injury in healthy renal parenchyma, and the resultant increase in warm ischemic time can increase the incidence rate of kidney failure.⁷ On the other hand, in partial nephrectomy without pedicle clamping, in which the surgery is performed while patients are bleeding, renal ischemia resulting from pedicle clamping can be prevented to some extent. However, this method has some limitations as it can decrease the surgical field's visibility during the surgery, raise the probability of tumor tissues remaining in the kidney after the surgery, and increase

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A review of the studies conducted on the use of these two techniques in performing partial nephrectomy revealed that the results are mixed. Therefore, in this study, we aimed to determine whether pedicle clamping can cause a decline in renal function in the short term.

Methods

This study was a cross-sectional study in which both descriptive and analytical methods were used. In this study, 40 patients undergoing partial nephrectomy during 1396 were investigated. Indications for partial nephrectomy, glomerular filtration rate (GFR) > 40, and hemoglobin > 10 were the inclusion criteria, and distant metastasis, coagulation disorder, overt diabetes mellitus, uncontrolled hypertension, and active cardiovascular disease were the exclusion criteria. After selecting patients based on inclusion and exclusion criteria, the patients' CT scan – and in some cases, the MRI images – were analyzed. Tumor and kidney size were obtained, and their involved kidney was detected. Then, diethylene triamine pentaacetic acid (DTPA) scan was carried out for all of the patients. Before the study, the patients were divided into two groups based on their condition and the required surgery technique. When this investigation began, no changes were made in the techniques of performing surgery on the patients. The routine tests, including hemoglobin, hematocrit, urinary, and biochemical (urea, creatinine, sodium, and potassium) tests were performed for all patients. In addition, chest X-ray (CXR) and electrocardiogram (ECG) were obtained from all of the patients before the surgery. Also, the night before the surgery, the prophylactic antibiotic was administered to all patients.

The surgeon, the vital signs used during the surgery, the anesthetic technique, and the anesthetic drug were all the same for both groups of patients. The surgery began with an anterior subcostal incision with a maximum length of 10 cm. After incision and obtaining a good exposure of the kidney, renal arteries were released, the tumor area was marked, and the tumor's exact location was determined. Then the tumor was excised with a minimum margin of 2 cm from the healthy tissue. The only difference between the two groups was pedicle clamping before tumor resection. After repairing defects, the possible mild bleedings were controlled using Surgicel. During the operation, the amount of blood loss (measured through counting the utilized gauze pads and measuring the amount of blood inside suction containers), the level of blood transfusion (measured based on the blood units transfused to the patients), tumor size (after resection and measurement outside of the body), the duration of the surgery, and warm ischemic time (in pedicle clamping group) were investigated. The patients were transferred to hospital wards after gaining consciousness. The patients' vital signs were controlled, the results of complete blood

count and biochemical tests were checked every day. Intravenous antibiotic was administered for all patients for the first 24 hours, which was replaced with oral antibiotics afterward. The amount of fluid in surgical drains was checked every day, urinary condition (urine output) and urinary incontinence were tested, and the surgical site was examined for the existence of infections during hospitalization, as well as the follow-up control visits. After being discharged from the hospital, the patients' pathology and margin border was evaluated. Then, following Kobayashi et al,⁹ DTPA scan was obtained from all of the patients 3 months after the surgery, and postoperative GFR in both of their kidneys were measured and evaluated.

During this research, the hemoglobin level was maintained in a normal range in all patients. Finally, the obtained data were all entered into SPSS software version 18, and the statistical analyses were performed using *t* test, chi-square test, and analysis of variance.

Results

The present study was conducted on 40 patients with renal cancer who were candidates for partial nephrectomy. The patients were divided into two groups, each consisting of 20 patients. The first group of patients underwent partial nephrectomy with pedicle clamping, and those in the second group received this surgery without pedicle clamping. Fourteen (70%) of the patients in the non-clamping group and 12 (60%) of patients in the clamping group were males. The patients' mean age was 54.7 ± 11.83 in the clamping group and 49.2 ± 11.44 in the non-clamping group ($P=0.157$). In this study, only one case of oncocytoma and one case of Von Hippel-Lindau were observed. Furthermore, the mean duration from diagnosis to surgery was 2.35 months in the non-clamping group and 2.4 months in the clamping group. The upper right area of the kidney was the most prevalent tumor site (Table 1). The tumor size analysis indicated that the mean sizes of large and small renal masses in patients of the clamping group were 47.85 ± 6.88 mm and 35.15 ± 5.9 mm, and in patients of the non-clamping group were 45.35 ± 9.96 mm and 38.731 mm, respectively. The mean renal size was 117.8 ± 3.67 mm in the patients of the pedicle clamping group and 119.35 ± 6.06 mm in the patients of the non-pedicle clamping group ($P=0.335$). The preoperative GFR of both kidneys in all of the patients was also assessed (Table 2). The amount of blood loss in the pedicle clamping group (240 mL) was significantly lower than that in the non-clamping group (660.5 mL) ($P=0.000$). Also, the level of blood transfusion in the pedicle clamping group was significantly lower than that in the non-clamping group ($P=0.001$) (Table 3). The mean duration of surgery and pedicle clamping in the pedicle clamping group was 139.25 ± 27.35 and 20.65 ± 3.85 minutes respectively, and the mean duration of surgery in the non-clamping group was 149 ± 26.38

Table 1. Clinical variables comparable between the two groups

Variable	Off-clump		On-clump		P value
	No.	%	No.	%	
Age (y)	≤40	3	15	3	0.179
	41-50	4	20	10	
	51-60	6	30	2	
	>60	7	35	5	
Sex	Male	14	70	12	0.507
	Female	6	30	8	
Duration of diagnosis (mon)	< 1	3	15	4	0.859
	1-2	8	40	6	
	2-3	8	40	8	
	> 3	1	5	2	
Side	Right	11	55	12	0.749
	Left	9	45	8	
Location	Upper	10	50	9	0.942
	Lower	7	35	8	
	Middle	3	15	3	

Table 2. The level of GFR before surgery between the two groups

Kidney	Group	Mean	SD	P value
Right	On-clamp	53.93	5.44	0.000
	Off-clamp	43.36	6.18	
Left	On-clamp	48.39	5.04	0.099
	Off-clamp	52.7	10.1	

minutes ($P=0.258$). The duration of hospitalization in the pedicle clamp and non-pedicle clamp groups was 5 ± 0.85 and 5.25 ± 0.91 days, respectively ($P=0.377$). In this study, the analysis of creatinine and hemoglobin levels before, immediately after, and 24 hours after the surgery did not show any significant differences (Table 4). The mean amount of fluid collected in the surgical drains was 185.5 ± 160.37 mL in the clamping group and 50.5 ± 37.9 mL in the non-clamping group ($P=0.001$). During three months of follow-up, only one case of urinoma and urinary incontinence was reported in the pedicle clamping group, and no other complications were observed ($P=0.311$). The analysis of GFR revealed that the two groups were not significantly different in this regard before the surgery. In contrast, after the surgery, GFR in the pedicle clamping group declined significantly ($P=0.000$). Moreover, the decline of GFR in the pedicle clamping group was more than that of the non-clamping group ($P=0.000$) (Table 5).

Discussion

Due to the recent developments in radiography, the diagnosis of small renal masses has increased considerably. Since these masses are in the first stage of development, the need for performing nephron-sparing surgeries while preserving renal function has grown. Moreover, considering the acceleration of parenchymal destruction

in the remaining kidney of the patients who have undergone partial nephrectomy, it is highly required that in the patients with renal cancer, the kidney tissue receive the least possible damage.¹⁰

In this study, which was conducted on 40 patients undergoing partial nephrectomy with (20 patients) and without (20 patients) pedicle clamping, the majority of the patients in both groups were male. The patients' mean age in the pedicle clamping group was 54.7 years, and in the non-clamping group was 49.2 years. This finding is consistent with the findings reported by Martin et al and Koo et al.^{10,11}

In Peyroonnet and colleagues' study, the blood transfusion level was 0% in the pedicle clamping group and 4.9% in the non-pedicle clamping group ($P=0.58$).¹² However, they found that the amount of blood loss during surgery was 284.6 mL in the clamping group and 266.4 mL in the non-clamping group ($P=0.048$). In Martin and colleagues' study,¹⁰ the amount of blood loss in the pedicle clamping group was 150 mL, and in the non-clamping group was 288 mL ($P<0.05$). Also, in the studies conducted by Anderson et al¹³ and Rosen et al,¹⁴ the amount of blood loss in the pedicle clamping group was significantly higher than the non-clamping group. However, in the studies performed by Koo et al¹¹ and Mahalingam et al,¹⁵ no such association was observed. In the present study, pedicle clamping could significantly decrease blood loss and the need for blood transfusion, which was in line with the findings of the majority of the previous studies in this area. The difference among different studies regarding the level of blood loss might be the result of different surgery techniques, different tumor sizes, and prolonged duration of surgery.

In Martin and colleagues' study, the mean duration of

Table 3. Short-term outcomes comparable between the two groups

Variable	Off-clump		On-clump		P value
	No.	%	No.	%	
Estimated blood volume(mL)	<150	0	0	10	0.000
	151-300	1	16.7	5	
	301-600	8	66.7	4	
	>600	11	91.7	1	
Packed cell	Without getting blood	6	25	18	0.001
	1 unit	5	71.4	2	
	2 units	8	100	0	
	>2 units	1	100	0	
Amount of hemovac drainage (mL)	<30	0	0	6	0.001
	31-100	6	31.6	13	
	101-200	10	90.9	1	
	201-300	3	100	0	
	>300	1	100	0	

Table 4. Changes in creatinine and hemoglobin between the two groups

	Time	Group	Mean	SD	P value
Patient creatinine	Creatinine before surgery	On-clamp	1.34	0.35	0.867
		Off-clamp	1.33	0.17	
	Creatinine after surgery	On-clamp	1.53	0.29	0.186
		Off-clamp	1.41	0.24	
	Creatinine Rising after surgery	On-clamp	0.17	0.05	0.174
		Off-clamp	0.08	0.03	
Patient Hemoglobin	Hemoglobin before surgery	On-clamp	14.14	0.86	0.236
		Off-clamp	13.83	0.72	
	Hemoglobin after surgery	On-clamp	13.61	0.86	0.099
		Off-clamp	13.13	0.93	
	Hemoglobin decreasing after surgery	On-clamp	0.42	0.43	0.149
		Off-clamp	0.7	0.72	

pedicle clamping was reported to be 32 minutes.¹⁰ Wiener et al found in their study that a warm ischemic time of less than 22 minutes could result in a significant decline in renal function for 6 to 12 months after the surgery.¹⁶ In Koo and colleagues' study, the mean duration of pedicle clamping was 28.9 minutes.¹¹ The mean warm ischemic time was reported to be 25.9 minutes in Anderson and colleagues' study and 15 minutes in Rosen and colleagues' study.^{13,14} This difference in the duration of pedicle clamping might stem from the use of different surgical techniques and the surgeons' level of experience.

In Peyronnet and colleagues' study, the level of decline in the renal function of the patients in pedicle clamping and non-clamping groups one month after the surgery was -0.2% and -6.9% ($P=0.22$) and 6 months after the surgery was 0% and 5.9% ($P=0.59$), respectively.¹² However, statistical analyses revealed that the differences between the two groups were not significant. In another study, Thompson et al reported that the decline in renal

function during the first three months after the surgery was significantly lower in non-pedicle clamping, as well as selective arterial clamping groups compared to the pedicle clamping group.¹⁷ However, this difference was no longer significant in the 6th and 12th months after the surgery. In the studies conducted by Mahalingam et al and Anderson et al, renal function decline was not found to be related to surgical techniques.^{13,15} In Rosen and colleagues' study, the decrease in the level of postoperative GFR was -10.4% in the pedicle clamping group and -4% in the non-clamping group.¹⁴ This difference was found to be statistically significant ($P=0.047$). Verze et al reported a similar finding during the first three months after the surgery.¹⁸ They also indicated that pedicle clamping could lead to a significant decline in renal function. In some of the previously conducted studies in this area, the decline of GFR in the short term has been found to be associated with surgery technique, while in some others, no association has been reported between them. These differences might

Table 5. Changes in GFR before and after surgery between the two groups

Kidney	Group	Mean	SD	P value
GFR before surgery	On-clamp	50.98	6.3	0.210
	Off-clamp	48	8.34	
GFR after surgery	On-clamp	31.23	6.86	0.000
	Off-clamp	42.45	10.21	
GFR decreasing after surgery	On-clamp	19.74	9.36	0.000
	Off-clamp	5.55	3.91	

result from some intervening factors such as preoperative renal function, the duration of ischemia, the level of blood loss, the surgeon's ability to restore intravascular volume during the surgery, and various other factors. Therefore, while pedicle clamping can have a considerable effect on renal function after the surgery, various intervening factors should be taken care of before, during, and after the surgery to prevent the postoperative decline in renal function.

In Peyronnet and colleagues' study, the incidence rate of complications for the patients in the pedicle clamping group was 7.7% and for those in the non-clamping group was 15.5% ($P=0.53$).¹² Moreover, the incidence rate of major complications was reported to be 3.9% and 4.9% in the clamping and non-clamping groups, respectively ($P=0.82$). However, the two groups were not found to be significantly different in these regards. In the studies conducted by Mahalingam et al, Petrasz et al, Porpiglia et al, and Tanagho et al, no significant association was reported between the incidence of complications in patients and the surgery technique (pedicle clamping or non-pedicle clamping).^{15,19-21} This finding was also confirmed in the present study. Therefore, pedicle clamping is unlikely to reduce the incidence of non-bleeding complications during and after the surgery.

Conclusion

The findings of this study indicated that non-pedicle clamping could lead to better renal function in the short term, but the amount of blood loss and the need for blood transfusion increases in the patients treated with this

technique.

Conflict of Interest

Authors declare no conflict of interest in this study.

Ethical Approval

The protocol of this study was approved by the Ethics Committee of Tabriz University of Medical Sciences with the code of IR.TBZMED.REC.1397.506.

Author's Contribution

All of the authors contributed equally.

Acknowledgements

We would like to thanks to all participants

Funding

There is no funding support to conduct the research.

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Study Highlights

What is current knowledge?

Kidney pedicle clamping during partial nephrectomy can lead to:

- 1. worsen of renal function
- 2. Reduced bleeding and need for blood transfusions

What is new here?

- In patient with single kidney or poor kidney function, partial nephrectomy without pedicle clamp is recommended.

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