TITANIUM CLIPS FOR VASCULAR CONTROL OF RENAL VESSELS DURING LAPAROSCOPIC NEPHRECTOMY: A SAFE AND COST EFFECTIVE TERTIARY CARE CENTER EXPERIENCE

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ABSTRACT

This study aimed to evaluate the safety and cost-effectiveness of practice of titanium clip application on renal vessels in laparoscopic nephrectomy (LN) in a tertiary care hospital. A total of 143 patients were included in our study undergoing laparoscopic nephrectomy from January 2018 to April 2023. In our study, 3 titanium clips were applied on each renal artery and vein 1-2 mm apart from each other in order to achieve vascular control of the renal pedicle. This data was obtained retrospectively through medical records. We reported 31 (22%) patients in our study with malignant conditions and 112 (88%) patients with benign diseases. Of these, 4 (3 %) patients required blood transfusion. There were four cases where laparoscopic nephrectomy was converted to open procedure. No incidence of slippage of titanium clips used for vascular ligation was reported in our study neither did we encounter any clip dislodgement during or after the surgery. No significant post-operative complications pertaining to clip application were seen. Cost analysis revealed that most cases required a total of 6 titanium clips costing around 8 USD (4 USD per cartridge of 6 titanium clips) in total for vascular control. Titanium clip application for securing renal vessels during laparoscopic nephrectomy is a safe and cost-effective approach.

Key Words: Titanium Clips, Renal Vessel, Laparoscopic Nephrectomy

INTRODUCTION

Laparoscopic nephrectomy was recommended by Ralph Clayman in 1991 for the first time ever as a safe and effective surgical approach for both benign and malignant kidney tumors (1). Ever since the proposal, this approach has been adopted and endorsed over open nephrectomy by urologists worldwide (2, 3). Laparoscopic nephrectomy has shown benefits over open technique due to its ability to provide a magnified field for surgery; and it results in shorter hospital stay and better cosmetic outcomes over the latter. The previously encountered reservations of longer duration of surgery have also been tackled with increasing expertise of surgeons and with better techniques to bring this surgery to fruition (4).

The two most pivotal steps in open and laparoscopic nephrectomy are hilar dissection and vascular control of the renal pedicle. Any mishandling encountered in attaining vascular control can result in catastrophic outcomes even if the morbidity and mortality reported due to any such event is around 0.03% to 0.07% (5). The US Food and Drug Association (FDA) has recommended usage of Gastrointestinal Anastomosis (GIA) stapling technique as the safest way to obtain vascular security; however, instances of its malfunctioning may result in dire complications (3, 6). There have been many other techniques that are being used by surgeons worldwide. These techniques include suture ligation, Hem-o-ok application and usage of titanium clip (7).

It has been presumed that using metallic titanium clips may be unsafe and risky pertaining to the chance of its slippage based off on the limited available data, but in a resource limited country, these are being widely used in laparoscopic surgeries. Other than that, there is lack of sufficient data of its usage on diseased kidneys un-

dergoing laparoscopic nephrectomy. Keeping this in mind, we conducted a retrospective study in our tertiary care hospital to assess the safety and reliability of using titanium clips to obtain vascular control in laparoscopic nephrectomy.

METHODS

We conducted a retrospective observational study in the Urology department of Dow University Hospital Karachi, Pakistan from January 2018 till April 2023 after seeking approval from Ethics Review Committee (IRB-3108/DUHS/EXEMPTION/2023/283). Using non probability convenient sampling, 143 patients were enrolled in our study that underwent laparoscopic nephrectomy for benign and malignant kidney diseases. Patients from all age groups were included in our study and patients undergoing laparoscopic donor nephrectomies were excluded from the study. The primary outcome studied included intraoperative blood transfusions, conversion to open and if additional surgery required to control bleeding. The secondary outcome studied include the length of hospital stay, post-operative complications and change in hemoglobin levels post operatively. We collected this data from medical records and clinical registers.

Material involved in this study included Ligaclips of sizes 400 and 300 used for renal vein and renal artery ligation respectively using a clip applicator. A total of 3 titanium clips was applied on each renal vessel 1 to 2mm apart. Once the clips were placed adequately, the renal vessels were transacted with the help of Ligasure. Each titanium clip cartridge that consists of 6 clips each costs 4 USD. We use 3 clips from each cartridge of sizes 300 and 400 but those cartridges are not used thereafter so we used the cost of 2 cartridges instead of 6 clips in our study analysis. Titanium clip application and renal vessel stump is shown in figures 1 and 2.

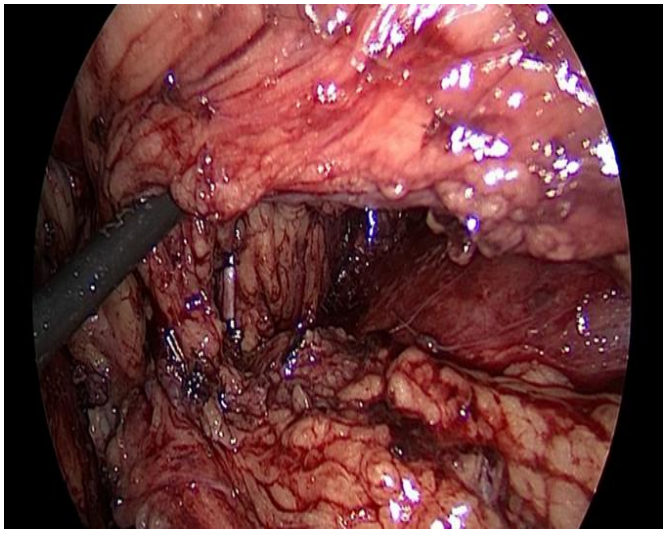

Figure 1. Placement of titanium clip on a renal vessel

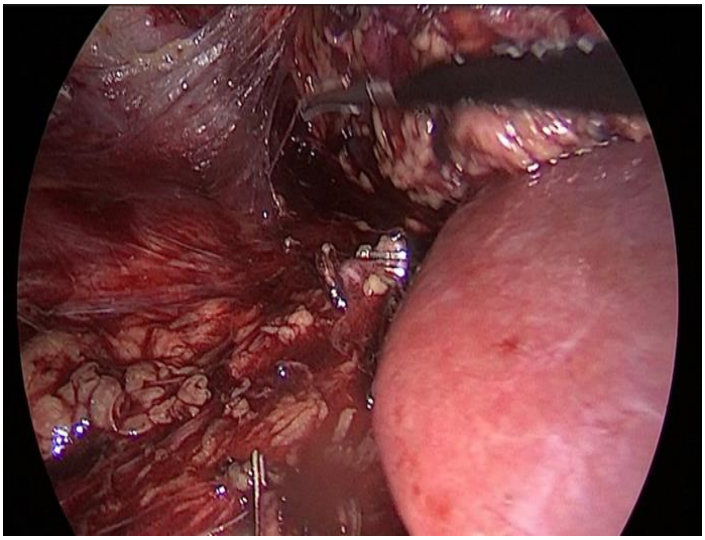

Figure 2. Residual renal vascular stump after ligation of vessel

Statistical analysis

Data analysis was done using SPSS version 21. Categorical variables were represented using metrics of frequencies and percentages and continues variables were represented as means and standard deviation. T-test and chi-square test were applied where needed and p-value of < 0.05 was considered significant.

RESULTS

To achieve renal vascular control, titanium clips were used on 143 consecutive patients with benign and malignant conditions of kidney undergoing laparoscopic nephrectomy. The mean age of the patients included in the study was 46.33±1.25 years and their mean Body Mass Index (BMI) was

30.2±1.34 kg/m2. Of this cohort, 74 (52%) patients were males and 69 (48%) were females. The demographics of the patients included the study are presented in Table 1.

Demographic variables		No. (percentages)
Gender	Male	74 (52%)
	Female	69 (48%)
Mean age in years		46.33±1.25
Mean BMI in Kg/m2		30.2±1.34
Comorbid	Asthma	4 (2.8%)
	DM	21 (15%)
	HTN	13 (9%)
	DM + HTN	2 (1.4%)
	IHD	3 (2%)

Table 1. Demographic characteristics of the patients who underwent laparoscopic nephrectomy

Amongst our study group, 31 (22%) patients had malignant conditions for which they underwent laparoscopic nephrectomy and 112 (78%) patients had benign diseases which included 38 cases with Pelvi-Ureteric Junction Obstruction (PUJO) with nonfunctioning kidney and 74 cases with renal and ureteric stone and nonfunctioning kidney. A total of 74 (52%) left sided and 69 (48%) right sided laparoscopic nephrectomies were performed. The mean operative wheel in to wheel out time was 125±23.4 minutes and estimated blood loss was 70±10.5ml.

123 (86%) of our patients undergoing this surgery had a single renal vein and 128 (90%) of them had a single renal artery. A total of 4 patients required blood transfusion, 2 of which were done intraoperatively and 2 were done post operatively, 4 cases were converted to open owing to dense adhesions encountered during kidney dissection and 12 patients developed post-operative complications that included intra-abdominal collection in 4 patients, post-operative ileus in 7 patients and surgical site infection in 5, all of which were managed conservatively. The operative parameters of our study population are given in table 2.

Titanium clips were sufficient in all cases to achieve renal hilar control. It is noteworthy that there were no incidences of slippage of clips applied on renal vessels and no intraoperative or post-operative instance of difficulty to control hemorrhage due to the clips' dislodgement.

Each titanium clip costs 8 USD. The cost of titanium clips (6 clips) used per nephrectomy was 48 USD and 15 patients with two renal arteries and 20 patients with two renal veins were charged 72 USD in total. The price of titanium clips with those of endovascular GIA Staplers and Hem-o-lok are compared in the table below. We have included price of two cartridges of titanium clips; one of size 300 another of size 400, instead of individual clips' cost as those cartridges are used in only a single case to ensure sterilized instrumentation.

DISCUSSION

Securing renal vessels is a vital step in minimally invasive nephrectomy and is the main determinant of its success. There has been an ongoing debate on the safety and quality of various methods available in the market to achieve this control. Using FDA database, various studies have been done. One such study indicated malfunctioning of titanium clips like scissoring and malformation and one manufacturer of titanium clips suggested against its use on renal arteries (8, 9). Despite such reported issues, serious complications with titanium clips have rarely been reported.

The literature has conflicting outcomes of usage of titanium clips on renal vessels. Kerbl et al occluded renal artery with 9mm titanium clips and observed that they were as safe as securing renal

vessels with 0 and 2-0 silk ligature. In the same study, it was also postulated that 2.5mm staples placed on renal arteries did not yield equally safe results. Based on these observations, they suggested usage of 3 titanium clips on each vessel stump during the renal pedicle dissection step in the surgery (10).

Table 2. Intraoperative and Postoperative parameters of patients who underwent Laparoscopic nephrectomy

Operative parameters		**Statistical metrics**
Mean operative time (Wheel in - wheel out time in minutes)		125±23.4
Operative site	Right	74(52%)
	Left	69 (48%)
Number of Renal Artery	1	128 (90%)
	2	15 (10%)
Number of Renal Vein	1	123 (86%)
	2	20 (14%)
Number of ports	3	128 (90%)
	4	15 (10%)
Estimated Blood Loss (ml)		70±10.5
Blood transfusions		4(3%)
Conversion to open		4(3%)
Length of hospital stay (pre-operative day until the day of discharge)		3.35±0.94
Post-operative complications	**Ileus**	7 (5%)
	Port site infection	5 (3.5%)
	Intra-abdominal collection	4 (3%)
Hemoglobin levels	**Pre-operative**	13.4±1.09
	Post-operative	11.8±0.8

Table 3. Comparison of devices' cost for renal hilar control.

Material for vascular control	**Maximum quantity of material required**	**Price incurred per case (in USD)**
Titanium clips	6-8	8 (4 USD Per cartridge)
Hem-o-lok clips	6-8	64
Endovascular GIA staplers	2	250

It has been suggested that the failure of clips to control renal vasculature could be attributed to surgeons' technique and expertise more than the physical limitations of the clips itself (5). Leaving a vascular cuff of 1 mm from the point of titanium clips applied on renal vessels has proven to be safe at both physiologic pressures and those higher than that (11). Other studies have demonstrated that multiple clips application adds to this safety (12, 13). One of the largest scale study conducted in Canada concluded that in the 489 cases of laparoscopic nephrectomy where titanium clips were

used to secure renal artery, only 5 intraoperative events were noted. These events included crossed clips and dislodgement of clips but there was no major event that warranted conversion to open nephrectomy (14).

Papaioannou et al was able to perform a test on silicone tubing which showed there was no leakage of blood when titanium clips were applied to it (15). Joseph et al tested various methods for renal vessel ligations all of which were able to tolerate pressures of more than 800mmHg (16). Sean et al also concluded that titanium clips safely attain vascular control at physiological pressures (17). No instance of migration of titanium clips was seen on a 4 year follow up by Chibber et al (18).

Liu et al concluded that residual vascular length was greater when clips were applied making it ideal for donor nephrectomies as well. The same meta-analysis showed that using titanium clips is also cost effective when compared with GIA Staplers and Hem-o-lok clips (19). The cost saving benefit has been shown by other researchers as well (18).

Our study has also shown that titanium clips when used in laparoscopic nephrectomies yielded good outcomes in terms of vascular ligation and were a safe and less expensive approach in a resource limited country when performed by experienced surgeons. These clips have made laparoscopic nephrectomies a financially feasible surgery in developing countries such as our own and the theories of clip dislodgement was not validated in our study.

The limitation of our study was that it was conducted in a single center and only one modality to secure renal pedicle was studied. However, in order to offer comparative study, it is important that surgeons should have expertise in performing all methods of renal hilar control. Therefore, we recommend a multicenter study to evaluate these techniques. Our experience clearly suggests that titanium clips are safe and cost effective means of securing renal vessel in a resource limited country.

CONCLUSION

The safest and most economically feasible method for renal vascular control is still controversial. However, as there was no episode of major bleeding during or after the surgery in our study, it is safe to say that titanium clips when applied by trained surgeons taking necessary precautions and following the guidelines for safety are a safe and cost effective means for achieving renal vascular control in laparoscopic nephrectomy. It is still important that the surgeons using these clips have adequate experience and expertise in terms of surgical technique in order to achieve successful results.

Conflict of interest:

Authors declare no conflict of interest

Funding source:

The study did not receive any external funding

Ethical Approval:

The study was approved by local research ethics committee.

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