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Prognostic Evaluation of Minimally Invasive Laparoscopic Nephrectomy for Non-Functioning Kidneys

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ABSTRACT
Background: Laparoscopic surgery is increasingly popular for difficult and oncologic treatments, in addition to straightforward ones. Recent developments in minimally invasive surgery and surgical technique result in a shorter hospital stay, decreased mortality, less analgesic use, and improved cosmetic outcomes as compared to open surgery.
Objective: The aim of the current study is to identify the predictive factors (etiology, demographic data and clinical characteristics) on the prognosis of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys.
Patients and methods: A one-arm clinical trial was conducted at Fayoum University Hospital. A total of 40 patients underwent laparoscopic nephrectomy for hydronephrotic non-functioning kidneys. All participants were subjected to history taking and complete clinical examination to determine their suitability for laparoscopic surgery.
Results: Age, sex, the side of the resected kidney and high serum creatinine levels did not significantly affect the success of the laparoscopic nephrectomy. A significant improvement was observed in the operative time, and preventing intra- and postoperative complications. **Conclusion:** Turbid content of the pelvicalyceal system and history of prior urological intervention were the most important predictive factors for bad prognosis of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys.
Keywords: Laparoscopy, Nephrectomy, Non-Functioning Kidney.

INTRODUCTION
Nowadays, minimally invasive surgery is the best option for treating many urological problems. Although it has achieved general acceptability, **Clayman *et al.*** [(1)] carried out the first laparoscopic nephrectomy in 1991. In benign conditions, a straightforward nephrectomy is performed laparoscopically. This procedure may be difficult despite the word "simple" being in the name because of the increased perirenal adhesions caused by viral illnesses [(2)].

In recent years, minimally invasive surgery has essentially taken the place of open surgery methods due to technological advancements. Laparoscopic surgery is increasingly popular for difficult and oncologic treatments in addition to straightforward ones. Recent developments in minimally invasive surgery and surgical technique result in a shorter hospital stay, decreased mortality, reduced analgesic use, and enhanced cosmetic outcomes as compared to open surgery [(3)]. The three types of surgeries are hand-assisted laparoscopic nephrectomy, transperitoneal, and retroperitoneal. The kidney is made visible via the retroperitoneal technique, which avoids trying to enter the peritoneal cavity. The optimal operating environment and the anatomical landmarks that are the simplest to identify are provided to the surgeon via the transperitoneal (through the abdominal cavity) technique. The transperitoneal technique might be finished using a hand or a full laparoscopic surgery. Using the incision in the hand port, the laparoscopic hand-assisted approach enables the surgeon to use his hand to help with dissection, retraction, and kidney excision [(4)].

The benign illness that has left the kidney inoperable is the most common rationale for laparoscopic nephrectomy. Some of them are people with chronic kidney failure and renovascular hypertension, chronic pyelonephritis with or without vesicoureteral reflux, non-functioning hydronephrotic kidneys, and patients with tiny kidneys. For a disease to merit treatment there must be sufficient signs and symptoms, such as ongoing discomfort or a urinary tract infection [(5)]. The aim of the current study is to identify the predictive factors (etiology, demographic data and clinical characteristics) on the prognosis of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys.

PATIENTS AND METHODS
A one-arm clinical trial was conducted at Fayoum University Hospital. A total of 40 patients underwent laparoscopic nephrectomy for hydronephrotic non-functioning kidneys.

Inclusion criteria: Patients with symptomatic benign hydronephrotic non-functioning kidneys and candidates for nephrectomy were enrolled.
Exclusion criteria: Patients with serious cardiac illnesses, intestinal blockage, active peritonitis, severe diaphragmatic hernia, previous repeated abdominal procedures, abdominal wall infection, or ascites were excluded.

Preoperative evaluation:
Before any procedure, all patients were subjected to the following:
History taking: A thorough history that paid particular emphasis to the disease's presentation, age, sex, past treatments, duration, and co-morbid conditions.
Physical examination: Patients with severe chronic obstructive pulmonary disease (COPD) are at risk of

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developing hypercarbia during laparoscopy and should undergo a chest and cardiac evaluation to rule out cardiopulmonary abnormalities that interfere with the laparoscopic approach, such as an aortic aneurysm. An examination of the abdomen was done to map the locations of the laparoscopic ports, assess the scars from previous surgeries, and check for intestinal blockage and infections of the abdominal wall.

Laboratory investigations: CBC, coagulation profile, blood sugar, and liver function tests, among others, with a focus on testing kidney function and identifying uremic patients in order to take precautions during surgery to prevent acidosis. For the proper administration of antibiotics, urine analysis, urine culture, and urine sensitivity were required.

Imaging studies:

- Abdominal pelvic ultrasound: used as a first step in the diagnosis of hydronephrosis, evaluation of the echogenicity of the contralateral kidney, and assessment of the contents of the dilated pelvicalyceal system. Volume of the hydronephrosis as measured by Formulae (volume = maximum of length, breadth, and height is 0.532).
- For patients with elevated kidney function, CT with and without intravenous contrast is used to assess the kidney's size, volume, and contents of the dilated pelvicalyceal system, the cause of hydronephrosis, the relationship of the surrounding viscera to the kidney, and to rule out malignant renal conditions.
- Radioactive isotope scanning (when the kidney's glomerular filtration rate is less than 10 ml/min, nephrectomy is recommended).

Surgical procedure:

Prophylactic antibiotics were given to all patients together with the induction of anesthesia. In every instance, general anesthesia was used. Every procedure was carried out using a transperitoneal technique. Patient positioning: After complete abdominal skin preparation and laparotomy-specific drapery, the patient was positioned in the lateral flank position. On the patient's abdomen, the surgeon stands. The opposite side of the monitor was used.

Post-operative complications:

The modified Clavien system was used to evaluate the postoperative complications. Accordingly, the postoperative complications were divided into five grades using this classification system: grade 1: complications not requiring surgery or radiological intervention and those requiring postoperative antiemetic, antipyretic, analgesic, diuretic, electrolyte, and physiotherapy applications; grade 2: complications requiring applications such as blood transfusions, parenteral nutrition, and antihypertensive drug treatments; grade 3: complications.

Ethical Approval:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Fayoum University, with a focus on the risks of the occurrence of anticipated problems and the potential for conversion to open surgery. Written informed consent was obtained from all participants. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical Analysis

The collected data were introduced and statistically analyzed by utilizing the Statistical Package for Social Sciences (SPSS) version 28 for windows. Qualitative data were defined as numbers and percentages. Chi-Square test and Fisher's exact test were used for comparison between categorical variables as appropriate. Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as mean and standard deviation (SD), and independent sample t-test/ Mann-Whitney U test was used for comparison between groups. The relationship between the length of the operation, the amount of blood lost, the length of the hospital stay, and other parameters was investigated using multiple linear regressions. To investigate the relationship between the likelihood of post-operative problems and other parameters, multiple logistic regressions were performed. P value ≤ 0.05 was considered to be statistically significant.

RESULTS

Table 1 summarizes the basic characteristics of the studied patients.

Table (1): Demographic and clinical chartestics of the studied patients.

Variable	Values	Range
Age (years)	**45.32 ± 14**	**(20-72)**
Body mass index (kg/m^2)	**28.37 ± 4.89**	**(20-39)**
Serum creatinine (mg/dl)	**1.31 ± 1.35**	**(0.6-1.7)**
Sex Female	**14 (35%)**	---
Male	**26 (65%)**	
Side Left	**24 (60%)**	
Right	**16 (40%)**	
Previous urological operation history		
No	**25 (62.5%)**	
Yes	**15 (37.5%)**	

The association between operative time and patient characteristics were studied using multiple linear regression. None of the studied variables showed a statistically significant association with the operative time except for having previous surgery and content of the obstructed system. Those who had history of urological surgery had longer operative time than those patients did not have this history by an average increase of 29 minutes (P-value 0.05). Those who had non-turbid content of pelvicalyceal system had shorter operative time as compared to those with turbid content by an average decrease of 25 minutes (P-value 0.041) **(Table 2)**.

Table (2): Multiple linear regression for the association between operative time and patient's characteristics

Variable	Coefficients	95% Confidence Interval		P-value
Age (>45)	-22.25	-48.53	4.03	0.094
Sex (female)	-2.42	-27.80	22.97	0.847
Side (Left)	1.24	-21.38	23.85	0.912
Previous urological surgery history (Yes**)**	28.93	0.06	57.81	**0.050**
Urinary stone disease (stone present)	8.66	-14.64	31.95	0.453
Contents of obstructed system (Pus)	25.16	1.09	49.22	**0.041**
Obesity (BMI >25)	-8.41	-31.52	14.70	0.462
Volume (>500)	13.54	-9.55	36.62	0.240
Serum Creatinine (elevated)	-2.18	-32.61	28.26	0.885

The association between amount of blood loss and other factors was studied using multiple linear regressions. None of the studied variables showed a statistically significant association with the amount of blood loss except for having a previous history of urological surgery. Patients who had having a previous history experienced more blood loss as compared to those who did not have a previous history by an average increase of 92 ml controlling for other variables (P-value 0.01) **(Table 3)**.

Table (3): Multiple linear regression for the association between estimated blood loss and patient's characteristics.

Variable	Coefficients	95% Confidence Interval		P-value
Age (more than 45)	-31.41	-106.32	43.51	0.399
Sex (female)	-2.92	-73.30	67.46	0.933
Side (Left)	-10.34	-74.07	53.39	0.743
Previous urological surgery history (Yes)	91.60	23.24	159.95	**0.010**
Urinary stone disease (stone present)	27.77	-36.84	92.38	0.387
Contents of obstructed system (Pus)	60.34	-10.62	131.31	0.093
Obesity (obese)	24.05	-41.81	89.91	0.462
Volume (more than 500)	28.63	-34.36	91.61	0.361
Serum Creatinine (elevated)	-13.66	-103.74	76.43	0.759

By using multiple linear regression, the association between hospital stay and other factors were studied. None of the studied variables showed statistically significant association with the length of hospital stay, except for the content of the obstructed system. Those who had urine content had lower length of stay as compared to those with pus content by an average decrease of 1.3 days (P-value 0.005) **(Table 4)**.

Table 4: Multiple linear regression for the association between hospital stay and patient's characteristics

Variable	Coefficients	95% Confidence Interval		P-value
Age (more than 45)	-0.39	-1.28	-0.39	0.385
Sex (female)	0.19	-0.65	0.19	0.655
Side (Left)	0.21	-0.55	0.21	0.580
Previous urological surgery history (Yes)	-0.28	-1.10	-0.28	0.485
Urinary stone disease (stone present)	0.36	-0.42	0.36	0.354
Contents of obstructed system (Pus)	1.27	0.43	1.27	**0.005**
Obesity (obese)	-0.01	-0.80	-0.01	0.977
Volume (more than 500)	-0.53	-1.28	-0.53	0.159
Serum Creatinine (elevated)	-0.08	-1.15	-0.08	0.885

When comparing the hemoglobin level of the cases pre- and post-operatively, there was a statistically significant reduction in hemoglobin level from preoperative level to postoperative level with a mean hemoglobin drop of 1.5 gm (12.7 versus 11.2, P<0,000l) **(Table 5)**.

Table (5): Comparison between pre- and post-operative Hemoglobin level.

Variable	Mean	SD
Pre-operative Hb %	**12.7**	**1.3**
Post-operative Hb %	**11.2**	**1.4**
Hb drop (gm)	**1.5**	**0.7**
P-value	**<0.000l***	

The association between the occurrence of intra- and post-operative complications and the predicting risk factors were studied using multivariate logistic regression. None of the studied variables showed a statistically significant association with the occurrence of complications, except for the content of the obstructed system, presence of pus is associated with higher odds of complications as compared to urine (OR 814.6, 95%CI: 1.6 - 419619) and history of previous urological surgery which was associated with higher odds of complication **(Table 6)**.

Table (6): Multivariate logistic regression analyses predicting risk factors for intra and post-operative complication.

Variable	OR	95% Confidence Interval		P-value
Age (> 45)	0.04	0.00	2.15	0.111
Sex (female)	3.35	0.10	113.77	0.502
Side (Left)	20.57	0.28	1505.93	0.168
Previous urological surgery (yes)	67.57	1.37	3321.14	0.034
Urinary stone disease (stone present)	0.99	0.04	23.66	0.994
Contents of obstructed system (pus)	814.6	1.6	419619	**0.035**
Obesity (obese)	5.12	0.32	81.32	0.247
Volume (> 500)	0.05	0.00	3.06	0.152
Serum Creatinine (elevated)	0.02	0.00	11.69	0.235

DISCUSSION

In the current investigation, the mean operating time was 190 minutes. According to **Eraky *et al.*** [6], the average length of the operation was 186 minutes [5].

A total of 43 patients had laparoscopic nephrectomy for non-functioning hydronephrotic kidneys as part of a study by **Yucel *et al.*** [2]. In 19 patients, urinary stone disease was the cause of obstruction, and the average operating time was 211 minutes. A total of 22 patients had laparoscopic nephrectomy for non-functioning kidneys blocked by urinary stone disorders in a research by **Kurt *et al.*** [7]. It was noticed that the mean surgical time for inflammatory kidneys was 129.5 minutes and for non-inflammatory kidneys was 117 minutes (described kidneys did not have hydronephrosis, stones, or a history of prior urological operation).

However, according to **Gülpnar *et al.*** [8], 15 patients had laparoscopic transperitoneal nephrectomy for hydronephrotic non-functioning kidneys. Urologic stone disease caused hydronephrosis in 6 patients. The typical procedure in their series took 90 minutes.

In terms of operational time compared to the other research mentioned earlier, our study is acceptable. With a steep learning curve, it was our first time performing laparoscopic surgery to treat urological diseases.

Through the use of numerous factors, it was found that the history of prior urological intervention (15/40 patients) and the presence of turbid contents in the pelvicalyceal system (10/40 patients), both of which were identified through the presence of echogenic material during preoperative imaging or through the drainage of pus during Veress needle placement, were both statistically significantly associated with longer operating times. Surgery took an average of 29 minutes longer for patients who had prior urological surgery than for those who had no history (P-value 0.050). Surgery took around 25 minutes longer for patients with non-turbid pelvi-calyceal system contents because of the presence of pus (P-value 0.041). The mean operating time for patients with hydronephrotic kidneys with volumes larger than 500ml and those with hydronephrosis <500 ml did not differ statistically significantly.

In the current study, the average estimated blood loss was 27588ml. Compared to what **Fornara *et al.*** [9] reported (230 ml).

In this study, patients with pyonephrosis experienced greater estimated blood loss with statistical significance (P-value 0.043). Without statistical significance, estimated blood loss was higher when there had been prior urinary tract surgery or when urinary stone disorders were present. Among obese male patients older than 45, it was discovered that estimated blood loss had increased. Using multiple linear regression, the effect of studying factors and the amount of blood loss was examined. Except for having a history of prior urological operations, none of the analyzed variables revealed a statistically significant association with the amount of blood loss (P-value 0.01). Controlling for other factors, patients who had prior urological surgeries lost an average of 91 ml more blood than those who had no prior history.

Urinary stone disorders, inflammatory renal illnesses, and perirenal fibrosis brought on by pyonephrosis, as well as a history of kidney surgery make it more difficult to advance with the dissection and increase the risk of bleeding.

Our study's mean hospital stay, which ranged from 2 to 6 days, was 3.05 days, which is consistent with **Rassweiler *et al.*** [10] result (5 days overall).

No problems, such as trocar injuries, were directly linked to the access method in our study. Gas embolism and hypercarbia were not observed.

According to **Gill *et al.*** [11], the placement of the trocar caused damage to the big hydronephrotic kidney.

Our open surgery conversion rate was 5% (2/40). That was very similar to the 6% observed by **Fornara *et al.*** [9] in 2001.

In the present study, we chose to use elective conversion to open surgery when we experienced significant difficulties in determining the appropriate operative planes. This was due to the fact that a laparoscopic nephrectomy required the surgeon to move rapidly, which made urgent conversion more challenging. The rush to stop the bleeding might lead to the other problem since one could hurt the gut when opening it. Limited dissection during laparoscopy restricts an acceptable surgical area for issue treatment and necessitates more dissection, adding time to the patient's recovery. It's possible that the surgical team and anesthesiologist aren't prepared for an open conversion. These variables increase the risk of death, which is what our endeavor aimed to reduce [12].

Similar to this study, several authors noted that conversion to open surgery was usually elective due to failure of progression because of noticeable adhesions, failure of entrapment of a large specimen, such as autosomal dominant polycystic kidney disease, and failure of a combination of these factors [13].

No major vascular injuries occurred throughout this analysis, and the rate of conversion to open surgery decreased from two patients (10%) in the first 20 instances to one patient (5%) in the last 20 cases, according to **Masoud *et al.*** [14]. The majority of open surgery conversions, according to some authors, are caused by technical problems such renal pathology, peri-renal inflammation, and surgical inexperience.

In the investigation at hand, it was discovered that two patients with urinary stone diseases and a history of past surgery on the urinary tract were females with a mean BMI higher than 25, had urinary stone diseases, and couldn't have their organs completely dissected by a laparoscope. Renal stone problems were the most frequent cause of renal functional loss following laparoscopic simple transperitoneal nephrectomy, according to **Soulie *et al.*** [15].

According to **Hemal *et al.*** [16], perirenal adhesions caused by prior cases of pyelonephritis and renal surgery frequently impede laparoscopic nephrectomy for patients with renal stones. In their evaluation of 96 patients undergoing laparoscopic nephrectomy for stone disorders, **Angerri *et al.*** [17] found 7 incidences of conversion to open surgery because of challenges with hilar dissection.

In the present study, none of the studied variable was found to have statistically significant impact on occurrence of open conversion. Performing the logistic regression test for the conversion into open surgery is not statistically possible as this only occurred with two cases. **S**imilar research on laparoscopic transperitoneal nephrectomy for 43 patients with non-functioning hydronephrotic kidney was published by **Yucel *et al.*** [2]. There were 48% postoperative complications. This study covered 40 patients in total; 26 of them were male patients, and 14 were female.

According to **Sammon *et al.*** [18], laparoscopic nephrectomy complications for patients of either gender did not differ, but women experienced higher rates of blood transfusions, a lower risk of postoperative complications, and a shorter hospital stay.

Men and women have the same intraoperative challenges, according to **Shah *et al.*** [19]. Similar to the last experiment, there was no statistically significant difference between male and female patients in terms of operation time, anticipated blood loss, or length of hospital stay. Complications were more likely to affect women. Yet, the danger did not turn out to be very significant. Elevated serum creatinine (>1.3 mg/dl) was noted in 8 individuals. Univariate and multivariate analysis showed that increased serum creatinine had no statistically significant impact on the outcome of the laparoscopic nephrectomy.

In studies by **Aguilera *et al.*** [20] and **Shah *et al.*** [19], it was shown that laparoscopic nephrectomy may be performed safely on elderly patients. It was determined that age had no statistical effect on how difficult the intraoperative process was during laparoscopic simple nephrectomy. Participants in the research were divided into two groups based on their average ages: those under 45 and those over 45.

Similar to previous mentioned studies, there was no statistically significant impact of age on outcome of laparoscopic nephrectomy for hydronephrotic kidneys.

Transperitoneal nephrectomy was once thought to be a relative contraindication for obesity; however it has since been shown to be possible. According to research by **Lafranca *et al.*** [21], higher BMIs of >29.9 kg/m2 are linked to longer recovery times and a higher likelihood of open conversion.

Visceral obesity was not linked to a rise in any intraoperative adverse event in a research by **Kumazawa *et al.*** [22].

On multivariate analysis, history of previous abdominal surgery in this work was associated with significant increased blood loss by about 91 ml (P-value 0.01).

In this work, two cases faced failure to progress during dissection and inability to complete laparoscopic nephrectomy. These two cases had previous history of open surgery for stone diseases. It is accepted due to the presence of marked adhesion. Previous urological surgery was associated with insignificant statistically effect on hospital stay. In a study by **Parson *et al.*** [23] it was seen that prior abdominal surgery is not associated with any increase in intraoperative blood loss, conversion to open or rate of operative complications.

As regards the intra-operative technique, we got a lot of benefits from the published work of other series and we followed their advice in several steps. Direct attention was given to colonic reflection, identification of anatomical landmarks such as psoas muscle on both sides and ureterogonadal package on the left side and ureter and inferior venal cava on the right side was helped in early renal pedicle identification. Dissection was outside Gerota's fascia in some cases to be away from sticky fat. Gerota's fascia was opened only to leave the ipsilateral adrenal gland. Hilar dissection started with the identification of major vessels and traced them for renal pedicle and to avoid dealing with perihilar fibrotic tissues [24].

Other series with 50 patients submitted to laparoscopic nephrectomy for inflammatory conditions, conversion was verified in 14 (28%) cases, owing to severe adhesions and fibrosis. These conversion rates appear to be higher when compared to radical nephrectomy. **Permpongkosol *et al.*** [25] reviewed their complications of 2775 laparoscopic urological procedures and found that open conversion rate was doubled for laparoscopic simple nephrectomy versus laparoscopic radical nephrectomy (5.9% vs. 2.9%, respectively).

Danilovic *et al.* [26] evaluated 83 cases of laparoscopic nephrectomies and conversion rate (19.2%) had remained in the patterns of the current literature, but still high compared to radical nephrectomy.

A review by **Modi *et al.*** [27] observed that conversion rate in the initial 20 cases was 30%. It occurred due to failure to progress.

These previous reviews about the learning curve and experience were observed through our work. As more cases were operated on, fewer complications and less operative time had occurred. More familiarity with the approach and how to deal with difficult cases was observed. Our experience in avoiding post-operative sequelae like wound infection and fever was improved.

The present study has the advantages of being prospective with restricted inclusion criteria, the surgical approach was the same for all patients (the transperitoneal route) which is the traditional method to perform laparoscopic surgery since it results in small incisions, gives latitude in the location of trocar

placement, affords an optimal working space and facilitates orientation by providing readily identifiable anatomic landmarks.

CONCLUSION

Turbid content of the pelvicalyceal system and history of prior urological intervention were the most important predictive factors for bad prognosis of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys.

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