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Univariate analysis for prediction of factors affecting outcome of laparoscopic simple nephrectomy

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Abstract

Introduction: For many urological pathologies, minimally invasive surgery has become the appropriate therapy. Because of technological advances, minimally invasive surgery has largely replaced open surgery techniques in recent years. Apart from simple procedures, laparoscopic surgery has become a prevalent procedure performed in oncologic and complicated circumstances. Recent developments in minimally invasive surgery and surgical technique result in a shorter hospital stay, reduced mortality, less analgesic use, and enhanced cosmetic outcomes as compared to open surgery.

Aim of the study: To study the impact of etiology, pathological changes, and patient demography on the prediction of the outcome of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys.

Subjects and Methods: This was a prospective randomized study for prediction of the outcome of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys. This study included 40 patients. A thorough history and full clinical examination were done for all study cases, with the exclusion of patients unfit for laparoscopic surgery.

Results: Although obese patients had increased estimated blood loss by about 24 ml over the non-obese group and a high risk for the incidence of complications, Baseline patient`s characteristics (age, sex, side of the resected kidney, elevated serum creatinine) didn`t have a significant impact on the outcome of laparoscopic nephrectomy. It was observed through our work in these 40 cases that there was a marked improvement with increased numbers of operating cases in dealing with difficult situations, reducing operative time, and avoiding intra- and postoperative complications.

Conclusion: In predicting the outcome of laparoscopic nephrectomy for a non-functioning hydronephrotic kidney, the turbid content of the pelvicalyceal system and history of previous urological intervention are the most considerable risk factors that should be estimated by the surgeon.

Keywords: Laparoscopic Nephrectomy; Non-Functioning Hydronephrotic Kidneys; Obesity.

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1. Introduction

For many urological pathologies, minimally invasive surgery had become the appropriate therapy. In 1991, Clayman *et al.*, accomplished the first laparoscopic

nephrectomy, which had obtained universal support even though [1]. In benign pathologies, a simple nephrectomy was conducted laparoscopically. Notwithstanding the word "simple" in its title, that surgery may be difficult due to the increased perirenal adhesions due to infectious processes [2].

Because of technological advances, minimally invasive surgery had largely replaced open surgery techniques in recent years. Apart from simple procedures, laparoscopic surgery had become a prevalent procedure performed in oncologic and complicated circumstances. Recent developments in minimally invasive surgery and surgical technique result in a shorter hospital stay, reduced mortality, less analgesic use, and enhanced cosmetic outcomes as compared to open surgery [3].

Laparoscopic nephrectomy techniques were classified as retroperitoneal, transperitoneal, and hand-assisted. Without trying to enter the peritoneal cavity, the retroperitoneal technique exposes the kidney. The transperitoneal (through the abdominal cavity) approach provides the surgeon with the optimal operating space and the most easily identifiable anatomical landmarks. The transperitoneal approach can be carried out either fully laparoscopically or with a hand assist [4].

Through the incision in the hand port, the laparoscopic hand-assisted method permits the surgeon to utilize his hand to aid with dissection, retraction, and kidney excision [5].

The most common reason for laparoscopic kidney removal is a nonfunctioning kidney caused by a benign condition. These include patients with nonfunctioning hydronephrotic kidneys, renovascular hypertension, patients with chronic pyelonephritis, either with or without vesicoureteral reflux, and those with small kidneys who were chronically ill with kidney failure. A condition must present with sufficient symptoms to justify the procedure, such as frequent pain or a urinary tract infection [6].

The current study sought to assess the influence of etiology, pathological alterations, and patient demographics on the success of laparoscopic nephrectomy for hydronephrotic non-functioning kidneys in a population from Egypt's Fayoum Governorate.

2. Subjects and methods

2.1. Subjects

The current prospective clinical study included 40 patients with hydronephrotic, nonfunctioning kidneys treated through transperitoneal laparoscopic nephrectomy. The study protocol was approved by the local institutional ethics committee. For all patients, written, fully informed consent was acquired, with special attention paid to the likelihood of the development of anticipated consequences and the potential for switching from laparoscopic to open surgery.

Inclusion criteria

Patients with symptomatic benign hydronephrotic nonfunctioning kidneys and candidates for nephrectomy

Exclusion criteria

That included patients with malignant renal conditions, uncorrected coagulopathy, severe cardiopulmonary diseases, intestinal obstruction, active peritonitis, a severe diaphragmatic hernia, previous multiple abdominal operations, an abdominal wall infection, and ascites.

2.2. Methods

Before any procedure, all patients were subjected to the following scheme of studies

Clinical assessment

1. Detailed history, with attention to the following points: presentation, age, sex, previous intervention, duration of the disease, and associated co-morbidities.
2. Physical examination:
   a. Chest and cardiac examination: To exclude cardiopulmonary conditions that interfere with the laparoscopic approach, such as an aortic aneurysm. The risk of developing hypercarbia during laparoscopic surgery arises in patients with severe chronic obstructive pulmonary disease (COPD).
   b. Abdominal examination: A full clinical examination was performed. Assess the sites of scars from previous surgery and map the sites of laparoscopic ports. Examine for the exclusion of abdominal wall infection and intestinal obstruction.

Investigations

1. Laboratory investigations: CBC, coagulation profile, blood sugar, and liver function tests with an emphasis on kidney function tests, identification of uremic cases calls for taking precautions during surgery to avoid acidosis. urine analysis and urine culture and sensitivity for appropriate antibiotic administration.
2. Imaging studies:
   a. Abdominal pelvic ultrasound: as an initial tool in the identification of the hydronephrotic kidney, assessment of the echogenicity of the contralateral kidney, and content of the dilated pelvicalyceal system. Measurement of hydronephrosis volume by FORUMALE (volume = maximum length maximum width maximum height 0,532).
   b. CT with and without intravenous contrast (for patients with elevated kidney functions) for assessment of kidney size, volume, and contents of the dilated pelvicalyceal system; etiology of hydronephrosis; anatomical relationship of the surrounding viscera; and exclusion of malignant renal conditions.
3. Nuclear isotope scanning (nephrectomy is indicated when the glomerular filtration rate for the kidney is < 10 ml/min).

The surgical procedure

All patients received prophylactic antibiotics with the induction of anesthesia. General anesthesia was performed in all cases. Every procedure was carried out using a transperitoneal approach. The patient was positioned in the lateral flank position, and the abdomen was completely prepped and draped in preparation for laparotomy. On the patient's side, facing the abdomen, the surgeon stands. The monitor was set up on the opposite side.

Post operative complications

The modified Clavien system was used to assess the postoperative complications. Therefore, they were graded based on that classification into 5 categories:

Grade 1: Complications requiring postoperative antiemetic, antipyretic, analgesic, diuretic, electrolyte, and physical therapy treatments but not requiring surgical or radiological procedures.

Grade 2: Conditions that necessitated the use of treatments such as blood transfusions, parenteral nourishment, and antihypertensive medication.

Grade 3: complications that call for surgery, an endoscopic, or a radiological procedure.

Grade 4: Issues that can result in fatal circumstances, like failure of an organ's function.

Grade 5: Death-causing complications.

2.3. Statistical analysis

For numerical variables, descriptive statistics were presented as mean and standard deviation, but for categorical variables, they were expressed as numbers and percentages. To compare surgical outcomes across patient characteristics, independent t tests, Mann-Whitney U tests, chi-squared or Fisher exact tests, and other statistical methods were used. The relationship between the length of the operation, the amount of blood lost, the length of the hospital stays, and other parameters was investigated using multiple linear regression. To investigate the relationship between the likelihood of postoperative complications and other parameters, multiple logistic regression was performed. The study was performed using IBM SPSS 28 for Windows, and a *P-value* of 0.05 or lower was regarded as statistically significant.

3. Results

In the current study, 40 patients with hydronephrotic, nonfunctioning kidneys treated through transperitoneal laparoscopic nephrectomy were recruited. The demographic characteristics of the study population were listed in Table 1.

Table 1: Baseline characteristics of the study group.

Variables		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%)	
Nonfunctioning kidney Side	Left	24 (60%)	
	Right	16 (40%)	
Previous urological operation history	No	25 (62.5%)	
	Yes	15 (37.5%)	

There was no statistically significant variation in operative time across various patient characteristics, as demonstrated by univariate analysis (Table 2). However, when the association between operative time and patient characteristics was studied using multiple linear regression, none of the studied variables showed a statistically significant association with the operative time except for having had previous surgery and the content of the obstructed system. Those who had a history of urological surgery had a longer operative time than those patients who did not had that history, by an average increase of 29 minutes (*P = 0.05*). Those who had non-turbid content in the pelvicalyceal system had a shorter operative time as compared to those with turbid content, with an average decrease of 25 minutes (*P = 0.041*) (Table 3).

Table 2: Univariate analysis of patient's characteristics affecting operative time.

Variables		Frequency	Operative time	*P-value*
Sex	Male	26 (65%)	191.92±34.06	0.627
	Female	12 (30%)	186.67±21.46	
Nonfunctioning kidney Side	Right	15 (37.5%)	190.67±31.27	0.948
	Left	23 (57.5%)	190±30.6	
Previous urological surgery history	No	25 (62.5%)	186±23.8	0.319
	Yes	13 (32.5%)	198.46±40.18	
Urinary stone disease	No stone	19 (47.5%)	189.47±35.35	0.876
	With stone	19 (47.5%)	191.05±25.58	
Contents of the obstructed system	Pus	10 (25%)	206±27.97	0.056
	Urine	28 (70%)	184.64±29.75	
Age	≤ 45	18 (45%)	195.56±26.84	0.316
	> 45	20 (50%)	185.5±33.32	
BMI	Non obese (< 25)	12 (30%)	198.33±32.71	0.273
	Obese (≥25)	26 (65%)	186.54±29.25	
Volume	≤ 500	23 (57.5%)	188.26±36.39	0.577
	> 500	15 (37.5%)	193.33±18.77	
Serum creatinine level	Normal (< 1.3)	30 (75%)	191±26.95	0.833
	Elevated (≥ 1.3)	8 (20%)	187.5±43.34	

*****Independent t-test was used to compare operative time across different patient characteristics.

Table 3: Multiple linear regression for the association between operative time and patient's characteristics.

Variables	95.0% Confidence Interval for Coefficients		Coefficients	*P-value*
	Min.	Max.		
Sex (female)	-27.80	22.97	-2.42	0.847
Nonfunctioning kidney Side (Left)	-21.38	23.85	1.24	0.912
Previous urological surgery history (Yes)	0.06	57.81	28.93	0.050*
Urinary stone disease (Present)	-14.64	31.95	8.66	0.453
Contents of obstructed system (Pus)	1.09	49.22	25.16	0.041*
Age (> 45 years)	-48.53	4.03	-22.25	0.094
Obesity (BMI>25%)	-31.52	14.70	-8.41	0.462
Volume (> 500 ml)	-9.55	36.62	13.54	0.240
Serum Creatinine (Elevated)	-32.61	28.26	-2.18	0.885

*Significant.

A univariate analysis of the patient's characteristics affecting estimated blood loss showed a statistically significant association between estimated blood loss and contents of the obstructed system (P = 0.043), as estimated blood loss was higher with pus content of the

obstructed system (320±82.5 ml) than with urine content of the obstructed system (260±120 ml). There was no statistically significant difference in the other characteristics.

Table 4: Univariate analysis of patient's characteristics affecting estimated blood loss.

Variables		Frequency	Estimated blood loss	*P-value*
Sex	Male	26 (65%)	279.62±79.67	79.67
	Female	14 (35%)	267.5±105.99	
Nonfunctioning kidney Side	Right	16 (40%)	287.5±79.71	0.487
	Left	24 (60%)	267.29±94.83	
Previous urological surgery history	No	25 (62.5%)	253.8±66.42	0.081
	Yes	15 (37.5%)	311.33±109.93	
Urinary stone disease	No stone	19 (47.5%)	268.95±83.92	0.668
	With stone	21 (52.5%)	281.19±94.29	
Contents of the obstructed system	Pus	10 (25%)	320±82.5	0.043*
	Urine	30 (75%)	260±120	
Age	≤ 45	20 (50%)	282.25±99.08	0.630
	> 45	20 (50%)	268.5±78.69	
BMI	Non obese (< 25)	12 (30%)	260±81.91	0.480
	Obese (≥25)	28 (70%)	281.96±91.94	
Volume	≤ 500	24 (60%)	290±150	0.633
	> 500	16 (40%)	260±85	

*Independent t-test was used to compare estimated blood loss across different patient characteristics.

The association between amount of blood loss and other factors was studied using multiple linear regression. 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 a previous history experienced more blood loss as compared to those who did not have a previous history, with an average increase of 92 ml after controlling for other variables (*P = 0.01*) (Table 5).

Table 5: Multiple linear regression for the association between estimated blood loss and patient's characteristics.

Variables	95.0% Confidence Interval for Coefficients		Coefficients	*P-value*
	Min.	Max.		
Sex (female)	-73.30	67.46	-2.92	0.933
Nonfunctioning kidney Side (Left)	-74.07	53.39	-10.34	0.743
Previous urological surgery history (Yes)	23.24	159.95	91.60	0.01*
Urinary stone disease (Present)	-36.84	92.38	27.77	0.387
Contents of obstructed system (Pus)	-10.62	131.31	60.34	0.093
Age (> 45 years)	-106.32	43.51	-31.41	0.399
Obesity (BMI>25%)	-41.81	89.91	24.05	0.462
Volume (> 500 ml)	-34.36	91.61	28.63	0.361
Serum Creatinine (Elevated)	-103.74	76.43	-13.66	0.759

*Significant.

There was a statistically significant association between the length of hospital stay and contents of the obstructed system in univariate analysis (*P = 0.004*), as the length of hospital stay was higher with pus content of the obstructed system (median = 4.00, IQR = 2.25), than with urine content of the obstructed system (median =2.25, IQR =1.00). However, there was no statistically significant difference in the other characteristics (Table 6).

Table 6: Univariate analysis of patient's characteristics affecting hospital stay.

Variables		Frequency	Hospital stays		*P-value*
			Median	IQR	
Sex	Male	26 (65%)	3.00	1.25	0.318
	Female	14 (35%)	3.00	2.25	
Nonfunctioning kidney Side	Right	16 (40%)	3.00	1.00	0.452
	Left	24 (60%)	3.00	2.00	
Previous urological surgery history	No	25 (62.5%)	3.00	2.00	0.173
	Yes	15 (37.5%)	2.00	1.00	
Urinary stone disease	No stone	19 (47.5%)	2.00	1.00	0.093
	With stone	21 (52.5%)	3.00	2.50	
Contents of the obstructed system	Pus	10 (25%)	4.00	2.25	0.004*
	Urine	30 (75%)	2.50	1.00	
Age	≤ 45	20 (50%)	3.00	1.50	0.231
	> 45	20 (50%)	2.00	1.75	
BMI	Non obese (< 25)	12 (30%)	3.00	1.75	0.850
	Obese (≥25)	28 (70%)	3.00	1.75	
Volume	≤ 500	24 (60%)	3.00	2.75	0.521
	> 500	16 (40%)	3.00	1.00	
Serum creatinine level	Normal (< 1.3)	32 (80%)	3.00	1.75	0.148
	Elevated (≥ 1.3)	8 (20%)	2.50	2.50	

*Independent t-test was used to compare estimated blood loss across different patient characteristics.

By using multiple linear regression tests, the association between hospital stay and other factors was studied. None of the studied variables showed a statistically significant association with the length of hospital stay except for the content of the obstructed system. Those who had urine content had a shorter length of stay as compared to those with pus content, with an average decrease of 1.3 days (P = 0.005) (Table 7).

Table 7: Multiple linear regression for the association between hospital stay and patient's characteristics.

Variables	95.0% Confidence Interval for Coefficients		Coefficients	*P-value*
	Min.	Max.		
Sex (female)	-0.65	0.19	0.19	0.655
Nonfunctioning kidney Side (Left)	-0.55	0.21	0.21	0.580
Previous urological surgery history (Yes)	-1.10	-0.28	-0.28	0.485
Urinary stone disease (Present)	-0.42	0.36	0.36	0.354
Contents of obstructed system (Pus)	0.43	1.27	1.27	0.005*
Age (> 45 years)	-1.28	-0.39	-0.39	0.385
Obesity (BMI>25%)	-0.80	-0.01	-0.01	0.977
Volume (> 500 ml)	-1.28	-0.53	-0.53	0.159
Serum Creatinine (Elevated)	-1.15	-0.08	-0.08	0.885

*Significant.

The Chi-Square test or Fisher exact test was used to study the association of post-operative complication with different patient characteristics (Table 8). There was a statistically significant difference between post-operative complications and contents of the obstructed system (*P = 0.003*), as 70% of the patients with pus content had post-operative complications, while only 16.7% of the patients with urine content had post-operative complications. There was no statistically significant difference between post-operative complication and other patient characteristics.

Table 8: Univariate analysis of patient's characteristics for post-operative complications.

Variables		Post operative complication		*P-value*
		No	**Yes**	
Sex	Male	19 (73.1%)	7 (26.9%)	0.720
	Female	9 (64.3%)	5 (35.7%)	
Nonfunctioning kidney Side	Right	12 (75%)	4 (25%)	0.452
	Left	16 (66.7%)	8 (33.3%)	
Previous urological surgery history	No	19 (76%)	6 (24%)	0.729
	Yes	9 (60%)	6 (40%)	
Urinary stone disease	No stone	15 (78.9%)	4 (21.1%)	0.093
	With stone	13 (61.9%)	8 (38.1%)	
Contents of the obstructed system	Pus	3 (30%)	7 (70%)	0.311
	Urine	25 (83.3%)	5 (16.7%)	
Age	≤ 45	13 (65%)	7 (35%)	0.231

	> 45	15 (75%)	5 (25%)	
BMI	Non obese (< 25)	10 (83.3%)	2 (16.7%)	0.240
	Obese (≥25)	18 (64.3%)	10 (35.7%)	
Volume	≤ 500	14 (58.3%)	10 (41.7%)	0.521
	> 500	14 (87.5%)	2 (12.5%)	
Serum creatinine level	Normal (< 1.3)	23 (71.9%)	9 (28.1%)	0.003*
	Elevated (≥ 1.3)	5 (62.5%)	3 (37.5%)	

When comparing the hemoglobin levels of the cases pre- and post-operatively, there was a statistically significant reduction in hemoglobin levels from the preoperative level to the postoperative level, with a mean hemoglobin drop of 1.5 gm (12.7 versus 11.2, respectively, (*P< 0.000l*).

Table 9: Comparison between pre- and post-operative Hemoglobin level.

Variables	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*

Hb: Hemoglobin**, SD:** standard deviation, *: significant with *P-value < 0.05*.

4. Discussion

Laparoscopic kidney surgery is the safest and most dependable choice for the kidney. A lower level of postoperative morbidity and pain, as well as an earlier return to regular activities, were potential advantages over open treatments. Additionally, the preferred method for benign kidney disorders is laparoscopic nephrectomy since it is less intrusive than open surgery [7].

Many urological pathologies were now treated as routine practice using minimally invasive surgery. The first laparoscopic nephrectomy procedure was performed by Clayman *et al.,* 1991 [1]. Hydronephrotic kidneys that were not functioning were removed using a simple laparoscopic nephrectomy. Longstanding urinary stone disease is one of the most important factors in the development of hydronephrosis and loss of kidney function. Hydronephrotic kidneys with urinary stone diseases showed pathological processes including renal parenchymal atrophy, chronic pyelonephritis, and finally xantho-granulomatous pyelonephritis. Recurrent attacks of infection and induced fibrosis that occur in perirenal tissues lead to the loss of surgical planes during nephrectomy. For these reasons, simple laparoscopic nephrectomy is not usually simple and carries a high degree of difficulty and risk of intraoperative complications [8].

The transperitoneal approach is preferred for laparoscopic nephrectomy for a hydronephrotic kidney because it provides a large working area in addition to anatomical landmarks like the kidney, liver, and colon that help orient the surgeon during surgery. It also prevents instrument collisions in the event that additional ports were added, which frequently happens with the retroperitoneal approach [9].

The purpose of the current study was to examine the impact of demographic parameters (sex, BMI, side of affected kidney), radiological factors (volume of hydronephrosis, presence of urinary tract stones, contents of the obstructed system), and anatomical factors (previous

urological surgery history) on the outcome of laparoscopic nephrectomy for the hydronephrotic nonfunctioning kidney. A laparoscopic nephrectomy was done for 40 patients with hydronephrotic, non-functioning kidneys through a transperitoneal approach.

The mean operative time was 190 minutes in the present study. In comparison to other studies, Eraky *et al.*, 1995, reported the mean operative time as 186 minutes [10]. Another study showed that the laparoscopic nephrectomy for non-functioning hydronephrotic kidneys was done for 43 patients [2]. The etiology of obstruction was urinary stone disease in 19 patients, and the mean operative time was 211 minutes. Another study involved 22 patients managed by laparoscopic nephrectomy for non-functioning kidneys obstructed by urinary stone diseases and recorded that the mean operative time was 129.5 minutes and was 117 minutes for non-inflammatory kidneys (describe kidneys that didn't had hydronephrosis, stones, or a history of previous urological operation) [11]. However, Gülpnar *et al.*, 2015, mentioned that fifteen patients underwent laparoscopic transperitoneal nephrectomy for non-functioning hydronephrotic kidneys. Hydronephrosis was due to urinary stone disease in six patients. The mean operative time in their series was 90 minutes [12].

The current study was accepted for operative time in comparison to other previously mentioned studies. It was our initial work of laparoscopic surgery for the treatment of urological pathologies with the early learning curve. On univariate analysis of the effect of different factors on the operative time, it was noticed that the operative time slightly increased in non-obese male patients who had urinary stone disease, turbid contents of the pelvicalyceal system, or a history of previous urological surgery, without statistical significance. The mean estimated blood loss in the present work was ~276 ml. Similar findings were reported at 230 ml [13], 156 ml [14], and 105 ml [11]. Estimated blood loss in our study was increased for patients with pyonephrosis. Estimated blood loss was increased in cases of previous surgery related to the urinary tract or the presence of urinary stone diseases without statistical significance. Estimated blood loss was found to be increased in obese male patients older than 45 years. The impact of studying factors and the amount of blood loss was analyzed using multiple linear regression. None of the studied variables showed a statistically significant association with the amount of blood loss except for having a previous urological operation history. Patients who had previous urological operations experienced more blood loss compared to those who had none, by an average of 91 mL after controlling for other variables.

Inflammatory renal conditions and perirenal fibrosis, which resulted from pyonephrosis, urinary stone diseases, and a history of previous surgery related to the kidneys, were predisposing factors to mask proper surgical planes, difficulty progressing, and a high incidence of bleeding during dissection. According to the operative data, bleeding should be readily controlled by monopolar coagulation (better with bipolar coagulation if available) or direct pressure using small pieces of gauze on blunt dissectors; otherwise, light absorption due to the accumulation of blood will worsen the vision and make identification of proper planes difficult. Attempts at aspiration would lead to loss of pneumoperitoneum and prolong the operative time [11].

The mean hospital stay in our study was 3.05 days. That agreed with previous studies reported 2.9 days [10], 4 days [13], 2.8 days [12], 3.8 days [2], and 5 days overall [15]. The mean hospital stay in patients with pyonephrotic kidneys (10/40) was 4 with an IQR of 2.25, which was statistically significant, in

comparable to that for patients with hydronephrotic kidney (30/40). The mean hospital stay for patients with hydronephrotic kidneys was 2.5 days. that increased hospital stay was due to the high incidence of postoperative fever, wound infection, and paralytic ileus. The association between hospital stay and other factors was studied using multiple linear regression. None of the studied variables showed statistically significant associations with the hospital stay except for the content of the obstructed system. Those with pus content had a longer length of stay as compared to those with non-turbid content by an average of 1.3 days. Increased volume of hydronephrotic kidneys, existence of urinary stone disease, and previous urological surgery history had no statistically significant impact on hospital stay in that study, which was also reported by Parsons *et al.*, 2002 [16].

In our study, no complications were directly related to the access technique, such as trocar injuries. Hypercarbia and gas embolisms were never encountered. A previous study reported that a large hydronephrotic kidney was injured during trocar placement [17]. Reviewing the preoperative CT more carefully and determining the relation of the hydronephrotic kidney to the surrounding structures and an enlarged liver or a significant Riedel's lobe that may shift medially when the patient is in the lateral decubitus position may had avoided that complication since the surgeon can choose an alternative initial port site [18]. The preoperative tomographic study helped us in the exclusion of cases with severe perirenal stranding and the presence of severe adhesion to the surrounding bowel, organs, or muscle, which was reflected in the study results by the reduced incidence of conversion to open surgery. Huge hydronephrotic kidneys that cross midline was evacuated before port placement by puncture needle or veress needle guided by laparoscope. If abdominal entry becomes difficult, perhaps because of inadvertent insufflation of the abdominal wall itself, the Hasson technique may be required. Although the Hasson technique had been reported to be a safe means of decreasing the risk of injuries, it can cause continuous air leakage and prolong the operative time [19].

Our conversion rate to open surgery was 5% (2/40). Similarly, previous studied reported 6% [13], 5% [11, 20], 11.5% [12], 10.3% [7], and 8.5% [10].

Our decision for open conversion was elective in these two cases (5%). We noticed that these cases had unclear anatomical landmarks and extensive adhesions, leading to difficult dissection in safe planes. Based on the post-operative pathological examination, these two individuals had xantho-granulomatous pyelonephritis, a persistent and dangerous bacterial infection of the renal parenchyma. The blockage of the collecting system brought on by kidney and ureteral stones is typically the source of chronic infection. Severe adhesion, including the renal pelvis, hilum, and surrounding tissues, and also the infiltration of the adjacent organs can result from that chronic parenchymal infection. Normal anatomical levels can also be difficult to see. Patients who were set to had a nephrectomy for XGP must had their CT scans thoroughly examined to determine how the surrounding tissue and organs were doing [21].

In the current study, whenever we encountered major challenges in determining the proper surgical planes, we preferred to employ elective conversion to open surgery. That was because laparoscopic nephrectomy's emergent conversion was more difficult because the surgeon needed to act quickly to handle the issue. One could harm the intestine when opening for bleeding control due to the other issue that could arise from the hurry. Laparoscopy's limited dissection does not provide a large enough surgical field for the treatment of problems, necessitating further dissection, which takes up more of the patient's

important time. It's possible that the surgical team, including the anesthesiologist, is not ready for an open conversion. These factors raise the mortality risk that was mitigated by that study [9]. Similarly, multiple authors mentioned that conversion to open surgery was elective mostly due to failure of progression because of marked adhesions or failure of entrapment of a large specimen, e.g., autosomal dominant polycystic kidney disease [18]. Masoud *et al.,* 2020, reported that there were no serious vascular injuries throughout their investigation and that the rate of conversion to open surgery fell from two patients at 10% in the first 20 cases to one patient at 5% in the last 20 cases [22]. According to some researchers, technical issues such as renal pathology, peri-renal inflammation, and surgical inexperience account for the bulk of open surgery conversions.

It was observed that the two cases in our study that couldn't be completely dissected by laparoscopy were females with a mean BMI greater than 25 who had urinary stone diseases and a history of previous surgery related to the urinary tract. A previous study reported that renal stone disorders were the most probable explanation for renal functional loss following laparoscopic nephrectomy [23], while another reported that perirenal adhesions caused by prior cases of pyelonephritis and renal surgery frequently impede laparoscopic nephrectomy for patients with renal stones [24]. Another study recruited a total of 96 patients, who underwent laparoscopic nephrectomy for stone disorders, where seven cases of conversion to open surgery because of challenges with hilar dissection [25].

In the present study, none of the studied variables was found to had a statistically significant impact on the occurrence of open conversion. Performing the logistic regression test for the conversion into open surgery is not statistically possible as that only occurred in two cases. The postoperative complication rate was 30% (12/40 cases). The postoperative complications were evaluated according to the modified Clavien classification system. A grade 1 complication was observed most frequently among all patients (9/12), as five patients developed fever postoperatively and were managed by the administration of intravenous antibiotics according to urine culture and sensitivity. A wound infection occurred in one patient. In the present study, we retrieve kidney specimens by extension of the site of the lower port or through a phrenistial incision. We observed that wound infection occurred in a patient with pyonephrosis. Improper irrigation of the abdomen might be the etiology that is avoided in the next cases. Surgical subcutaneous emphysema is diagnosed in one patient as diffuse swelling and crepitus on palpation at the abdominal wall. It was resolved spontaneously within a few days. Paralytic ileus occurred in two cases where that abdominal distension lasted for a few days after surgery. The expected risk factors in these cases were a long period of anesthesia and intraperitoneal manipulation [26].

The conservative treatment was effective in two cases where a nasogastric tube was inserted and intestinal prokinetic medications were prescribed. Nothing by mouth was recommended until intestinal sounds were clearly heard and patients passed flatus when intake of oral fluids was started. Blood was transfused to two cases where routine post-operative hemoglobin and hematocrit assessment revealed a marked decline. Blood transfusion was classified as grade 2 on the Clavien complication system. One patient was re-admitted to the hospital after discharge on the 10th postoperative day because of fever, abdominal distension, tenderness, and vomiting. Abdominopelvic computed tomography with oral and intravenous contrast revealed a colonic injury. Abdominal exploration and colostomy were done with the assistance of general surgeons. Similar study reported that a

laparoscopic transperitoneal nephrectomy for 43 patients with a non-functioning hydronephrotic kidney, where the postoperative complications were 48% [2]. On the contrary, other studies reported a 23% and 21% incidence of postoperative complications [11, 13].

Post-operative complications in that work were statistically affected by the presence of pus as the content of an obstructed system. These complications increase in patients with urinary stone diseases and patients with BMI 25 kg/m2 without statistical significance. Age, sex, side of the affected kidney, and volume of hydronephrosis had no statistical significance with post-operative complication incidence. The association between the occurrence of intra- and postoperative complications and other factors was studied using multiple logistic regression tests. None of the studied variables showed a statistically significant association with the occurrence of complications except for the content of the obstructed system and previous urological surgery history. The presence of pus is associated with higher odds of complications as compared to urine. A previous study observed that the intraoperative complications of laparoscopic nephrectomy were similar in both sexes [27]. But the female patients required more blood transfusions, had a lower risk of postoperative complications, and were discharged from the hospital sooner. Also, according to the study by Shah *et al.*, 2015, males and females experienced the same perioperative difficulty [28].

Previous investigations showed that the laparoscopic nephrectomy was demonstrated to be feasible and secure in elderly patients. The impact of age on the difficulty of the intraoperative procedure was shown to be statistically negligible [28, 29]. According to their average age, study participants were split into two groups: those under 45 and those over 45. Similar to earlier research, the results of laparoscopic nephrectomy for hydronephrotic kidneys were not significantly affected by age.

Transperitoneal nephrectomy was thought to be a relative contraindication for obesity; however, it had since been shown to be possible. Another study reported higher BMIs of > 29.9 kg/m^2 were linked to longer surgical times and a higher likelihood of open conversion [30]. Another study revealed a visceral obesity was not linked to a rise in the incidence of intraoperative adverse events [31]. Also, the average BMI was 22.68±4.41 kg/m2. Laparoscopic nephrectomy was more difficult in patients with a lower BMI (4.55±2.66 compared to 3.46±1.86), when comparing the two groups [28].

According to our study population, the average BMI was 28.37±4.89, and patients were subdivided into two groups according to their BMI (non-obese, where BMI was less than 25 kg/m2, and obese, more than 25 kg/m^2). Obesity was associated with increased postoperative complications (10/28) with no statistical significance. It might be due to the high incidence of postoperative fever, wound infection, and ileus in obese patients. In spite of the fact that the non-obese group was smaller in number than the obese group (12:28), the operative time was longer in the non-obese group by about 8 minutes. There was no statistically significant difference in operative time between the two groups, as reported before [26]. In clinical settings, senior doctors had observed that proper plane dissection in thin patients is more challenging than in obese people [28].

The average volume of hydronephrosis for the study cases was 468 ml, which indicates that the study cases had a relatively large volume and so required more time for dissection. in the division of cases according to volume of hydronephrosis below or above 500 ml. 17 cases (42.5%) had volumes greater than 500 ml. By multiple linear regression test, patients with

volumes greater than 500 mL demonstrated more operative time and more blood loss but less hospital stay without statistical significance. In addition to the presence of urinary stone diseases in 21 cases (52.2%), turbid pelvicalyceal system contents in 10 cases (25.2%), and a history of previous urological intervention in 15 cases (37.5%), these multiple risk factors contributed to the increased operative time. Regarding volume as a risk factor for the occurrence of a complication of laparoscopic nephrectomy, there was no statistical difference between cases with volumes greater than or less than 500 ml. Complications were found to be increased in cases with hydronephrotic volume more than 500 ml. The presence of severe inflammatory reactions and perirenal adhesions due to stones, pyonephrosis, and previous surgery and their relation to a large surface area were reasons for the difficulty in identifying proper surgical planes, the longtime of dissection for reaching the renal pedicle, and the meticulous securing and division of the renal artery and vein. So, more blood loss occurred. It had been demonstrated that kidney size affects intraoperative difficulties. It was demonstrated that kidney size was not a major factor in their analysis, which is similar to our findings [28].

Pyonephrosis is a condition defined by the progressive development of infectious hydronephrosis. It results in pyogenic damage to the renal parenchyma, and kidney function is almost totally deteriorated. The early stage of pyonephrosis can be thought of as the end stage of infectious hydronephrosis [32].

A summary of the ultrasonographic findings in 73 cases of hydronephrosis revealed that sustained low-to-moderate internal echoes inside a distended collecting system were indicative of the diagnosis of pyonephrosis. It was determined that ultrasonography can diagnose pyonephrosis with a sensitivity and specificity of 90% and 97%, respectively [33].

In our study, pyonephrosis was found in 10 patients (25%). Studying the impact of the presence of turbid content in the pelvicalyceal system as a risk factor for laparoscopic nephrectomy, it was found that the mean operative time for these cases was 206 minutes and the average blood loss was 309 ml. In comparison, the mean operative time for cases with a non-turbid pelvicalyceal system was 172 minutes, and the blood loss was 264 ml. There was a statistically significant association between hospital length of stay and contents of an obstructed system (p-value = 0.004), as hospital length of stay was higher with pus content in an obstructed system (median = 4.00, IQR = 2.25), than with non-turbid content in an obstructed system (median =2.25, IQR =1.00). Pyonephrosis is associated with significant increased incidence of complication for laparoscopic nephrectomy in univariate analysis. Pyonephrosis was discovered to significantly increase the difficulties of laparoscopic nephrectomy [28]. They support the findings of our study that the presence of pyonephrosis was the primary factor contributing to the challenges of laparoscopic nephrectomy.

In the present study, 15 cases (37,5%) had previous urological surgery histories. According to the risk factors assessment for laparoscopic nephrectomy, a multivariate regression test was done to study the impact of the history of previous urological surgery on the outcome of laparoscopic nephrectomy for hydronephrotic kidneys and revealed that these patients had a longer operative time by 29 minutes. that increased operative time was statistically significant. These patients had a significant increase in blood loss of about 91 ml. The history of previous urological intervention is associated with a statistically significant risk of complication. A previous study mentioned that previous surgery at the same anatomical site was associated with a longer operative time compared with no history of surgery related to

the urinary tract [34]. It was likely associated with the increased difficulty of laparoscopic surgery in an anatomical region previously subjected to operative dissection. Another study found that the operative time was longer in patients who had previous renal surgery [35].

On the contrary, some reports documented that there was no significant effect of the history of previous abdominal surgery on operative time. That was also reported in the Kurt et al., 2016, study, which included 11 patients with previous urological surgery and 38 patients with no history of surgery [11]. The operative time was similar between the two groups. Previous studies reported that operative time could be significantly reduced with cumulative experience [10], and that it depended mainly on renal pathology [15].

In that work, two cases faced failure to progress during dissection and inability to complete a laparoscopic nephrectomy. These two cases had previous histories of open surgery for stone diseases. It is accepted due to the presence of marked adhesion. Previous urological surgery was associated with an insignificant statistical effect on hospital stay. A previous abdominal surgery was not linked to a higher risk of operative morbidity, conversion to open surgery, or intraoperative blood loss [16]. On the other hand, patients in a clinical trial had a history of past renal surgery. Some of them had undergone multiple surgeries. On univariate analysis, prior renal surgery was linked to higher operative complexity [28].

As regards the intra-operative technique, we got a lot of benefit from the published work of other series, and we followed their advice in several steps. Direct attention was given to colonic reflection, and identification of anatomical landmarks such as the psoas muscle on both sides, the ureterogonadal package on the left side, and the ureter and inferior vena cava on the right side 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 tracing them for the renal pedicle to avoid dealing with perihilar fibrotic tissues [36].

Urinary stones cause a strong inflammatory process and fibrosis at the site of the renal pedicle. So, it is very difficult to safely dissect and secure the renal vein and artery during surgery. The CT preoperative radiological scan is crucial in the preoperative planning of the nephrectomy for urinary stones. Anatomical alterations in the urinary system and other structures can be the outcome of the associated urine infection. Some CT results may foresee the complexity of the surgery and assist the surgeon in planning the appropriate renal approach. There were 21 patients with urinary stone disorders in the current study. These patients underwent operations that took longer, resulted in more blood loss, required longer hospital stays, and experienced more complications. That effect, meanwhile, was not statistically significant.

Generally, laparoscopic nephrectomy procedures had a high open conversion rate. In research involving 62 uncomplicated laparoscopic nephrectomies with benign etiologies, seven cases (7.2%) required conversion to open surgery because it was hard to dissect the renal hilum [25]. A conversion was confirmed in 14 cases (28%) of another group with 50 patients who underwent laparoscopic nephrectomy for inflammatory diseases because of significant adhesions and fibrosis. Compared with radical nephrectomy, these conversion rates seem to be higher. In a review of their 2775 urological laparoscopies, Permpongkosol *et al.*, 2007, discovered that the open conversion rate for laparoscopic simple nephrectomy versus laparoscopic radical nephrectomy was doubled [37]. In 83 cases of laparoscopic nephrectomies,

the conversion rate (19.2%) was consistent with previous studies but nevertheless high when compared to radical nephrectomies [38].

Few studies in the medical literature had identified the risk factors for problems following nephrectomy. Inflammatory diseases (xanthogranulomatous pyelonephritis and pyonephrosis) and prior renal surgery were found to be risk factors for morbidity. In 84 cases of laparoscopic nephrectomy performed because of inflammatory diseases, a previous study found that kidney sizes greater than 10 cm and the presence of hilar lymphadenopathy were indicators of a greater risk of complications [14]. Another study revealed that higher ASA scores, urgency because of sepsis, preoperative abscess, and kidney size was 12 cm (hypernephrosis was the most prevalent finding in 79.8% of cases) were linked to a higher risk of postoperative complications [38]. Similarly, that present study is among the few in the literature that analyzes risk factors for laparoscopic nephrectomy for hydronephrotic non-functioning kidney. The observed wide confidence interval for some parameters is attributed to the small sample size. Such as the presence of pus, which is associated with higher odds of complications as compared to urine.

Laparoscopic skills require a slow learning curve to master since they develop through repetition [39]. After the first 50 patients, Eraky *et al.,* 1995, observed a substantial improvement in the outcome and a decline in the complication rate [10], they regarded the first 50 cases as early experience.

The success of laparoscopic nephrectomy for benign etiology was greatly influenced by the learning curve [12]. With practical experience, anatomical landmark recognition and dissection methods improved, which ultimately resulted in a considerable reduction in operating room time, blood loss, and the requirement for open conversion, which was also observed in our study. The bulk of problems, conversion rates, and reintervention rates were found to occur in each surgeon's first 20 patients, during the early learning curve phase [15]. Also, they reported that the learning curve significantly improved during the course of operating on 100 patients [15]. The complication rate, conversion rate, and open reintervention rate were, respectively, 14, 10, and 6% in the first 50 cases, which reduced to 2, 4, and 2% in the final 50 patients.

In a study conducted by Gill *et al.,* 1995, it was shown that the first 20 patients were responsible for 71% of the problems [17]. Another review observed that the conversion rate in the initial 20 cases was 30%. It occurred due to failure to progress [40].

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 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 had the advantages of being prospective with strict inclusion criteria; the surgical approach was the same for all patients (the transperitoneal route), which is the classic approach for performing laparoscopic surgery since it leads to small incisions, gives flexibility in the placement of trocars, provides an ideal working environment, and eases orientation by providing easily recognizable anatomic landmarks.

Conclusion

In predicting the outcome of laparoscopic nephrectomy for non-functioning hydronephrotic kidney, turbid content of the pelvicalyceal system and history of previous urological intervention were the most considerable risk factors that should be estimated by the surgeon.

Ethical considerations: The study was approved by the Faculty of Medi-cine, Fayoum University Research Ethical Commit-tee.

Patient consent: Approval and consent to participate: In-formed written consent from patients who were invited to participate in the research was obtained.

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Conflicts of Interest: All authors declare no conflict of interest.

Availability of data and materials: The datasets used and/or analyzed during the current study were available from the corresponding author on reasonable request

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