

A Prospective Comparative Study of Renal Function in Live Renal Donors Who Underwent Open and Laparoscopic Nephrectomy.

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Introduction: Open nephrectomy surgery in a kidney donor involves pain and many risks after the surgery, which leads to the inability to perform normal activities. For this reason, today the laparoscopic nephrectomy method is preferred in order to avoid complications and to return to normal life sooner. However, it is very critical to assess the impact of modifying the surgical technique on the outcome of kidney donation. Thus, the present study was undertaken with the following specific objective: a comparative study of the renal profile of live kidney donors who have undergone open and laparoscopic nephrectomy.

Materials and methods: The study in the present report was cross-sectional in nature. Participants included 91 kidney donors who had undergone either open nephrectomy (n = 46) or laparoscopic nephrectomy (n = 45). Data on the level of initial basic renal function, the duration of surgery, and the duration of hospitalization, together with the course of renal function in the 6 months after surgery, were collected. The data were analyzed using the Statistical Package for the Social Sciences, version 27 (SPSS version 27).

Results: The mean age of kidney donors was 29.4 ± 4.8 years, and all patients were male (100%). Body mass index and weight were comparable between the open and laparoscopic nephrectomy groups, with no statistically significant differences ($P > 0.05$). The mean duration of surgery in the open nephrectomy group (2.37 ± 0.30 hours) was significantly shorter than that in the laparoscopic group (3.37 ± 0.13 hours) ($P < 0.001$). The mean length of hospital stay was significantly shorter in the laparoscopic group (3.31 ± 0.31 days) compared to the open group (4.06 ± 0.04 days) ($P < 0.001$). GFR decreased significantly in both groups at discharge and 6 months postoperatively compared to baseline (paired t-test, all $P < 0.001$), but there was no significant difference in GFR between groups at any time point ($P > 0.05$). Both groups experienced a significant postoperative decline in hemoglobin, with a greater reduction in the open group (-1.59 ± 0.79 g/dL) compared to the laparoscopic group (-1.05 ± 0.95 g/dL) ($P = 0.004$). White blood cell counts increased postoperatively in both groups, with no significant difference between them ($P = 0.118$). Surgical complications included transection of the superior polar artery in 5.5% of cases.

Conclusion: In laparoscopic nephrectomy, the time of surgery is longer, but the days of hospitalization after surgery do not differ and do not negatively affect the return of donor kidney function compared to the open method. Moreover, post-surgical problems have not been very frequent and are manageable in the best way possible.

Keywords: renal transplantation; donor nephrectomy; renal function; laparoscopic surgery; open surgery

INTRODUCTION

Chronic kidney disease (CKD)⁽¹⁾ is defined as kidney damage or a glomerular filtration rate (GFR)⁽²⁾ less than 60 mL/min/1.73 m² for at least 3 months and can lead to end-stage renal disease (ESRD)⁽³⁾, which is the final stage of chronic kidney disease and requires kidney replacement therapy⁽¹⁾. It is estimated that over 500 million people worldwide suffer from chronic kidney disease, which, if left undiagnosed and untreated in the early stages, is susceptible to developing ESRD. In fact, ESRD represents the tip of the iceberg, and the actual number of patients with CKD is much higher⁽²⁾. According to the latest available statistics, the estimated global prevalence of chronic kidney disease is about 13.4%, of which approximately 4 to 8 million people require kidney replacement therapy^(3,4). It is also currently estimated that there are more than 24,000 patients with ESRD living in Iran, and their population has increased significantly in recent years⁽⁴⁾.

ESRD is a clinical condition defined as the irreversible loss of kidney function, and the patient requires permanent treatment to maintain life and prevent critical uremic conditions^(5,6). According to estimates, about 8 million people worldwide suffer from ESRD, and this disease causes numerous disabilities and functional problems for patients⁽⁶⁾.

Diabetes is one of the main causes of ESRD. Other common causes of ESRD include hypertension, atherosclerosis, autoimmune diseases such as systemic lupus erythematosus, polycystic kidney disease, and exposure to toxic drugs such as certain antibiotics, chemotherapy, radiographic contrast agents, and pain relievers⁽⁷⁾. Given the significant growth in the prevalence of the two main underlying diseases of ESRD, namely diabetes mellitus and hypertension, ESRD has become a global concern⁽⁴⁾. Dialysis and kidney transplantation are the two main treatments for patients with ESRD⁽⁸⁾. An individual with ESRD who undergoes kidney replacement

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Table 1. Demographic and baseline characteristics of kidney donors according to the type of nephrectomy

Feature	Open Nephrectomy (Mean ± SD)	Laparoscopic Nephrectomy (Mean ± SD)	P-value ^(a)
Body Mass Index (kg/m ²)	25.06 ± 2.08	24.49 ± 4.86	0.351
Weight (kg)	78.04 ± 4.63	76.09 ± 9.76	0.354
Surgical Time (hours)	2.37 ± 0.30	3.37 ± 0.13	< 0.001
Length of Stay (days)	4.06 ± 0.04	3.31 ± 0.31	< 0.001

^(a) Independent t test for comparison between groups.

therapy uses either dialysis or a kidney transplant. Since the quality of life of a person who receives a kidney transplant is significantly better than that of a person on dialysis, kidney transplantation is preferred when conditions permit⁽⁹⁾. For kidney transplantation, a kidney from a living or deceased donor can be used. When comparing these two options in terms of long-term outcomes, patient survival, and graft survival, those who receive a kidney from a living donor have longer survival rates compared to those who receive a kidney from a deceased donor. Therefore, using a kidney from a living donor is preferred⁽¹⁰⁾. A living donor must be physically and psychologically healthy, at least 18 years old, and free of diseases such as high blood pressure, diabetes, cancer, AIDS, hepatitis, or infections that could prevent organ donation.

The traditional surgical method for nephrectomy in a kidney donor is open surgery. Due to the large incision, up to 30 centimeters, in the patient's flank, which is often accompanied by the removal of a rib, it causes complications such as prolonged pain, disability, and delayed return to normal activities. Therefore, these complications can be reduced and patient safety can be increased with minimally invasive surgeries⁽¹¹⁾. For kidney transplantation, open surgery, laparoscopic surgery, or robotic surgery can be used. Laparoscopic donor nephrectomy is now widely performed. Due to smaller incisions, more aesthetically pleasing scar placement after surgery, and the absence of rib removal, patients experience less postoperative pain. Consequently, hospital stays are typically one day shorter, requiring fewer pain medications. Patients experience a shorter recovery period after discharge and can return to normal activities and work sooner. The advantage of open surgery over laparoscopy is a shorter operative time. However, in laparoscopic surgery, there is a warm ischemia time of approximately 5 minutes, which is absent in open surgery. The operative time for laparoscopic nephrectomy is longer than that of open surgery. Intra-abdominal pressure in laparoscopic surgery is higher due to the insufflation of gas, typically 15 mmHg. It has been shown that this higher pressure can lead to oliguria and decreased GFR in the early postoperative days. If the donor's serum creatinine levels are elevated during hospitalization, the length of stay also increases.

The novelty and significance of this study lie in comparing the impact of open and laparoscopic nephrectomy on the kidney function of living kidney donors. Urmia Kidney Transplantation Center is one of the oldest and most active kidney transplantation centers in the country, having performed over three thousand kidney transplants using open surgery. In Iran, laparoscopic kidney transplantation has been performed in a limited number of highly specialized centers due to potential complications and the complexity of this procedure. However, Imam Khomeini Hospital in Urmia is the second center in the country to perform laparoscopic kidney transplantation. Therefore, this study was designed and conducted to investigate one of the important aspects of the clinical differences between laparoscopic and conventional open nephrectomy, with the aim of comparing the kidney function of living kidney donors undergoing open and laparoscopic nephrectomy.

MATERIALS AND METHODS

This cross-sectional, analytical study aimed to determine and compare the kidney function of living kidney donors undergoing open and laparoscopic nephrectomy at Imam Khomeini Hospital in Urmia. This study was conducted after obtaining ethical approval from the Ethics and Research Committee of Urmia University of Medical Sciences with the ethics code IR.UMSU.HIMAM.REC.1402.66. In this study, using the target population in the Biat and colleagues' study, 45 living kidney donors who underwent laparoscopic nephrectomy were selected as the study group and were evaluated based on the study objectives. Additionally, 46 living kidney donors who underwent open nephrectomy during the previous year were retrospectively selected by reviewing existing records in the archive as the open nephrectomy group and were evaluated based on the study objectives. The sample size was determined based on a predicted medium effect size (Cohen's $d = 0.5$), power of 80%, and significance level of 0.05, requiring a minimum of 45 participants per group.

Parameters related to the surgical process, including the duration of surgery (minutes) along with secondary parameters related to the donor's kidney function after surgery, such as the time interval from surgery to the establishment of urine flow and urine volume in the initial hours, were collected from the nephrectomy records

Table 2. Serum creatinine levels of kidney donors according to the type of nephrectomy

Time Point	Open Nephrectomy (Mean ± SD)	Laparoscopic Nephrectomy (Mean ± SD)	Open Nephrectomy (Median [IQR])	Laparoscopic Nephrectomy (Median [IQR])	P-value ^(a)
Baseline	1.04 ± 0.15	1.05 ± 0.15	1.02 (0.96–1.11)	1.01 (0.97–1.13)	0.710
Discharge	1.54 ± 0.24	1.57 ± 0.25	1.50 (1.39–1.72)	1.53 (1.42–1.69)	0.515
6 Months	1.30 ± 0.12	1.32 ± 0.12	1.28 (1.23–1.38)	1.29 (1.25–1.38)	0.355
Discharge to Baseline Change	0.50 ± 0.25	0.52 ± 0.25	0.51 (0.35–0.68)	0.47 (0.36–0.63)	0.678
6-Month Change	0.26 ± 0.17	0.27 ± 0.17	0.28 (0.14–0.37)	0.27 (0.16–0.36)	0.735

^(a) Independent t test for comparison between groups.

Table 3. Glomerular filtration rate (GFR) of kidney donors according to the type of nephrectomy

Time Point	Open Nephrectomy (Mean ± SD)	Laparoscopic Nephrectomy (Mean ± SD)	Open Nephrectomy (Median [IQR])	Laparoscopic Nephrectomy (Median [IQR])	P-value ^(a)
Discharge	78.14 ± 6.78	77.40 ± 12.95	77.12 (66.85–85.66)	78.04 (66.78–87.60)	0.543
Baseline	116.21 ± 4.11	115.58 ± 21.67	117.03 (101.66–130.09)	113.45 (101.68–128.09)	0.783
6 Months	91.13 ± 8.91	90.84 ± 11.71	92.71 (84.18–99.67)	89.60 (81.56–100.31)	0.556
Discharge to Baseline Change	37.18 ± 7.37	38.18 ± 18.68	41.03 (23.35–48.67)	37.21 (27.71–47.39)	0.893
6-Month Change	24.17 ± 5.24	24.73 ± 17.25	26.57 (12.75–34.72)	27.34 (13.66–33.49)	0.963

^(a)Independent t test for comparison between groups.

and operative notes and recorded in a prepared checklist. Information regarding postoperative complications such as fever, hemoglobin drops, urinary retention, and the level of pain in patients based on the amount of opioid received in the ward was recorded and collected. Outcomes such as the donor's creatinine level during hospitalization from the day before surgery to the second day after surgery were collected and compared. It is worth noting that all 91 kidney donors underwent laparoscopic or open nephrectomy by a single surgeon. After appropriate coding of the collected data, it was entered into SPSS version 27 for final analysis and was analyzed based on the study objectives. Data analysis was performed using SPSS version 27. To display descriptive results, mean and standard deviation were used for quantitative parameters, and frequency percentages were used for qualitative parameters. Tables and graphs were used as needed to better display the data. For univariate comparison of parameters between the two study groups, statistical tests were selected based on data characteristics. For continuous variables, the Shapiro–Wilk test was used to assess normality. Normally distributed variables were compared using the independent t test, while non-normally distributed variables were analyzed using the Mann–Whitney U test. For categorical variables, the chi-square test was used when all expected cell counts were ≥ 5 ; otherwise, Fisher's exact test was applied. A two-tailed *P* value of < 0.05 was considered statistically significant. The study was conducted between April 2022 and March 2024. Since all cases occurred after the peak of the COVID-19 pandemic, no analysis comparing pre- and during-COVID outcomes was performed. All kidney donations in this study were performed by unrelated living donors⁽¹²⁾.

RESULTS

Demographic and clinical characteristics of kidney donors in the study

Figure 1 shows the age distribution of kidney donors by surgical method (laparoscopic and open surgery). The mean age of all kidney donors was 29.4 ± 4.8 years, with a range of 20 to 42 years. This value was 30.8 ± 4.6 years (range: 21–42 years) in the group of patients undergoing open nephrectomy and 28.1 ± 4.7 years (range: 20–39 years) in the group of patients undergoing laparoscopic nephrectomy. According to the results

of the independent t test, there was no significant difference between the two groups ($P=0.06$).

Figure 1. Figure shows the age distribution of kidney donors by surgical method (laparoscopic and open surgery).

Table 1 presents the demographic and baseline characteristics of kidney donors, categorized by surgical method (open vs. laparoscopic nephrectomy). The mean body mass index (BMI) and weight did not differ significantly between groups (both $P > 0.05$). The mean duration of surgery in the open nephrectomy group (2.37 ± 0.30 hours) was significantly shorter than that in the laparoscopic group (3.37 ± 0.13 hours) ($P < 0.001$). The length of hospital stay was significantly shorter in the laparoscopic group (3.31 ± 0.31 days) compared to the open group (4.06 ± 0.04 days) ($P < 0.001$).

Baseline and post-transplant kidney function of kidney donors in the study

Table 2 presents serum creatinine levels of kidney donors at baseline (pre-nephrectomy), at discharge, and 6 months post-nephrectomy, categorized by surgical method (open vs. laparoscopic). In both groups, serum creatinine levels significantly increased at discharge compared to baseline (paired t test, both $P < 0.001$). In the open nephrectomy group, the mean serum creatinine increased from 1.04 ± 0.15 mg/dL to 1.54 ± 0.24 mg/dL, while in the laparoscopic group, it increased from 1.05 ± 0.15 mg/dL to 1.57 ± 0.25 mg/dL. The median (IQR) values also reflected this change: from 1.02 (0.96–1.11) to 1.50 (1.39–1.72) in the open group, and from 1.01 (0.97–1.13) to 1.53 (1.42–1.69) in the laparoscopic group.

At 6 months post-donation, serum creatinine levels declined toward baseline in both groups. The mean levels were 1.30 ± 0.12 mg/dL in the open group and 1.32 ± 0.12 mg/dL in the laparoscopic group, with corresponding medians of 1.28 (1.23–1.38) and 1.29 (1.25–1.38). The changes from discharge to baseline and from baseline to 6 months were minimal and comparable between the two groups, both in terms of mean values (all $P > 0.05$) and median (IQR). No statistically significant difference was found in the magnitude of these changes between surgical methods.

Table 3 presents the glomerular filtration rate (GFR) of kidney donors before nephrectomy, at discharge, and 6 months post-nephrectomy, categorized by surgical

Table 4. Comparison of complication frequency based on Clavien–Dindo classification between laparoscopic and open surgery groups

Clavien–Dindo Grade	Open Nephrectomy (n = 46)	Laparoscopic Nephrectomy (n = 45)
No complications	30 (65.2%)	29 (64.4%)
Grade I–II	13 (29.5%)	12 (27.3%)
Grade III	3 (6.8%)	2 (4.5%)
Grade IV	0	2 (4.5%)
Grade V	0	0

Table 5. Changes in hemoglobin and white blood cell count in donors by surgical method

Variable	Time Point	Open Nephrectomy (Mean ± SD)	Laparoscopic Nephrectomy	P-value ^(a)
Hemoglobin (g/dL)	Preoperative (Admission)	15.42 ± 1.06	15.63 ± 1.30	0.412
Hemoglobin (g/dL)	Postoperative (Discharge)	13.83 ± 1.02	14.58 ± 1.38	0.004
Hemoglobin (g/dL)	Change (Discharge – Admission)	-1.59 ± 0.79	-1.05 ± 0.95	0.004
WBC (×10 ³ /μL)	Preoperative (Admission)	6.31 ± 1.93	6.83 ± 1.65	0.170
WBC (×10 ³ /μL)	Postoperative (Discharge)	9.95 ± 2.77	9.70 ± 2.71	0.670
WBC (×10 ³ /μL)	Change (Discharge – Admission)	3.63 ± 2.17	2.87 ± 2.44	0.118

(a) Independent t test for comparison between groups.

^(a)Independent t test for comparison between groups.

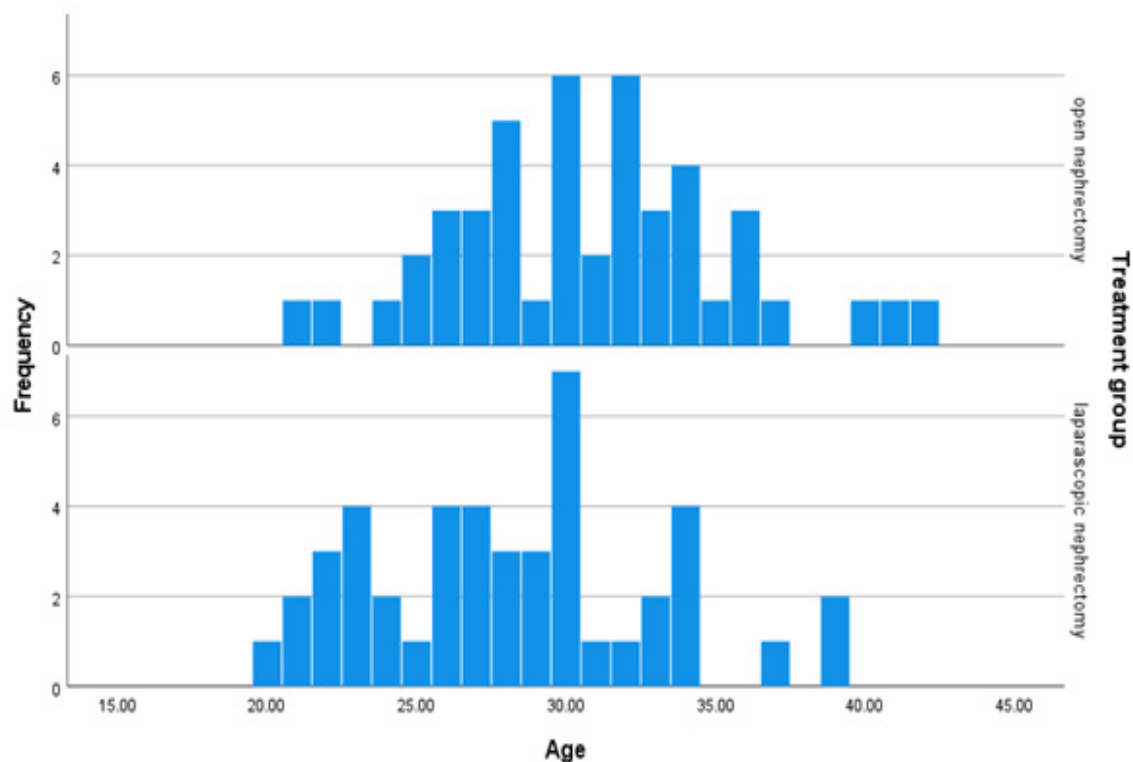
method (open vs. laparoscopic). In both groups, GFR declined after surgery at both discharge and 6 months compared to baseline values (paired t test, all $P < 0.001$). In the open nephrectomy group, the mean GFR was 116.21 ± 4.11 mL/min/1.73 m² at baseline, decreasing to 78.14 ± 6.78 mL/min/1.73 m² at discharge and 91.13 ± 8.91 mL/min/1.73 m² at 6 months. In the laparoscopic group, the corresponding values were 115.58 ± 21.67 , 77.40 ± 12.95 , and 90.84 ± 11.71 mL/min/1.73 m², respectively. The median (IQR) values showed similar trends. According to the independent t test, there was no statistically significant difference between surgical methods at any time point ($P > 0.05$). Postoperative complications were classified using the Clavien–Dindo grading system (Table 4). The majority of patients in both groups experienced no complications (65.2% in open nephrectomy vs. 64.4% in laparoscopic nephrectomy). Minor complications (Grade I–II) occurred in 29.5% of open cases and 27.3% of laparoscopic cases. Grade III complications were reported in 6.8% and 4.5% of open and laparoscopic groups, respectively. Grade IV complications occurred only in the

laparoscopic group (4.5%). No Grade V complications were observed in either group.

The average warm ischemia time was 5.3 minutes in the laparoscopic group and 2.1 minutes in the open group. Other perioperative outcomes such as hemoglobin (Hb) and white blood cell count (WBC) were analyzed (Table 5). Both groups experienced a decline in hemoglobin levels postoperatively, with a significantly greater drop in the open group (-1.59 ± 0.79 g/dL) compared to the laparoscopic group (-1.05 ± 0.95 g/dL) ($P = 0.004$). White blood cell counts increased postoperatively in both groups, with a higher elevation observed in the open group ($+3.63 \pm 2.17 \times 10^3/\mu\text{L}$) compared to the laparoscopic group ($+2.87 \pm 2.44 \times 10^3/\mu\text{L}$), but this difference did not reach statistical significance ($P = 0.118$).

DISCUSSION

Surgical techniques for live donor nephrectomy have a rich history^(12–14). However, despite the risk of serious complications including life-threatening hemorrhage,

**Figure 1.** Figure shows the age distribution of kidney donors by surgical method (laparoscopic and open surgery).

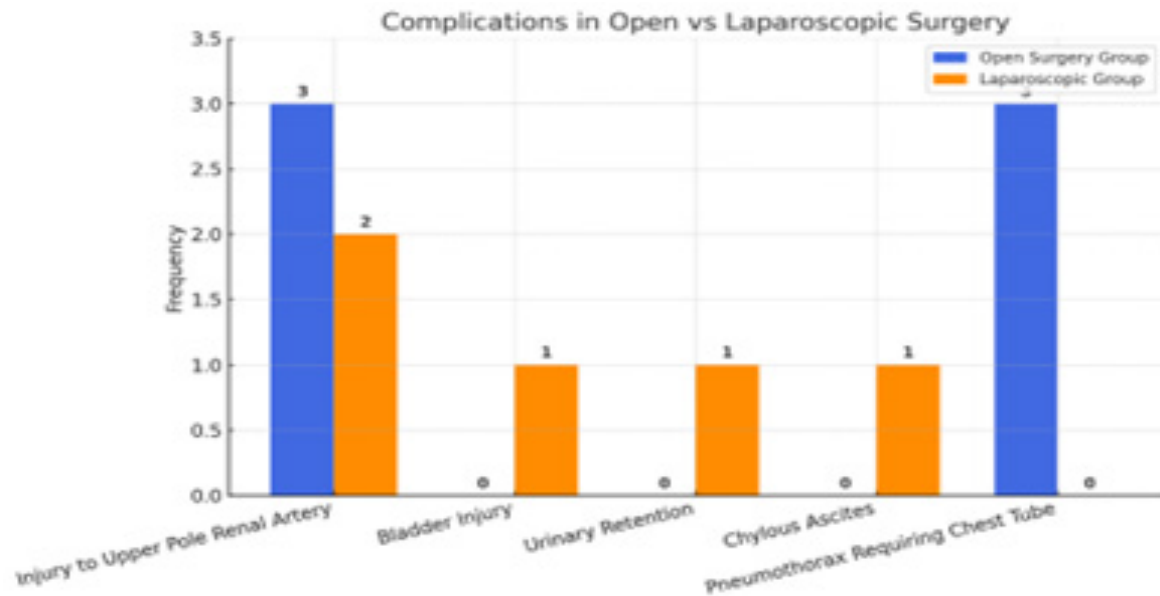


Figure 2. Postoperative complications in kidney donors by type of nephrectomy

pulmonary thromboembolism, and sepsis, less invasive approaches have gradually become the focus of transplant surgeons. The advent of laparoscopy in transplant surgery has undeniably reduced patient morbidity, postoperative pain, and hospital stay, while at the same time making the donation process more acceptable for donors due to better tolerance of the surgical procedure in the laparoscopic approach⁽¹⁵⁾. Laparoscopy has been applied in nephrectomy for tumor cases and subsequently for transplantation. However, despite the widespread use of laparoscopy in live donor nephrectomy, open nephrectomy is still performed in most transplant centers. Two main reasons for this are surgeons' unfamiliarity with the technique of laparoscopic nephrectomy for transplantation and a lack of scientific evidence regarding the advantages and disadvantages of this surgical method compared to open nephrectomy. Moreover, previous studies have mostly focused on the short-term and long-term effects of laparoscopic nephrectomy on graft outcome, and very little information is available regarding the differences in the effects of this method on the kidney donor. In this regard, the present study aimed to compare the clinical conditions and kidney function of live donors undergoing nephrectomy using both open and laparoscopic techniques, in an attempt to assess the effects of the type of surgery on the donor's speed of return to normal life and the degree of decline in kidney function. While statistical testing was used to compare outcomes between groups, the interpretation of our results was not based solely on *P* values⁽¹⁶⁻¹⁸⁾. For each finding, we considered whether the observed differences were likely to be meaningful in a clinical context. For example, differences in serum creatinine and GFR values between open and laparoscopic nephrectomy groups, although statistically detectable in some cases, were small in magnitude and unlikely to translate into differences in long-term renal function. Similarly, variations in perioperative parameters such as hemoglobin drop and warm ischemia time were interpreted with respect to their potential impact on donor recovery and surgical safety.

In the present study, 91 live kidney donors were evaluated in two groups: open and laparoscopic nephrectomy. The results showed no significant difference in age, sex, or body mass index between the two groups of live donors. Most were aged 25–35 years, all were male, and they all had a normal body mass index. In a similar study by Brzanov et al. in 2023 in Macedonia, which examined 60 kidney transplants in two groups of laparoscopic and classic open nephrectomy, both study groups did not have significant differences in baseline and demographic characteristics, similar to the present study. However, unlike the present study, 2–25% of kidney donors were female, and the mean age of donors was in the range of 40–50 years, which is significantly different compared to the present study⁽¹⁹⁾. In a study by Carnabatu et al. in 2023 in the United States, which examined the baseline, clinical, and outcome characteristics of laparoscopic nephrectomy in live kidney donors, similar to the present study, most cases were in the normal or overweight BMI range. However, unlike the present study, more than half of the kidney donors were female, and the mean age of kidney donors was significantly higher compared to the present study⁽²⁰⁾. In contrast, Simforoosh et al. in 2004, in a study of kidney transplants using both laparoscopic and classic open methods, reported, similar to the present study, that most donors were male and had a mean age of 25–30 years^(21,22). Overall, studies show that globally, especially in high-income countries, women often make up the majority of live kidney donors⁽²²⁾. However, the results of the present study and other Iranian studies show that a significantly younger male population constitutes the majority of live kidney donors in Iran, so considering the secondary consequences of nephrectomy on the health and life of these individuals becomes more important.

According to the results of the present study, the average surgical duration in the group of patients undergoing open nephrectomy was approximately 1 hour less than in patients undergoing laparoscopic nephrectomy; however, patients with laparoscopic nephrectomy

stayed in the hospital for approximately 1 day less than patients with open nephrectomy. Some studies have found similar results consistent with the present study. Shahbazov et al. in 2019, in a study of open and laparoscopic nephrectomy cases, similar to the present study, showed that the surgical time was longer in the laparoscopic nephrectomy group but the length of stay was shorter⁽²³⁾. Studies by Nicholson et al.⁽²⁴⁾ and Shokeir et al.⁽²⁵⁾ also found similar results. However, in some other studies, the surgical time for the laparoscopic group was reported to be shorter than for open nephrectomy surgery, and at the same time, the length of stay was shorter, consistent with the present study, indicating the superior advantage of the laparoscopic method compared to open nephrectomy⁽²⁶⁻²⁸⁾.

The results of this study showed that superior polar artery injury (5.5%) was the most common complication reported in kidney donors. Additionally, pneumothorax occurred exclusively in the open surgery group, while three complications—chyluria, urinary retention, and bladder rupture—each occurred in only one case in the laparoscopic surgery group. Statistically, there was no significant difference in the type or rate of complications between the laparoscopic and open groups. In a study by Nicholson and colleagues, consistent with the results of the present study, there was no significant difference in the occurrence of complications after nephrectomy in the laparoscopic and open groups. In this study, the most common complications were chest infections and wound infections⁽²⁴⁾. In the clinical trial by Simforoosh and colleagues, postoperative complications occurred rarely in both nephrectomy methods, and there was no significant difference between the two groups⁽²¹⁾.

The results of this study demonstrated that laparoscopic nephrectomy can be considered a suitable alternative to open nephrectomy, especially in younger donors. Although the surgical duration in laparoscopic nephrectomy increases due to the technical complexity of the procedure and the need for advanced surgical skills, the length of hospital stay post-surgery decreases and does not negatively impact the return of kidney function in the donor compared to the open method. Additionally, postoperative complications are rare and manageable. However, due to the limitations of this study, such as the small number of cases examined, it is recommended that the laparoscopic method be used more extensively at Imam Khomeini Urmia Transplant Center, and that transplant surgeons undergo necessary retraining in laparoscopic surgical techniques. It is also recommended that longitudinal studies with long-term follow-up be conducted to assess the outcomes of nephrectomy and transplantation using both laparoscopic and open methods, in order to obtain more reliable and accurate results.

CONCLUSIONS

In laparoscopic nephrectomy, operative time is longer, but hospital stay is shorter and donor renal recovery is comparable to open nephrectomy. Complications are infrequent and manageable, supporting broader adoption of laparoscopic techniques with appropriate expertise.

SUMMARY

Laparoscopic donor nephrectomy takes longer but

shortens hospital stay and does not worsen donor renal function versus open surgery. Complications were uncommon and similar between groups in this cohort of 91 male donors.

AUTHORS' CONTRIBUTIONS

Saman Farshid: Designed the study and supervised the research.

Ali Tayyebi Azar: Assisted in study design and provided clinical expertise.

Behnam Habibi: Collected data, performed statistical analysis, and wrote the manuscript. (Corresponding Author)

Alireza Pasha: Reviewed and revised the manuscript critically.

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