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Three-dimensional vs. two-dimensional laparoscopic approach in donor nephrectomy: A prospective randomized study

Arife Şimşek, Sertaç Usta, Ertuğrul Karabulut, Gökalp Okut, Fatih Özdemir, Fatih Sümer, Sait M. Doğan, Turgut Pişkin, Cüneyt Kayaalp

Department of General Surgery, Inonu University Faculty of Medicine, Malatya, Türkiye

ABSTRACT

Introduction: This prospective randomized study aimed to compare the effectiveness and outcomes of three- dimensional (3D) versus two-dimensional (2D) laparoscopic systems in donor nephrectomy.

Materials and Methods: A total of 25 laparoscopic donor nephrectomy cases, which were performed between March 30, 2022, and January 12, 2023, were randomized into 2D and 3D groups. Donor demographics, perioperative data, postoperative complications, pain scores, hospital stay, and graft function up to 18 months were evaluated.

Results: No significant differences were observed between the 2D (n=12) and 3D (n=13) groups regarding donor characteristics, operative time, warm ischemia time, complication rates, transfusion requirements, postoperative pain, or length of hospital stay. Although multiple renal vessels were more frequent in the 2D group (p=0.039), this did not affect overall outcomes. Postoperative kidney function remained comparable in both groups. The use of 3D systems did not result in statistically significant improvements in surgical metrics but may provide enhanced depth perception.

Conclusion: While 3D laparoscopy may improve depth perception and spatial orientation, this study did not demonstrate statistically significant advantages over 2D systems in donor nephrectomy outcomes. Larger, multicenter studies are needed to further assess the clinical impact of 3D laparoscopy in this setting.

Keywords: Laparoscopic donor nephrectomy, laparoscopic systems, living donor nephrectomy, three-dimensional renal transplantation

Introduction

Conventional two-dimensional (2D) laparoscopy systems have limitations, including reduced depth perception and restricted spatial orientation.[1] In contrast, three-dimensional (3D) laparoscopy systems provide stereoscopic vision by integrating different images captured by each eye to create a perception of depth.[1] This study aimed to compare conventional 2D laparoscopy with 3D laparoscopy in donor nephrectomy.

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Correspondence: Arife Şimşek, M.D., Department of General Surgery, Inonu University Faculty of Medicine, Malatya, Türkiye
e-mail: draksimsek@yahoo.com.tr

Materials and Methods

In this prospective randomized study, 25 donor nephrectomy cases were allocated using a computer-based system (Research Randomizer), which employs the "Math. random" function in JavaScript. The study was conducted between March 30, 2022, and January 12, 2023. Donor nephrectomy cases performed using laparoscopic techniques were included, whereas cases performed with open techniques were excluded. The following data were recorded: Donor age, sex, comorbidities, smoking history, surgical history, body mass index (BMI), presence of multiple graft vessels, side of donation, number of trocars used during surgery, operative time, warm ischemia time, drain usage, transfusion requirement, conversion to laparotomy, reoperation, intraoperative and/or early postoperative complications (within the first postoperative week), early visual analog scale (VAS), duration of parenteral analgesic use, and length of hospital stay. Complica- tions observed within eighteen months postoperatively were also recorded. Surgeries were performed by five dif- ferent surgeons.

Data were analyzed using SPSS 17.0 for Windows. Continuous variables were presented as mean±SD, while categorical variables were presented as percentages. The Shapiro-Wilk test was used to assess normality. Chi-square or Fisher's Exact Test was used for categorical variables. Student's t-test was applied for normally distributed continuous variables, and the Mann-Whitney U test was used for non-normally distributed variables. A p-value of <0.05 was considered statistically significant.

Ethical approval was obtained from the Inönü University Ethics Committee (No:2019/104, Date: 22/05/2019) as part of a scientific research project (BAP, Project code: TSG-2020-1884) and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Of the 32 kidney transplants performed, 28 (87.5%) utilized grafts from living donors. While three donor nephrectomies (10.71%) were performed using the open technique due to anatomical considerations identified by the surgeons, 25 (89.28%) were performed laparoscopically. The mean age of donors was 49.08 ± 13.21 years (13 males, 12 females). Only two donors had a history of previous abdominal surgery.

The mean age of donors was 49.08±13.21 years (13 male, 12 female). Only two had a history of previous abdominal surgery. Comorbidities included pseudothrombocytopenia (n=1), chronic obstructive pulmonary disease (n=1), diabetes mellitus (n=1), and scoliosis (n=1). Twelve donors reported a history of smoking. The mean BMI was 27.9±4.6.

Of the 25 laparoscopic cases, 13 were performed us- ing 3D laparoscopy and 12 using 2D laparoscopy. Twelve cases used 3 trocars, another 12 used 4 trocars, and one case used 5 trocars. The mean warm ischemia time was 184.92 ± 62.34 seconds, and the mean total operative time was 265.44 ± 49.5 minutes. None of the cases required conversion to laparotomy. Two patients underwent laparotomy on postoperative day 1 due to hemorrhage and received blood transfusions. One patient required a transfusion on postoperative day 3 due to anemia. Surgical drains were placed in 7 patients. One patient required re- catheterization for urinary retention. Two patients received antibiotics for positive urine culture. One patient was diagnosed with COVID-19 on postoperative day 5 and was discharged on day 13. The highest reported VAS score was 4.72 ± 1.24. The mean duration of parenteral analgesia was 3.44 ± 1.75 days. Fifteen patients received tramadol hydrochloride in addition to paracetamol for pain management. The mean hospital stay was 6.28 ± 1.92 days.

No significant differences were observed between the two groups regarding age (p=0.301), sex (p=0.277), or BMI (p=0.502). No significant difference was found in graft laterality (p=0.672), although multiple vessels in the graft were more common in the 2D group (p=0.039). No significant differences were observed in warm ischemia time (p=0.886) or total operative time (p=0.683). No significant differences were found between the groups regarding conversion to open surgery, reoperation (p=0.74), transfusion requirement (p=0.531), use of additional trocars (p=0.157), drain placement (p=0.45), or infections (p=0.328). The highest VAS score, duration of parenteral analgesia, tramadol requirement, and length of hospital stay were also statistically similar (p=0.388, p=0.536, p=0.404, and p=0.798, respectively). No significant differences were found in postoperative creatinine levels at 1, 6, and 18 months (p=0.65, p=0.556, and p=0.656). The incidence of incisional hernia was not statistically significant (p=0.109) (Table 1).

There were no deaths, except for a 58-year-old female patient who died due to the Kahramanmaraş earthquake on February 6, 2023, unrelated to donor nephrectomy.

Table 1. Donor characteristics according to 2D laparoscopy and 3D laparoscopy methods

Characteristics	Laparoscopy method		p
	2D	3D	
Age	51.58±15.1	46.76±11.29	0.301
Gender, n (%)			
Male	5 (41.7)	8 (61.5)	0.277
Female	7 (58.3)	5 (38.5)	
Body mass index	28.55±3.76	27.3±5.37	0.502
Smoking, n (%)			
No	8 (66.7)	5 (38.5)	0.157
Yes	4 (33.3)	8 (61.5)	
Graft side, n (%)			
Left	10 (83.3)	11 (84.6)	0.672
Right	2 (16.7)	2 (15.4)	
Multiple vessels in graft, n (%)			
No	8 (66.7)	13 (100)	0.039
Yes	4 (33.3)	-	
Number of trocars, n (%)			
3	4 (33.3)	8 (61.5)	0.157
>3	8 (66.7)	5 (38.5)	
Warm ischemia time	186.83±63.20	183.15±64	0.886
Operative time	261.5±47.17	269±53.22	0.683
Drain usage, n (%)			
No	8 (66.7)	10 (76.9)	0.45
Yes	4 (33.3)	3 (23.1)	
Transfusiıon, n (%)			
No	11 (91.7)	11 (84.6)	0.531
Yes	1 (8.3)	2 (15.4)	
Reoperation, n (%)			
No	11 (91.7)	12 (92.3)	0.74
Yes	1 (8.3)	1 (7.7)	
Infection, n (%)			
No	11 (91.7)	10 (76.9)	0.328
Yes	1 (8.3)	3 (23.1)	
Visual analog scale (highest)	4.5±0.9	4.92±1.49	0.388
Analgesia requirement (day)	3.4±1.3	3.46±2.14	0.536
Tramadol hydrochloride, n (%)			
No	4 (33.3)	6 (46.2)	0.404
Yes	8 (66.7)	7 (53.8)	
Hospital stay (day)	6.7±2.59	5.84±0.89	0.798
Incisional hernia, n (%)			
No	8 (66.7)	12 (92.3)	0.109
Yes	4 (33.3)	1 (7.7)	
Postoperative creatinine value (28 day)	1.26±0.24	1.22±0.22	0.650
Postoperative creatinine value (6 month)	1.12±0.2	1.18±0.14	0.556
Postoperative creatinine value (18 month)	1.16±0.32	1.1±0.27	0.656

Discussion

There are few studies comparing conventional 2D and 3D laparoscopy systems.[1-10] In studies on laparoscopic chole-cystectomy, there is no strong evidence demonstrating the superiority of 3D laparoscopy,[4,5] possibly due to the technical limitations at the time 3D systems were first introduced.[1,4,5]

A meta-analysis comparing outcomes of gastrointestinal cancer surgeries found that 3D laparoscopy did not show superiority over 2D in colorectal cancer, but did reduced operative time and intraoperative bleeding in gastric cancer surgeries.[6] No significant differences were observed in lymph node dissection or postoperative complications.[6] Similarly, in cervical cancer surgeries, 3D laparoscopy reduced operative time and blood loss without affecting complication rates or lymph node counts.[7]

Some studies on urological surgeries were conducted in laboratory settings with trainees.[8] In surgeries performed by a single surgeon, including pyeloplasty, simple and radical nephrectomy, 3D laparoscopy was superior in terms of total operative time, dissection and suturing time, and blood loss, although no differences were observed in complications, postoperative pain, or hospital stay.[1] A meta-analysis including pyeloplasty, partial nephrectomy, and radical prostatectomy showed that 3D laparoscopy shortened warm ischemia time and reduced blood loss in radical prostatectomy, but no significant differences were observed in partial nephrectomy.[9]

Donor nephrectomies must prioritize donor safety, distinguishing them from other types of nephrectomy. Preserving graft function further increases the complexity of the procedure. Only two studies specifically focused on donor nephrectomy.[10,11] In one study of 38 patients, all underwent hand-assisted left nephrectomy, with 3D laparoscopy (n=19) demonstrating shorter operative and warm ischemia times, reduced blood loss, and shorter hospital stay, but no difference in complication rates or renal function.[10] Another study with 73 patients (n=16, 3D laparoscopy) showed similar findings.[11]

This study did not demonstrate statistically significant differences in surgical outcomes compared to conventional 2D systems in donor nephrectomy. Although cases performed with 3D laparoscopy showed shorter warm ischemia time, operative time, and hospital stay, these differences were not statistically significant. Drain usage was lower, and transfusion requirement higher in the 3D group, whereas the reoperation rate was lower; however, none of these differences reached statistical significance. The highest VAS scores were slightly higher in the 3D group, and more trocars were required in the 2D group due to higher prevalence of multiple vessels; nevertheless these differences were not statistically significant. Unlike previous studies, these differences may be attributed to the involvement of more surgeons, their extensive experience with 2D laparoscopy, or the relatively small sample size. Consistent with previous research, we found that postoperative kidney function was not affected by the type of laparoscopic system. Nevethless, the small sample sizes remain a limitation.

This study was not designed to evaluate surgeons' perceptions of laparoscopy systems. Although all five surgeons re- ported improved depth perception with 3D systems, more standardized, multicenter studies are necessary for objective conclusions.

Conclusion

Enhancing depth perception and orientation in laparoscopic systems is critical for surgical success. Although 3D laparoscopic systems offer improved visualization, our study did not demonstrate statistically significant differences in surgical outcomes compared to conventional 2D systems in donor nephrectomy. Considering the high level of surgeon experience and the limited sample size, these findings should be interpreted with caution.

Further multicenter studies with larger sample sizes, including assessments of surgeon ergonomics and learning curves, are needed to better define the potential benefits of 3D laparoscopy in living donor nephrectomy.

Disclosures

Ethics Committee Approval: Ethical approval was obtained from the Inönü University Ethics Committee (No:2019/104, Date: 22/05/2019) as part of a scientific research project (BAP, Project code: TSG-2020- 1884).

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