

Evaluating the outcomes of 3D laparoscopic nephrectomy for benign non-functioning kidneys

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Abstract

Introduction: Previous endoscopic systems with 2D (2D) screens provide the surgeon with an indirect vision. To improve this, 3D laparoscopic surgery was performed and has become a breakthrough in the era of minimally invasive surgery with high image definition, stability, good depth sense, reducing the burden on the surgeon's vision. At Hue Central Hospital, since 2020 we have applied regularly 3D endoscopic surgery for urological kidney diseases but not too many research projects to evaluate the safety, effectiveness and applicability of these means. Therefore, we carried out the topic: "Evaluating the results of 3D laparoscopic nephrectomy due to benign pathology".

Patients and methods: 3D LN was performed on patients diagnosed with non-functioning kidneys at Hue central hospital from 1/2021 to 11/2021. Variables including standard features, clinical, subclinical, preoperative and postoperative results, perception of surgeons after surgery and how 3D vision impact their emotional states, were recorded. In addition, the duration of operation between high and low BMI groups as well as the adhesion inflammation level in kidney were also analyzed and compared.

Results: Samples included 17 cases, with male:female is 6:11. Mean age was 58.18 11.66 (32-85). All cases were performed by transperitoneal laparoscopic nephrectomies. Mean operation time was 136,76 37,66 minutes, average blood loss was 85,0 21,36 ml (50-120). Mean length of stay was 8,88 3,44 days (5-18). Mean VAS score was 6,57 1,42. Complications had 3 cases: 2 cases had pyonephrosis, 1 case had acute pancreatitis without re-operated need. High BMI, hydronephrosis or nephritis didnt impact excessively on operation time.

We recorded diversity of side effects from 3D lapararoscopy such as headache, nausea with some initial cases. Average STAI-6 score was 12,88 2,67. According to feeling of surgeons, they concurred with image quality, depth perception, eye-hand coordination during surgery were acceptable.

Conclusion: 3D laparoscopic nephrectomy is safe, efficient. Using 3D vision

for laparoscopy in order to obtain better image quality, has more depth and improve eye-hand coordination rather than 2D system.

Keywords: Laparoscopic nephrectomy; 3D laparoscopy; non-functioning kidney.

Introduction

Throughout 100 years of advancement, laparoscopy has become common technique and been applied more frequently on urology.

Previous laparoscopic systems with 2D (2D) screens provide with an indirect visual field view. The use of binocular vision on 2D screens causes many visual misperceptions, mainly depth. The biggest challenge for surgeons is eye-hand coordination in stereoscopic space that is viewed on a 2D screen [12].

These not only prolong the learning curve for new surgeons, but also jeopardize the depth perception, especially the current trend of laparoscopic surgery is to approach deeper regions with higher risk as vascular. These bring motivation to the advent of 3D laparoscopic surgery facilities. This is a breakthrough in the era of minimally invasive surgery, with high image definition, stability, good depth sense, reducing the pressure on the surgeon's vision [5]. In early 2012 Buchs et al.[4] reported several activities related to the use of laparoscopic surgery with FPR passive 3D imaging technology and since then, many surgeons around the world have shared the same point of view on the benefits of laparoscopic surgery with 3D screens and its application is increasingly widespread. According to Suresh B et al (2020), 3D laparoscopic surgery compared to 2D helps to reduce more surgery time, reduce intraoperative blood loss, reduce dissection time and make the surgeon more comfortable in surgery. [10].

At Hue Central Hospital, 3D laparoscopic surgery was first deployed by the laparoscopic unit in 2015 as

a test, familiarized with the new machine system and then invested and deployed regularly in 2017. Since 2020, we have applied 3D laparoscopic surgery for urological kidney diseases, but there have not been many reports to evaluate the safety, effectiveness and applicability of this means. Therefore, we carried out the research with topic is: "Evaluating the outcomes of 3D laparoscopic nephrectomy for non-functioning kidney due to benign pathologies".

Patients and methods

Research included patients with confirmed diagnosis of non-functioning kidney who received nephrectomy with transperitoneal 3D laparoscopic surgery at Hue Central Hospital from 1/2021 to 10/2021.

Diagnosis is confirmed by the following criteria:

Isotope renogram: kidney function less than 10%.

Hydronephrosis grade IV on CT-Scan.

Glomerular filtration rate less than 15 mL/min/1.73 m² with parenchyma thinner than 5mm.

Remaining renal function within normal range or glomerular filtration rate above 60 mL/min/1.73 m².

There are complications such as chronic infection, bleeding causing persistent hematuria, high blood pressure, constant hip pain, and compression of surrounding organs.

Exclusion: Postoperative pathology showed cancerous, precancerous results.

Firstly, we record the variables of general, clinical, subclinical characteristics, surgical and postoperative results, the surgeon's perception after surgery, the level of impact of the 3D screen on the surgeon's mental state.

We also compared surgery time between groups with high and low BMI, the degree of adhesion inflammation of the pathological kidney.

We monitored complications during the postoperative period and one month after surgery.

Excel 2013 and SPSS 22.0 software were used, the difference was statistically significant when $p < 0.05$.

Some pictures of non-functioning kidney with complications



Fig 1. Non-functioning kidney due to calculus of ureter.

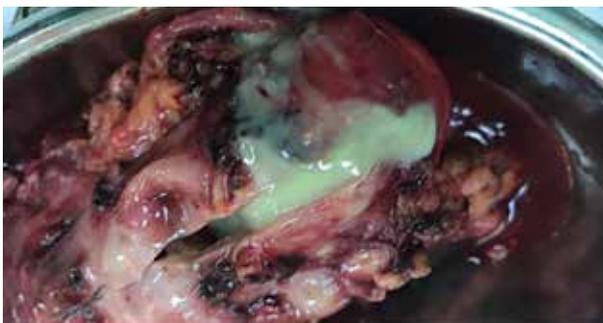


Fig 2. Non-functioning pyonephrosis caused by calculus of ureter.

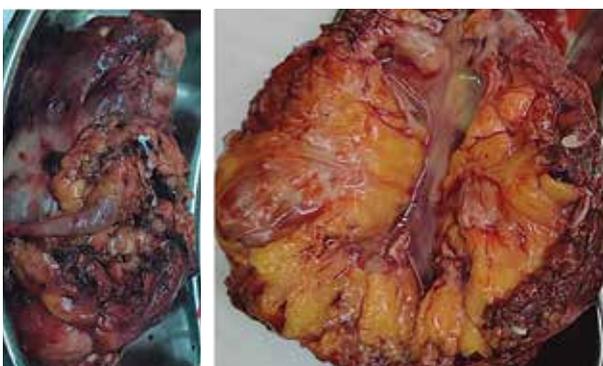


Fig 3. Atrophic kidney.



Fig 4. Atrophic kidney causes the high blood pressure.

Equipment

The 1S-3D Karl Storz endoscope system includes the Optic 30o Integrated Camera, which has two parallel image sensors. Images from these sensors are transmitted to the image processing system and signal through a Full HD screen that supports 3D image projection with glasses. It can also alternatively switch between 2D and 3D signals with the button right on the camera.

Surgical results were evaluated based on surgery time, blood loss during surgery, and length of hospital stay. The surgeon's subjective assessment is based on the perception of image quality, depth of perception, the degree of surgical stress, the coordination of hand-eye movements during surgery according to the Likert 5 scale. The Adult Anxiety Scale (Stai-6), which also has the abridged version, Spielberger 5, was used to assess the emotional, physical, and cognitive stress experienced by PTV during surgery.



Fig 5. Laparoscopic optic 3D with two image sensors plus a light control.



Fig 6. Image of 3D on Karl Storz endoscope system.

Surgical techniques: the patient was anesthetized by endotracheal intubation. The patient was positioned side-lying with 300 leading surgeons and assistant surgeons standing in front. Trocar placement: use 3 or 4 trocars (Figure 1). One 10mm trocar for transumbilical camera beyond the rectus abdominis muscle according to Hansson, one 10mm trocar below the ribs and one 5mm trocar across the umbilicus above the midclavicular line, possibly adding a trocar below the sternal tip for liver or colon roll-up depending on the left side or right. Insufflation of CO₂ into the abdominal cavity, pressure 10-14 mmHg.



Fig 7. Surgeons and laparoscopic system setting up for left laparoscopic nephrectomy.

Dissect and move down the right or left colon, revealing the anterior surface of the kidney; depending on the degree of hydronephrosis and adhesion inflammation, we would have different approaches. If the kidney is too large and can occupy the entire abdomen, it is necessary to drain before surgery or during surgery, aspirate to collect fluid for

culture and antibiogram (if necessary). Peritoneal dissection can be conducted to liberate the margins and sides of the kidney, respectively. Direct pedicle access from the outset can provide rapid surgical control, which depends on the surgeon's experience as well as the degree of adhesions and the complexity of the renal vasculature. The advantage of the 3D endoscope is the ability to access in-depth the stage of renal vascular dissection, which helps to manipulate more delicately, limiting blood loss as well as damage to blood vessels. We usually rely on anatomical margins such as inferior vena cava for right nephrectomy and genitourinary vein for the left side. The renal vein is generally located anterior to the artery. Treat arteriovenous vessels evenly with Hem-o-lok or Harmonic instruments in cases of small blood vessels.

In many cases of urethral stricture and inflammation, it can cause obstruction in which the process of dissection of the ureter will be complicated. Therefore, it is possible to follow the Psoas muscle border or expose the lower kidney region to access the ureter, which will have more advantages, depending on the surgeon's pre- and intraoperative assessment, to have an appropriate strategy. In case of obstruction due to ureteral stones, it is necessary to dissect the ureter through the segment with stones, clamp, cut the ureter right below the stone, and remove the stone along with the kidney.

After treatment of the renal pedicle, ureter, and dissection of the remaining sides of the kidney, the kidney is placed into the capsule or out through the following routes: trocar camera expansion or manipulation (pararectal), Gibson's iliac fossa, or Pfannenstiel.

Note: Combine with anesthesia to relax muscle to make kidney removal more accessible; the procedure of renal peduncle treatment must be concurred within the surgical team.

Close the peritoneal layer of the kidney incision before the laparoscopic examination

Laparoscopy is used to observe renal vasculature

to prevent bleeding. Place a renal fossa drain through the 10mm trocar and suture the remaining trocar hole and the nephrectomy.

The patient is kept in the recovery room for monitoring 24 hours after surgery to prevent bleeding before being transferred to the care department as a normal cut.

*Indications to convert to open surgery in cases of: uncontrollable bleeding, and damage to internal and retroperitoneal organs. Choose the incision of the hip and back, the upper and lower abdominal lines, the lower costal line, the middle white edge, depending on the case. This is a backup plan that needs to be taken into account when performing a nephrectomy. Therefore, preparing an open surgical kit in the laparoscopic operating room is imperative.



Fig 8. Location of the trocar holes and site to take the kidney out

The surgeon's subjective assessment of image quality, depth perception, and hand-eye coordination on a Likert scale of 5 (1-Strongly disagree, 2-Disagree, 3-Normal, 4-Agree, 5-Strongly agree)

Questionnaires of subjective evaluation of the surgeon after surgery.

Questions	Scale				
	1	2	3	4	5
Best image quality					
Good depth perception					
Good eye-hand coordination					

Results

The study included 17 patients, 6 patients were male and 11 patients were female. The study sample characteristics were summarized (Table 1). The mean age of the study group was 58.18 ± 11.66 (32-85). All cases underwent laparoscopic transperitoneal nephrectomy. There were no cases requiring conversion to open surgery. The average surgery time was 136.76 37.66 minutes, the average blood loss was 85.0 21.36 ml (50-120). The average length of hospital stay was 8.88 3.44 (5-18). The average VAS score after surgery was 6.57 1.42. There were 3 cases of postoperative complications: 2 cases of surgical wound infection after pyelonephritis resection, one case of acute pancreatitis after surgery. They all received active medical treatment, with no cases requiring re-operation after surgery. The high BMI, the degree of dilatation of the kidney or the high degree of inflammatory nephritis did not affect the time of surgery (Table 2).

The first few cases in the research group recorded related effects of 3D endoscopic imaging such as headache, nausea. Average STAI-6 score 12.88 2.67. Subjective assessment of the surgeon all agreed on the image quality, depth sense, hand-eye coordination in surgery at a decent level.

Tab 1: Sample study characteristic

Characteristic	Value
Cases number (n)	17
Right	7 (41,18%)
Left	10 (58,82%)
Male	6 (35,29%)
Female	11 (64,71%)
Average age	58,18 11,66 (32-85)
BMI	23,0 ± 3,68
Pre-operative serum creatinine (mol/l)	97,96 ± 50,98
Post-operative serum creatinine (mol/l)	94,46 ± 27,78
Pre-operative GFR (ml/min)	64,53 ± 21,95 (23,84-113,39)
Surgical duration (min)	136,76 37,66

Blood loss volume (mL)	85,0 21,36
Bowel movement time	1,18 0,39 (1-2)
Removal of drainage time	2,65 1,12 (2-6)
Pain relief time	3,41 2,85
Post operative stays	8,88 3,44 (5-18)
Cases numbers which have 1 renal arteries, 1 vein	14/17 (82,35%)
Intraoperative complications	0
Postoperative complications	3
Conversion of open surgery (n)	0
Blood transfusion	0
VAS score	6,57 1,42

Tab 2. Correlation among BMI, renal pathology and surgical duration

Related factors	Number of patients (n = 17)	Average surgical duration (min)	p
BMI < 25	14	132,14 ± 28,13	> 0,05
BMI ≥ 25	3	158,33 ± 73,2	
Hydronephrosis severity			
Mild or moderate	13	137,31 ± 42,56	> 0,05
Severe	4	135,0 ± 17,8	
Adhesion inflammation level			
None, mild or average	11	133,18 ± 43,49	> 0,05
Severe	6	143,33 ± 26,01	

Discussions

The 3D imaging industry has existed for more than 50 years. But it is only considered as a breakthrough and widely applied in recent years, especially in laparoscopic surgery systems. Compared with the traditional 2D endoscopic system, the 3D system provides high definition surgical field images, better depth sense. Thus, improving endoscopic skills and shortening the learning curve. Surgeons can operate faster and safer in surgery [11,12]. This advancement has implications for surgeons undergoing surgical training, and many studies have also shown a

shortened learning curve for new surgeons, especially in the field of urology [6].

However, despite the advantages of the 3D system that have been reported, there are still some noted disadvantages, such as eye fatigue and headaches when the surgery time is long and the cost is high [1, 3, 11]. But compared to its benefits, the 3D system is still preferred by surgeons. Current 3D laparoscopic techniques are also equipped with robotic-assisted surgical vehicles, but the cost is expensive, and the economic efficiency for the patient is controversial. [7]

Surgical result such as the average operative time on our 3D system, was similar to that from some domestic and international authors [1, 2, 4]. Compared with the 2D system, the operative time was significantly shorter in several studies. However, the number of cases in the study group was still small, and there was no control group to compare, but we believe that in the future, when a good learning curve is achieved, we can shorten the operative duration.

The amount of blood loss during surgery on 3D laparoscopic staging compared to 2D was less due to better dissection and vascular identification. Especially in the bleeding case, good depth sense helps surgeons control blood vessels quickly and accurately.

Postoperative complications included 2 patients with surgical site infection on nephrectomy due to pus stasis. A patient with acute pancreatitis after left nephrectomy may be due to the process of removing the renal hilum's inflammation, touching the pancreas's tail, and causing secondary pancreatic injury. However, the above cases all responded well to medical treatment and did not need to be re-operated, although the postoperative period of stay and pain relief was somewhat longer.

The shortcoming in our study was the lack of data related to glare, shadowing, and difficulty performing renal hilum dissection in case of bleeding (because the image would be darker). The number of patients in the study group was small, and the surgical results

have not been evaluated with the 2D system. In the future, we will study and apply 3D laparoscopic system for other urological kidney diseases such as: adrenal gland tumor, total and partial nephrectomy in cancer, and uteropelvic junction management.

Conclusions

3D laparoscopic surgery for nephrectomy for non-functioning kidney due to benign pathology is safe and effective surgery equivalent to traditional 2D laparoscopic surgery. Using the 3D system in laparoscopic surgery gives better image quality, more depth, and better hand-eye coordination than the 2D system. The application of 3D in urologic surgery in the future is very promising.

Conflict of interest: The authors declare that they have no conflict of interest.

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