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Comparison of the clinical effectiveness of 3D and 2D imaging systems for laparoscopic radical cystectomy with pelvic lymph node dissection

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Abstract

Objective: To compare the clinical effectiveness of three-dimensional (3D) and two-dimensional (2D) laparoscopic imaging systems for radical cystectomy (RC) with pelvic lymph node dissection.

Methods: This was a retrospective analysis of data collected from all patients who underwent RC with pelvic lymph node dissection between January 2013 and May 2014, performed by a single surgeon in our clinic. Demographic characteristics and operative data from the procedure were collected and compared.

Results: Data were available from 42 patients (mean age 63 ± 6.7 years) of whom 18 were operated on using a 3D imaging laparoscope (Group 3D) and 24 were operated on using a conventional 2D laparoscope (Group 2D). There were no statistically significant differences in patient characteristics between the two groups ($P > 0.05$). There was no difference between groups in the mean ($\pm$SD) number of lymph nodes retrieved from each patient (13.2 ± 4.6 and 12.5 ± 4.3, for the 3D and 2D groups respectively), or in blood loss. PLND duration and total operative time were statistically significantly lower in Group 3D than in group 2D. There were no statistically significant between-group differences in postoperative hospital stay or total cost of the procedures. Serious postoperative complications occurred in one patient (5.6%) in group 3D, and four patients (16.7%) in group 2D ($P = 0.075$).

Conclusions: With the assistance of 3D stereoscopic imaging, surgeons may be able to reduce both the duration of lymph node dissection and overall operative time during laparoscopic RC with pelvic lymph node dissection, without increasing postoperative hospital stay or total cost.

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Keywords
Bladder cancer, laparoscopic radical cystectomy, pelvic lymph node dissection, 3D imaging laparoscopy, 2D imaging laparoscopy

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Introduction

In many countries, laparoscopic radical cystectomy with pelvic lymph node dissection has become the most widely used treatment for nonmetastatic muscle-invasive and some high-risk nonmuscle-invasive bladder cancers.[1] Traditionally, laparoscopic surgeries were based on two-dimensional (2D) imaging systems.[2] However, technological advancements have led to the introduction of three-dimensional (3D) systems.[3] In some institutions, 3D laparoscopic visual systems are increasingly used for urinary surgery.[4,5]

Studies have shown that for performing laparoscopic tasks, such as peg transfer, ring manipulation and cannulation, surgeons using 3D laparoscopy could save time and make fewer mistakes compared with standard 2D imaging systems.[6,7] However, there has been limited investigation into the usefulness of 3D laparoscopy in urology, especially in radical cystectomy with pelvic lymph node dissection. The purpose of this retrospective review was to compare the clinical effectiveness of 3D and 2D laparoscopic imaging systems for radical cystectomy with pelvic lymph node dissection.

Patients and methods

Patients

This was a retrospective analysis of data collected from all patients who underwent radical cystectomy with pelvic lymph node dissection between January 2013 and May 2014, performed by a single surgeon in our clinic. The inclusion criteria were: (1) diagnosis preoperatively by computed tomography (CT) and pathological examination under cystoscope; (2) no other malignant diseases; (3) no other extensive abdominal operation history. Laparoscopy had been performed with either the 3D (Group 3D) or conventional 2D (Group 2D) system, with the choice of system being based mostly on patient preference; the surgeon (L.Q.) had extensive experience of laparoscopic radical cystectomy with pelvic lymph node dissection.

Primary tumours were graded preoperatively from CT scans. Similar to a previous study from our centre,[8] a standardized method was used to evaluate the preoperative CT T stage (CTx) of bladder cancer. Patients were divided into five categories according to their CTx stage (i.e., CT1, CT2a, CT2b, CT3b, and CT4a). All patients were informed about the surgical procedures and written consent was obtained from each patient for both the procedure and the study. The ethics committee of Central South University approved the study (No. 20147834).

Imaging system and surgery

Group 3D patients were operated on using the Viking laparoscopic imaging system (Viking 3D HD system, Viking Systems, San Diego, CA, USA), for which surgeons are required to wear polarized glasses. Group 2D patients were operated on using the Olympus 2D high definition (HD) laparoscopic system (Olympus 2D HD system, Olympus Corporation, Nagano, Japan). The same conventional laparoscopic surgical instruments (e.g., ligasure system, harmonic scalpel and bipolar coagulation) were used on both groups of patients.

Patients were placed into the supine position after successful general anesthesia.[9,10]

In total, five trocars were used on each patient. The first 12-mm trocar, which was placed below the umbilicus, was reserved for the laparoscope. Following the establishment of the pneumoperitoneum, two 5-mm and two 10-mm trocars were placed in the line between the umbilicus and the anterior superior spine. Standard lymph node dissection for bladder cancer was performed.[11] The bilateral pelvic lymph nodes (including the region between the genitofemoral nerve, the obturator fossa, along the internal iliac artery and along the common iliac artery up to the crossing of the ureter) were removed. All lymph nodes were sent for pathological analysis in separate packages for various anatomical regions (i.e., obturator, external, internal, common iliac and presacral lymph nodes); the pathologists were blinded to the treatment groups. The ureters, bladder base, vas deferens, seminal vesicles, the Denonvilliers' fascia, the anterior surface of the rectum and posterior surface of the prostate were dissected out, step by step. After controlled endopelvic fascia incision and dorsal vein complex, the prostate apex and urethra were incised. In female patients, the bladder, urethra, uterus, adnexa and anterior vaginal wall were removed. A small longitudinal incision (5–8 cm long) below the umbilicus was made and the specimen was removed. Patients chose to undergo either urinary diversion (achieved by a Bricker ileal conduit) or cutaneous ureterostomy. All postoperative follow-up and treatment was performed in a standardized manner.[9]

Data collection

Patients' medical records were retrospectively reviewed for baseline demographic characteristics and operative data relating to the procedure. Number of dissected and positive bilateral pelvic lymph nodes, pathological staging of the tumour, time taken for pelvic lymph node dissection (min), total operative time (min), blood loss (ml), postoperative hospital stay (day), total cost (Chinese yuan) and any serious complications (e.g. bowel obstruction, rectal perforation, damage of important vein or artery [such as external iliac vein or artery] or injury of nervi obturatorius]) were recorded. Each patient's dissected and positive lymph nodes were counted according to the final pathological report. Blood loss was measured by the drainage of suction apparatus during the procedure. The total cost equated to all expenses covered by the patient and the insurance company, including the cost of the 3D system where appropriate.

Statistical analyses

Continuous variables were expressed as mean ± standard deviation (SD). Categorical data were presented as n or n%. All data evaluation and analyses were performed using SPSS® (version 19.0 for Windows®). Student's t-test and X^2-analysis were used to compare the two treatment groups as appropriate. A P value of < 0.05 was considered statistically significant.

Results

Data were available from 42 patients: seven women and 35 men, mean ± SD age 63 ± 6.7 years. Of the 42 patients, 18 were in Group 3D and were operated on using the 3D imaging laparoscope and 24 were in Group 2D, and were operated on using the conventional 2D laparoscope.

Demographic characteristics of the study participants are shown in Table 1. There were no statistically significant differences in patient characteristics between the two groups ($P > 0.05$). One patient in the 3D group had previously undergone laparoscopic appendectomy; three others (one in the 3D group and two in the 2D group) had previously undergone laparoscopic cholecystectomy (Table 1). All radical

Table 1. Demographic baseline characteristics for patients undergoing laparoscopic radical cystectomy with pelvic lymph node dissection, using new three-dimensional (Group 3D) or conventional two-dimensional (Group 2D) techniques.

Characteristic	Group 3D	Group 2D	Statistical significance
Patients, *n*	18	24	
Age, mean ± SD, years	63.3 ± 6.8	64.2 ± 6.7	$P = 0.675$
Sex, male/female	15/3	20/4	$P = 1.000$
Urothelial cell carcinoma stage (CT_{2a}:CT_{2b}:CT_{3b}:CT_{4a})[8]	5:8:3:2	6:11:5:2	$P = 0.976$
BMI, mean ± SD, kg/m^2	21.89 ± 2.72	21.58 ± 2.98	$P = 0.730$
Previous history of laparoscopy, *n*	1 appendectomy; 1 cholecystectomy	2: 2 cholecystectomy	$P = 0.762$

BMI, body mass index.

Table 2. Perioperative results from patients undergoing laparoscopic radical cystectomy with pelvic lymph node dissection, using new three-dimensional (Group 3D) or conventional two-dimensional (Group 2D) techniques.

Parameter	Group 3D	Group 2D	Statistical significance
Patients, *n*	18	24	
Dissected lymph nodes, mean ± SD	13.2 ± 4.6	12.5 ± 4.3	$P = 0.627$
Bilateral common iliac	1.8	1.7	
Presacral	1.0	0.5	
Bilateral internal iliac	4.3	3.6	
Bilateral external iliac	1.1	1.1	
Bilateral obturator	5.0	5.6	
Number of postive lymph nodes, mean ± SD	0.6 ± 1.0	0.5 ± 0.9	$P = 0.710$
Tumour stage, pT_{2a}:pT_{2b}:pT_{3a}:pT_{4a}	4:7:5:2	5:9:8:2	$P = 0.978$
Time of PLND, mean ± SD, min	44.7 ± 11.0	60.0 ± 12.0	$P < 0.001$
Operative time, mean ± SD, min	133.1 ± 24.4	150.6 ± 19.6	$P = 0.014$
Blood loss, mean ± SD, ml	211.7 ± 90.3	217.5 ± 82.4	$P = 0.829$
Postoperative hospital stay, mean ± SD, day	8.9 ± 2.2	9.1 ± 2.2	$P = 0.840$
Total cost, mean ± SD, Chinese yuan	67731 ± 6418	68637 ± 6056	$P = 0.643$
Complications, *n* (%)	1 (5.6)	4 (16.7)	$P = 0.271$
Bowel obstruction	1	3	
Lymphatic leakage	0	1	
Rectal damage	0	0	
Injury of major vessels or nerves	0	0	

pT, pathological tumour stage; PLND, pelvic lymph node dissection.

cystectomies with pelvic lymph node dissection were completed successfully and no patient required conversion to open surgery. All 42 patients were pathologically confirmed as having urothelial cell carcinoma with negative margins at the urethral and ureteric stumps.

Perioperative results are shown in Table 2. There was no statistically significant between-group difference in the number of

lymph nodes retrieved ($P = 0.627$). In Group 3D, an average of 13.2 lymph nodes (range, 6–25) were retrieved, while in Group 2D, an average of 12.5 lymph nodes (range, 6–23) were retrieved. The distributions of retrieved lymph nodes are shown in Table 2. There was no statistically significant between-group difference groups in the average number of positive lymph nodes retrieved ($P = 0.710$); for Group 3D this was 0.6 (range, 0–3) and for Group 2D it was 0.5 (range, 0–4). There were no statistically significant differences between groups in blood loss or postoperative complications. In addition, there were no statistically significantly differences between the two groups in postoperative hospital stay or total cost of the procedure. However, the duration of the pelvic lymph node dissection and the total operative time were statistically significantly lower in Group 3D compared with Group 2D ($P < 0.001$ and $P = 0.014$) (Table 2). Of the 42 patients involved in the study, 40 had urinary diversion achieved by a Bricker ileal conduit and, in accordance with their preferences, the remaining two patients each underwent cutaneous ureterostomy.

Discussion

Over the past 20 years, the majority of laparoscopic surgeries have been completed using 2D imaging technology. A disadvantage of this system is the reduced depth perception of the operative field, which may increase the operation time or the chances of injuring surrounding organs. The development of 3D visualization technology in the 1990s was proposed as a way of improving laparoscopic performance.[12] However, early 3D laparoscopic technology was limited in terms of image quality, serious visual fatigue and a heavy burden caused by the helmet-like glasses.[13] The 3D laparoscopic system has evolved substantially, over time, however.

In our institute, the 3D laparoscopic system has been used in almost all regular laparoscopic procedures and in complicated operations such as radical cystectomy with pelvic lymph node dissection. In this retrospective study, data were available from 18 cases of laparoscopic radical cystectomy using 3D imaging and 24 cases using the conventional 2D imaging. Compared with the conventional 2D system, 3D laparoscopic surgery showed significant advantages in terms of the operative time of lymph node dissection and total operative time. Moreover, there were no differences between the two groups in postoperative hospital stay or total cost of the procedure. To our knowledge, this was the first study to compare the two laparoscopic imaging systems in patients undergoing radical cystectomy with pelvic lymph node dissection.

In a study of laparoscopic training sessions involving 20 medical students and 10 laparoscopic experts, Storz *et al.*[6] showed that 3D imaging systems allowed surgeons to be faster and more accurate compared with 2D imaging systems. In another study, Bilgen *et al.*[14] showed that the 3D imaging systems caused a significant reduction in the performance time of laparoscopic cholecystectomy. Cicione *et al.*[15] found that, in a laboratory setting, the 3D viewing system facilitated surgical performance of urologic surgeons without any laparoscopic background. Pelvic lymph node dissection is an integral part of radical cystectomy.[16–20] The number and anatomical regions of dissected lymph nodes are both regarded as surrogates for surgical expertise.[16–20] A well-performed pelvic lymph node dissection for bladder cancer requires at least 10 nodes to be removed.[21] In this study, irrespective of the viewing system, an average of 13 lymph nodes was removed from each patient. However, the surgeon took less dissection time and less operative time with the 3D system compared with the 2D system. We feel this suggests that the surgeon was more

confident in dissecting lymph nodes from vessels under 3D visualization compared with 2D visualization. We postulate that the surgeon acted decisively when dissecting the tissues or organs because 3D system provides a stereoscopic view.

Another advantage of 3D laparoscopy systems, compared with 2D systems, might be the improvement of suture technique brought about by clearer visualization. The control of the deep dorsal venous complex is a key stage of radical cystectomy.[9] Under the conventional 2D view, the entry angle of the needle is difficult to adjust, especially for an inexperienced surgeon.[5] However, a stereoscopic view with the 3D laparoscope could make this task easier, which may have a beneficial impact on operation time. However, a limitation of the 3D laparoscope is that the user needs to wear passive polarized glasses, which could result in visual fatigue if the operation time is considerable.

Limitations of the present study include the small number of cases that were performed with the 3D system, and the fact that all procedures were performed by only one surgeon. Further studies are needed, and more long-term follow up data on patients who undergo laparoscopic surgery are required.

In conclusion, it has been suggested that the 3D laparoscopic system provides stereoscopic vision, which guarantees a clearer view and more accurate dissection, compared with conventional 2D laparoscopy.[6,7] The findings of this small study showed that, when performing laparoscopic radical cystectomy with pelvic lymph node dissection using 3D imaging, surgeons could improve the operative time of lymph node dissection and reduce overall operation time without increasing postoperative hospital stay or total cost.

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Declaration of conflicting interest

The authors declare that there are no conflicts of interest.

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