Original Article

Three-dimensional vs. Two-dimensional Laparoscopic Colectomy and Protectomy for Colon Cancer and Rectal Cancer: A Single Center Experience

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Key Words
3-dimensional (3D) image system;
Laparoscopic colon surgery;
Long-term outcomes

Purpose. Previous studies have shown several advantages of laparoscopic colectomy over open surgery. With the evolution of the three-dimensional laparoscopy image system, many two-dimensional laparoscopic colectomy surgeries were replaced by three-dimensional laparoscopy. Although some studies have compared the outcomes of three-dimensional vs. two-dimensional laparoscopic colectomy and protectomy in colon cancer and rectal cancer, the results of long-term follow-up are lacking. We analyzed the long-term oncological outcomes of three-dimensional vs. two-dimensional laparoscopic surgery for colon cancer and rectal cancer.
Methods. We retrieved the data of patients who underwent laparoscopic colectomy or protectomy at a single medical center (Kaohsiung Veterans General Hospital) between November 2017 and November 2018. Surgical outcomes, including intraoperative parameters, postoperative outcomes, pathological characteristics, and 3-year survival rate, were compared between the three-dimensional (n = 63) and two-dimensional laparoscopy groups (n = 63).
Results. The duration of surgery was significantly shorter in the three-dimensional group than in the two-dimensional group (257 ± 99 vs. 206 ± 57 min, $p = 0.002$). There was no significant difference in postoperative outcomes. Time to pass the first flatus was lesser in the three-dimensional group than in the two-dimensional group (3 ± 1 vs. 4 ± 1, $p = 0.053$); however, there was no significant difference. The rate of complications was similar in both groups (7.94%, 5/63). The number of harvested lymph nodes was higher in the three-dimensional than in the two-dimensional group (24 ± 10 vs. 22 ± 8, $p = 0.055$); however, the difference was not statistically significant. The survival rates in the three-dimensional vs. two-dimensional laparoscopy group were not significantly different (disease-free survival rate, 85.7% vs. 73.0%, $p = 0.066$; overall survival rate 88.9% vs. 82.5%, $p = 0.275$, respectively).
Conclusions. Our study showed that three-dimensional laparoscopy reduces the operative time compared to two-dimensional laparoscopy in colectomy and protectomy surgery. Larger, prospective, randomized, controlled studies are necessary to evaluate whether three-dimensional laparoscopy has better oncological outcomes and long-term survival rate in laparoscopic colon cancer and rectal cancer surgery.
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In recent decades, laparoscopic colon cancer surgery has evolved considerably. In 1991, the first report about laparoscopic colectomy was published,[1] and since then, laparoscopic colectomy has been the standard procedure for treating patients with colon cancer worldwide. Studies comparing laparoscopic colon cancer surgery with open surgery found that laparoscopic colectomy has some advantages in short-term outcomes such as lower intraoperative blood loss, lower costs, lower complication rate, and shorter length of hospital stay.[2-4]

Conventional laparoscopy is performed using the two-dimensional (2D) imaging system. However, the 2D vision has some limitations, including the lack of depth perception and spatial orientation. These limitations can cause technical difficulty during laparoscopic surgery.

Three-dimensional (3D) imaging system provides the surgeon a better depth of field and hand-eye coordination compared with the 2D image system.[5] Furthermore, the 3D image system is also advantageous for surgical techniques such as laparoscopic suturing and knotting.[6]

Previous studies have compared 3D laparoscopy versus 2D laparoscopy in terms of their clinical outcomes; however, the number of patients enrolled was small. Hence, we conducted this study in a larger sample of patients to power this study.

This study aimed to analyze the long-term oncological outcomes of 3D colectomy and protectomy for colon cancer and rectal cancer compared with 2D laparoscopic colectomy and protectomy.

Materials and Methods

This retrospective cohort study compared the outcomes of 3D laparoscopy and 2D laparoscopy in patients with colon cancer and rectal cancer undergoing laparoscopic surgery. We recruited patients between November 2017 and November 2018 at Kaoshiung Veterans General Hospital Colorectal Surgery Department. Inclusion criteria were patients with cancer at any location in the colon and rectum, who underwent 3D or 2D laparoscopic colectomy. Exclusion criteria were as follows: patients with (1) synchronous colon cancer, (2) previous history of abdominal surgery, (3) simultaneous major surgery with colectomy such as gastrectomy or hepatectomy, and (4) emergent surgery. We enrolled 126 patients in this study: 63 patients each in the 3D and 2D groups. The data of these patients were collected and analyzed retrospectively. All operative parameters were recorded, including the duration of surgery, estimated blood loss, and blood transfusion. Postoperative outcomes included postoperative hospital stay, time to pass the first flatus, time to commence water intake, time to commence clear liquid diet, and complications. Postoperative complications were defined as complications occurring within 30 days after surgery. Pathological staging was defined according to the American Joint Committee on Cancer (AJCC) TNM system (7th edition, 2013).

We used the Olympus CV-190 image system (Olympus coporation, Tokyo city, Japan) in both 3D and 2D laparoscopic colectomy surgery, and the resolution of the screen was full HD.

We used Student's t-test or the Mann-Whitney U test to compare the quantitative variables. Statistical analysis was performed using SPSS 19.0 (IBM, State of New York, America) for Windows. $p < 0.05$ was considered as statistical significance. Survival rate was analyzed by the Kaplan-Meier method and log-rank test, and overall survival and disease-free survival were compared between the groups.

Results

There were 63 patients each in the 3D and 2D groups. Fig. 1 showed the patient selection algorithm. Table 1 showed the baseline characteristics of the 126 patients whose data were analyzed. There were no differences between the 3D and 2D groups with respect to age, sex, BMI, American Society of Anesthesiologists (ASA) score, tumor location, TNM stage, and history of previous abdominal surgery. Table 2 showed the operative parameters. The duration of surgery was significantly shorter in the 3D group than in the 2D group (257 ± 99 vs. 206 ± 57 min, $p = 0.002$).

Table 3 shows the postoperative outcomes. Time

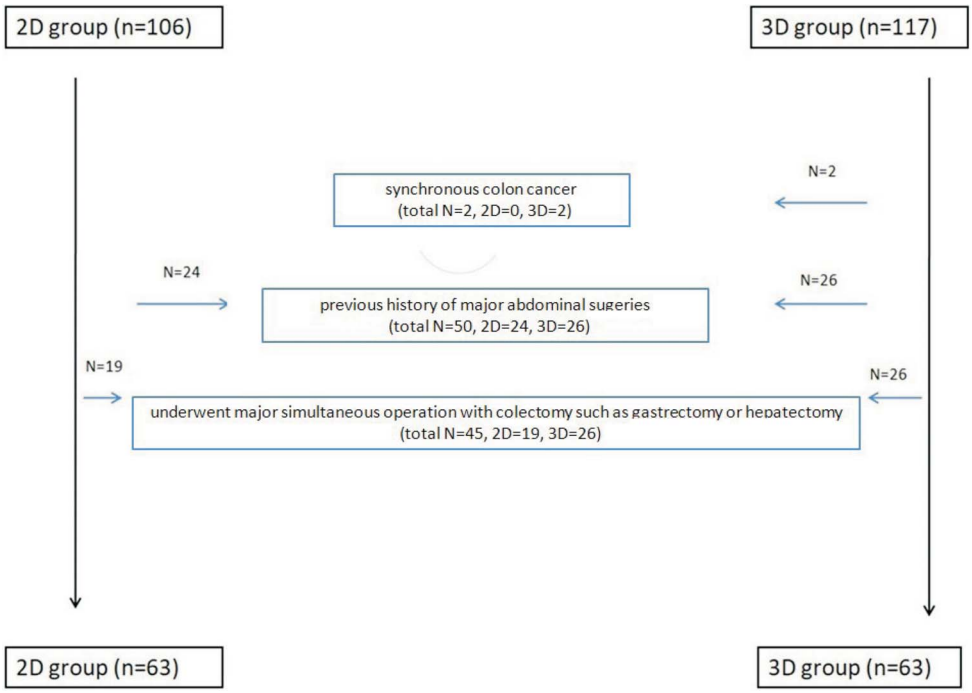


Fig. 1. Patient selection algorithm.

Table 1. Baseline characteristics of the patients

Variables	2D group (N = 63)	3D group (N = 63)	*p*
Age (yrs. median (range))	64 (26-88)	65 (38-91)	0.941
Sex			0.303
Male	35 (55.6%)	38 (60.3%)	
Female	28 (44.4%)	25 (39.7%)	
ASA score (n (%))			1.000
I	32 (50.8%)	32 (50.8%)	
II	27 (42.9%)	27 (42.9%)	
III	4 (6.3%)	4 (6.3%)	
BMI (kg/m^2)	24 (17-53)	24 (13-35)	0.347
Tumor location (n (%))			0.536
Cecum	4 (6.3%)	3 (4.8%)	
Ascending colon	7 (11.1%)	9 (14.3%)	
Transverse colon	6 (9.5%)	3 (4.8%)	
Descending colon	3 (4.8%)	3 (4.8%)	
Sigmoid colon	21 (33.3%)	26 (41.3%)	
Recto-sigmoid junction	8 (12.7%)	12 (19%)	
Rectum	14 (22.2%)	7 (11.1%)	
Clinical stage TNM			0.285
I	17 (27%)	22 (34.9%)	
II	15 (23.8%)	9 (14.3%)	
III	22 (34.9%)	27 (42.9%)	
IV	9 (14.3%)	5 (7.9%)	

ASA, American Society of Anesthesiologists; BMI, body mass index; TNM, 2D, two-dimensional; 3D, three-dimensional.

Table 2. Operative parameters

Variables	2D group (N = 63)	3D group (N = 63)	*p*
Duration of surgery (minutes)	257 (126-600)	206 (125-385)	0.002
EBL (ml)	49 (10-300)	46 (5-300)	0.717
Blood transfusion			1.000
Yes	0 (0%)	0 (0%)	
No	63 (100%)	63 (100%)	
Operative procedures			0.548
Right hemicolectomy	11 (17.5%)	12 (19%)	
Extended right hemicolectomy	3 (4.8%)	3 (4.8%)	
Left hemicolectomy	5 (7.9%)	4 (6.3%)	
Anterior resection	24 (38.1%)	27 (42.9%)	
Low anterior resection	16 (25.4%)	15 (23.8%)	
Abdominoperitoneal resection	4 (6.3%)	2 (3.2%)	

EBL, estimated blood loss; 2D, two-dimensional; 3D, three-dimensional.

to pass the first flatus was earlier in the 3D group than in the 2D group (3 ± 1 vs. 4 ± 1, $p = 0.053$); however, there was no significant difference. The rate of complications was similar between the two groups (7.94%, 5/63). There were 5 cases of postoperative complications in the 3D group, including 1 case with ischemia

Table 3. Postoperative outcomes

Variables	2D group (N = 63)	3D group (N = 63)	*p*
Postoperative hospital stay	10 (5-31)	10 (7-31)	0.079
Time to pass the first flatus	4 (1-8)	3 (1-8)	0.053
Time to resume water intake	3 (1-23)	3 (1-6)	0.755
Time to resume clear liquid diet	4 (1-24)	4 (1-7)	0.459
Complications			1.000
Anastomosis leakage	4 (6.4%)	0	
Ischemia of end colostomy	0	1 (1.6%)	
Pancreatic injury	1 (1.6%)	0	
Wound infection	0	2 (3.2%)	
Ileus	0	1 (1.6%)	
Respiratory infection	0	0	
Urinary tract infection	0	0	
Urine retention	0	1 (1.6%)	

2D, two-dimensional; 3D, three-dimensional.

Table 4. Pathological characteristics

Variables	2D group (N = 63)	3D group (N = 63)	*p*
Tumor size (cm, max length)	3.83 (0-8)	3.62 (0-15)	0.632
Number of harvested lymph nodes	22 (2-55)	24 (4-46)	0.055
Positive lymph nodes	1 (0-13)	2 (0-23)	0.111
pT stage			0.495
1	11 (17.5%)	12 (19%)	
2	12 (19%)	6 (9.5%)	
3	35 (55.6%)	42 (66.7%)	
4	5 (7.9%)	3 (4.8%)	
pN stage			0.203
0	34 (54%)	40 (63.5%)	
1	21 (33.3%)	16 (25.4%)	
2	8 (12.7%)	7 (11.1%)	
Overall stage			0.523
I	16 (25.4%)	16 (25.4%)	
II	16 (25.4%)	23 (36.5%)	
III	23 (36.5%)	17 (27%)	
IV	8 (12.7%)	7 (11.1%)	

2D, two-dimensional; 3D, three-dimensional.

of the end colostomy, 2 cases with wound infection, and 1 case each with ileus and urinary retention. Five cases of postoperative complications in the 2D group consisted of 4 cases with anastomotic leakage and 1 case with pancreatic injury. 4 cases with anastomotic leakage were all diagnosed of rectal cancer, and all of them received colostomy.

Table 4 shows the pathological characteristics of the groups. The number of harvested lymph nodes was higher in the three-dimensional group than in the two-dimensional group (24 ± 10 vs. 22 ± 8, $p = 0.055$). However, there was no significant difference.

Fig. 2 shows the survival rate and Kaplan-Meier curve of the disease-free survival and overall survival rates at the 3-year follow-up. Between the 3D group and the 2D group, the disease-free survival rate (85.7% vs. 73.0%, $p = 0.066$) and the overall survival rate (88.9% vs. 82.5%, P=0.275) were not significantly different. Disease-free survival analysis included all pathological stage patients even stage IV patients. 3D group had less patients in stage III (2/63 = 3.17% vs. 4/63 = 6.35%) and stage IV (5/63 = 7.94% vs. 8/63 = 12.7%) patients in tumor progression compared to the 2D group.

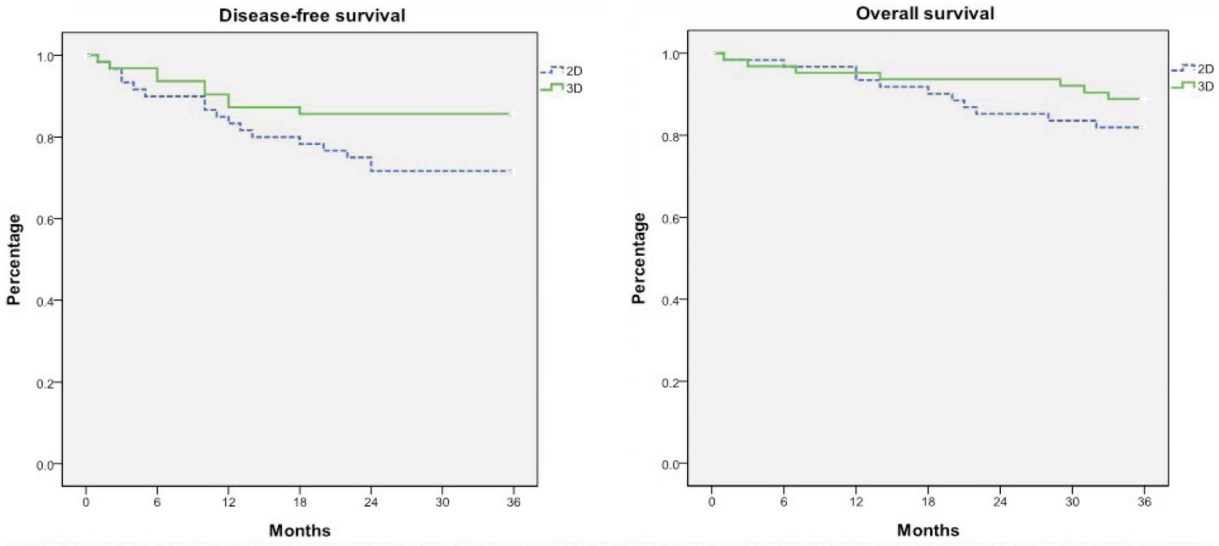
Discussion

In recent decades, there has been a significant increase in the cases of laparoscopic colectomy for the management of colon cancer. Initially, the 2D image system was used in most laparoscopic colectomy surgeries. In 1993, the first-generation 3D image system was used in gynecological laparoscopic surgery and indicated the exact preparation and more rapid application of endoscopic suturing techniques.[7]

Subsequently, the 3D laparoscopy image system was used in various surgeries, including cholecystectomy, gastrectomy, nephrectomy, radical prostatectomy, bariatric surgery, and hernial repair (TAPP).[5,8-11]

The earlier 3D image systems provided coarse images due to lower resolution and brightness. Furthermore, the 3D glasses were too bulky to be worn for a long time and caused discomfort to the surgeon, including dizziness, headache, blurring, and fatigue. Hence, 3D laparoscopy was not popular. With the evolution of technology, 3D laparoscopy has significantly developed and provides better visualization than before.[12] The 3D glasses also have a novel design so that they do not cause discomfort to the surgeon during longer surgeries.

Several studies showed some benefits of the 3D



Disease-free survival			
	2D group (N=63)	3D group (N=63)	P
1 year survival rate	85.7%	90.5%	0.406
3 year survival rate	73.0%	85.7%	0.066

Overall survival			
	2D group (N=63)	3D group (N=63)	P
1 year survival rate	96.8%	95.2%	0.652
3 year survival rate	82.5%	88.9%	0.275

Fig. 2. Kaplan-Meier curve for comparison of overall survival and disease-free survival between the patients who underwent 2D and 3D laparoscopic colectomy, at the 3-year follow-up.

image system over the 2D system in laparoscopic colectomy surgery, such as shorter duration of surgery or lesser blood loss.[13,14] Other studies showed no difference between the 3D and 2D image systems.[15]

In this study, we compared the long-term outcomes of 3D laparoscopic colon cancer and rectal cancer with those of 2D laparoscopy. Our study showed that 3D laparoscopy has a significantly shorter duration of surgery than 2D laparoscopy. This result was consistent with that reported in some previous studies.[14,16,17] Table 3 shows the postoperative outcomes. The outcomes were similar between the groups except that the time to pass the first flatus was lesser by 1 day in the 3D group than in the 2D group. However, there was no statistically significant difference. Complication rates were similar between the two groups (7.94%, 5/63), and this result was similar to that reported by Portale et al.[15] There was no significant difference in the intraoperative parameters and postoperative outcomes except the duration of surgery between the 3D and 2D groups. This could be due to two reasons. One is that the number of cases was too small to detect a significant difference, although the sample size was larger than that in the previous studies. The other reason might be that an experienced surgeon can overcome the limitations of 2D laparoscopy; hence, no difference in the duration of surgery was observed between the two methods.

Table 4 shows the pathological characteristics of the groups. The number of harvested lymph nodes was similar in the two groups. Although the number was higher in the 3D group than that in the 2D group (24 ± 10 vs. 22 ± 8, $p = 0.055$), there was no significant difference. However, Pantalos et al.[16] showed that a significantly higher number of lymph nodes could be retrieved by 3D laparoscopy.

Fig. 2 shows the survival rates of the two groups during the 3-year follow-up. Although the 3D laparoscopy group had higher survival rates than the 2D group (disease-free survival rate, 85.7% vs. 73.0%, $p = 0.066$; overall survival rate 88.9% vs. 82.5%, $p = 0.275$), the difference was not statistically significant. We included all pathological stage patients to analyze overall survival rate and disease-free survival. Table 4 showed 2D group had more cases of stage III and stage IV patients than 3D group, and the disease pro-

gression rate in comparison with two group were as follow (2D vs. 3D, stage III 6.35% vs.3.17%; stage IV 12.7% vs. 7.94%). The higher ratio of stage IV patients of 2D group may influence the overall survival and disease-free survival.

There was shortage of studies of long-term follow-up of 3D laparoscopy colectomy patients neither the comparison of two laparoscopy image system before.

Our study has some limitations. One limitation is that the sample size was too small. Nevertheless, significantly lower duration of surgery was seen in the 3D group. A larger sample size might be necessary to demonstrate the differences between the two groups in terms of other operative and postoperative outcomes. Moreover, a 3-year follow-up after surgery might not be adequate, and a longer follow-up such as of 5 years or 7 years, is necessary.

In addition, since this study was a retrospective, single-center study, there might be a selection bias. However, our small case number would not have enough power to find other subtle results.

Conclusion

Our study found that 3D laparoscopy has a lower duration of surgery compared to that of 2D laparoscopy in colectomy and protectomy. However, other differences were not evident due to the small sample size. Larger, prospective, randomized, controlled studies are necessary to evaluate whether 3D laparoscopy has better oncological outcomes and a long-term survival rate in laparoscopic colon cancer and rectal cancer surgery.

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原　著

3D 腹腔鏡及 2D 腹腔鏡對於大腸癌手術的術後結果分析比較：來自一家醫學中心的臨床經驗

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背景　之前有許多研究比較 3D 腹腔鏡大腸癌手術相對 2D 的術後結果，但是缺乏長期的術後追蹤，這篇研究的目的就是要分析 3D 腹腔鏡大腸癌手術相對 2D 腹腔鏡的長期術後結果。

方法　我們收案自己醫院接受腹腔鏡大腸癌手術的病人，分成 3D 腹腔鏡跟 2D 腹腔鏡兩個組別，每一組各有 63 人，並從兩組病人比較術後結果及 3 年的存活率。

結果　3D 組的手術時間明顯短於 2D 組 (257 vs. 206 min, $p = 0.002$)，術後結果只有此項有顯著差異，3 年追蹤的無病存活率 (85.7% vs. 73.0%, $p = 0.066$) 及整體存活率 (88.9% vs. 82.5%, $p = 0.275$) 在 3D 組的結果都比較高，然而這些也都沒有顯著差異。

結論　我們的研究發現 3D 腹腔鏡相對於 2D 腹腔鏡在大腸癌手術確實可以降低手術時間，未來還需要更多病例的前瞻性研究來分析 3D 腹腔鏡的術後結果及長期存活率。

關鍵詞　3D 腹腔鏡、2D 腹腔鏡、大腸癌及直腸癌手術、術後結果追蹤、3 年存活率。