Cost-Effective and Potential Benefits in Three-Port Hand-Assisted Laparoscopic Sigmoidectomy

Natthawut Phothong MD*,**,
Thawatchai Akaraviputh MD*, Vitoon Chinswangwatanakul MD*,
Asada Methasate MD*, Atthaphorn Trakarnsanga MD*

** Minimally Invasive Unit, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*
*** Department of Surgery, Panyananthaphikkhu Chonprathan Medical Center, Srinakharinwirot University, Nonthaburi, Thailand*

Objective: *To demonstrate potential benefits of three-port hand-assisted laparoscopic sigmoidectomy (HALS) compared with open sigmoidectomy (OS) in terms of short-term outcomes and cost-benefit.*
Material and Method: *A retrospective review of a database of cases that matched 100 sigmoid cancer patients treated with sigmoidectomy at the Department of Surgery, Siriraj Hospital was performed. Short-term outcomes and costs of treatment were collected and analyzed.*
Results: *There were no differences in age, gender, body mass index, American Society of Anesthesiologists' score, Charlson comorbidity index score, and previous surgery between OS and HALS groups. The three-port HALS group had significantly less blood loss (50 (5-400) mL vs. 120 (10-1,000) mL, p<0.001), faster time to regular diet (64.6±20.7 hours vs. 97.6±52.5 hours, p<0.001), and lower pain score (4.3±1.7 vs. 5.3±1.6, p = 0.008). The hospital-stay related cost was significantly lower in HALS group ($114 ($47-$789) vs. $190 ($57-$1,462), p<0.001). The low rate of infection was a major contributory factor (12% vs. 0%, p = 0.03). This was further emphasized in subgroup analysis of surgical site infection (SSI). While there are great benefits, the operative cost is higher in HALS. However, there is no significant difference in total costs of OS and HALS (US $2,243 ($1,321-$5,241) vs. $1,942 ($1,427-$11,910), p = 0.054).*
Conclusion: *Simplified three-port HALS can be successfully performed with superior short-term outcomes and preserved oncologic outcomes. Cost-benefit advantage was highlighted especially in the area of high rate of SSI.*

Keywords: *Hand-assisted laparoscopic sigmoidectomy, Short-term outcomes, Cost analysis*

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Laparoscopic surgery is generally considered to be a novel approach in the treatment of colorectal cancer owning to its notable benefits such as less postoperative pain and short recovery time. Laparoscopic surgery provides a two-dimensional perception of three-dimensional structures. Surgeons need to have excellent hand-eye coordination skills, especially in advanced operations[1]. Hand-assisted laparoscopic technique was initiated in the early 1990s to combine the superior laparoscopic visions with retained tactile sensation[2,3]. These resulted in clearer identification of internal structures, better exposure and faster control of bleeding[4]. In colorectal surgery, the hand-assisted laparoscopic colectomy (HALC) with four-port was employed as a more ergonomic technique providing a more effective intra-operative manipulation. Many published studies supported these benefits; however, higher costs and longer operative time were still disadvantages under discussion[5,6]. Hence, the authors conducted a study of three-port hand-assisted laparoscopic sigmoidectomy (HALS) to demonstrate its potential benefits in terms of short-term outcome, oncologic outcome, and detailed costs, compared with open sigmoidectomy (OS).

Correspondence to:
Trakarnsanga A, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.
Phone: +66-2-4198006, Fax: +66-2-4121370
E-mail: atthaphorn.tra@mahidol.ac.th

Material and Method

Patients with sigmoid cancer who underwent sigmoidectomy with different techniques (50 cases of HALS and 50 cases of OS) in Siriraj Hospital between January 2008 and September 2013 were retrospectively reviewed. Patients in both groups underwent surgery by experienced consultants and/or surgical trainees under direct supervision. Patients with preoperative imaging evidence of locally advanced disease, distant metastasis, or acute intestinal obstruction were excluded. Demographic data collected included age, gender, body mass index (BMI), American Society of Anesthesiologists' (ASA) score, Charlson comorbidity index, history of previous surgery, stage of disease,

and tumor size. For the HALS procedure, the patient was placed in the lithotomy position. A 6 cm midline incision was made for placement of the GelPort system (Applied Medical, CA, USA). Additional 12 mm camera port and 5 to 12 mm port were placed as shown in Fig. 1. Sigmoidectomy was performed using the medial to lateral approach. Dissection was performed with monopolar hook device and bleeding was controlled with ultrasonic devices. Extracorporeal anastomosis was made with GIA™ 80 mm and TA™ 90 mm (Covidien, MA, USA). These devices had been employed in OS. All devices were reusable. Operative and postoperative data including rate of conversion to open surgery, operative time, estimated blood loss, time to regular diet, pain score, length of hospital stay, and postoperative complications (anastomosis leakage, bowel ileus, surgical site infection (SSI), and lung complication) were recorded. Hospital costs for each patient including room charges, operating room costs, anesthesia costs, instrument costs, other hospital costs (nursing, medication, laboratory, and radiology), and total costs were also collected. This study was approved by the Siriraj's Institutional Review Board.

Statistical analysis

Data were analyzed using frequency, percentage, median, range and mean ± standard deviation (SD). Statistical analysis was performed with Chi-squared test or Mann-Whitney U test, where appropriate. SPSS statistical software version 20 was used for statistical analysis. A p-value <0.05 was considered as statistically significant.

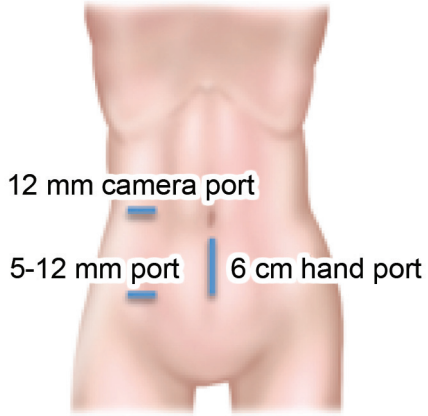

Fig. 1 Port placement position.

Results

One hundred patients with sigmoid cancer (50 cases of HALS and 50 cases of OS) were included in the present study.

Demographic variables of the patients including age, gender, BMI, ASA score, Charlson comorbidity index, history of previous surgery, stage of disease, and tumor size were not significantly different between two groups (Table 1).

Operative outcomes were shown in Table 2. Two cases in the HALS group were converted to open surgery (4%). Blood loss was significantly lower in HALS group compared with the OS group (50 (5-400) mL vs. 120 (10-1,000) mL, respectively, p<0.001). There was no significant difference in operating time between the groups

Table 1. Demographic variables of patients

Characteristic	HALS (n = 50)	OS (n = 50)	p-value
Age (years)	66.1±13.0	66.7±11.6	0.945
Male	58%	52%	0.549
BMI (kg/m^2)	23.1±4.0	22.3±3.1	0.353
Mean ASA score	2	2	0.482
Mean Charlson index	6	6	0.286
History of previous surgery	4 (8%)	6 (12%)	0.507
TNM stage (n)			0.624
I	9 (18%)	15 (30%)	
II	12 (24%)	6 (12%)	
III	29 (58%)	29 (58%)	
Tumor size (cm)	4.4±2.0	4.2±1.8	0.755

HALS = hand-assisted laparoscopic sigmoidectomy; OS = open sigmoidectomy; BMI = body mass index; ASA = American Society of Anesthesiologists; TNM = tumor node metastasis
Values are presented as mean ± standard deviation or number (%)

(169.1±62.2 minutes vs. 149.0±54.8 minutes, respectively, $p>0.05$).

In postoperative period, HALS patients had a shorter length of hospital stay (7.5±1.9 days vs. 11.1±6.5 days, $p<0.001$). Moreover, HALS patients reported significantly lower pain scores and earlier intake of regular diet than those with OS. Postoperative complications were not significantly different between the two groups, except the SSI rate. This was 12% in OS group while none in HALS patients ($p = 0.01$). Postoperative outcomes were shown in Table 3.

Although patients undergoing the HALS procedure demonstrated significant higher operative costs and instrumental costs ($p = 0.023$, $p<0.001$, respectively), room costs and other hospital costs including nursing, medication, laboratory, and radiology costs were significantly higher in the OS group ($p<0.001$). However, the total costs were not significantly different between the two groups ($p = 0.054$) (Table 4).

Comparing SSI patients with non-SSI patients in OS group, there had been longer length of hospital stay in SSI group than non-SSI group (23.5±9.8 days, 9.8±3.8 days, respectively, $p<0.001$). In addition, there were increased room costs, operative costs, other hospital costs, and total costs in SSI group ($466 ($156-$661) vs. $184 ($55-$1,413), $823 ($432-$1,278) vs. $543 ($260-$1,176), $1,966 ($569-$7,991)

Table 2. Operative outcomes

Characteristic	HALS (n = 50)	OS (n = 50)	*p*-value
Conversion to open surgery	2 (4%)	0 (0%)	1.000
Operating time (minute)	169.1±62.2	149.0±54.8	0.091
EBL (mL)	50 (5-400)	120 (10-1,000)	<0.001

HALS = hand-assisted laparoscopic sigmoidectomy; OS = open sigmoidectomy; EBL = estimated blood loss
Values are presented as mean ± standard deviation, number (%), or median (range)

Table 3. Surgical outcomes

Characteristic	HALS (n = 50)	OS (n = 50)	*p*-value
Length of hospital stay (day)	7.5±1.9	11.1±6.5	<0.001
Number of lymph nodes	19.9±9.8	11.2±10.5	0.384
Anastomosis leakage	0 (0%)	2 (4%)	0.155
Bowel ileus	3 (6%)	2 (4%)	0.560
Wound infection	0 (0%)	6 (12%)	0.012
Lung complication	0 (0%)	2 (4%)	0.560
Pain score	4.3±1.7	5.3±1.6	0.008
Time to regular diet (hour)	64.6±20.7	97.6±52.5	<0.001

HALS = hand-assisted laparoscopic sigmoidectomy; OS = open sigmoidectomy
Values are presented as mean ± standard deviation or number (%)

Table 4. Cost detail comparison between HALS and OS group

Cost variable	HALS (n = 50)	OS (n = 50)	*p*-value
Room costs	$114 ($47-$789)	$190 ($57-$1,462)	<0.001
Operative costs	$695 ($378-$1,691)	$590 ($269-$1,322)	0.023
Anesthesia costs	$234 ($128-$498)	$236 ($104-$507)	0.600
Instrument costs	$785 ($22-$2,613)	$134 ($3-$984)	<0.001
Other hospital costs	$388 ($44-$2,341)	$637 ($365-$8,269)	<0.001
Total costs	$2,243 ($1,321-$5,241)	$1,942 ($1,427-$11,910)	0.054

HALS = hand-assisted laparoscopic sigmoidectomy; OS = open sigmoidectomy
Costs are presented as median (range) in US$
Other hospital costs were costs of nursing, medication, laboratory, and radiology.

Table 5. Costs and length of hospital stay in OS group with SSI

Characteristic	Surgical site infection in OS group		*p*-value
	Yes (n = 6)	No (n = 44)	
Length of hospital stay (day)	23.5±9.8	9.8±3.8	<0.001
Room costs	$466 ($156-$661)	$184 ($55-$1,413)	0.024
Operative costs	$823 ($432-$1,278)	$543 ($260-$1,176)	0.020
Anesthesia costs	$267 ($145-$490)	$225 ($101-$407)	0.107
Instrument costs	$237 ($19-$852)	$127 ($0-$951)	0.257
Other hospital costs	$1,966 ($569-$7,991)	$569 ($353-$3,623)	0.003
Total costs	$4,348 ($2,185-$11,509)	$2,140 ($1,379-$6,277)	0.004

OS = open sigmoidectomy; SSI = surgical site infection
Values are presented as mean ± standard deviation and median (range) in US$
Other hospital costs were costs of nursing, medication, laboratory, and radiology.

vs. $569 ($353-$3,623), and $4,348 ($2,185-$11,509) vs. $2,140 ($1,379-$6,277), respectively, $p<0.05$) (Table 5).

Discussion

HALS has been developed as a hybrid laparoscopic technique integrating advantages of both laparoscopic and traditional open techniques[7]. With HALS, surgeons can fully realize the benefits of laparoscopic surgery while retaining the tactile sensation. A previous trial of a HALS study group had demonstrated these advantages[1]. They conducted a prospective, randomized, and multicenter study comparing 18 patients undergoing standard laparoscopic surgery (SLS) with 22 patients undergoing HALS in the treatment of colorectal disease. There were no significant differences in the operative time, postoperative pain, bowel function, and patient recovery compared with the SLS group. These results underlined the benefits of minimally invasive surgery and encouraged surgeons to perform HALS with greater confidence.

Another favorable aspect of HALS is the shorter learning curve required for less experienced surgeons, than traditional laparoscopic surgery[7]. The lower conversion rate was shown in the study of Taragona et al[4]. They reported a prospective randomized, single-center trial comparing laparoscopic-assisted colectomy with HALS. Fifty-four patients were enrolled in the study (27 patients each groups). The operative time was slightly shorter in the HALS group than in the laparoscopic group. The conversion rate was higher in the laparoscopic group (22%) than in the HALS group (7%). Moreover, oncologic outcomes (length of the specimen and the amount of harvested lymph nodes) and short-term outcomes including the use of analgesic drugs, postoperative pain, and postoperative complications were not significantly different between the two groups.

Many studies demonstrated a conversion rate of HALS from 0% to 10%[8,9]. Likewise, our study showed that the HALS group had a conversion rate of 4%. Thus, HALS is a good start for surgical apprentices when laparoscopic surgery is a more complicated procedure with limited two-dimensional perception.

Furthermore, HALS is an option for more complex procedures[10]. Marcello et al[11] reported a prospective, randomized, multicenter trial studying the short-term outcomes of HALS and laparoscopic-assisted method (LAP) for segmental resection of the left colon and total colectomy. There were 47 HALS patients and 48 LAP patients. The primary outcome was the difference in operative time. They found that total operative time for both the total colectomy and segmental colectomy was significantly shorter in the HALS group compared with LAP group ($p = 0.015$ and $p = 0.021$, respectively). For the secondary outcomes, there were no significant differences in bowel function recovery time, length of stay, postoperative pain, narcotic usage, conversion rate, and complications between the HALS group and LAP group. These results revealed the advantages of HALS as a faster operation with preserved desirable short-term outcomes of laparoscopic surgery.

Among the short-term advantages of laparoscopic surgery over open surgery, HALS as a hybrid technique has been studied and compared with standard open colectomy. The results of previous trials and the present study were illustrated in Table 6.

Table 6. Results of clinical trials comparing HALS with OS

Characteristic	Maartense et al.[5]		Sheng et al.[6]		Liu et al.[12]		Present study (2014)	
	HALS	OS	HALS	OS	HALS	OS	HALS	OS
Length of hospital stay (day)	10	11	8.3[a]	12.1[a]	8[a]	11[a]	7.5[a]	11.1[a]
Wound infection rate	3.3%	3.3%	1.7%	7%	2.4%	2.2%	0%[a]	12%[a]
Material costs	$2,615[a]	$1,193[a]	N/A	N/A	$226[a]	$1,992[a]	$785[a]	$134[a]
Total costs	N/A	N/A	$5,797[a]	$5,211[a]	$5,593	$5,638	$2,243	$1,942

HALS = hand-assisted laparoscopic sigmoidectomy; OS = open sigmoidectomy; N/A = not applicable

[a] Significantly different

Values are presented as mean or number (%)

Costs were presented in US$ with the current exchange rate 1 Euro€ = 1.11 US$, 1 Renminbi (RMB) = 0.16 US$ (May 11, 2015).

The authors' study showed the advantages of HALS in terms of blood loss, postoperative pain score, lower SSI rate, and hospital stay. Operative time and oncologic outcome of retrieved lymph nodes number in the HALS group were not significantly different from the OS group. The authors' results have supported the previous studies except the study of Maartense et al[5]. They reported a longer operative time and higher cost with HALS while other short-term outcomes did not show any significant difference when compared with the open procedure. This might be due to the complexity of their operation (restorative proctocolectomy with ileal pouch anal anastomosis). Of note, intraoperative blood loss and length of hospital stay in non-complex colectomy of later studies[6,12], including the present study, were reported to be lesser and shorter than earlier studies[5]. This may reflect the experience surgeons have gained with the procedure over time.

In term of cost-benefit, total costs of HALS and OS demonstrated no statistical difference. In details, HALS operative costs and instrument costs were higher than those of OS. On the other hand, OS patient paid more for room costs and other hospital costs. From Table 3, the patients undergoing OS procedure had to be hospitalized longer than HALS patient (p<0.001). This might be the result of significantly longer time required to regular diet (p<0.001) and higher rate of surgical site infection (12% vs. 0%, p = 0.012). Table 5 demonstrated the costs of OS patient with SSI compared with those without SSI. As a result of SSI, patients were prolonged hospitalized compared with those without SSI (9.8±3.8 days vs. 23.5±9.8 days, p<0.001). This resulted in the higher room costs and other hospital costs (p = 0.024, p = 0.003, respectively). Interestingly, the operative cost is also statistically higher. This is due to OR-based procedures such as extensive wound debridement.

In previous published studies, they had revealed the impact of SSI after open colon surgery on the length of hospital stay (LOS) and the costs. The results showed the LOS was increased by 4.5-7.8 days and the total hospital cost was increased by $1,216 in SSI group. These benefits emphasized why the total costs between the HALS and OS groups were not significantly different.

In Thailand, SSI is still a common postoperative problem. Overall SSI in colon surgery is 10.2%[13] compared with 3% in international large-scale randomized control trials[14]. The potential causes were including inadequate bowel preparation from high-fiber foods, lack of using of wound protection and inadequate hemostasis. Our study showed 12% of SSI in OS group whereas no SSI in the HALS group. Routine use of wound protector in HALS procedure is one of the important protective factors. Others include smaller surgical incision and less blood loss.

In the country where infection is still a common problem, HALS minimizes SSI, thus, a key advantage. Morbidity from infection and related additional costs could be unexpectedly extensive while instrument costs could be decreased as the knowledge in the future including the low-price substitutes or new technology of device production.

Base on these results, the authors encouraged the use of the HALS technique. The authors' approach employed one hand port and two additional ports for a telescope and a laparoscopic device. This three-port technique requires only one assistant surgeon, instead of two with traditional four-port technique. This may be a more favorable approach especially in medical centers or hospitals with a limited number of skillful laparoscopic surgeons. Moreover, the HALS technique can reduce length of hospital stay and unnecessary costs. However, the authors still have limited number of patients and non-randomized study.

Conclusion

HALS has shown superior short-term advantages with similar oncologic outcomes, operative time and total costs, compared to standard OS in non-complex colorectal surgery, particularly in the center that still having high rate of SSI. Fewer surgeons are required in the operation adding to the benefits of the three-port approach. In the future, development of new reusable parts of instruments could expand their use by reducing the financial limitation of this valuable minimally invasive technique.

What is already known on this topic?

Laparoscopic colectomy is a well-established procedure that showed benefice in short-term outcome and comparable oncologic outcome with conventional technique in the patient with colon cancer. However, laparoscopic technique required experienced surgeons. As a result HALS has been developed as a hybrid laparoscopic technique integrating the advantages of both laparoscopic and traditional open techniques. Many studies supports these advantages including shorter operative time, less experience required for starter, and lower conversion.

What this study adds?

The financial problem is the main limitation for patients to undergo minimally invasive surgery. As a result, cost and effectiveness in HALS should be considered and compared with conventional technique. There has not been conclusive data on this topic from either international or Thai publication. Consequently we developed the present study with an aim to demonstrate short-term surgical outcome, as well as cost effectiveness in Thai patient.

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Trakarnsanga A initiated the study, and participated in its design and coordination. Akaraviputh T, Chinswangwatanakul V, Methasate A, Trakarnsanga A, and Phothong N participated in the database collection and follow-up. Hokierti C made the picture of port placement position. Phothong N performed the statistical analysis and drafted the manuscript. All authors read and approved the final manuscript.

Potential conflicts of interest

None.

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ผลการรักษาและความคุ้มค่าของการผ่าตัดมะเร็งลำไส้ใหญ่ส่วน sigmoid ด้วยวิธีผ่าตัดผ่านกล้องโดยใช้มือช่วย แบบ 3 แผลเล็ก

ณัฐวุฒิ โพธิ์ทอง, ธวัชชัย อัครวิพุธ, วิทูร ชินสว่างวัฒนกุล, อัษฎา เมธเศรษฐ, อัฐพร ตระการสง่า

วัตถุประสงค์: *เพื่อศึกษาผลการรักษาผู้ป่วยมะเร็งลำไส้ใหญ่ส่วน sigmoid ด้วยวิธีผ่าตัดผ่านกล้องโดยใช้มือช่วย แบบ 3 แผลเล็ก โดยเปรียบเทียบกับวิธีผ่าตัดแบบเปิดปกติ โดยการประเมินผลการรักษาเบื้องต้น และค่าใช้จ่ายในการรักษาของผู้ป่วย*

วัสดุและวิธีการ: *เป็นการศึกษาแบบย้อนหลังเพื่อเปรียบเทียบผลการรักษาผู้ป่วยมะเร็งลำไส้ใหญ่ส่วน sigmoid ทั้งหมด 100 ราย ระหว่างกลุ่มที่ได้รับการผ่าตัดด้วยวิธีผ่าตัดผ่านกล้องโดยใช้มือช่วย แบบ 3 แผลเล็ก กับวิธีผ่าตัดแบบเปิดปกติ กลุ่มละ 50 ราย แล้วนำข้อมูลผลการรักษาเบื้องต้น และรายละเอียดค่าใช้จ่ายของผู้ป่วย ทั้ง 2 กลุ่ม มาวิเคราะห์เปรียบเทียบกันทางสถิติ*

ผลการศึกษา: *พบว่ากลุ่มผู้ป่วยที่ได้รับการรักษาด้วยวิธีผ่าตัดผ่านกล้องโดยใช้มือช่วย แบบ 3 แผลเล็ก มีข้อดีกว่ากลุ่มผู้ป่วยที่ได้รับการผ่าตัดแบบเปิดปกติ ในแง่ของปริมาณเลือดที่เสียระหว่างผ่าตัด ระยะเวลาที่ผู้ป่วยเริ่มรับประทานอาหาร ความเจ็บปวดหลังผ่าตัด และระยะเวลาในการนอนโรงพยาบาล โดยที่ค่าใช้จ่ายที่ใช้ในการรักษา ไม่ได้มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ*

สรุป: *การผ่าตัดรักษาผู้ป่วยมะเร็งลำไส้ใหญ่ส่วน sigmoid ด้วยวิธีผ่าตัดผ่านกล้องโดยใช้มือช่วย แบบ 3 แผลเล็ก สามารถทำได้อย่างคุ้มค่าในแง่ของค่ารักษา และยังได้ประโยชน์จากแผลผ่าตัดที่มีขนาดเล็ก*