Hand-assisted laparoscopic colectomy versus standard laparoscopic colectomy: a cost analysis


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Abstract

Objective There is a relative dearth of literature comparing hand-assisted (HALC) to standard (SLC) laparoscopic colectomies. HALC seems beneficial in terms of shorter operative times and lower conversion rates, but this is counterbalanced by a greater inflammatory response, larger incisions and higher direct costs. Nevertheless, these results are not consistent throughout existing studies and there are to date no detailed cost comparisons. Our hypothesis was that HALC would not incur significantly higher institutional costs compared with standard laparoscopic techniques.

Method Patients undergoing either SLC or HALC between August 2004 and September 2006 were retrospectively reviewed. All patients were managed using a standard protocol. Outcomes assessed included operative times, conversion rates, pain scores, time to resolution of ileus, length of stay and complications. Total costs were calculated from the day of surgery. Statistical analyses included \( \chi^2 \), Fisher’s exact test, the Mann–Whitney \( U \)-test or nonparametric bootstrapping method.

Results Seventy-three patients underwent SLC while 101 had HALC. Demographics and indications for surgery in both groups were similar; the majority were performed for colorectal cancers. Operative times were shorter (147.5 min vs 172.5 min, \( P < 0.05 \)) and complication rates lower (28.7% vs 45.2%, \( P < 0.025 \)) for HALC. There was no significant difference in the other clinical outcomes. Operative costs and cost of consumables were higher for HALC (US$4024.2 vs US$3568.1, \( P = 0.01 \) and US$1724.7 vs US$1302.7, \( P < 0.001 \), respectively). However, total costs were not significantly different (HALC US$8999.8, SLC US$7910.7, \( P = 0.11 \)).

Conclusion Institutional costs are not significantly higher for HALC compared with SLC.

Keywords Cost, cost analysis, laparoscopy, colectomy, comparative study

Introduction

Laparoscopic-assisted colorectal resection has seen a resurgence in the last 3 years, following the results of a number of multi-centre, randomized controlled trials showing superior short-term outcomes when compared with open resections [1,2]. Early concerns of port-site recurrences and adequacy of oncologic clearance in cancer surgery have been found to be unwarranted [3–5], especially in the hands of experienced laparoscopic colorectal surgeons.

However, while standard or total laparoscopic colectomy (SLC) has become an essential component of the colorectal surgeon’s armamentarium, the role of hand-assisted laparoscopic colectomy (HALC) is less well defined. Proponents of the latter technique say that it retains many of the benefits of the standard laparoscopic approach while restoring tactile sensation to the surgeon [6,7]. This results in superior traction and ease of haemostasis, faster surgery and laparoscopic completion of challenging cases, which would otherwise have been
converted with the standard approach. In addition, it may be a useful bridging technique for surgeons still acquiring the complex skill sets required for the standard technique [8].

On the contrary, purists argue that introduction of the hand results in a larger incision, a more invasive procedure, and interferes with the field of vision [6,8]. Furthermore, a major bone of contention is the added expense of hand-assist devices, a critical point in this age of cost-conscious healthcare systems [9].

Despite the culmination over the last decade or so of a vast amount of literature concerning laparoscopic-assisted colectomy, there have been few head-to-head comparisons of HALC and SLC. The data that is available confers some benefit to HALC in terms of shorter operative times [10–12] and lower conversion rates [10,13], but this is counterbalanced by a greater inflammatory response [13]. Nevertheless, short-term clinical outcomes appear to be similar [10–14]; and although cost is an oft-quoted issue, there are to date no detailed cost comparisons of the two techniques.

Our study aims to compare short-term outcomes and ascertain institutional costs of HALC vs SLC for all surgical indications, with the hypothesis that there would be no difference.

Method

Approval from our institutional review board was obtained prior to commencement of data collection. Elective laparoscopic-assisted colorectal resections performed by the four colorectal surgeons in the unit from August 2004 to September 2006 were retrospectively reviewed. Exclusion criteria included patients with acute intestinal obstruction, preoperative radiological evidence of locally advanced disease and those with contra-indications to pneumoperitoneum. Data collected included patient demographics, operative and histopathological details.

The decision regarding the type of laparoscopic-assisted approach was made prior to commencing surgery, and generally depended on the individual surgeon’s preferred approach. All cases would have been amenable to either technique, based on preoperative investigations. Informed consent was obtained in every case. Standard laparoscopic resections were converted to an open procedure when difficulties were encountered, and not to a hand-assisted approach. As there is currently no consensus in the literature regarding its precise definition, we defined conversions as the need to make an incision exceeding 7 cm [15,16], or modification of the planned extraction site because of the inability to complete the original minimally invasive procedure.

Immediate postoperative outcomes assessed were operative time, pain scores, time to return of bowel function, length of hospitalization, complications and 30-day readmission rates. Pain scores recorded were maximum scores (on movement) as charted by ward nurses. Complications were graded according to the modified Clavien score [17].

All patients were managed according to a standardized colectomy pathway [18], which has been utilized in our institution since 2001. This pathway included predefined criteria for resuming feeds and discharge, allowing objective assessment and decision-making by medical staff not directly involved in this study.

The technique of, and equipment used for, standard laparoscopic resections has been reported in the literature [19]. The resected specimens were removed through the planned extraction incision with the aid of a nonproprietary wound protector. The hand-assisted technique differed with respect to the following: the incision for the hand-assist device was placed in the midline, and tailored to the surgeon’s hand; this subsequently served as the extraction site. The hand-assist devices used were the LAP DISC Hand Access Device (Ethicon Endo-Surgery Inc., Cincinnati, Ohio, USA) or the GelPort System (Applied Medical, Rancho Santa Margarita, California, USA), incorporating an Alexis retractor which also served as a wound protector. Two or three ports for the camera and other instruments were additionally inserted.

In general, the medial-to-lateral approach was utilized in the first instance; the lateral-to-medial approach was occasionally employed when there were difficulties with the former method.

The total cost per patient was calculated based on unsubsidized rates (i.e. the actual cost to the institution) and comprised the following: room charges, treatment fee, consumables, investigations, medication, operative costs, therapy, counselling and other procedural costs.

Statistical analysis

All statistical analyses were carried out using SPSS version 14.0 (SPSS Inc., Chicago, Illinois, USA). The $\chi^2$ test or Fisher’s exact tests were used for categorical variables and the Mann–Whitney $U$-test was used for continuous variables.

The bootstrap statistical method [20] was employed to compare the mean costs. A total of 10 000 simulations were carried out for each calculation. $P$-values of $< 0.05$ were taken to indicate statistical significance.

Results

One hundred and one patients underwent HALC, while 73 underwent SLC. In general, both groups had similar...
demographics (Table 1). However, a larger proportion of the SLC patients (20.5%) had undergone previous abdominal surgery compared with 8.9% of HALC patients.

The indications for surgery were also similarly distributed between the two arms, with the vast majority of cases being colorectal cancers (HALC 73%, SLC 78%), followed by adenomatous polyps (HALC 13%, SLC 10%), diverticulosis (HALC 9%, SLC 9%) and others (HALC 2%, SLC 1%).

Data on length of resected specimens were available for 75 (74.3%) of HALC patients. The overall mean length of HALC specimens was 19 cm; for left-sided resections, it was 16.4 cm (n = 55), right-sided resections, 21.3 cm (n = 18), while that for total colectomies was 73.8 cm (n = 2).

The comparative figures for SLC cases were similar: mean length, 18.9 cm (n = 62, 84.9%), mean length for left-sided resections, 15.5 cm (n = 43), mean length for right-sided resections, 24.8 cm (n = 18); the specimen length for the only total colectomy was 61.5 cm.

For cancer patients, distribution of tumor, node, metastases (TNM) staging was: HALC stage I, 11 (14.9%), stage II, 35 (44.6%), stage III, 21 (28.4%) and stage IV, 9 (12.2%); SLC stage I, 8 (14.3%), stage II, 19 (33.9%), stage III, 23 (41.1%) and stage IV, 6 (10.7%). Mean tumour size (in its largest dimension) was 4.2 cm [standard deviation (SD) 1.6 cm] for HALC and 4.5 cm (SD 1.9 cm) for SLC. Mean lymph node harvest was 16.5 (SD 9.9) for HALC and 16.2 (SD 7.6) for SLC.

Left-sided resections were performed for more than two-thirds of all patients in both arms, with a much smaller proportion of right-sided resections and very few total colectomies (Table 2).

Although a greater proportion of SLC patients had undergone previous surgery, only eight patients required operative adhesiolysis, compared with five of the HALC group.

In terms of outcomes (Table 3), there was a modest reduction of 25 min in median operative time for the HALC group; this was statistically significant. The median operative time for patients who had undergone previous surgery (HALC 135 min, SLC 150 min) was not longer than the overall median for either HALC or SLC, as not all these patients required adhesiolysis. However, when adhesiolysis was required for the present surgery, median operative time was lengthened for HALC (180 min, range 85–340 min) but not for SLC (137.5 min, range 105–180 min).

Overall, there was no difference in postoperative pain scores, time to return of bowel function and length of hospital stay.

Complications occurred in 22 HALC patients (21.8%) and 22 SLC patients (30.1%), P = 0.21. However, some patients suffered more than one complication. Hence, the

### Table 1 Demographics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>HALC (n = 101)</th>
<th>SLC (n = 73)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), median (range)</td>
<td>61 (26–89)</td>
<td>63 (32–89)</td>
<td>NS*</td>
</tr>
<tr>
<td>Sex (ratio), male:female</td>
<td>58:43 (1.35:1)</td>
<td>42:31 (1.35:1)</td>
<td>NS*</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>47 (46.5)</td>
<td>27 (37)</td>
<td>NS*</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>20 (19.8)</td>
<td>18 (24.7)</td>
<td>NS*</td>
</tr>
<tr>
<td>Ischaemic heart disease, n (%)</td>
<td>10 (9.9)</td>
<td>13 (17.8)</td>
<td>NS*</td>
</tr>
<tr>
<td>Previous abdominal surgery, n (%)</td>
<td>9 (8.9%)</td>
<td>15 (20.5%)</td>
<td>0.028</td>
</tr>
</tbody>
</table>

*NS, not significant.

HALC, hand-assisted laparoscopic colectomy; SLC, standard laparoscopic colectomy.

### Table 2 Procedures.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>HALC n (%)</th>
<th>SLC n (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left-sided resections</td>
<td>74 (73.2)</td>
<td>49 (67.1)</td>
<td></td>
</tr>
<tr>
<td>Right-sided resections</td>
<td>22 (21.7)</td>
<td>23 (31.5)</td>
<td></td>
</tr>
<tr>
<td>Total colectomies</td>
<td>3 (2.9)</td>
<td>1 (1.3)</td>
<td></td>
</tr>
</tbody>
</table>

HALC, hand-assisted laparoscopic colectomy; SLC, standard laparoscopic colectomy.

### Table 3 Outcomes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>HALC</th>
<th>SLC</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time (min), mean (range)</td>
<td>147.5 (80–340)</td>
<td>172.5 (90–330)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Conversions (n %)</td>
<td>16 (15.8)</td>
<td>12 (16.4)</td>
<td>NS*</td>
</tr>
<tr>
<td>Incision length [mean (cm) (SD)]</td>
<td>5.9 (0.4)</td>
<td>5.4 (1.0)</td>
<td>0.35</td>
</tr>
<tr>
<td>Pain scores (n %)</td>
<td>85 (84.2)</td>
<td>59 (80.4)</td>
<td></td>
</tr>
<tr>
<td>24 h [median (range)]</td>
<td>3 (0–8)</td>
<td>3 (0–8)</td>
<td>NS*</td>
</tr>
<tr>
<td>48 h [median (range)]</td>
<td>2 (0–7)</td>
<td>2 (0–6)</td>
<td>NS*</td>
</tr>
<tr>
<td>72 h [median (range)]</td>
<td>1 (0–5)</td>
<td>1 (0–7)</td>
<td>NS*</td>
</tr>
<tr>
<td>Bowel function [days, median (range)]</td>
<td>3 (1–15)</td>
<td>3 (1–153)</td>
<td>NS*</td>
</tr>
<tr>
<td>Length of stay [days, median (range)]</td>
<td>4.5 (2–23)</td>
<td>4.0 (1–26)</td>
<td>NS*</td>
</tr>
</tbody>
</table>

*NS, not significant.

HALC, hand-assisted laparoscopic colectomy; SLC, standard laparoscopic colectomy; SD, standard deviation.
conversions occurred in left-sided resections (HALC 12.9% vs SLC 19.5%). The majority of complications were wound-related or ileus (HALC 6 (20.7%) vs SLC 1 (3.0%) for wound complications; HALC 9 (31.0%) vs SLC 9 (27.3%) for ileus). The most common complications were wound-related or prolonged ileus (Table 4). Wound complications were three times more common in SLC, and this was also statistically significant ($P < 0.025$). However, the severity of complications was fairly similarly distributed in both arms, with more than 70% of patients being grade I or II (Table 4). Ordinal regression analysis (proportional odds model) of the most severe complication in each patient showed no significant difference ($P = 0.22$).

Incision size (excluding converted cases) was recorded in 71 (83.5%) HALC patients and in 31 (50.8%) SLC patients. There was no significant difference (Table 3).

A trend towards a higher conversion rate in the SLC group (16.4% vs 12.9% in HALC) proved not to be statistically significant, although this trend appeared to increase when sub-analysis of the second year was carried out (SLC 15.8% vs HALC 19.5%). The majority of conversions occurred in left-sided resections (HALC 13/16, SLC 8/12).

The main reason for conversion was difficulties in mobilization, either for (i) anatomical reasons such as a low rectal tumour, narrow deep pelvis or dilated bowel (HALC 6, SLC 2); (ii) a bulky tumour (HALC 1, SLC 2); or (iii) adhesions (HALC 4, SLC 3). Other reasons were failure to localize the tumour (HALC 2, SLC 1) or urerter (SLC 1), anastomotic leak identified intra-operatively (HALC 2), failure to tolerate the pneumoperitoneum (SLC 1), bowel perforation (SLC 1) and equipment malfunction (HALC 1).

Patients requiring conversion from a laparoscopic to open approach had a longer median length of postoperative hospital stay compared with the overall median: HALC: 6 days (5–11 days) vs SLC 4.5 days (2–23 days); SLC: 5 days (3–8 days) vs SLC 4 days (1–26 days). Median operative times for converted cases were longer compared with the overall median for HALC at 175 min (range: 120–300 min), but shorter for SLC at 137.5 min (range 95–200 min).

Three patients (2.9%) in the HALC group, and five (6.8%) in the SLC group, required readmission within 30 days. These were for intestinal obstruction, wound infection and ureteric injury, respectively, in the HALC group, and occurred between 7 and 15 days postoperatively. In the SLC group, readmissions were for dehydration, acute retention of urine, hypoglycaemia, necrotizing fasciitis and wound infection (one of each), and occurred between 9 and 17 days postoperatively.

There were two deaths in the HALC group (1.9%). One patient died following a myocardial infarction, while the other died after bleeding complications following a re-laparotomy for intestinal obstruction. Of the three deaths in the SLC group (4.1%), one was from an acute myocardial infarction, one was as a result of complications following massive upper gastrointestinal haemorrhage, with the remaining death occurring from multi-organ failure after re-laparotomy for presacral haemorrhage. All deaths occurred during the admission for the primary surgery.

The mean total cost for HALC was US$8999.8 (SD US$3651) compared with US$7910.7 (SD US$4697.1) for SLC. This difference in overall cost was not statistically significant ($P = 0.11$).

Although consumables and operative costs were significantly higher in HALC (Table 5), this did not result in an overall difference. The hand-assist device and a greater use of Seprafilm, disposable ports and more expensive energy sources were the main reasons for the higher consumables cost, while additional procedures (such as ureteric stenting) contributed to the operative costs. The reduction in operative time did not appear to impact on operative costs. There were no significant differences in the other cost categories.

After excluding patients with complications, the mean total cost for HALC was US$8007 while that for SLC was US$6767, which was significantly different ($P < 0.001$).
The cost of readmissions for HALC ranged from US$502.7 to US$29374.1, while those for SLC ranged from US$324.6 to US$135105.9. When the readmissions cost was added to total cost, the mean for HALC was US$9359.7 while for SLC it was US$9807.3, which was not significantly different, although the trend was reversed towards a higher value for SLC.

**Discussion**

As medical technology fast outstrips medical budgets, it is incumbent on healthcare systems to assess the cost-effectiveness of new procedures. Unfortunately, such cost analyses are fraught with difficulties, owing to inherent and often unavoidable variability in institutional cost structuring, indicators, time-frame, case-mix and patient management.

This has been true of cost comparisons between open and standard laparoscopic colorectal resections. Results have been mixed, with both higher and lower costs being attributed to the laparoscopic approach [9,15,21,22]. In addition, such studies do not always provide strong evidence of clinical benefit.

In the few cost analyses conducted comparing the hand-assisted to the open approach, results were mixed, with only operative and consumables costs being analyzed. There are no published detailed cost analyses comparing these two techniques to our knowledge.

Our study demonstrates no significant difference in overall costs for HALC and SLC, despite higher consumables and operative costs in the former.

However, with the exception of the hand-assist device, many consumables were not essential to the performance of HALC, and could potentially be discarded in order to cut costs.

Although a significantly shorter operative time was demonstrated in HALC, this did not seem to impact on operative costs. One explanation could be that in our institution, charges related to operative time are based on hourly blocks; therefore, a difference of 25 min would not have an impact on operative costs. However, for institutions in which 15-min blocks, for instance, are utilized, there could be a significant cost reduction.

Although we show a higher complication rate for SLC compared with HALC, the fact that most of these complications were minor is reflected in the otherwise similar outcome measures in the two arms. It could be argued that complications could have resulted in additional costs that masked the true difference between uncomplicated HALC and SLC; however, if one procedure is consistently associated with a higher morbidity, then ultimately, the cost of this must be considered in terms of the impact on the institution.

More difficult to explain was the increased incidence of wound complications in SLC, particularly when a reduced incidence compared with open surgery has been previously shown [5]. Neither pathology nor wound size could be correlated to the difference. Although a significant reduction in tissue oxygen levels has been demonstrated in SLC, the reason for this reduction is not entirely clear nor has it been correlated to clinical outcome. Furthermore, if the reduction were related to the presence of pneumoperitoneum, a similar effect would be expected in HALC.

We postulate that the increased incidence in SLC may be related to the use of nonproprietary ‘wound-protectors’ during specimen extraction in these patients. Although less expensive than commercial wound-protectors, they migrate easily and may inadvertently allow wound contamination during the extraction. If commercial wound-protectors were to be used, this would further diminish the consumables cost-differential between HALC and SLC, and mitigate any decrease in cost from reduced infections.

A drawback of our study is that owing to the relatively small numbers of patients, and large as well as unequal SD of costs, the statistical power to detect a small difference is limited. Based on our data, assuming a mean cost of $9000 for HALC, and a similar SD of $4000 for both HALC and SLC, then in order to show a difference of 10%, with a power of 0.80, approximately 200 patients would have to be enrolled in each arm. However, as this data has not been previously available in the literature, we feel that our study provides a useful starting point for designing a randomized controlled trial.

If we accept that HALC can be performed with similar costs to SLC, the question of selection then remains as to...
which patients would benefit most from HALC and which patients should continue to have SLC. Our results suggest that more complex cases, such as previous total colectomies/proctocolectomies, diverticulitis or the obese patient, would benefit most from the hand-assist approach.

Another consideration would be the required size of the extraction incision, which is both surgeon and patient related. HALC performed by a surgeon with smaller hands would be appropriate for tackling larger tumours, when the extraction incision length would not be significantly reduced by SLC.

Lastly, the surgeon’s experience and preference should be paramount, given that similar clinical outcomes can be achieved when either technique is performed competently. Whichever technique is used, further strategies for reducing cost should be implemented. Choice and judicious use of energy sources, staples, hand devices and other consumables, as well as patient selection, all have a role to play in driving down the costs of these procedures.

Conclusion

Based on our current data, our institutional costs are not significantly higher for HALC compared with SLC.

References