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ORIGINAL ARTICLE

Laparoscopic versus open right hemicolectomy: a comparison of short-term outcomes

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Abstract
Background The laparoscopic approach is increasingly becoming the gold standard for colorectal resections. While laparoscopic surgery of the left colon and rectum has been evaluated in many studies, laparoscopic resection of the right colon has not been as widely examined. The aim of this study was to examine the short-term outcomes after laparoscopic right hemicolectomies and to determine if they were superior when compared with those after open resection.
Patients and methods Consecutive cases of laparoscopic right hemicolectomies performed between May 2005 and December 2007, in the Department of Colorectal Surgery, Singapore General Hospital, were compared with a matched series of patients who underwent open surgery.
Results From a total of 37 laparoscopic cases, 36 patients successfully underwent laparoscopic right hemicolectomies. There was one conversion, giving a conversion rate of 2.7%. These 37 patients were compared with 40 patients who underwent open right hemicolectomies. The laparoscopic arm was characterised by shorter length of incisions (5.7 vs. 11.2 cm, $p<0.001$) but longer operating times (110.8 vs. 71.6 min, $p<0.001$). Mean number of lymph nodes harvested and length of proximal and distal margins were similar in both groups. There were also no significant differences between the groups in terms of narcotic use, recovery of bowel function, length of stay, post-operative morbidity and 30-day mortality.
Conclusion Laparoscopic right hemicolectomies are as feasible and safe as the open technique. They confer improved cosmesis with smaller incisions but at the expense of longer operating time.

Keywords Right hemicolectomy · Laparoscopic · Colorectal · Conversion · Outcome

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Introduction

Laparoscopic colorectal resections have become increasingly accepted as the technique of choice in the treatment of colorectal diseases, with proven advantages such as less post-operative analgesic requirements, earlier return of bowel function and shorter hospital stay [1-6]. Numerous studies have also demonstrated that there has been no compromise in adequacy of oncological clearance as disease control and overall survival are comparable to open colectomies [1-5, 7-12]. However, the main bulk of the literature centres mainly on either an overall comparison of laparoscopic and open colorectal resections or solely on left-sided laparoscopic resections, with fewer publications comparing solely the outcomes of laparoscopic right hemicolectomies (LRH) with those performed via the open approach. The aim of our study was to evaluate short-term outcomes of LRH performed in our unit against a matched series of patients (matched for age, sex, ASA status and pathology) who underwent open right hemicolectomies (ORH) during the same period. The outcomes evaluated were 30-day mortality, peri-operative complications, duration of operation, length of incision, patient recovery and oncological clearance. We wanted to determine if these outcomes were indeed superior with the laparoscopic approach.

Methods

This study was approved by the Institutional Review Board of Singapore General Hospital (SGH). Medical records of consecutive patients who had elective right hemicolectomies at the Department of Colorectal Surgery, SGH, from May 2005 to December 2007 were retrieved from a prospectively collected computer database. Both benign and malignant diseases were included in the study. Only patients who had colorectal resections were included in the study. Patients who underwent laparoscopic exploration or colonic diversion without resections were excluded.

In the event of colorectal cancer, pre-operative staging of disease was evaluated by plain chest radiographs, ultrasound and/or computed tomography of the abdomen and pelvis. Staging of disease was according to AJCC Cancer Staging Manual, 6th edition [13] after surgical resection with review of the pathological specimen and investigations of distant metastases.

Pre-operatively, all patients received prophylactic enoxaparin for deep vein thrombosis (DVT) prophylaxis and mechanical bowel preparation (polyethylene glycol 2 L) the evening before surgery. Prophylactic antibiotics were administered on induction of anaesthesia. All surgeries were performed by consultant colorectal surgeons experienced in both open and laparoscopic approaches. As this was a retrospective review of data, there was no strict selection criterion to determine if a patient qualified for the laparoscopic approach. The choice of approach was left up to surgeon preference and to the patient after informed consent had been taken.

LRH commenced after insertion of a camera port below the umbilicus and the use of two to three other ports, depending on the preference of the individual surgeon. Transection of the ileocolic and right colic vessels was performed intra-corporeally with either laparoscopic linear staples or with LigaSure Vessel Sealing System (Valleylab, Boulder, CO). Mobilisation of bowel from the ileum to the proximal transverse colon was performed via a medial to lateral approach. The specimen was extracted either through extension of the camera port wound or a limited right-sided transverse incision. Transection of bowel and creation of a functional end-to-end ileocolic anastomosis was completed extra-corporeally with linear staples.

Laparoscopic conversion was defined as incision made to perform any part of the procedure before the right colon was completely mobilised. Reasons for conversion included patient's safety, equipment failure, tumour factors undiagnosed pre-operatively with anatomical uncertainty and invasion to surrounding organs or the development of complications such as bleeding or visceral injury. In our unit, elective ORHs were performed either via a right transverse skin crease incision on the right flank or a short midline incision. Mobilisation of colon was performed using a lateral to medial approach. This was followed by division of vessels and the creation of a functional end-to-end anastomosis with linear staples.

Postoperatively, all patients were managed according to a standardised protocol in a coordinated clinical pathway (CCP; Table 1). This included post-operative chest and ambulatory physiotherapy, dietitian reviews as well as counselling on post-operative care of wounds by specialised colorectal nurse clinicians. Postoperative analgesia was administered via patient-controlled analgesia or continuous infusion of morphine. Advancement of diet post-operatively was carried out as suggested by the CCP. Deviation from CCP was made at surgeon's discretion. All patients received DVT prophylaxis and anti-embolic stockings during the entire duration of hospital stay. Patients were reviewed by their respective surgeons in the clinic 2 weeks after discharge from hospital.

Demographic data such as age, gender, body mass index (BMI) and co-morbidities were assessed. In addition, operative details (operative time, incision length and peri-operative complications), recovery parameters (duration of narcotic usage, time to first flatus and bowel movement, time to full diet and length of stay) and details of resected specimen (pathology, size of lesion, number of lymph nodes and stage of cancer where appropriate) were obtained and analysed.

All statistical analyses were performed using Statistical Package for Social Science (version 14.0; SPSS, Chicago, IL). The chi-square test, Fisher's exact test and Mann–Whitney *U* test were used where appropriate. All statistical tests were assessed at the conventional 0.05 level of significance.

Table 1 Coordinated clinical pathway

POD 1	IV morphine infusion or patient controlled analgesia
	Sips of water to small clear feeds
	Chest physiotherapy and limb exercises
	Sit up in bed
POD 2	Intravenous analgesia discontinued, oral analgesia commenced
	Small feeds
	Urinary catheter removed
	Chest physiotherapy
	Sit out of bed
POD 3	Feeds to Diet of Choice
	Exercise rehabilitation programme
	Ambulate by walking

Results

Thirty-seven patients underwent LRH during this 2.5-year period (May 2005 to December 2007). During the same period, 227 consecutive patients underwent elective ORH. Of these, 40 patients who were matched for age, gender, BMI, ASA status and pathology were selected to be in the control group. This matched group was chosen as the total group of 227 patients who underwent ORH was a disparate group, with a proportion of patients having recurrent or metachronous cancers. The matched group of 40 patients, thus, served as a better comparison group. The clinical and demographic data for the two groups are shown in Table 2. The majority in both groups were males (LRH 51%, ORH 55%) and the mean age was 67.5 years old (Range 37 to 87). Mean BMI was 23 in both groups and the majority of the patients were ASA 2 (LRH 54%, ORH 60%). The most common indications for surgery in both groups were cancer and polyps (LRH 81%, ORH 88%). More than 60% of the patients had stages II or III cancer. Eight patients (22%) in the LRH group had history of previous open abdominal or pelvic surgery compared to seven patients (18%) in the ORH group. The site of incisions was relatively similar between the two groups. In the LRH group, there were five right-sided abdominal incisions and three pfannestiel incisions compared to five and two, respectively, in the ORH group. Type of incisions made for previous operations are listed in Table 3. Patients in the two arms were not specifically matched for history of previous surgery.

The conversion rate in LRH was 2.7% (n=1). In the converted case, mobilisation of the colon commenced but revealed tumour adherence to the duodenum as well as to the superior mesenteric vein that was not apparent in the pre-operative computed tomographic scan. Conversion was made to complete the dissection safely. There was no history of previous abdominal or pelvic surgery in this patient.

Patients who underwent laparoscopic resection had significantly smaller incisions (5.6 vs. 11.2 cm, $p<0.01$) but required longer operating time (111 vs. 72 min, $p<0.01$). The incision length mentioned for the LRH group was the length of the incision used to extract the specimen. It did not include the cumulative length of all the trocar incisions. There were no significant differences in tumour size (LRH 3.9 cm vs. ORH 4.3 cm), number of lymph nodes harvested for cancer resections (LRH 18 nodes vs. ORH 15 nodes) as well as proximal and distal margin clearances (Table 4). Interestingly, post-operative recov-

Table 2 Clinical and demographic data of patients

Factor	LRH (%)	ORH (%)
Gender		
Male	19 (51)	22 (55)
Female	18 (49)	18 (45)
Mean Age (range)	68 (37 to 83)	67 (42 to 87)
Mean BMI (range)	23.5 (17.6 to 35.8)	22.9 (17.1 to 32.7)
ASA		
1	10 (27)	12 (30)
2	20 (54)	24 (60)
3	7 (19)	4 (10)
History of cardiac disease		
Yes	7 (19)	5 (13)
No	30 (81)	35 (88)
History of pulmonary disease		
Yes	1 (3)	1 (3)
No	36 (97)	39 (98)
Pathology		
Cancer	23 (62)	27 (68)
Diverticular Disease	5 (14)	3 (8)
Polyps	7 (19)	8 (20)
Others**	2(5)	2 (5)
AJCC stage	(n=23)	(n=27)
I	4 (17)	5 (19)
II	10 (43)	6 (22)
III	6 (26)	11(40)
IV	3 (13)	5 (19)

Values in parentheses are in percentages unless otherwise stated. **Two cases of Caecal ulcers operated via LRH; one case of Caecal lipoma and one case of Caecal Crohn's disease operated via ORH

Table 3 Patients with previous operations

Factor	LRH	ORH
Type of incisions		
Gridiron	4 appendectomies	2 appendectomies
Pfannestiel	1 myomectomy	1 caesarian section
	1 total hysterectomy	1 total hysterectomy
	1 caesarian section	
Right Subcostal	Nil	1 cholecystectomy
Right Loin	1 nephrectomy	Nil
Laparoscopic	1 tubal ligation 1 cholecystectomy	Nil
Right paramedian	Nil	1 appendectomy and cholecystectomy
Right Subcostal and Gridiron	Nil	1 appendectomy and cholecystectomy
Nil	27	33

Table 4 Comparison between operative and pathological differences

Factor	LRH	ORH	*p* Value
Mean operative time(minutes)	111 (65 to 190)	72 (35 to 160)	<0.01
Type of incision			
Skin crease	29 (78%)	22 (55%)	NA
Vertical	8 (22%)	18 (45%)	
Mean length of incision (cm)	5.6 (3–10)	11.2 (6–20)	<0.01
Mean diameter of tumour (cm)	3.9 (*n*=30)	4.3 (*n*=36)	0.772 (NS)
Mean number of lymph nodes removed	18 (*n*=23)	15 (*n*=27)	0.174 (NS)
Mean proximal margin (cm)	10.1 (*n*=30)	11.2 (*n*=36)	0.704 (NS)
Mean distal margin (cm)	8.6 (*n*=30)	8.7 (*n*=36)	0.852 (NS)
Mean length of lesion (cm)	4.2 (*n*=30)	4.3 (*n*=36)	0.949 (NS)

NA not applicable *NS* not significant

Table 5 Postoperative recovery parameters and complications

Factor	LRH	ORH	*p* Value
Median duration of narcotic usage (days)	2	2	0.478 (NS)
Median time to flatus (days)	2	2	0.199 (NS)
Median time to bowel movement (days)	3	3	0.233 (NS)
Median time to full diet (days)	4	4	0.328 (NS)
Median length of hospital stay (days)	5	5	0.481 (NS)
Peri and post-operative blood transfusions (*n*)	5 (14%)	8 (20%)	0.549 (NS)
Postoperative complications			0.251 (NS)
Superficial wound infection	2	1	
Intra-abdominal abscess	1	0	
Cardiac complication	1	1	
Respiratory complication	1	0	

NS not significant

ery was similar in patients who underwent LRH and ORH (Table 5). In particular, median duration of narcotics use, median time to passing flatus, median time to bowel movement and median time to restoration to full normal diet were similar for both groups. The median length of hospital stay was also similar at 5 days in both groups.

There was also no difference for peri-operative or post-operative blood transfusions in both groups (Table 5). Five patients (14%) in the LRH group and eight (20%) in the ORH group required peri-operative transfusions. All but two of these patients had pre-operative transfusions as they presented with anaemia secondary to a bleeding right-sided neoplasm. The last two patients had transfusions post-operatively when the haemoglobin level was noted to be low.

There was no significant difference between the two groups in terms of post-operative morbidity (Table 5). In the LRH group, two patients developed superficial infections of the wound through which the colon was extracted and were treated sufficiently with antibiotics and wound dressings. Other morbidities included an intra-abdominal abscess away from the anastomostic site possibly due to an infected hematoma, peri-operative acute myocardial infarction and respiratory failure secondary to pneumonia necessitating intubation. In the ORH group, the morbidities consisted of a superficial wound infection and acute myocardial infarction. All patients were treated conservatively and were discharged well. There were no anastomotic leaks or 30-day mortalities in both groups.

Discussion

Laparoscopic colonic resection is increasingly becoming the gold standard of management for both benign and malignant colonic lesions, with good oncologic clearance as well as comparable long term outcomes to open surgery [1-5, 7-12]. Laparoscopic resection of left-sided colonic and rectal lesions has been reported widely. However, in comparison, resection of the right colon via the laparoscopic approach has developed more slowly. There are two possible reasons for this. Firstly, laparoscopic resection of the right colon is commonly regarded as a laparoscopic-assisted procedure rather than a pure laparoscopic procedure, as bowel transection and anastomosis are both carried out extra-corporeally. The second reason is likely because of more complicated anatomy and requirement for more technical expertise in right-sided resections performed laparoscopically. This prompted us to review our results not only to evaluate the safety and feasibility of performing laparoscopic right hemicolectomies in our unit but also to determine if the short-term outcomes were superior to those after the open approach.

The reported rate of conversion for both left and right laparoscopic colorectal surgery varies from 5% to 41% [5, 6, 14, 15]. Conversion rates for right-sided laparoscopic resections range from to 0% to 18% [16-22]. In our series, conversion was performed in only one patient (2.7%), and this was done to complete mobilisation for a locally advanced cancer. We attribute the low conversion rate in our series to optimal patient selection and careful technique during colon mobilisa-

Table 6 Operative time (minutes)

Source	LRH	ORH	*p* Value
Leung et al (1999) [20]	191.8 (mean)	148.6 (mean)	<0.001
Baker et al (2004) [16]	107.2 (mean)	97.4 (mean)	0.155 (NS)
Zheng et al (2005) [18]	152.65 (mean)	147.25 (mean)	0.562 (NS)
Lohsiriwat et al (2007) [23]	207.7 (mean)	104.5 (mean)	<0.001
Tong et al (2007) [19]	165 (mean)	115 (mean)	<0.001
Braga et al (2007) [21]	131 (mean)	112 (mean)	0.01
Chung et al (2007) [22]	110 (median)	97.5 (median)	0.003
Ng et al (2008) [17]	187.5 (median)	145 (median)	0.034

NS not significant

Table 8 Time to bowel recovery (days)

Source	LRH	ORH	*p* Value
Zheng et al (2005) [18] (flatus)	2.24 (mean)	3.25 (mean)	0.012
Lohsiriwat et al (2007) [23] (bowel movement)	3.2 (mean)	3.7 (mean)	0.25 (NS)
Tong et al (2007) [19] (bowel movement)	4 (median)	4 (median)	NS
Chung et al (2007) [22] (flatus)	2 (median)	3 (median)	0.003
Ng et al (2008) [17] (bowel movement)	5 (median)	5 (median)	0.645 (NS)

NS not significant

tion. However, the conversion rate may increase as surgeons attempt LRH on larger and more advanced tumours.

In our LRH series, we have demonstrated equivalent results for the time taken to perform the procedure as well as adequacy of oncologic clearance against other reviews. While it is not surprising that a laparoscopic approach requires a significantly longer amount of time to perform due to the increased complexity of the procedure, the mean operative time of 111 min in our series for a LRH is comparable with reported operative times ranging from 107 to 208 min in other reviews [16-23]. In addition, the mean operative time of 72 min for an ORH in our study was shorter than that reported in other series [16-23] (Table 6). This would have contributed to the difference in operative time being significant. Previous concerns that the number of lymph nodes harvested could be compromised with the laparoscopic approach have been dispelled by numerous studies demonstrating this to be untrue [2, 3, 7]. Similarly, in our subset analysis of the patients who underwent surgery for cancer (23 LRH, 27 ORH), the mean number of lymph nodes harvested were equivalent at 18 and 15, respectively. Margins necessary for oncologic clearance were similar in both groups as well.

One interesting phenomenon in our series is the lack of differences in outcome between both groups. As in other reviews, parameters such as duration of narcotic usage, restoration of bowel function, time to resumption of normal diet and hospital stay were used to compare post-operative recovery. We feel, however, that this may not be adequate in assessing outcome. Firstly, all our post-operative patients are on a CCP. This multidisciplinary approach encourages early ambulation, improves social well-being, thus, hastening discharge and reduces hospital stay. In our unit, ORH patients, thus, have a much shorter length of stay (5 days) as compared to other reviews (range 7 to 18 days; Table 7). This CCP was used similarly for the LRH group, and we have comparable lengths of stay with other LRH reviews (Table 7). Length of stay, however, is influenced by multiple factors including the patient's social support at home and the patient's perception of recovery after a major surgery. Nonetheless, for significant improvements to reduce length of stay, mindsets of our medical personnel involved in post-operative recovery of these patients may

Table 7 Length of stay (days)

Source	LRH	ORH	*p* Value
Leung et al (1999) [20]	5 (median)	7 (median)	0.002
Baker et al (2004) [16]	9.9 (mean)	12.8 (mean)	0.073 (NS)
Zheng et al (2005) [18]	13.94 (mean)	18.25 (mean)	0.043
Lohsiriwat et al (2007) [23]	6.2 (mean)	7.1 (mean)	0.3 (NS)
Tong et al (2007) [19]	6 .0 (median)	7.0 (median)	<0.001
Braga et al (2007) [21]	5.4 (mean) 5 (median)	6.4 (mean) 5 (median)	0.002
Chung et al (2007) [22]	7 (median)	9 (median)	0.004
Ng et al (2008) [17]	7 (median)	9 (median)	0.251 (NS)

NS not significant

Table 9 Time to resuming normal diet (days)

Source	LRH	ORH	*p* Value
Leung et al. (1999) [20]	4 (median)	5 (median)	<0.001
Baker et al (2004) [16]	3.65 (mean)	4.42 (mean)	0.005
Zheng et al (2005) [18]	5.65 (mean)	7.30 (mean)	0.060 (NS)
Lohsiriwat et al (2007) [23]	3.9 (mean)	4.3 (mean)	0.39 (NS)
Tong et al (2007) [19]	3 (median)	4 (median)	<0.001
Braga et al (2007) [21]	2.1 (mean)	3.0 (mean)	0.0001
Chung et al (2007) [22]	3 (median)	3 (median)	0.001
Ng et al (2008) [17]	4 (median)	3 (median)	0.178 (NS)

NS not significant

need to be altered to gear patients with laparoscopic resection for shorter hospital stays.

In addition, we noticed that although the length of incision was significantly shorter in the LRH group, there was no difference in the duration of narcotic usage. One possible reason for this is the type of incision that we use for ORH. In some reviews, LRHs were associated with better pain control and less opioid analgesic usage as compared to ORHs [16, 18]. These open procedures were performed mainly with a midline incision in these studies. In our study, however, the majority of patients in the ORH group had limited transverse skin crease incisions. Numerous studies have found transverse incisions to be associated with less post-operative pain as well as improved pulmonary function as compared to a midline incision [24-28]. Our findings are similar to those reported by Lohsiriwat et al., in which transverse skin crease incisions were used for both open and laparoscopic cases [23].

There have been conflicting results with regard to recovery of bowel function after laparoscopic colectomy, with some studies showing earlier recovery of bowel function with laparoscopic colectomy [18, 22] and others not demonstrating any benefit [17, 19, 23] (Table 8). The difference in time to resumption of normal diet also varies between studies (Table 9). Firstly, assessment of bowel function is often very subjective and is based on restoration of bowel sounds and passage of flatus or stool. In addition, bowel function is also dependent on various factors including quantity of narcotics used, length and type of incision used as well as patient mobility. Progression to diet and rehabilitation, thus, have to be individualised. Lastly, improvements in restoration of bowel function in laparoscopic patients may have been due to treatment biases as many of these reviews were unblinded, and recovery decisions may have been influenced by the mode of operation performed.

Conclusion

We have demonstrated that laparoscopic right hemicolectomy can be performed with minimal complications and oncological clearance in terms of number of lymph nodes removed, and resection margins are comparable to the open method. The operative time required is about 30 min longer with the laparoscopic approach but short term outcomes are similar to that of open right hemicolectomies. There is also the advantage of a shorter incision and, thus, better cosmesis.

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