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ORIGINAL ARTICLES

Perioperative analysis of laparoscopic versus open liver resection

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Abstract

Background Over the past decade there has been an increasing trend toward minimally invasive liver surgery. Initially limited by technical challenges, advances in laparoscopic techniques have rendered this approach safe and feasible. However, as health care costs approach 50% of some provincial budgets, surgical innovation must be justifiable in costs and patient outcomes. With introduction of standardized postoperative liver resection guidelines to optimize patient hospital length of stay, the advantages of laparoscopic liver resection (LLR) compared with open liver resection (OLR) measured by perioperative outcomes and resource utilization are not well defined. It remains to be established whether LLR is superior to OLR by these measurements.

Methods Eighteen LLRs performed at the Vancouver General Hospital from 2005 to 2007 were prospectively analyzed. These data were compared with an equivalent group of 12 consecutive OLRs undertaken immediately prior to the introduction of LLR. Outcomes were evaluated for differences in perioperative morbidity, hospital length of stay, and operative costs.

Results There were no differences between LLRs and OLRs in demographics, pathology, cirrhosis, tumour location or extent of resection. There were no deaths. LLRs had significantly decreased intraoperative blood loss (287 ml versus 473 ml, $p = 0.03$), postoperative complications (6% versus 42%, $p = 0.03$), and length of stay (4.3 versus 5.8 days, $p = 0.01$) compared with OLRs. There were no differences in operating time for LLRs compared to OLRs (135 min versus 138 min, respectively), total time in the operating theatre (214 min versus 224 min), or costs related to stapler/trocar devices (CA $1267 versus CA $1007).

Conclusions LLR is associated with decreased morbidity and decreased resource utilization compared with OLR. Perioperative patient outcomes and cost-effectiveness justify LLR despite introduction of standardized postoperative liver resection guidelines and decreased length of stay for OLR.

Keywords Laparoscopy · Liver resection · Outcomes

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Over the past decade there has been an increasing trend toward a minimally invasive approach to liver surgery [1–4]. Initially, laparoscopic liver resections (LLR) were limited by technical challenges; however, advances in laparoscopic techniques and instrumentation have rendered this approach safe and feasible [5, 6]. A myriad of devices have been introduced that have allowed for easier parenchymal dissection and reliable control of vascular and biliary pedicles. These instruments include stapler devices, ultrasonic dissectors, and coagulator devices adapted for laparoscopic use. In addition, laparoscopic ultrasound probes allow for accurate mapping of liver lesions and their relationship to intrahepatic structures. Further, availability of hand ports can increase a surgeon's confidence to maintain vascular control. All of these advances allow the conduct of the laparoscopic approach to liver surgery to parallel that of an equivalent open liver resection (OLR).

A number of nonrandomized and case series reports have shown that short to intermediate term outcomes are equivalent in LLR compared with OLR [7]. In general, but not uniformly, these studies also suggest that LLR has an advantage over OLR in terms of hospital length of stay (LOS), complication rate, and requirement for blood transfusions [7].

However, as health care costs approach 50% of some provincial budgets [8], every surgical innovation must be justifiable in terms of costs and patient outcomes. Improved patient selection and advances in surgical techniques and perioperative management for patients undergoing LLR or OLR have resulted in decreased morbidity and mortality [7]. Further, with the introduction of standardized postoperative liver resection pathways adapted from colorectal postoperative "fast-track" pathways to optimize patient LOS [9, 10], LOS for patients undergoing OLR has decreased. With the costs associated with laparoscopic devices and decreased LOS for all patients undergoing OLR, it is uncertain whether LLR is superior to OLR in terms of perioperative clinical outcomes and resource utilization. The objective of this study is to determine if LLR was cost-effective and clinically equivalent to OLR in the perioperative setting.

Materials and methods

A prospective analysis of our initial 18 consecutive patients undergoing LLR at Vancouver General Hospital from 2005 to 2007 was performed. Patients were selected for a laparoscopic approach based upon location of lesion, proximity to major vascular structures, and extent of resection. Both benign and malignant lesions were considered for LLR. Patients having lesions requiring right hepatectomy, extended hepatectomy (right or left), central liver resection (segments 4, 5, and 8) or lesions amenable to percutaneous or laparoscopic ablation were excluded. Data from the LLR group were compared with data from an equivalent group of 12 consecutive patients undergoing OLR in the 12 months immediately prior to the introduction of LLR at our institution. These 12 patients undergoing OLR were considered potential candidates for LLR but were performed by laparotomy as a stepwise progression in preparation for the start up of the LLR program. All patients were placed on a standardized postoperative protocol aimed at early mobilization and early feeding regardless of LLR or OLR technique. This protocol initiates oral intake on the first postoperative day with early ambulation aiming for discharge by the fifth postoperative day. Parameters for discharge include full fluid diet, absence of ileus, ambulation, and adequate pain control on oral analgesia. Patients receive a follow-up phone call from a nurse clinician 48 h later to assess their clinical condition. Data regarding patient demographics, presence or absence of underlying liver disease, diagnosis, extent of liver resection, morbidity and mortality, estimated blood loss, LOS, operative time, and cost of surgical devices were retrieved from the prospective database, clinical charts, and hospital databases. The outcomes were evaluated for differences between the LLR and OLR groups in stapler and trocar costs, complication rates, operative times, blood loss, and LOS. The test statistic used for each comparison is indicated in each table, and includes Student's t-test, chi-square contingency table analysis, Fisher exact test, Wilcoxon rank-sum test, and z-test of proportions, as appropriate. Differences were considered statistically significant at $p < 0.05$.

Surgical techniques for LLR and OLR were similar, apart from abdominal access, and were adapted from procedures as previously described [4, 6]. Briefly, for OLR, all patients were given epidural catheters followed by general anaesthetic and placement of hemodynamic monitoring lines, and vascular access. Central venous pressure was maintained between 0 and 5 cmH_2O. A right subcostal incision was used with left subcostal extension if necessary for exposure. Following ultrasound examination, parenchymal dissection and control of major vascular structures was performed with stapler devices. Control of bleeding from the transected liver surface was by argon beam coagulation, diathermy or suture ligation. For LLR, epidural catheters were used selectively. Patients were placed in low lithotomy position. Central venous pressure was maintained at approximately 5 cmH_2O. The laparoscope was introduced using the Hassan technique with initial placement dependent upon the presence or absence of previous incisions. Abdominal pressure was maintained at <15 mmHg. Other trocar sites were placed depending upon the location of the tumor to allow for optimal approach to the proposed line of resection and/or laparoscopic evaluation. In one case, a hand port was used. Parenchymal dissection was by diathermy and stapler application with major pedicles and vascular structures controlled with the stapler device. Any bleeding from the transected surface of the liver was controlled by clip application or cautery coagulation. Argon beam coagulation was avoided. The resection specimen was placed in a modified EndoBag and removed via extension of the periumbilical port site incision. In both OLR and LLR, the Pringle maneuver, tissue sealants, and drains were not used.

The major differences in the disposable devices used between LLR and OLR were stapler devices and a specific disposable trocar used in LLR. The stapler used for LLR was the Echelon Endoscopic Cutter 60-mm stapler (CA $355.60) with reload cartridges (CA $165.10). For laparoscopic access, an EndoPath Xcel Bladeless Trocar (CA $105.42) was used. For OLR, a different set of staplers were used, including the TLC Proximate Linear Cutter 100 mm (CA $191.23) with cartridge reloads (CA $112.04), and the Proximate TX Linear 30-mm vascular stapler (CA $139.84) with reload cartridges (CA $57.14).

Results

There were no differences between LLR and OLR patients with regard to age, gender, underlying pathology or presence of cirrhosis (Table 1). There were no differences in Child–Pugh or Model of End Stage Liver Disease (MELD) scores between the LLR and OLR groups (data not shown).

Extent and types of resection were similar in the LLR and OLR groups (Fig. 1). One patient in the LLR group was converted to OLR because of bleeding from a caudate vein branch.

The average operative time and total theatre time for the LLR and OLR groups are shown in Fig. 2. There was no difference in the operative time required for LLR compared with OLR (mean 135 ± 33 min versus 138 ± 42 min, respectively, $p = 0.5$). Similarly, there was no difference in the total theatre time, which included time required for epidural catheter placement, anaesthetic induction, vascular line placement, and patient positioning in addition to actual operating time, for LLR compared with OLR (mean 214 ± 30 min versus 224 ± 45 min, respectively, $p = 0.8$).

The average utilization of stapler devices, reload cartridges, and disposable trocars for LLR and OLR is shown in Table 2. The average cost of stapling devices and trocars was not significantly different between the LLR and OLR groups (mean CA $1267 ± 409 versus CA $1007 ± 502, respectively, $p = 0.17$).

Table 1 Patient characteristics

	Laparoscopic liver resection ($n = 18$)	Open liver resection ($n = 12$)	p value
Age (years)			
Mean	59	58	0.9*
Range	22–82	32–90	
Gender			
Male	8 (44%)	4 (33%)	0.71**
Female	10 (56%)	8 (67%)	
Pathology			
Hepatocellular carcinoma	9 (50%)	4 (33%)	0.18†
Metastatic disease	5 (28%)	7 (58%)	
Fibronodular hyperplasia	3 (17%)	0	
Hemangioma	1 (6%)	0	
Ciliated foregut cyst	0	1 (8%)	
Cirrhosis	6 (33%)	2 (17%)	0.56§

* Student's t-test

** Fisher exact test

† Chi-square contingency table analysis

§ z-test of proportions

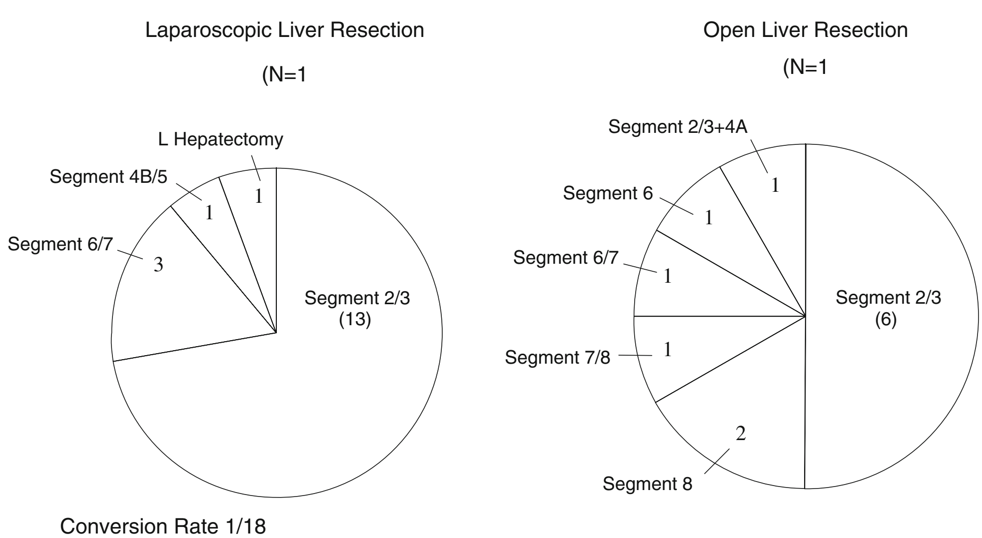

Fig. 1 Type of resection performed

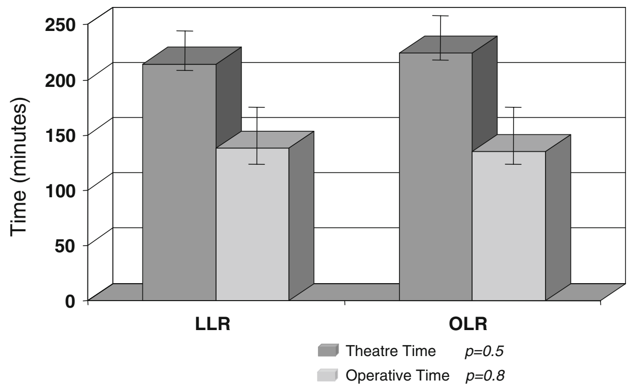

Fig. 2 Operating room time

Table 2 Stapler utilization

Laparoscopic liver resection ($n = 18$)		Open liver resection ($n = 12$)	
Echelon stapler	1.0	TLC linear stapler	1.6
Stapler reloads	5.0	TLC stapler reloads	5.0
XCel trocar	1.0	TX vascular stapler	0.3
		TX stapler reloads	0.7

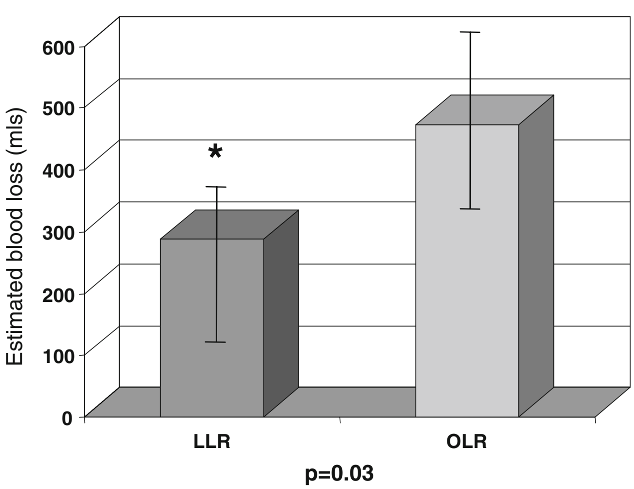

Fig. 3 Estimated blood loss

There were no perioperative deaths, and no patients required blood transfusions. However, as shown in Fig. 3, average estimated intraoperative blood loss was significantly less in the LLR group (mean 287 ± 109 ml versus 473 ± 286 ml, $p = 0.03$). As shown in Table 3, there was also a significantly lower rate of postoperative complications in the LLR group (6% versus 42%, $p = 0.03$), with the increased postoperative complication rate in the OLR group primarily due to wound infections.

As shown in Fig. 4, there was a significantly reduced LOS in the LLR group (4.3 ± 2.3 days versus 5.8 ± 1.7 days, $p = 0.01$).

Table 3 Postoperative complications

	LLR ($n = 18$)	OLR ($n = 12$)
Complication		
UTI	1	1
Wound infection	0	3
Pneumonia	0	1
Complication rate	1/18	5/12 ($p = 0.05$*)

* *z*-test of proportions

UTI urinary tract infection

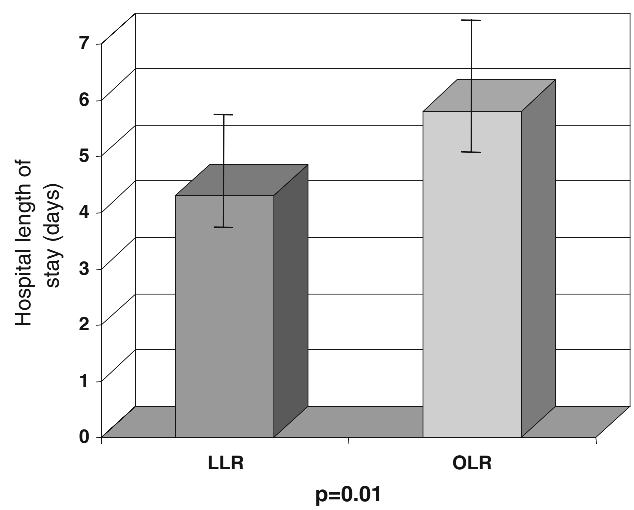

Fig. 4 Hospital length of stay

Discussion

Advances in surgical technology have allowed patients requiring liver resections to be considered for a laparoscopic approach. The major advantages described include reduced complication rates, decreased LOS, cosmesis, and earlier return to work [1–7, 11]. Published reports generally indicate that outcomes following laparoscopic resection of benign and malignant hepatic tumors are comparable to those of conventional open liver resections, particularly with regard to incidence of negative resection margins and disease recurrence [1–7, 11–14].

While many published reports describe the feasibility and favourable results of LLR, the surgical peer-reviewed literature is not universally supportive. While the consensus appears to be that LLR is associated with decreased blood loss and fewer postoperative complications, reported LLR operative times are typically longer than those of OLR [7]. Various studies report a wide range of postoperative LOS following LLR, ranging from 1.4 to 5 days [1–6, 11–14]. A meta-analysis of nonrandomized studies concluded that there is a decreased LOS for LLR compared to OLR, by 2.6 days on average. On the other hand, there are studies that report no significant difference in LOS between LLR and OLR [7].

The discussion surrounding the cost-effectiveness of each surgical innovation is driven by the expense of the new technique and its associated equipment. With health care costs accounting for up to 50% of some provincial budgets [8], the implementation of surgical innovations needs to be reviewed and justified on financial as well as clinical grounds. While the use of stapler devices for hepatic parenchymal dissection is more costly than the traditional fracture technique, these devices are associated with decreased operative times and thereby improved access to scarce operating room resources. In our study, the operative time was just under 140 min for both LLR and OLR. However, the total theatre time was over 200 min and, in some instances, the nonoperative (anaesthesia) time exceeded the operative times. The lengths of nonoperative times were not different between the LLR and the OLR so this cannot be attributed to time required for epidural catheter placement in patients undergoing OLR. Judicious use of new technology and equipment may impact upon LOS and hospital costs by reducing complications and requirements for blood transfusions. In this study, all complications were recorded, with the complication rates significantly decreased with LLR versus OLR. Not surprisingly, the increased complications in the OLR group were related to wound infections and respiratory complications. Blood loss was measured and similarly found to be significantly reduced in the LLR group compared with the OLR group. It is possible that the decreased blood loss in the LLR group was secondary to the raised intra-abdominal pressure from the pneumoperitoneum resulting in a tamponade of low-pressure venous oozing during the procedure. Finally, our data also demonstrated a significantly decreased LOS with LLR compared with OLR.

Standardized postoperative liver surgery guidelines have been in place at Vancouver General Hospital since 2004, which were based on fast-track protocols for colon surgery [10, 15]. Following introduction of fast-track colon resection protocols, the LOS for colon resection has decreased significantly for both open and laparoscopic approaches. According to the Canadian Institutes for Health Information, the average LOS for patients undergoing major hepatobiliary procedures is approximately 9 days. Since the implementation of the standardized postoperative liver surgery protocols at our institution, the expected LOS for major hepatobiliary procedures is 6 days, an improvement in efficiency and cost-effectiveness at least partially attributable to these postoperative protocols.

Some studies report average LOS following LLR of 1–3 days [4–6], which is shorter than reported herein. The difference in LOS between our study and those with shorter LOS may relate to the number of patients in our study who had underlying cirrhosis, a comorbidity that often complicates the postoperative course, and extends the LOS. The impact on LOS caused by the physiological effects of liver resections on cirrhotic patients would be distinct from the effect of the size of the incision. Other studies, though, describe LOS in the range of 4–7 days [12–14, 16].

The focus of this study is on the postoperative aspects of LLR compared with OLR. While not part of the data analysis, there did not appear to be any untoward intermediate-term effects on disease recurrence on any of the resected lesions performed by LLR or OLR (data not shown). These results taken together with the immediate perioperative results suggest that the approach for LLR and OLR was equivalent apart from the technique used to access the abdominal cavity and in keeping with the principle that resection technique should not be compromised when undertaking an LLR.

The findings of this study support the conclusion that use of LLR is equivalent or superior to OLR with regard to instrument costs, operative time utilization, complication rate, and LOS. With standardized postoperative liver resection protocols, however, the perioperative advantages of LLR over OLR with respect to LOS were not as pronounced in this patient population. In conclusion, selective use of LLR is an effective and cost-efficient alternative to OLR.

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