# Starting a new laparoscopic liver surgery program: initial experience and improved efficiency

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**Background:** Owing to the anatomic complexity of the liver and the risk of hemorrhage, most liver resections are still performed using an open procedure. We evaluated the outcomes of introducing a laparoscopic liver program to a community teaching hospital.

**Methods:** We retrospectively reviewed laparoscopic liver resections performed between August 2010 and July 2013 at St. Joseph's Health Centre in Toronto. The primary outcomes were mortality, major morbidity and negative margins. Secondary outcomes included other perioperative outcomes. We used nonparametric tests to compare the outcomes during the first (group A) and second (group B) halves of the study period.

**Results:** Group A included 19 patients and group B had 25 patients; 9 and 4 patients, respectively, had major resections. Group A had the only death due to liver failure. There was no difference in major complications (10.6% v. 16%) or length of stay (4.5 v. 4.6 d) between the groups. One patient in group B had a positive margin. There was a significant decrease in duration of surgery (from 237 to 170 min, $p = 0.007$), with a trend toward shorter duration for major resections (from 318 to 238 min, $p = 0.07$). Furthermore, more procedures were performed for malignancy in group B than group A (36.8% v. 84.0%, $p = 0.001$).

**Conclusion:** Laparoscopic liver resection can be safely introduced into a Canadian community teaching hospital. Average duration of surgery decreased by 67 minutes despite a 2-fold increase in the number of cases performed for malignancy.

**Contexte :** En raison de la complexité anatomique du foie et du risque d'hémorragie, la plupart des résections hépatiques s'effectuent encore par chirurgie ouverte. Nous avons évalué les résultats d'un programme hépatique laparoscopique instauré dans un hôpital d'enseignement communautaire.

**Méthodes :** Nous avons passé en revue de manière rétrospective les résections hépatiques laparoscopiques effectuées entre août 2010 et juillet 2013 au St. Joseph's Health Centre de Toronto. Les paramètres principaux étaient la mortalité, la morbidité majeure et les marges négatives. Les paramètres secondaires incluaient d'autres variables périopératoires. Nous avons utilisé des tests non paramétriques pour comparer les variables durant la première moitié (groupe A) et la seconde moitié (groupe B) de la période de l'étude.

**Résultats :** Le groupe A incluait 19 patients et le groupe B, 25 patients; 9 et 4 patients, respectivement, ont subi des résections majeures. Le groupe A a enregistré le seul décès attribuable à une insuffisance hépatique. On n'a noté aucune différence quant aux complications majeures (10,6 % c. 16 %) ou quant à la durée de l'hospitalisation (4,5 c. 4,6 jours) entre les groupes. Un patient du groupe B a présenté une marge positive. On a noté en général une diminution significative de la durée de l'intervention (de 237 à 170 minutes, $p = 0,007$); dans le cas des résections majeures, on a noté une tendance à la diminution de la durée de l'intervention (de 318 à 238 minutes, $p = 0,07$). En outre, un plus grand nombre d'interventions ont été effectuées pour des cas de cancer dans le groupe B que dans le groupe A (36,8 % c. 84,0 %, $p = 0,001$).

**Conclusion :** La résection hépatique laparoscopique peut être pratiquée de manière sécuritaire dans un hôpital d'enseignement communautaire canadien. La durée moyenne des interventions a diminué de 67 minutes, malgré une augmentation du double du nombre d'interventions effectuées pour des cas de cancer.

 

Laparoscopy was first applied to liver resections in the 1990s.[1] Initially, the procedure was confined to wedge resections. Since then, growing expertise in advanced laparoscopic skills, development of new laparoscopic instruments and established anesthetic techniques for laparoscopy have led to the widespread application of laparoscopy to liver surgery. Now it is more commonplace for hemihepatectomy to be performed laparoscopically; extended hepatectomy and central hepatectomy are less commonly performed in comparison, but there is growing experience reported in recent literature.[2–6] While early experience was focused on benign diagnoses, this approach is now used for many hepatic malignancies.[7–11] It is accepted that minimally invasive liver resections have similar perioperative morbidity, mortality and long-term survival as open resections,[5,9] and some studies have shown that laparoscopic liver resection is associated with less blood loss, shorter hospital stay and comparable long-term survival.[12] However, the procedures are technically demanding, and advanced skills in laparoscopy are required. Owing to the anatomic complexity of the liver and the risk of hemorrhage, most liver resections are still performed in an open fashion.

The purpose of the present study was to report the perioperative outcomes of laparoscopic liver resection when it was first introduced to a hepato-pancreatico-biliary (HPB) surgeon's practice in a Canadian community teaching hospital. The primary outcomes focused on perioperative measures of safety, defined as mortality, intraoperative complications, major postoperative complications, conversion rate and negative tumour margins. Secondary outcomes included other perioperative outcomes, such as duration of surgery, margin revision, percentage of resections performed for malignant etiology and length of stay in hospital (LOS).

## Methods

### Patients

We retrospectively reviewed all laparoscopic liver resections performed between August 2010 and July 2013 at St. Joseph's Health Care Centre (SJHC), Toronto, Ont. Group A consisted of patients whose liver resections were performed during the first half (18 mo) of the study period, and Group B consisted of those who had the procedure during the second half. We included patients who underwent liver resections for benign, symptomatic benign, suspected malignant, premalignant and malignant lesions of the liver, proximal biliary tree or gallbladder. Patients who underwent multivisceral resection or simultaneous major abdominal surgeries of other organs were excluded. Patients were not necessarily excluded owing to a history of chemotherapy and cirrhosis. Surgeon discretion was used in selecting such cases. All cases were discussed in a multidisciplinary tumour board before surgery. The possibility of conversion to open surgery was discussed with patients at preoperative visits, and converted cases were included in our analysis. The SJHC Research Ethics Board approved our study.

All laparoscopic liver resections were performed or supervised by 1 surgeon (S.J.). We defined major hepatic resections as resections with the removal of 3 or more segments and right posterior sectorectomy. There is a lack of universal definition of major hepatectomy in the literature. There have been studies that defined major hepatectomy as 3, 4 or 5 segments resected.[13–16] We sought to adhere to a definition that was compatible with existing literature and reasonable for a laparoscopic approach, especially in the context of introducing laparoscopic liver resections to a surgeon's practice. As a result, the main definition of major hepatectomy in the present study was resection of 3 or more segments. The addition of right posterior sectorectomy was based on the fact that it is a very difficult anatomic area to approach laparoscopically, and its technical demand and duration tend to be closer to that of a hemihepatectomy rather than minor wedge resection.

### Surgical technique

Patients were usually placed in a supine position. For lesions on the right posterior sector, the patient was placed in the right lateral decubitus position with split leg draping. Pneumoperitoneum was established by the open technique at the umbilicus, and intra-abdominal carbon dioxide gas pressure was set to 12 mm Hg. An additional 3–5 trocars of 5–10 mm were placed depending on the tumour location. A diagnostic laparoscopy was performed first, followed by laparoscopic ultrasonography and Doppler assessment of major intrahepatic vasculature. The resection line was first marked on the surface with electrocautery with frequent ultrasound confirmation of the tumour location and planned margin. The liver capsule was divided using a Harmonic scalpel (Ethicon Endo-Surgery Inc.). The parenchyma was divided using the Harmonic scalpel, surgical staplers and clips. Additional surface hemostasis was achieved using the Argon beam coagulator (Erbe USA Inc.). Minor vessels and bile ducts were clipped or divided using ultrasonographic scissors. Larger vessels were divided using mechanical staplers (Endo-GIA, US Surgical Corporation). The Pringle manoeuvre was not routinely used. The resected specimen was removed from a Pfannenstiel incision.

### Data collection

Data on demographic, clinical, perioperative and oncologic characteristics were prospectively collected. The preoperative evaluations collected from electronic charts included clinical history; physical examination; blood

work; tumour markers; and computed tomography (CT) and magnetic resonance imaging (MRI), endoscopy and biopsy findings. Intraoperative findings were collected from operative dictations and the anesthesia record. Mortality was defined as death within 90 days or before hospital discharge. Postoperative complications were recorded by the residents and verified by the attending surgeon at monthly morbidity and mortality rounds. The severity of complications was graded using Clavien–Dindo classification. Histopathology data were collected from online electronic records.

### *Statistical analysis*

All data were prospectively entered into a database. The data were collected as numerical and categorical variables. Bivariate comparisons of nonparametric characteristics and outcomes of groups A and B were performed using Mann–Whitney *U* tests. We compared continuous variables using the Student *t* test. We considered results to be significant at $p < 0.05$.

## RESULTS

A total of 44 patients underwent laparoscopic liver resection during the study period: 19 patients during the first half (group A) and 25 during the second half (group B). Table 1 shows the preoperative, intraoperative, histopathologic and postoperative findings. Converted cases were included in the analysis.

### *Demographics and preoperative variables*

There was no significant difference between groups A and B regarding sex, comorbidity, history of prior abdominal surgery or preoperative chemotherapy (all $p > 0.05$). More procedures were performed on older patients in group B than group A (mean 62.7 v. 47.8 yr, $p = 0.001$).

### *Primary outcomes*

There was 1 death in group A due to liver failure likely related to parenchymal changes (steatohepatitis) from preoperative chemotherapy. There was no statistical difference between groups A and B in the rates of intraoperative complications (15.8% v. 8.0%), intraoperative bleeding resulting in hypotension (15.8% v. 8.0%) or severe postoperative complications of Clavien–Dindo grade III and above (10.6% v. 16%) (all $p > 0.05$). Table 2 summarizes the types of severe postoperative complications. The conversion rate was similar between the groups (2 [10.5%] in group A v. 3 [12.0%], $p > 0.99$). The conversion rate for major resections (more than 3 segments resected) was 23%, and that for minor resections was 6.5%. Table 3 lists the reasons for conversion. One patient in group B underwent wedge resection of liver segment 2 for hepatocellular carcinoma (HCC) had a positive parenchymal margin on final pathology.

### *Secondary outcomes*

There was a significant 67-minute decrease in mean duration of surgery between groups A and B (237 v. 170 min, $p = 0.013$). There was a nonsignificant trend toward shorter major resections (318 min v. 238 minute, $p = 0.07$), with a

**Table 1. Preoperative, intraoperative, histopathologic and postoperative characteristics of study patients**

| Characteristic | Group, no (%) or mean ± SEM | | *p* value |
|---|---|---|---|
| | Group A, *n* = 19 | Group B, *n* = 25 | |
| Preoperative findings | | | |
| Male sex | 5 (26.3) | 12 (48.0) | 0.21 |
| At least 1 comorbidity | 12 (63.2) | 21 (84.0) | 0.16 |
| Prior abdominal surgery | 5 (26.3) | 6 (24.0) | > 0.99 |
| Systemic chemotherapy | 5 (26.3) | 4 (16.0) | 0.47 |
| Age, yr | 47.8 ± 2.8 | 62.7 ± 2.9 | 0.001 |
| Intraoperative findings | | | |
| Complications | 3 (15.8) | 2 (8.0) | 0.64 |
| Bleeding resulting in hypotension | 3 (15.8) | 2 (8.0) | 0.64 |
| Duration of surgery, min | 237 ± 24 | 170 ± 9.5 | 0.007 |
| Duration for major resections, min* | 318 ± 33 | 238 ± 20 | 0.07 |
| Conversion to open | 2 (10.5) | 3 (12.0) | > 0.99 |
| Histopathologic findings | | | |
| Size of largest tumour, cm | 2.6 ± 0.48 | 2.6 ± 0.35 | 0.93 |
| Bilobar tumours | 2 (10.5) | 3 (12.0) | > 0.99 |
| Margin positivity | 0 (0) | 1 (5.0) | > 0.99 |
| Margin revision required | 1 (5.3) | 1 (4.0) | > 0.99 |
| Procedure performed for malignancy | 7 (36.8) | 21 (84.0) | 0.001 |
| Postoperative findings | | | |
| Complications | 3 (15.8) | 5 (20.0) | > 0.99 |
| Major complications | 2 (10.6) | 4 (16.0) | > 0.99 |
| 90-day or in-hospital mortality | 1 (5.26) | 0 (0) | 0.43 |
| LOS, d | 4.5 ± 1.2 | 4.6 ± 0.62 | 0.59 |

LOS = length of stay in hospital; SEM = standard error of the mean.
*$n = 9$ in group A and $n = 4$ in group B.

**Table 2. Breakdown of postoperative complications by type and severity***

| Complication | Group A, *n* = 19 | Group B, *n* = 25 | *p* value |
|---|---|---|---|
| All complications | 15.8% | 20.0% | > 0.99 |
| Severe complications | 10.6% | 16.0% | > 0.99 |
| Type of severe complications | GI bleed, death (V)<br>Pleural effusion (IIIA) | Intra-abdominal hemorrhage (IIIB)<br>GI bleed (IIIA)<br>Biloma (IIIA)<br>Pleural effusion (IIIA) | |

GI = gastrointestinal.
*Severe complications are defined as Clavien–Dindo grades III and above.

difference of 80 minutes. The average LOS did not differ significantly between the groups (4.5 v. 4.6 d, $p = 0.59$).

More than twice as many procedures were performed for malignant etiology in group B as in group A (84.0% v. 36.8%, $p = 0.001$). One patient (5.3%) in each group required intraoperative margin revision after frozen section. Table 4 summarizes the different histopathologic diagnoses. In total, 29 cases were performed for malignancy with colorectal metastasis, HCC and gallbladder cancer being the most common tumour types. Fifteen cases were performed for benign disease; the 3 most common tumour types were focal nodular hyperplasia, biliary adenoma and hepatic cysts that were suspicious for malignancy on preoperative assessments.

## Discussion

Two decades after the first reports of laparoscopic liver resection, more HPB centres are attempting to incorporate laparoscopic liver resection into their practices. The indications for laparoscopic liver resection in early reports were limited to benign lesions, and over the last decade there has been growing experience with adopting laparoscopic liver resection for primary and metastatic lesions.[17–19] The present study demonstrates that within 3 years of introducing laparoscopic liver resection to an HPB surgeon's practice in a Canadian HPB centre of excellence, one can achieve a median decrease in duration of surgery of 67 minutes despite a more than 2-fold increase in malignant caseload while maintaining perioperative outcomes comparable to those at other experienced centres.

During the first 18-month period, young patients and patients with benign diseases were selected. This was a necessary precaution because this population of patients tends to have fewer comorbidities, lower incidence of cirrhosis and better tolerance of intraoperative hemorrhage should it occur. In a review of laparoscopic liver resection, Nguyen and colleagues[5] found that 34% of conversion reported in the literature was because of bleeding. Therefore, we advocate for careful patient selection for the initial portion of the learning curve. As the surgeon gains confidence and experience in advanced laparoscopic skills, older patients and patients with malignant disease become candidates for laparoscopic liver resection. Likewise, it is essential for a surgeon to demonstrate the ability to obtain negative laparoscopic surgical margins before embarking on minimally invasive liver resection for malignancies. Our study shows that over our 3-year study period, the average age of patients increased from 47.8 to 62.7 years and the proportion of resection performed for malignant disease increased from 36.8% to 84.0% without any compromise in perioperative or oncologic outcomes.

Our study showed a significant decrease in duration of surgery and a trend toward decreased duration of major resections by an average of 80 minutes. The mean duration of surgery in our study is within the range reported by previous studies.[7–9,11,12] The only intraoperative complication that occurred in our study was intraoperative bleeding resulting in hypotension, and it accounted for 4 of 5 conversions to open surgery in 3 years. The remaining conversion was because of poor visualization of the tumour. The conversion rates of 6.5% and 23% for minor and major resections, respectively, are close to the rates reported in other large case series.[7,8] Conversion to open surgery should not be a discouragement; instead, timely conversion demonstrates good intraoperative judgment and ensures the safety of the patient.

Regarding histopathologic findings, the tumours tended to be small in size (2.6 cm), and there was 1 case of a positive margin in the 3-year study period. Notably, more malignant cases were incorporated into the surgeon's practice in the second half of the study (group B). This reflects the contemporary trend of an increase in the number of studies reporting laparoscopic liver resections performed for malignant lesions.[5,11,17,19] A recent meta-analysis of 15 studies with long-term oncologic outcomes showed that laparoscopic liver resections resulted in equivalent survival

**Table 3. Reasons for conversion from laparoscopic to open liver resection**

| Group A , $n = 19$ (10.5% conversion rate) | | Group B, $n = 25$ (12.0% conversion rate) | |
|---|---|---|---|
| Converted procedure | Reason for conversion | Converted procedure | Reason for conversion |
| Right hepatectomy | Bleeding, adhesions | Wedge segments 5 and 7 | Bleeding |
| Right hepatectomy | Fatty liver, bleeding | Wedge segments 4A, 6 and 7 | Bleeding |
| | | Wedge segments 4A and 8 | Cannot visualize the tumour |

**Table 4. Final histopathologic diagnosis**

| Pathology | No. (%) |
|---|---|
| Malignant | |
| CRC metastasis | 21 (72.4) |
| HCC | 3 (10.3) |
| Gallbladder cancer | 2 (6.9) |
| Intrahepatic cholangiocarcinoma | 1 (3.4) |
| Adenocarcinoma of unknown primary | 1 (3.4) |
| Breast cancer metastasis | 1 (3.4) |
| Benign | |
| FNH | 4 (26.7) |
| Biliary adenoma | 2 (13.3) |
| Hemangioma | 2 (13.3) |
| Hepatic cyst | 2 (13.3) |
| Focal fat | 2 (13.3) |
| Hepatic adenoma | 1 (6.7) |
| Biliary stricture | 1 (6.7) |
| Chronic cholecystitis | 1 (6.7) |

CRC = colorectal cancer; FNH = focal nodular hyperplasia; HCC = hepatocellular carcinoma.

at 1, 3 and 5 years for patients with malignant tumours.[10] More studies with longer follow-up times are required, and there have been no randomized studies comparing laparoscopic and open liver resections.

One postoperative death (within 90 d) occurred in our study; the patient died of liver failure from underlying steatohepatitis, not the operation itself. The rate of postoperative complications reported in the literature varies among studies, with lower rates reported in series with predominantly minor resections[8,12] and higher rates reported in series with predominantly major resections.[6,7,20] Most severe complications can be managed with interventions without general anesthesia. Only 1 patient in our study required reoperation, and this was because of postoperative intra-abdominal hemorrhage. Although there was no statistical difference in the rate of intraoperative and postoperative complications or oncologic outcomes between the groups, our study may have been underpowered owing to small sample size. Our study is not a comparative study between laparoscopic and open liver resections at the same institution. However, comparing our study to previous literature, the LOS of 4.5–4.6 days in our study is less than that reported for open liver resection, which ranges from 6.5 to 21.6 days.[11] It is still debatable whether the outcomes of laparoscopic liver resections are clearly superior to those of open resections, and it may be difficult to compare outcomes across different centres owing to different policy and culture in postoperative enhanced recovery programs.

## Conclusion

Laparoscopic liver resection can be safely introduced into an HPB surgeon's practice in a community teaching hospital. Average duration of surgery decreased by 67 minutes despite a 2-fold increase in cases performed for malignancy, which is likely a reflection of increased efficiency of the surgeon and the surgical team.

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**Contributors:** Both authors designed the study, acquired and analyzed the data, wrote and reviewed the article and approved the final version for publication.

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