# Starting a laparoscopic hepatectomy programme

Wang E, Kow A W C, Chan C Y, Liau K H, Ho C K


## ABSTRACT

**Introduction: Laparoscopic hepatectomy has been performed in many overseas centres. By avoiding long incisions associated with open hepatectomies, patients suffer less pain, recover faster and enjoy a shorter hospital stay. In Singapore, many centres have recently embarked on this approach. We believe that careful patient selection can facilitate scaling the learning curve. The aim of this study was to review our centre's initial outcome with laparoscopic anatomical liver resection when stringent selection criteria were applied.**

**Methods: For our initial experience, we based our patient selection on criteria recommended by centres more experienced with laparoscopic hepatectomy. We selected only patients with small lesions confined to Couinaud's liver segments of II, III, IVB, V and VI. The surgical technique was similar in all cases, including intraoperative ultrasonography for localisation, ultrasonic shears and surgical staplers for parenchymal transection, and delivery of the specimen via a Pfannenstiel incision. No hand ports were used. Patients' records were retrospectively reviewed.**

**Results: Between July 2006 and August 2007, we had five consecutive patients. Their median age was 50 (range 36–66) years. Four of these patients had hepatocellular carcinomas and one had a liver abscess. The median operation time was 275 (range 250–290) minutes, and median intraoperative blood loss was 400 (range 200–700) ml. The median hospital stay was four days.**

**Conclusion: At the initial stages of a laparoscopic hepatectomy programme, we propose that a stringent patient selection criteria coupled with the proper surgical expertise can ensure favourable outcomes, comparable to more established centres.**


**Keywords: hepatectomy, laparoscopic hepatectomy, laparoscopy, liver surgery, liver tumour**

*Singapore Med J 2009; 50(4): 354-359*

## INTRODUCTION

Laparoscopic surgery has supplanted traditional open surgery in many areas, notably in simple uncomplicated cholecystectomies. The avoidance of long incisions translates into faster recovery and a shorter hospital stay. This has made minimally-invasive operations a popular choice among patients and surgeons, finding a niche in nephrectomies, splenectomies and even colectomies and gastrectomies. After the first anatomical laparoscopic liver resection by Azagra et al in 1996,[1] this procedure has become increasingly popular in many centres. Such centres have consistently reported similar dividends with laparoscopic hepatectomies, with less postoperative pain, faster recovery, earlier discharge and return to function.

Traditional open hepatectomy, by itself, is a technically challenging procedure. In order to reproduce this laparoscopically, it is reasonable to expect a steeper learning curve. Fortunately, hepatobiliary surgeons today have better instruments and camera systems for mounting this challenge. The advancements in optics and instrumentation have made this endeavour easier. The selection criteria for laparoscopic hepatectomies, with regard to a patient's function and lesion characteristics, have been identified.[1-3] Understandably, these are more stringent than those for conventional open resection. A few experienced centres have embarked on more challenging procedures than just wedge resections and segmentectomies, such as laparoscopic right hepatectomies.[3]

In Singapore, a few tertiary healthcare institutions are beginning to take up laparoscopic hepatectomies. In order to sustain any programme, it is crucial to minimise adverse outcomes, particularly at the initial stages of the clinical programme, otherwise this may result in the premature termination of such programmes. Recognising the importance of appropriate case selection and its

**Digestive Disease Centre, Hepatobiliary and Pancreatic Surgery Service, Centre for Advanced Laparoscopic Surgery, Department of General Surgery, Tan Tock Seng Hospital, 11 Jalan Tan Tock Seng, Singapore 308433**

Wang E, BA, MBBS
Medical Officer

Kow AWC, MMed, MRCSE, MRCS
Registrar

Chan CY, MMed, MD, FRCSE
Associate Consultant

Liau KH, MMed, FRCSE, FAMS
Consultant

Ho CK, MMed, FRCSE, FAMS
Consultant

**Correspondence to:**
Mr Ho Choon Kiat
Tel: (65) 6357 7807
Fax: (65) 6357 7809
Email: choon_kiat_ho@ttsh.com.sg

impact on outcomes, the aim of this paper was to assess the operative and early postoperative outcomes of our first few anatomical liver resections when we adhered strictly to the selection criteria as recommended in the literature.[2] We present a series of five cases that make up our initial experience with laparoscopic segment-orientated hepatectomies. The technical aspects of our approach are also described.

## METHODS

The selection criteria we used for our initial cases followed closely those recommended by Gagner et al.[2] Lesions in Couinaud's segments II, III (left lateral), V, and VI (inferior) were most accessible and amenable for laparoscopic resection with minimal manipulation of the entire liver. The maximum tumour size for laparoscopic resection was set at 5 cm, unless it was an exophytic tumour with the bulk of it outside the liver margin. The number of lesions for resection was kept to a maximum of three. Prior to resection, it was routine, in our department, for all patients with underlying chronic liver disease to have their hepatic reserve assessed using the Child-Pugh scoring system. Good baseline liver function was a prerequisite. This would mean a Child-Pugh class grading of A for those patients with underlying chronic liver disease. In addition to the Child-Pugh's grading, all Child class A patients were further subjected to the indocyanine-green clearance test, where we looked at the retention value of the dye at 15 mins (ICG-15). Major hepatectomy or the resection of more than three liver segments would be considered if less than 14% of the dye remained within the plasma at 15 mins. For patients with a retention value of 15%–20%, only one or two segments could be resected. For values above 20%, liver resection was contraindicated. While the presence of cirrhosis was not an exclusion criterion for the consideration of laparoscopic hepatectomy, we excluded those patients with significant portal hypertension that could be inferred from the presence of splenomegaly or oesophageal varices. Triphasic computed tomography (CT) of the abdomen and liver was performed as part of preoperative planning. Patients were also required to be of either American Society of Anesthesiologists (ASA) grade I or II, and able to tolerate a pneumoperitoneum.

All patients were placed in the supine position. After induction with general anaesthesia, a central venous line was inserted so as to allow low central venous pressure facilitated parenchymal transection. The camera was introduced via an umbilical incision using the open technique and three to four working ports were then introduced into positions depending on the location of the liver lesion. The positions of the ports were such that they allowed the surgeon and his assistant to triangulate onto the lesion (Fig. 1). The surgeon would stand on the patient's side, opposite to where the lesion was located, while the monitor was placed at the level of the patient's shoulder on the ipsilateral side of the lesion. A pneumoperitoneum with a pressure of 12 mmHg was created. Adhesions and the falciform/triangular ligaments were divided to mobilise the liver.

Intraoperative ultrasonography was performed to assess for the presence of unsuspected lesions, as well as to determine the boundaries of the lesion and its relationship with major vascular structures. The segmental anatomy was mapped out by delineating the lie of the inflow


**Fig. 1** Photograph shows the port placement for laparoscopic segments V/VI bisegmentectomy. 5/12 mm working ports were placed at "A" and "C". A 10-mm subumbilical (B) port was placed for the camera. A 5-mm working port was placed at "D". A Pfannenstiel incision (E) was made for specimen extraction.

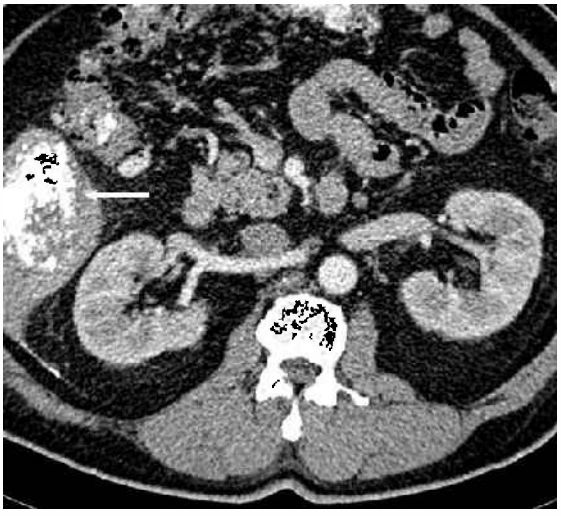

**Fig. 2** A 63-year-old man with a ruptured HCC in segment V/VI which was subsequently angio-embolised. Axial CT image shows the lesion which was filled with lipoidal following the angio-embolisation (arrow).

**Table I. Patients' demographics, preoperative assessment results, operative results and postoperative outcomes.**

| | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---|---|---|---|---|---|
| Age (years) | 48 | 63 | 66 | 50 | 36 |
| Gender | Male | Male | Male | Male | Female |
| Liver cirrhosis | None | None | Yes | None | None |
| Child-Pugh classification | A | A | A | A | NA |
| ICG-15 (%) | NA | 17 | 12.5 | 9.2 | NA |
| Operation time (min) | 290 | 250 | 275 | 285 | 270 |
| Estimated blood loss (ml) | 200 | 300 | 700 | 600 | 400 |
| Tumour size (cm) | 3.5 | 6.8 | 3.8 | 3 | NA |
| Postoperative hospitalisation (days) | 3 | 4 | 4 | 3 | 4 |
| Days to first feed | 1 | 1 | 1 | 1 | 1 |
| Days to full diet | 2 | 2 | 3 | 2 | 3 |
| Time to ambulate (days) | 1 | 1 | 2 | 2 | 1 |
| No. of days of parenteral analgesia | 1 | 1 | 1 | 1 | 1 |
| Liver segments involved | III | V/VI | VI | VI | II/III |
| Histology | HCC Schirrous type Edmondson 2 | HCC Trabecular type Edmondson 2 | HCC grade 3 | HCC Edmondson 1 | Liver abscess |
| Surgical margins (mm) | 2 | 3 | 5 | 17 | NA |

HCC: hepatocellular carcinoma; ICG-15: retention value of indocyanine green at 15 mins; NA: not applicable.

pedicles and the hepatic veins. The resection margins were then scored with monopolar diathermy. A tape was passed around the hepatoduodenal ligament in case inflow occlusion was required. Parenchymal transection was then performed from a superficial to deep fashion using the harmonic scalpel (Ethicon Endosurgery, Johnson and Johnson, Cincinnati, OH, USA). Small biliovascular structures were divided using the harmonic scalpel or with the application of endoscopic clips. Main inflow pedicles and hepatic veins were divided using endoscopic stapling devices with 2.5-mm staples.

The raw liver surface was inspected carefully for bile leaks before being coated with Tisseel glue (Baxter Healthcare, Deerfield, IL, USA). We did not perform a cholecystectomy at the same sitting so as to perform an on-table methylene blue test. The resected specimen was placed into the 15-mm Endocatch retrieval system (United States Surgical Corporation, Norwalk, CT, USA) and retrieved via a small Pfannenstiel incision or by extending the umbilical port site wound. Hand ports were not used. Intraoperative blood loss was estimated by measuring blood aspirated from the operative field. A 12F closed-suction drain was placed through one of the 5-mm ports. The drain was removed when the output was less than 20 ml over a day.

## RESULTS

Table I summarises the results and characteristics of our five patients. Between the time period of July 2006 and August 2007, we identified five suitable patients. Four were men with hepatocellular carcinoma (HCC), and one was a woman with a hepatic abscess. All had lesions in peripherally-located segments. Their median age was 50 (range 36–66) years. Of the four patients with HCC, one had presented as an emergency case with a ruptured HCC. The tumour was angio-embolised with lipoidal and gelfoam to arrest the bleeding (Fig. 2). He was subsequently followed-up with repeated imaging. His viral hepatitis serology was negative. An operation was recommended when the tumour was assessed to be stable without the appearance of new lesions. Intraoperatively, a thorough diagnostic laparoscopy was performed to ensure the absence of any extrahepatic disease before we proceeded. We found the omentum plastered onto the tumour, and this was removed en bloc with the lesion. For the other three patients, two were known Hepatitis B carriers. Their tumours were detected during routine surveillance as part of Singapore's HCC early detection programme for Hepatitis B carriers. The last patient had a recently diagnosed non-muscle invading transitional cell carcinoma of the bladder. An enhancing lesion in the liver was detected during his metastatic workup (Fig. 3). As he had no clinical evidence to suggest a HCC, he was offered either a percutaneous biopsy of the lesion or the option to proceed straight to surgical resection. He chose the latter. Consequently, as we had not suspected a HCC, he was not subjected to the indocyanine green clearance test. For the other three patients who had HCC, their ICG-15 had ranged from 9.2% to 17%. As all our patients in this initial series only had a maximum of two segments removed, these ICG-15 values fell within our inclusion criteria.

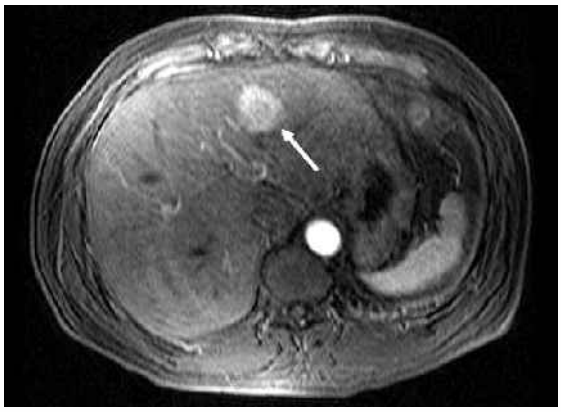

**Fig. 3** A 48-year-old man who had a space-occupying lesion detected in the liver following a metastatic work-up for his newly-diagnosed bladder transitional cell carcinoma. Contrast-enhanced axial T1-W MR image shows a flash enhancing lesion in segment II/III (arrow).

**Fig. 4** A 36-year-old domestic helper who was admitted with a liver abscess. Axial CT image shows a multiloculated abscess in segment III (arrow).

The woman with the liver abscess was a domestic worker who had presented acutely with upper abdominal pain associated with fever. CT demonstrated a multiloculated abscess in segment III of her liver (Fig. 4). This was drained percutaneously but the yield was minimal. Despite intravenous antibiotics, she remained septic. Serial imaging did not demonstrate any reduction in the size of the abscess. She was hence referred to the Hepatobiliary Surgery Service for the consideration of operative management. A diagnostic laparoscopy was performed first. As expected, there were dense adhesions overlying the lateral segment. We managed to divide these laparoscopically and subsequently proceeded to perform the segmentectomy.

The median size of the tumours in our patients with HCC was 3.6 (range 3–6.8) cm. An exception was made for one of our patients (Case two) as his tumour was exophytic, with the bulk of it lying outside the liver margins. The median estimated intraoperative blood loss of our five patients was 400 (range 200–700) ml. None of our patients required an intraoperative blood transfusion. We did not apply inflow occlusion to any of our patients. The median surgical operation time in our patients was 275 (range 250–290) mins. Our patients were all started on feeds and were ambulant on the first postoperative day, and progressed to a full diet by the third postoperative day. All patients also only required one day of parenteral analgesia in the form of patient-controlled analgesia. Consequently, the median length of stay for this series was 4 (range 3–4) days. There were no postoperative complications in any of our patients in this series.

## DISCUSSION

Laparoscopic liver resection has been shown to be more advantageous than open surgery in terms of reduced operative blood loss, less need for Pringle's manoeuvre and a shorter hospital stay.[4] Previous comparative studies on laparoscopic hepatectomy vs. conventional open hepatectomy have consistently shown statistically significant reductions in postoperative recovery time and hence shorter hospitalisations.[5-7] In terms of oncological clearance, it has not been shown to be inferior to traditional open hepatectomies. The earliest report on survival was a three-year mid-term follow-up published in 2006.[8] The authors found that the overall and disease-free three-year survival rates were 93% and 64%, respectively, which was comparable to those of previous reports of open resection for small HCCs.

Encouraged by such findings, our hospital was keen to start our own laparoscopic hepatectomy programme. This was done in a systematic manner. To begin with, the senior author of the paper was sent by the hospital to pursue a clinical fellowship in Australia with a liver surgeon who was already world-renowned for his work on laparoscopic liver resection. At the same time, budgetary projections were made for the purchase of key instruments like the harmonic scalpel, an ultrasound machine with a laparoscopic probe, and the Argon Plasma Coagulator. Following his return, we assembled a dedicated team of surgeons and nurses. Fortunately, we had a team of seasoned laparoscopic hepatobiliary surgeons who have been regularly performing advanced laparoscopic work, such as laparoscopic common bile duct exploration and laparoscopic pancreatectomy.[9] Although we had experience with open hepatic surgery, we attended animal workshops just to familiarise ourselves with liver resection in a laparoscopic environment. Critical skills such as intracorporeal suturing and the proper use of hand ports were learnt. In-house courses were organised for the nurses to familiarise themselves with the instruments and

machines as well as to learn how to troubleshoot.

We then set about defining the inclusion criteria. In this regard, we were extremely conservative, since we were acutely aware that should any adverse outcome occur in the infancy stages of any clinical programme, this may lead to a premature death of that programme. Various authors have already identified certain tumour characteristics to be favourable for the laparoscopic approach. These include the tumour location, with tumours in Couinaud's segments II, III, IVb, V and VI being the most approachable. This is mainly due to the peripheral nature of these segments, thus reducing the need for extensive liver mobilisation. A segment-orientated approach has been reported by Liau et al to be advantageous.[10] Anatomical resection of these segments contribute to the reduction of blood loss, the preservation of healthy liver parenchyma, as well as the avoidance of major conduits, thus reducing the need for vascular or biliary reconstruction. Hence, we decided to select only those patients whose tumour location fit the criteria mentioned, were not more than 5 cm in size and which allowed for an anatomical resection.

With regard to the assessment of hepatic reserve for patients with underlying chronic liver disease, it was our practice to use the Child-Pugh scoring system as the initial test. Only patients in Child-Pugh class A were considered for surgical resection. In addition, we augmented the Child-Pugh score with the ICG-15 test.[11] While some authors have shown that major hepatectomy may still be safe even with an ICG-15 of 20%,[12] our department only offered major hepatectomy for patients whose ICG-15 was less than 14%, and reserving resection of up to a maximum of two segments for those whose ICG-15 was between 15% and 20%. Cirrhosis was not a contraindication to a laparoscopic approach as some authors have already shown that laparoscopic hepatectomy was still feasible in patients with compensated cirrhosis.[13,14]

We found that the intraoperative blood loss and operation time of our series were comparable to those of other centres. The median blood loss of our five patients was 400 (range 200–700) ml, compared to a range of 120–400 ml in other centres.[5,6,15] None of our patients required an intraoperative blood transfusion. This encouraging result may be because of the segment-orientated approach which we had adopted. Another reason, we hypothesised, could be the tamponade effect of the pneumoperitoneum created during laparoscopic surgery, which helped to reduce blood loss along with the low central venous pressure instituted during surgery. Furthermore, the magnified laparoscopic view allowed for the easy identification and control of biliovascular pedicles. Notably, our mean postoperative stay of 3.6 days was lower than most other centres, with some Western centres reporting postoperative stays of 6–8 days following laparoscopic resection,[15,16] and the Japanese centres having inpatient stays of 12–14 days.[5,6] Certainly the seemingly longer stay, particularly of the Japanese series, might reflect some differences in the healthcare system, rather than an actual clinical need for prolonged inpatient care.

Theoretical drawbacks to laparoscopic hepatectomy include the risk of carbon dioxide embolisation. The same pneumoperitoneum that provided the tamponade effect on the bleeding liver surface was thought to be able to push air into the blood vessels, leading to air embolism. This was unfounded as there has been no case report on this complication thus far. Nevertheless, preventive measures were taken, notably by maintaining a pneumoperitoneum of 12 mmHg or less, and maintaining the patient at a slight Trendelenburg position. Our anaesthetist colleagues were also alerted when parenchymal transection was commenced. We felt that our encouraging result was mainly attributed to our patient selection. By adhering closely to the recommended criteria, even though it was only our initial experience, laparoscopic liver resection could be performed safely.

More recent series have reported that major hepatectomies can also be performed safely. Naturally, these reports hail from centres that have extensive experience with this approach and have begun to push the envelope. These included resections of lesions close to the hepatic vein confluence, major hepatectomies with more than three segments resected including right hepatectomies,[3] as well as combined surgical procedures such as laparoscopic colectomies for primary malignancy.[17] Such feats were not achieved overnight, and are the cumulative results of years of experience. Nonetheless, such centres provided us with some insight on what is technically possible as the experience builds up.

The encouraging results of our initial experience underscore the impact of proper patient selection on the outcome, as it was able to compensate for our otherwise novice experience in this surgical technique. For surgical units wishing to start a laparoscopic liver resection programme, we have shown that by adopting the recommended selection criteria, one can obtain good initial outcomes and reap the same dividends associated with minimal access operations as more established centres. With experience and further conquering of the learning curve, the selection criteria can then be extended to a wider range of patients requiring liver resection.

## REFERENCES


1. Azagra JS, Goergen M, Gilbart E. Laparascopic anatomical (hepatic) left lateral segmentectomy: technical aspects. Surg Endosc 1996; 10:758-61.
2. Gagner M, Rogula T, Selzer D. Laparoscopic liver resection: benefits and controversies. Surg Clin North Am 2004; 84:451-62.
3. O'Rourke N, Fielding G. Laparoscopic right hepatectomy: surgical technique. J Gastrointest Surg 2004; 8:213-6.
4. Morino M, Morra I, Rosso E, Miglietta C, Garrone C. Laparoscopic vs open hepatic resection: a comparative study. Surg Endosc 2003; 17:1914-8.
5. Kaneko H, Takagi S, Otsuka Y, et al. Laparoscopic liver resection of hepatocellular carcinoma. Am J Surg 2005; 189:190-4.
6. Shimada M, Hashizume M, Maehara S, et al. Laparoscopic hepatectomy for hepatocellular carcinoma. Surg Endosc 2001; 15:541-4.
7. Mamada Y, Yoshida H, Taniai N, et al. Usefulness of laparoscopic hepatectomy. J Nippon Med Sch 2007; 74:158-62.
8. Cherqui D, Laurent A, Tayar C, et al. Laparascopic liver resection for peripheral hepatocellular carcinoma in patients with chronic liver disease: midterm results and perspectives. Ann Surg 2006; 243:499-506.
9. Das De S, Kow AWC, Liau KH, Lim KH, Ho CK. A novel approach to laparoscopic resection of tumours of the distal pancreas. ANZ J Surg 2009; 79:288-93.
10. Liau KH, Blumgart LH, DeMatteo RP. Segment-oriented approach to liver resection. Surg Clin North Am 2004; 84:543-61.
11. Schneider PD. Preoperative assessment of liver function. Surg Clin North Am 2004; 84:355-73.
12. Poon RT, Fan ST, Lo CM, et al. Extended hepatic resection for hepatocellular carcinoma in patients with cirrhosis: is it justified? Ann Surg 2002; 236:602-11.
13. Belli G, Fantini C, D' Agostino A, et al. Laparoscopic versus open liver resection for hepatocellular carcinoma in patients with histologically proven cirrhosis: short- and middle-term results. Surg Endosc 2007; 21:2004-11.
14. Ker CG, Chen HY, Juan CC, et al. Laparoscopic subsegmentectomy for hepatocellular carcinoma with cirrhosis. Hepatogastroenterology 2000; 47:1260-3.
15. Lesurtel M, Cherqui D, Laurent A, Tayar C, Fagniez PL. Laparoscopic versus open left lateral hepatic lobectomy: a case-control study. J Am Coll Surg 2003; 196:236-42.
16. Bachellier P, Ayav A, Pai M, et al. Laparoscopic liver resection assisted with radiofrequency. Am J Surg 2007; 193:427-30.
17. Vibert E, Perniceni T, Levard H, et al. Laparoscopic liver resection. Br J Surg 2006; 93:67-72.