Outcome of minimally invasive liver resection for extrapancreatic biliary malignancies: A single-institutional experience

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Abstract

Background: Minimally invasive liver resection (MILR) has been increasingly adopted over the past decade, and its application has been expanded to the management of extrapancreatic biliary malignancies (EPBMs). We aimed to evaluate the peri- and post-operative outcome of patients undergoing MILR for suspected EPMB.

Methods: Forty-four consecutive patients who underwent MILR with a curative intent for EPBM at Singapore General Hospital between 2011 and 2018 were identified from a prospectively maintained surgical database. Clinical and operative data were analysed and compared to provide information and make comparisons on peri- and post-operative outcomes.

Results: A total of 26, 5 and 13 patients underwent MILR for intrahepatic cholangiocarcinoma (ICC), perihilar cholangiocarcinoma (PHC) and gallbladder carcinoma (GBCA), respectively. Six major hepatectomies were performed, of which one was laparoscopic assisted and another was robot assisted. Ten patients underwent posterolateral segmentectomies. There was one open conversion. The mean operative time was 266.5 min, and the mean blood loss was 379 ml. The mean length of hospital stay was 4.7 days with no incidences of 30- and 90-day mortality. The rate of recurrence-free survival (RFS) was 75% (at least 12-month follow-up). There was a significantly higher rate of robot-assisted procedures in patients undergoing MILR for GBCA/PHC as compared to ICC \( (P = 0.034) \). Patients undergoing posterolateral segmentectomies required longer operative time \( (P = 0.018) \) with an increased need for \( (P = 0.001) \) and duration of \( (P = 0.025) \) Pringles manoeuvre. There were no differences in operative time, blood loss, morbidity, mortality or RFS between the above groups.

Conclusion: Minimally invasive surgery can be adopted safely with a low open conversion rate for EPBMs.

Keywords: Evolution of minimally invasive hepatectomy, laparoscopic hepatectomy, laparoscopic liver, major hepatectomy, minimally invasive hepatectomy, robotic hepatectomy

INTRODUCTION

The advent of laparoscopic liver resections (LLR) over the past two decades has led to extensive research comparing outcomes of the laparoscopic and open approaches. Although operative time was the one variable commonly...
cited to be significantly longer in LLR, most studies showed similar morbidity and mortality rates between LLR and open liver resections (OLR). In addition, there were significantly less blood loss, blood transfusions, post-operative pain, post-operative morbidity, shorter hospital stay and quicker return to normal function in patients undergoing LLR.[1]

In contrast, the minimally invasive surgery (MIS) has not had the same popularity with extrapancreatic biliary malignancies (EPBM). This trend is especially stark with regard to gallbladder carcinoma (GBCA) where the MIS approach has potential benefits of staging (avoiding a non-therapeutic laparotomy), radical surgery for resectable disease and palliative bypass for locally advanced or metastatic disease. In addition, feasibility is contributed by the relatively limited liver resection required, considerable distance from hilar structures and rare need for complex microanastomoses. However, the MIS approach has traditionally not been widely adopted for GBCA due to early studies’ report on the risks of port-site recurrence.[2,3] Nonetheless, multiple recent studies have demonstrated the feasibility of MIS approach with similar peri-operative and long-term outcomes (port-site recurrence, recurrence-free survival [RFS] and overall survival [OS]).[3,4]

Intrahepatic cholangiocarcinoma (ICC) represents only 5%–7% of laparoscopic resections, with isolated and specific studies being few and far between.[4,5] The need for extensive perihilar dissection, major hepatectomies and biliary vascular microanastomoses precludes MIS from being the go-to option for ICC. Similar challenges are faced with peri-hilar cholangiocarcinomas (PHC), with an equally dismal quantity and quality of pre-existing literature on the MIS approach.[6]

The objective of this study was to report on our centre’s experience with LLR performed in the context of EPBM (GBCA, ICC, PHC and mixed cholangiohepatomas) and to compare between the individual subtypes with regard to peri-operative and post-operative outcomes.

**METHODS**

**Patient selection**

Forty-four consecutive patients who underwent minimally invasive liver resection (MILR) for suspected EPBM between 2011 and 2018 were identified from a prospectively maintained database. This study was approved by our Institutional Review Board. All data were obtained from the patients’ clinical, radiological and pathological records. These were obtained from two prospective computerised clinical databases (Sunrise Clinical Manager version 5.8, Eclipsys Corporation, Atlanta, Georgia, and OTM 10, IBM, Armonk, NY, USA).

**Definitions**

In this study, EPBM included GBCA, ICC, PHC and mixed cholangiohepatomas. Patients included in this study underwent MILR due to a pre-operative diagnosis or pathologically proven diagnosis of these pathologies. The type of hepatectomies was classified according to the Brisbane classification.[6]

**Surgical procedure**

Laparoscopic-assisted procedures involved hepatic mobilisation performed laparoscopically and transection via a planned mini-laparotomy incision. Hybrid procedures involved liver resection (mobilisation/parenchymal transection) performed entirely by MIS (laparoscopically/robotically) but concomitant surgery such as hilar lymphadenectomy/bilioenteric anastomosis performed via a mini-laparotomy incision. All procedures whereby the robot was docked to assist were defined as robotic-assisted procedures.[7] All procedures with a pre-operative plan for MILR but needing to be completed prematurely via an open incision were defined as an open conversion. The operative techniques and approaches adopted have been described in previous studies.[8,9,10] Post-operative complications were classified according to the Clavien–Dindo grading system and were recorded up to 90 days or during the same hospital stay including any readmissions.[9] In-hospital and 90-day mortalities were also recorded.

**Statistical analysis**

All statistical analyses were conducted using the computer program Statistical Package for Social Sciences for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA). Statistical analyses were performed using the Mann–Whitney U-test, Chi-square test or Fisher’s exact test, when appropriate. All tests were two sided, and $P < 0.05$ was considered statistically significant.

**RESULTS**

This study comprised 44 patients who underwent MILR for suspected EPBM. The mean age was 64.3 years, and body mass index was 24.2. There were 23 female and 21 male patients. The mean pre-operative haemoglobin (Hb) was 13.4 g/dl, prothrombin time was 10.4 s, bilirubin was 13.4 µmol/L and albumin was 41 g/L. Ten patients belonged to Class 3 according to the American Society of Anesthesiologists classification, whereas the rest belonged to Classes 1 and 2. Six patients had pre-operative cirrhosis, all of which belonged to Child–Turcotte–Pugh Grade A.
A total of 26, 5 and 13 patients underwent MILR for suspected ICC, PHC and GBCA, respectively. Eight patients underwent robot-assisted liver resections, 1 laparoscopic assisted, 3 hybrid and the remaining 32 underwent pure LLR. Six major hepatectomies (>3 segments) were performed, of which one was laparoscopic assisted and another was robot assisted. Ten patients underwent posterosuperior segmentectomies (I, IVa, VII and VIII) as part of the MILR procedure, of which all but one (laparoscopic assisted) underwent laparoscopically. Two patients had multifocal tumours, with surgery performed completely laparoscopically. Twenty-six patients underwent concomitant cholecystectomy, 15 underwent perihilar lymph node dissections and 1 underwent repair of a concomitant unrelated incisional hernia. The mean tumour size was 5.0 cm. Five patients had post-operative pathologies revealing involved margins (all R1). Only one patient required open conversion due to bleeding intraoperatively.

The mean operative time was 266.6 min, and the mean blood loss was 379 ml. Only four patients required intraoperative transfusion. The mean length of hospital stay was 4.7 days, with only three patients staying beyond 1 week (one patient with bile leak causing intra-abdominal sepsis, one patient requiring intraoperative open conversion due to bleeding and one patient due to social issues). One patient required re-operation (post-operative bleeding from liver bed on post-operative day [POD] 1) and was subsequently discharged on POD 6 in a good condition. Perihilar lymph node dissection, tumour size and multifocality were all not statistically significantly associated with operative time, blood loss, morbidity, RFS or a greater need for open conversion or assisted procedures (P > 0.05). There were no incidences of 30- and 90-day mortality.

All patients were followed-up for at least 12 months. The median follow-up time was 35 months (range, 12-79 months) and there were 11 recurrences (25%). The median RFS was 37 months (range, 2-79 months) with only 2 recurrences occurring in patients with R1 margins (n = 5). Of note, these two patients presented with systemic recurrences in the lung. None of the recurrences were localized to port sites or peritoneum.

The clinicopathological characteristics of patients included in this study are summarised in Table 1. Hb levels of patients with GBCA/PHC were significantly lower than those with ICC. Platelet levels of patients with ICC were significantly lower than those with GBCA/PHC. Expectedly, all patients with hepatitis (n = 8) and cirrhosis (n = 6) presented with ICC. There were no other significant differences between patients undergoing MILR for ICC or GBCA/PHC. Final histology revealed 8 benign and 36 malignant pathologies including 20 ICC, 4 PHC and 12 GBCA. The benign pathologies included gallbladder adenoma, gallbladder adenomyomatosis and sclerosing haemangioma.

Comparison between peri- and post-operative outcomes of patients with ICC and GBCA/PHC undergoing MILR demonstrated no significant differences apart from the need for robotic-assisted or hybrid procedures. Nine patients with GBCA/PHC underwent robot-assisted (n = 6) or hybrid (n = 3) procedures. Robotic assistance was used in these cases for bilio-enteric anastomoses. Hybrid procedures were used for a combination of bilio-enteric anastomoses and hilar lymphadenectomy. Only one laparoscopic-assisted (open resection) procedure was performed for the entire cohort (ICC). This was performed for a patient during our early experience whereby adhesiolysis and mobilisation of the right lobe was performed laparoscopically, and resection of segments 7 and 8 was performed via a mini-laparotomy incision. There was a statistically significantly higher rate of robot-assisted procedures in patients undergoing MILR for GBCA/PHC as compared to their counterparts with ICC (P = 0.033). This difference was not statistically significant for laparoscopic-assisted and hybrid procedures (P = 0.146). Apart from the above, there were no other significant differences between the two groups [Table 2].

A further comparison was conducted between patients undergoing anterolateral hepatectomies and posterosuperior segmentectomies (I, IVa, VII and VIII). Expectedly, the group requiring posterosuperior segmentectomies required longer operative time, with an increased need for Pringle’s manoeuvre. The duration of Pringle’s manoeuvre was also significantly longer in patients undergoing posterosuperior segmentectomies. Of note, however, there were no significant differences in need for assisted procedures, margin status, open conversion, blood loss and immediate post-operative outcomes (length of hospital stay, readmissions, mortality and morbidity). There was also no significant difference with regard to RFS [Table 3].

**DISCUSSION**

Biliary tract cancers are defined as malignancies arising from the epithelium of the gallbladder and bile ducts. Complete surgical resection is almost always the only chance for cure, whereas systemic therapy is mainly used in the palliative or adjuvant setting. Unfortunately, EPBMs have a high propensity for vascular and lymphatic metastasis,
with <10% of patients presenting with early-stage disease amenable to curative resection.\(^{[13]}\)

The open approach to surgical management of EPBMs is well documented, is standardised and is competently executed at many tertiary centres, making it the standard option of choice for this technically demanding group of diseases. On comparison, the MIS approach is considered novel with few well-powered studies reported in the current literature for meaningful comparison or guidance to patient selection and surgical technique. This study represents our experience with LLR for EPBMs, showing promising peri- and post-operative results and identifying difficulties faced when managing this entity.

Radical cholecystectomy with regional lymphadenectomy and liver resection is the treatment of choice for Stage 1b and above GBCA, most commonly diagnosed incidentally after cholecystectomy performed for a presumed benign aetiology. Previous arguments against the MIS approach for GBCA mainly revolved around the risk of port-site recurrence, peritoneal metastasis from bile leak and concerns regarding the oncologic adequacy of laparoscopic clearance.\(^{[2,3,14]}\) However, the bulk of these studies were performed in the early 2000s, with a significant number of patients suffering from port-site recurrence and peritoneal metastasis having bile leakages occurring during laparoscopic cholecystectomy for undiagnosed GBCA.\(^{[14]}\) In the setting of GBCAs diagnosed post-cholecystectomy

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**Table 1: Comparison between baseline clinicopathologic features and perioperative outcomes of different groups**

|                      | Total | ICC | GBC/PHC | SD       | P     |
|----------------------|-------|-----|---------|----------|-------|
| n                    | 44    | 26  | 18      |          |       |
| Age (years), mean    | 64.3  | 62.5| 66.2    | 10.657   | 0.181 |
| Male, n (%)          | 23 (52.3) | 16 (61.5) | 7 (38.9) | 0.505   | 0.146 |
| BMI, mean            | 24.3  | 23.5| 25.5    | 5.331    | 0.231 |
| CVRF, n (%)          | 35 (79.6) | 19 (73.1) | 16 (88.9) | 0.338   | 0.335 |
| Hepatitis, n (%)     | 8 (18.2) | 8 (30.8) | 0 (0.0) | 0.390   | 0.008 |
| Haemoglobin (g/dL), mean | 13.4 | 13.9| 12.6    | 1.753    | 0.017 |
| Platelets (x10^3/L), mean | 256.2 | 227.8| 297.2   | 90.024   | 0.010 |
| PT (s), mean         | 10.4  | 10.5| 10.4    | 0.516    | 0.429 |
| Albumin (g/L), mean  | 41.1  | 41.5| 40.3    | 4.813    | 0.421 |
| Bilirubin (µmol/L), mean | 13.4 | 12.1| 15.3    | 7.141    | 0.146 |
| Cirrhosis, n (%)     | 6 (13.6) | 6 (23.1) | 0 (0.0) | 0.123   | 0.016 |
| CTP score, mean      | 6.1   | 5.7 | 6.2     | 1.023    | 0.236 |
| ASA score, mean      | 2.2   | 2.1 | 2.3     | 0.526    | 0.217 |
| Previous abdominal surgery, n (%) | 12 (27.3) | 5 (19.2) | 7 (38.9) | 0.362   | 0.238 |
| Previous liver surgery, n (%) | 0     | 0   | 0       |          |       |
| Tumour size (mm), mean | 50.4 | 32.7| 76.4    | 134.203  | 0.306 |

BMI: Body mass index, CVRF: Cardiovascular risk factors (i.e., diabetes mellitus, hypertension, hyperlipidaemia, ischaemic heart disease), PT: Prothrombin time, CTP: Child-Turcotte-Pugh score, ASA: American Society of Anesthesiologists, ICC: Intrahepatic cholangiocarcinoma, GBC: Gallbladder carcinoma, PHC: Perihilar cholangiocarcinoma, SD: Standard deviation

**Table 2: Comparison between outcomes of minimally invasive liver resection approach in different subgroups**

|                      | Total | ICC | GBC/PHC | SD       | P     |
|----------------------|-------|-----|---------|----------|-------|
| n                    | 44    | 26  | 18      |          |       |
| Robot assisted, n (%)| 8 (18.2) | 2 (7.7) | 6 (33.3) | 0.275   | 0.033 |
| Laparoscopic assist/hybrid, n (%) | 4 (9.1)  | 1 (3.9) | 3 (16.7) | 0.396   | 0.146 |
| Closest margins (mm), mean | 8.7   | 7.2 | 11.6    | 10.732   | 0.298 |
| Close margins (<1 mm), n (%) | 5 (11.4)  | 2 (8.3) | 3 (15.8) | 0.324   | 0.142 |
| Open conversion, n (%) | 1 (2.3)  | 1 (4.2) | 0 (0.0) | 0.013   | 0.798 |
| Need for Pringles manoeuvre, n (%) | 16 (36.4) | 11 (42.3) | 5 (27.8) | 0.798   | 0.426 |
| Pringles duration (min), mean | 18.3  | 24.5| 9.2     | 27.644   | 0.070 |
| Operative time (min), mean | 266.6 | 231.4| 317.4   | 167.804  | 0.095 |
| Lymph node harvest, mean | 10.3  | 9.9 | 10.5    | 1.927    | 0.286 |
| Blood loss (ml), mean  | 378.6 | 469.0| 248.1   | 715.143  | 0.319 |
| Intraoperative transfusion, n (%) | 10 (22.7) | 5 (19.2) | 5 (27.8) | 0.291   | 0.401 |
| Length of hospital stay (days), mean | 4.7   | 4.0 | 5.8     | 4.338    | 0.190 |
| 30-day re-admission, n (%) | 2 (4.6)  | 1 (3.9) | 1 (5.6) | 0.432   | 0.899 |
| Post-operative all-cause morbidity, n (%) | 11 (25.0) | 6 (23.1) | 5 (27.8) | 0.236   | 0.625 |
| Major CD complications, n (%) | 3 (6.8)  | 1 (3.9) | 2 (11.1) | 0.255   | 0.359 |
| 30-day mortality       | -     | -   | -       |          | -     |
| 90-day mortality       | -     | -   | -       |          | -     |
| RFS (yes), n (%)       | 33 (75.0) | 20 (76.9) | 13 (72.2) | 0.438   | 0.170 |

ICC: Intrahepatic cholangiocarcinoma, GBC: Gallbladder carcinoma, PHC: Perihilar cholangiocarcinoma, SD: Standard deviation, CD: Clavien-Dindo, RFS: Recurrence-free survival
for an inaccurately assumed benign pathology, more recent studies have shown no survival benefit of open surgery over MIS for repeated oncological resections if performed by a trained hepatobiliary surgeon.[15–17] Agarwal et al. reported similar promising results in the largest study to date of 147 patients with GBCA undergoing radical cholecystectomy. In this study, there were no significant differences found between patients undergoing laparoscopic (laparoscopic radical cholecystectomy [LRC]) and open radical cholecystectomy with regard to morbidity, mortality, lymph node yield and RFS. While the group undergoing LRC had a relatively longer operating time, it was associated with significantly less blood loss. Importantly, there were no reports of port-site or peritoneal recurrence in either group.[13] Interestingly, in a study involving 402 patients, Whalen et al. reported that laparoscopic manipulation of a malignancy-containing gallbladder (performed unsuspecting for presumed benign aetiology) did not result in a significant difference in survival as compared to patients undergoing a standard open cholecystectomy, if afforded the appropriate definitive oncological therapy post-cholecystectomy.[18] Elmoghazy et al. reported promising results in a recent case series of ten patients with GBCA undergoing MILR. There were no conversions to open, median blood loss minimal at 110 ml, with all patients achieving an R0 resection and a median lymph node harvest of 10. The post-operative mortality was limited to one patient due to pulmonary embolism.[19] The results of our study are similarly encouraging with no open conversions, hand assistance or laparoscopic assistance. There were a 100% rate of R0 resection, mean lymph node harvest of 10, mean blood loss of 190 ml and mean operative time of 250 min. Three patients had MILR performed with robotic assistance and another two received hybrid procedures. No patient had major post-operative morbidity (Clavien–Dindo 3–5) and 30- or 90-day mortality. There were three recurrences at 8, 14 and 28 months in the lungs and liver, respectively.

Extrapancreatic cholangiocarcinomas (ICC and PHC) represent unique challenges with an MIS approach, mostly relating to the need for biliary and vascular anastomoses. The MIS approach is rarely used for this disease entity and offered to only approximately 5%–10% of patients.[19,20] Elmoghazy et al. reported a case series of 25 patients with extrapancreatic cholangiocarcinomas (14 ICC; 11 PHC) treated with an MIS approach. In this study, the median blood loss was 225 ml, conversion rate was 25% and mean lymph node harvest was 5.6. The post-operative mortality was 12%. Nearly 80% of patients achieved an R0 resection and 24% of the patients had complications of biliary leak (2 ICC; 4 PHC). Of note, patients with PHC treated with MIS generally fare worse than their counterparts with ICC (blood loss, operative time, need for open conversion, rates of R0 resection, morbidity and mortality), with rates of open conversion and operative time being the two factors significantly different.[4] This remains the most recent and second-largest study on MIS for PHC. Yu et al. performed, in 2011, the largest study on MILR for PHC to date (14 patients with Bismuth I and II PHC). In their study, the median operating time and blood loss were 305 min and 386 ml, respectively. Bismuth II lesions presented with significantly lower R0 resection rates (60% vs. 100%), longer hospital stays (19 days vs. 9 days) and higher rates of bile leaks (60% vs. 14.3%). Port-site metastases occurred in two cases of Bismuth II tumours, with in-hospital morbidity and mortality reported at 35.7% and 0% for patients with Bismuth I and

### Table 3: Comparison between minimally invasive approach to conventional and posterolateral laparoscopic liver resections

|                         | Total | Normal LLR | Posterosuperior LLS | SD   | P   |
|-------------------------|-------|------------|---------------------|------|-----|
| n                       | 44    | 34         | 10                  |      |     |
| Robot assisted, n (%)   | 8 (18.2) | 6 (17.7) | 2 (20.0)            | 0.836| 0.286|
| Laparoscopy assisted/hybrid, n (%) | 4 (9.1) | 2 (5.9) | 2 (20.0)            | 0.408| 0.072|
| Closest margins (mm), mean | 8.7   | 10.5       | 4.8                 | 10.732| 0.173|
| Close margins (<1 mm), n (%) | 5 (11.4) | 2 (5.9) | 3 (30.0)            | 0.652| 0.078|
| Open conversion, n (%)  | 1 (2.3) | 1 (2.9) | 0 (0.0)             | 0.013| 0.592|
| Pringles manoeuvre, n (%) | 16 (36.4) | 7 (20.6) | 9 (90.0)            | 0.126| 0.018|
| Pringles duration (min), mean | 18.3 | 49.6 | 49.6                |      |     |
| Operative time (min), mean | 266.6 | 241.7 | 351.0               | 167.804| 0.025|
| Blood loss (ml), mean   | 378.6 | 325.3 | 560.0               | 715.343| 0.368|
| Blood transfusion, n (%) | 10 (22.7) | 7 (20.6) | 3 (30.0)          | 0.263| 0.378|
| Length of hospital stay (days), mean | 4.7 | 3.8 | 5.0 | 4.338| 0.439|
| 30-day re-admission, n (%) | 2 (4.6) | 2 (5.9) | 0 (0.0)            | 0.263| 0.286|
| Post-operative all-cause morbidity, n (%) | 11 (25.0) | 7 (20.6) | 4 (40.0)          | 0.286| 0.178|
| Major CD complications, n (%) | 3 (6.8) | 2 (5.9) | 1 (10.0)          | 0.255| 0.659|
| 30-day mortality         | -     | -         | -                   | -    | -   |
| 90-day mortality         | -     | -         | -                   | -    | -   |
| RFS (yes), n (%)          | 33 (75.0) | 26 (76.5) | 7 (70.0)          | 0.473| 0.826|

LLR: Laparoscopic liver resection, LLS: Laparoscopic liver surgery, SD: Standard deviation, CD: Clavien–Dindo, RFS: Recurrence-free survival.
II tumours, respectively. Twelve out of 14 patients had an OS in excess of 2 years. Since then, there have been no further robust comparisons of outcomes of MILR between the different Bismuth classifications.

Fiorentini et al. performed the largest analysis on open versus MILR for ICC to date (101 patients). In their study, there were no significant differences in terms of RFS, OS and post-operative morbidity and mortality. In addition, the rate of open conversion when performed by trained hepatobiliary surgeons was comparable to that of other advanced laparoscopic procedures. Uy et al. were one of the first to document a case series of patients with ICC treated with laparoscopic surgery. Eleven patients with ICC who underwent MIS were compared against 26 propensity-matched counterparts who underwent open surgery. This gave early encouragement with no significant differences in surgical margins, R0 resections, lymph node harvest, OS and RFS. In Uy et al’s study, patients undergoing MIS had significantly less intraoperative blood loss and shorter hospital stays. Interestingly, the 11 patients who underwent MIS presented with a lower rate of recurrence (36% vs. 46%) and better 3-year survival rates (77.9% vs. 66.2%), although this result did not reach statistical significance. Ratti et al. reports on the second-largest case series to date of 20 patients with ICC undergoing LLR compared against a matched control group of sixty patients undergoing OLR. LLR was associated with less blood loss, shorter hospital stays and comparable rates of morbidity, mortality and recurrence. Lee et al. reported in a case series of 14 patients with ICC undergoing LLR that the MIS approach was associated with lower blood loss and decreased need for Pringles manoeuvre, with no impact on long term survival. Results from this study are similarly encouraging. Twenty-six and five patients underwent MILR for ICC and PHC, respectively. One patient required a laparoscopic-assisted procedure with mini-laparotomy due to adhesions and intraoperative blood loss, whereas another required open conversion due to haemorrhagic shock. The remaining 29 patients had the procedure completed via an MIS approach, with five patients having robotic assistance for bilivascular anastomosis and one patient requiring a hybrid procedure. The mean operative time was 252 min and the mean blood loss was 457 ml, with less than half of the cases needing a Pringles manoeuvre (45%). Nearly 87% of the patients achieved an R0 resection and the mean number of lymph nodes harvested was 9.6. The average hospital stay was 6.3 days, with major morbidity occurring in 9.7% of patients (n = 3; bile leak in two patients and post-operative haemorrhage requiring re-laparotomy in one patient). There was a 0% rate of 30- and 90-day mortality and a 74% rate of RFS (followed up for a minimum of 12 months). For patients that did recur, the mean time to recurrence was 12.6 months. Of note, the patient with post-operative haemorrhage requiring re-laparotomy was among the first few cases in our early experience with MILR for EPBMs.

LLRs have gained rapid popularity since its introduction in 1991 as a wedge resection for a benign lesion. Although many studies have shown the safety and oncological non-inferiority of the laparoscopic approach, its technical difficulty and paucity of training opportunities make for a long and arduous learning curve. Buell et al. reported at the Louisville Consensus Conference in 2008 that laparoscopic major hepatectomies should only be performed by expert hepatobiliary surgeons and only in a specific subgroup of patients (solitary lesion, <5 cm, segments II–VI, away from hepatic hilum and vena cava). Since then, however, standardisation of surgical technique and multiple robust reports on learning curves and competency scoring systems have led to LLR becoming commonplace at many tertiary centres, with outcomes comparable and even superior to the open approach. Recent reports have begun to be directed at more advanced techniques including the outcomes of MIS approaches to technically challenging posterior superior tumours and biliary anastomoses.

In our practice, the total laparoscopic/robotic approach is preferred with the hand-assisted and laparoscopic-assisted hybrid approaches used sparingly, mainly during our early experience. As our institution gained further experience, the total laparoscopic/robotic approach was used almost exclusively. The use of laparoscopic-assisted hepatectomy and hand-assisted laparoscopic hepatectomy has been proposed by several authors to be useful, especially for complex hepatectomies during the initial learning phase. Nonetheless, it is difficult to determine that at present which MIS approach is superior to the other, and individual surgeon preference remains an important determining factor. However, it is important to note the findings from a recent study which suggested that the hand-assisted technique of laparoscopic hepatectomy is becoming obsolete as although it is considered advantageous for liver mobilisation, the technique tended to decrease visualisation of the operative field.

CONCLUSION

We have demonstrated that MILR can be adopted safely with a low open conversion rate for EPBMs. Outcomes with MILR across all types of EPBMs are generally comparable with no incidences of early procedure-related mortality. Future studies will be directed at comparisons.
with the open approach and evaluation of different safety profiles of the MILR approach with regards to high-risk patients (e.g., Bismuth II lesions, multifocal tumours and posterolateral segmentectomies). Studies with long-term oncological outcomes are also needed to determine the definitive role of MIS in these malignancies.

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Conflicts of interest
There are no conflicts of interest.

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