Minimally invasive vs traditional liver resection in managing small hepatocellular carcinoma

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Background
Laparoscopic liver resection (LLR) has been progressively developed along the past two decades. Surgical technique and equipment have been evolved to overcome technical limitations, making LLR safe and feasible. Surgeons develop skills in a stepwise approach, beginning with low complexity operations for benign diseases and reaching high-complexity surgeries for malignant cases and living donor organ harvesting.
Patients and methods
In this prospective randomized study, a comparison between laparoscopic and open resection was done to compare short-term results regarding intraoperative details, postoperative management, and complications. This study was conducted on 30 patients with hepatocellular carcinoma (HCC): 15 (50%) patients were treated by LLR (group A), whereas the other 15 (50%) patients were treated by open liver resection (group B).
Results
Regarding the demographic data, the presence of past history of medical condition, and the preoperative laboratory results, no statistically significant difference was found. The mean operative time has a statistically significant difference between the two groups, with decreased operative time in the laparoscopic group ($P<0.001$). Postoperative follow-up showed that the most frequent complication was postoperative ascites, which was seen in 12 (80%) cases in the open group and in six (40%) cases in laparoscopic group, with highly significant difference between both groups. Recurrence occurred in one patient in the LLR group and no cases in the other group.
Conclusion
LLR is a safe and feasible treatment option for HCC in cirrhotic patient needing minor resection at laparoscopic liver segments II, III, IVa, V, and VI. LLR for HCC has superior short-term and comparable oncological outcomes to open liver resection. LLR should be performed for carefully selected patients and by an expert surgical team.

Keywords:
anatomical resection, cirrhotic patients, hepatocellular carcinoma

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Introduction

A wide variety of both benign and malignant tumors develop in the liver. Malignant tumors in liver can be classified as primary and secondary tumors. The most common primary tumor is hepatocellular carcinoma (HCC), which is the fifth most common tumor worldwide, and it is currently the third leading cause of cancer-related death [1–3].

The first liver resection was performed in 1716 by Berta who removed partially the liver of a patient with trauma. However, the first successful elective liver resection, a left lobectomy in a patient presenting with a hepatic mass, was performed only in 1888 by Langenbuch. However, the real breakthrough was set by Pringle in 1908 and then by Couinaud in 1957 owing to their great role in anatomical and operative liver surgery [4].

The first case of laparoscopic liver resection (LLR) for malignant disease was reported by Wayand and Woisetschlager in 1994. Liver resection remains a high-risk procedure with significant morbidity and mortality rates. Perioperative blood transfusion and intraoperative bleeding are usually considered to be the major reasons affecting these rates. However, the advantages of laparoscopic resection over open resection include reduced postoperative pain, early mobilization, minimal ileus, earlier resumption of oral intake, enhanced cosmetic outcome, and shorter hospital stay. Most LLRs have been directed toward easily accessible lesions. Regarding the tumor location, tumors in the peripheral portion of the anterolateral segments of the liver (segments II, III, V, VI, and the inferior part of IV) have been considered suitable for LLR. Conversely, lesions located in the posterior or superior part of the liver (segments I, VII, VIII, and the superior part of IV) have been considered poor candidates for a LLR owing to the limited visualization and difficulty in bleeding control [5].

In the past few decades, surgical techniques to facilitate hemostasis have been developed, and they have improved the outcomes of liver resection. The techniques include monopolar and bipolar diathermy, infrared coagulation, argon beam coagulation, cavitron ultrasonic aspirator, ultrasonic (harmonic) scalpel, water jet cutter, and radiofrequency-assisted resection [6,7]. No single method for parenchymal transaction is proven to be better than the other [8,9].

Certainly, as stated by many authors, LLR procedure should be practiced by experienced surgeons, with an extensive experience in both types of resection and advanced laparoscopy in specialized centers [7] and who should be experienced with the use of all surgical devices for liver transection and should have mastered laparoscopic suture before starting LLR [10].

Better integrity of the abdominal wall may be attributable to early discharge from hospital and to reduction of pain at the surgical site. Rapid recovery from surgery and an earlier discharge from the hospital provide further evidence for the safety and feasibility of LLR [11].

The aim of our work was to assess the feasibility and safety of performing LLR and comparing it with the traditional liver resection in small lesions for minor resections.

Patients and methods

This prospective randomized study involved 30 liver cirrhotic patients presenting with primary malignant hepatic tumors (with Child A classification fit for surgical resection), and their data were collected during the period from January 2018 to June 2019 with follow-up till December 2019 (i.e. minimum 6 months). The patients were divided into two groups. Group A (15 patients) was managed with laparoscopic resection technique, and group B (15 patients) was managed with traditional open surgical resection technique. Ethical approval was taken from Ain Shams University Ethical Committee. A written consent form was taken from every patient after explanation of all details of the operation; advantages; disadvantages; realistic expectations; the possibility of conversion to open surgery; and all the possible intraoperative, early, and late postoperative complications. Surgeries were done by the same surgical team throughout the study.

Inclusion criteria

The following were the inclusion criteria:

(1) Age: 30–60 years.
(2) Sex: male or female.
(3) Patients with unifocal HCC as well as cirrhosis, Child A, requiring resection with intent to cure.
(4) Lesion localized at segments II, III, IVb, V, and VI (i.e. for nonanatomical resection).

Exclusion criteria

The following were the exclusion criteria:

(1) American Society of Anesthesiologists IV and American Society of Anesthesiologists V.
(2) Patients not candidate for laparoscopy (previous upper abdominal surgery and morbid obesity, with BMI>35).
(3) Malignant liver tumors in advanced stage.
(4) Multifocal lesions in right and left hepatic lobe.
(5) Lesions greater than or equal to 10 cm.
(6) Liver cirrhosis with Child-Pugh classes B and C.
(7) Lesions proved to be metastatic.
(8) Patients with moderate to severe portal hypertension.
(9) Patients needing major resection (i.e. formal or extended right or left hepatectomy).

All patients were subjected to the following assessments:

(1) Full history:
    (a) Personal history: name, age, sex, occupation, residence, and special habits.
    (b) History of present illness (how to be diagnosed, when and is it symptomatic or not), hepatic diseases (hepatitis and cirrhosis), bleeding varices, ascites, encephalopathy, etc.
    (c) History of associated medical diseases, previous operations, blood transfusion, viral hepatitis, anti-Bilharzial treatment, or esophageal varices.
(2) Examination
    (a) General condition, weight and length of the patient, and vital signs, including pulse, blood pressure, temperature, and respiratory rate.

(b) Examination of all body systems to exclude signs of liver cell failure or associated diseases.
Abdominal examination:
To assess the condition of the liver, signs of portal hypertension or metastasis, old scars, or any other abdominal abnormality.

(3) Laboratory investigations:
- (a) Complete liver functions.
- (b) Prothrombin time and activity and coagulation profile.
- (c) Viral serology (hepatitis C virus, hepatitis B virus, and HIV).
- (d) α-Fetoprotein (AFP) and carcinogenic embryonic antigen (CEA).
- (e) Complete blood picture.
- (f) Blood urea and serum creatinine.
- (g) Blood group and ABO/RH status if transfusions needed.
- (h) Serum Na and K.
- (i) Fasting and postprandial blood sugar.

(4) Radiological investigations and upper gastrointestinal (UGI) endoscope:
- (1) Abdominal ultrasound.
- (2) Triphasic computed tomography (CT) scan on the abdomen.
- (3) Color Doppler ultrasound (on portal vein).
- (4) Plain radiography on the chest.
- (5) Dynamic MRI liver (when needed in uncertain diagnosis).
- (6) CT chest.
- (7) Bone scan.
- (8) Positron emission tomography (PET) scan (if AFP >400 ng/ml).

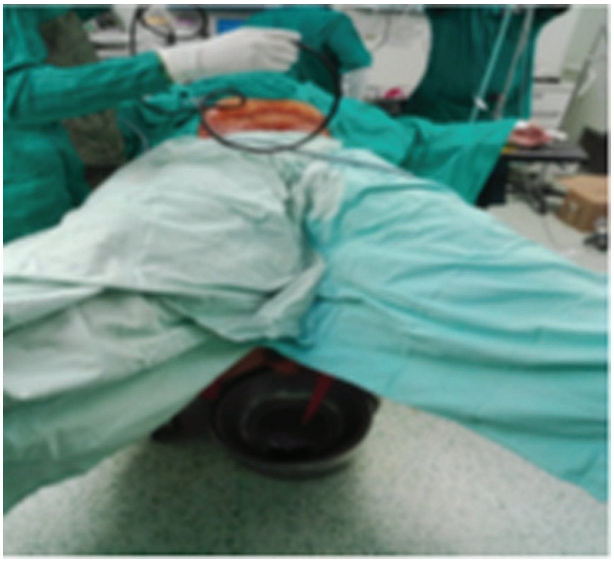
(9) Counseling and Informed consent signing.

Operative technique of laparoscopic hepatic resection

The patient was positioned in the French position, in which the patient was supine with the legs in stirrups and reversed Trendelenburg position and the surgeon is positioned between the patient's legs. Endotracheal intubation, central venous catheter, arterial line, and serial ABG and HB% analyses were done during perioperative time. Antithrombotic measures are applied. Urinary catheter is inserted. The abdomen and lower chest (till nipple line) were prepared and swabbed by antiseptic solution.

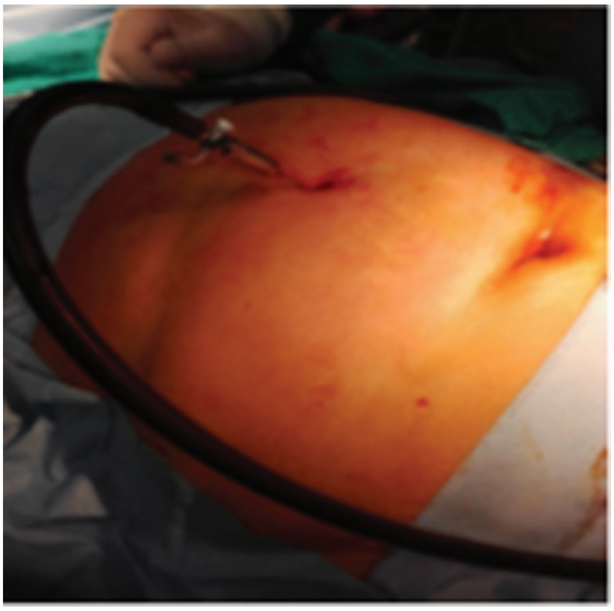
Pneumoperitoneum was established at 11 or 12 mmHg, and a 11 mm port was placed 2–3 cm above and to the right of umbilicus for 30° laparoscope camera introduction and then two to three additional ports are placed under direct visualization as required according to the site of the segment to be resected (Figs 1–3).

Figure 1



Draping of the patient after anesthesia.

Figure 2



Pneumoperitoneum using Veress needle.

These ports should be placed to ensure optimal ergonomics for the surgeon (roughly equidistant and traversing a shallow arc just below the trans pyloric plane and above the umbilicus (Fig. 4). In some cases, an additional port (12 mm) was placed to apply the retractor of the liver. A complete sonographic examination was then completed with a flexible tip laparoscopic ultrasound probe. Despite the flexible probe, it may be necessary to take down the falciform ligament to facilitate access and good visualization. The mobilization of the liver was seldom required and was better avoided. Although in some cases with left-sided lesions, the left

Figure 3

Basic positioning of the ports for working on both right and left lobe of the liver. Additional ports are put as needed.

Figure 4

Positioning of the ports to work on right lobe of the liver. Ports are placed according to suitable ergonomics of the surgeon.

triangular ligament was incised and freed close to the liver (By Harmonic scalpel) (Fig. 5).

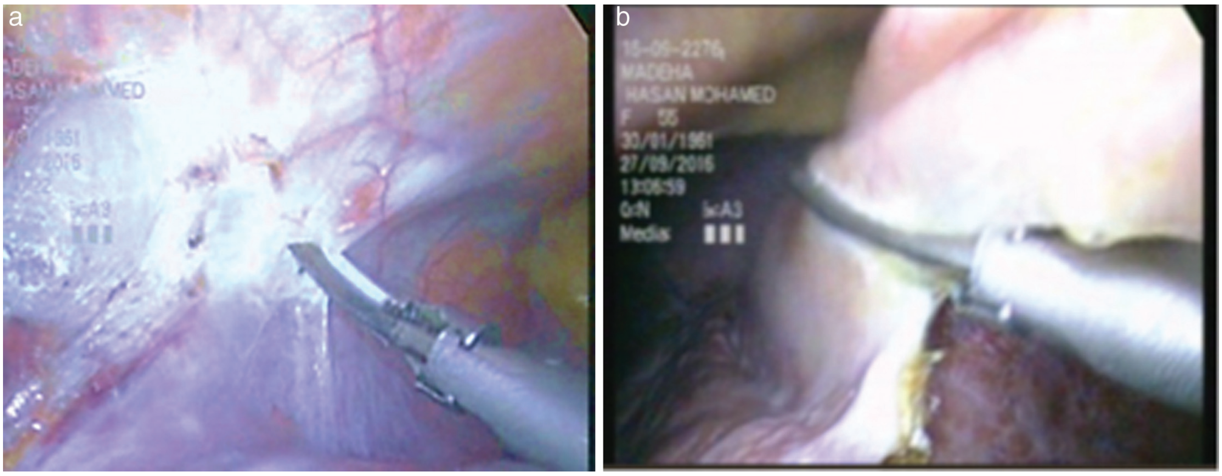
Vascular control was done by passing a Nylon tap or rubber tube around the liver pedicle so as to be ready to do Pringle's maneuver if unexpected bleeding happened; otherwise, Pringle's maneuver was not done. As for the biliary system, routine cholecystectomy and insertion of a small tube (4 French) into the cystic duct was done, so as to do completion cholangiogram at the end to detect any leakage.

After marking the line of dissection by monopolar diathermy (with safety margins 1–2 cm), hepatic dissection was undertaken using the Harmonic scalpel or Habib 4X sealer (Fig. 6). Hemostasis of the raw liver surface was done by bipolar cautery and then application of hemostatic materials. Conversion to open technique was undertaken if excess bleeding occurred or any instrumental failure happened or failure of localization of the lesion. Extraction of the resected part of the liver was done after its placement in plastic bag (Endobag) by extending the subcostal incision (about 5 cm) or small Pfannenstiel incision in some cases. Specimen extraction and port wound closure were done, with intra-abdominal drain in the resection bed applied in some cases. Operative blood loss was estimated (ml) at the end of the operation and recorded along with perioperative blood transfusion (if needed). Operative time (min) (from the start of the procedure to closure of the abdomen) was recorded as well.

Procedure of open hepatic resection

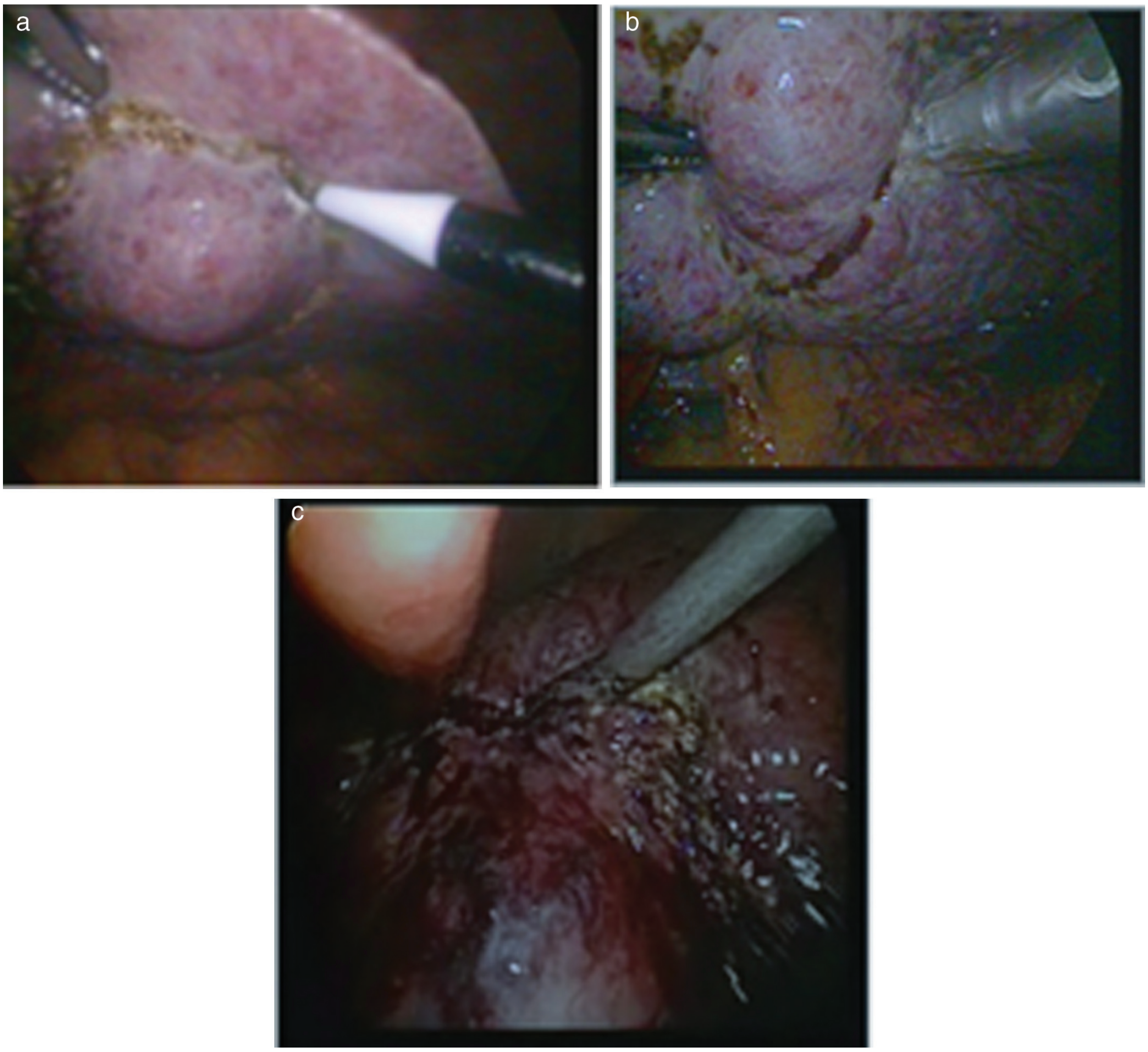
The patient was positioned supine with both arms extended and pronated at right angles to the body (beside the patient's body). Tilting of the table could be used to improve the exposure, and then the same steps of preparation were followed. A fixed metal sterile abdominal wall retractor (subcostal) was placed and attached to the table (KENT retractor, Takasago Medical Industry Co., Ltd., Tokyo, Japan). The most commonly used incisions were the inverted L incision in right lobe-situated hepatic focal lesions and

Figure 5



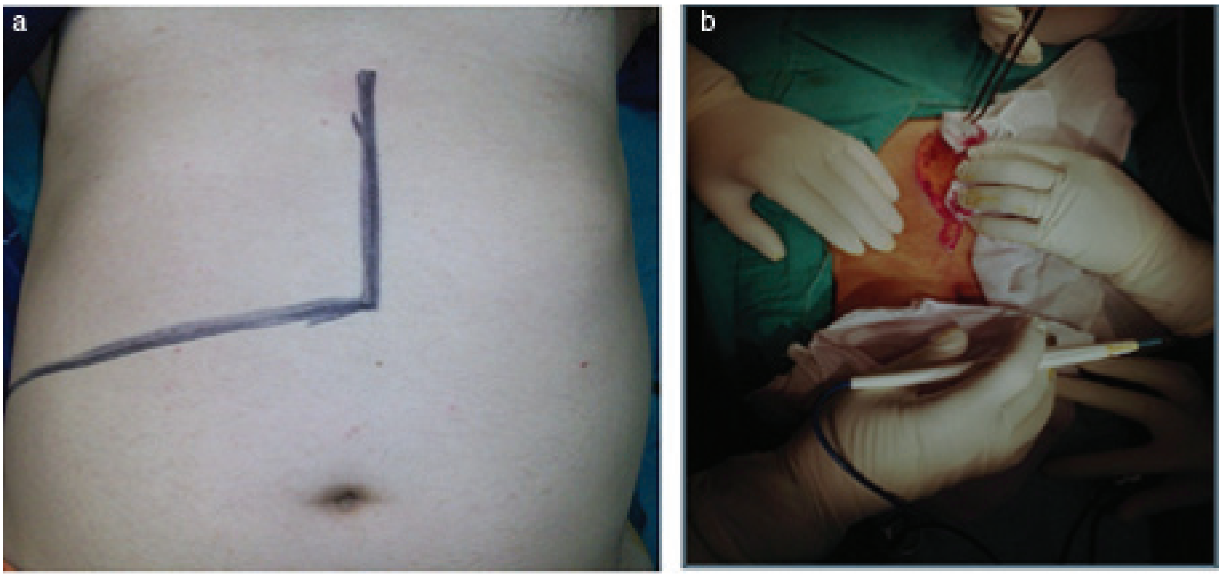
(a) Left triangular ligament incised and freed by harmonic scalpel. (b) Falciform ligament is incised by harmonic scalpel.

Figure 6



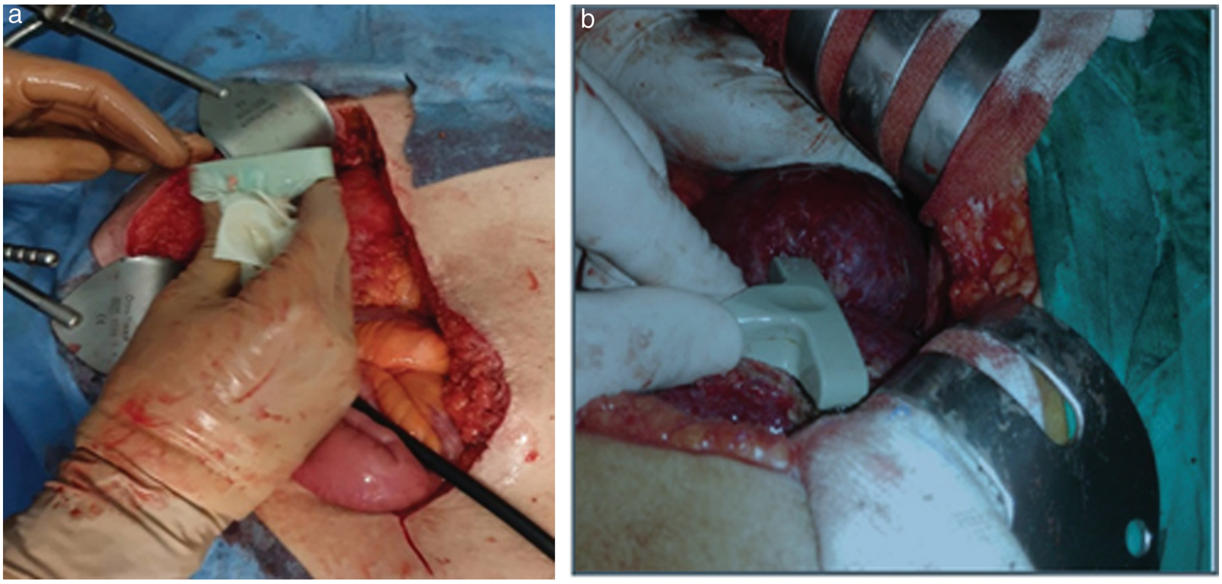
(a) Marking the line of resection using monopolar diathermy. (b) Hepatic parenchymal dissection using Habib 4× sealer. (c) Hepatic parenchymal dissection using laparoscopic harmonic scalpel.

Figure 7



Incisions used in open resection in this study: (a) inverted L incision for right hepatic focal lesions resection and (b) midline incision for left hepatic focal lesions resection.

Figure 8



Intraoperative ultrasound needed in some cases of open resection if there is difficulty in lesion localization.

midline incision in left lobe-situated hepatic focal lesions (Fig. 7).

Once the abdomen was opened, the falciform ligament was divided using diathermy and separated from the anterior abdominal wall. A thorough examination was made for the peritoneum and regional lymph nodes to exclude extrahepatic dissemination of malignancy. The liver was carefully palpated, and intraoperative ultrasonography was undertaken, if needed, to confirm the position of the tumor and to assess its relationship with adjacent vascular structures (Fig. 8).

For the left-sided lesions, the left triangular ligament was incised and freed close to the liver to avoid injury of inferior phrenic vein. However, for the right-sided lesions, the right lobe could be mobilized by division of the anterior leaf of the coronary ligament, and the dissection was continued posteriorly to separate the adhesions between the adrenal gland and the bare area of the liver. Hepatic vascular inflow control was used in selective cases in the form of Pringle's maneuver (using vascular tap surrounding hepatic pedicle to be tightened on demand while recording total time that was used for). After marking the line of dissection by monopolar diathermy (with safety margins 1–2 cm), hepatic dissection was undertaken using Habib 4X sealer or the Harmonic scalpel followed by hemostasis with mono or bipolar diathermy. The minor blood vessels and bile ducts were divided after clipping them by hemoclips or sutures. Wound closure was done with intra-abdominal drain in the resection bed and/or hepatorenal angle in all cases after good hemostasis. Operative blood loss was estimated (ml) at the end of the operation and recorded along with perioperative blood transfusion (if needed). Operative time (min) was recorded as well.

All patients were transferred from the operative theater to the ICU with careful monitoring of vital signs, administration of proper analgesia, and meticulous titration of intravenous fluids. Monitoring and charting of urinary catheter, nasogastric tube, and drain output were done. Once the condition of the patient is stable, he/she is transferred to the ward. The duration of ICU stay was recorded. The urinary catheter is removed once the patient is able to ambulate, and the drain is removed when it has a negligible output and the duration was recorded.

Histopathological features of the tumor and surrounding liver were examined macroscopically and microscopically. Maximal diameter of the tumor (cm) was taken as tumor size, and margin was measured (mm).

Postoperative follow-up

Daily follow-up full laboratory investigations were done every other day in the first week, and then after discharge, full laboratory investigations and pelviabdominal ultrasound (PAUS) were done every month.

After 3 months, PAUS, full laboratory investigations, and AFP were done.

After 6 months, pelviabdominal computerized tomography (PACT) triphasic, full laboratory investigations, and AFP were done.

Statistical analysis

Randomization was done as follows: each patient was given an identity number, and the patients were allocated into two equal groups. Patients were randomly allocated into these groups using 'random number generator' software.

Analysis of data was performed with a personal computer using graph pad prism version 5. The tests used were as follows: mean, SD to measure the central tendency of data and the distribution of data around their mean. Student *t*-test was used for testing statistical significant difference between means of two samples. Median is a measure of central tendency when extremes of values are found in data. χ^2 test was used to test statistically significant relation between different variable or grades (qualitative data) or percentages. Probability was set as follows: *P* value less than 0.05 was considered significant and *P* value less than 0.001 was considered as highly significant.

Results

On comparing the means of laboratory results between both groups, no significant differences could be found except for alkaline phosphatase (Tables 1 and 2).

Table 1 The demographic data among the patients included in the study

	Group A (*n*=15) [*n* (%)]	Group B (*n*=15) [*n* (%)]	*P* value
Age (years)			
Range	53–60	47–60	0.136
Mean age±SD	56.3±3.9	53.9±4.6	
Sex			
Male	6 (40)	5 (33.3)	0.705
Female	9 (60)	10 (66.7)	
Smoking			
Nonsmoker	11 (73.3)	10 (66.7)	0.690
Smoker	4 (26.7)	5 (33.3)	
Comorbidity			
None	7 (46.7)	8 (53.3)	0.041*
HTN	7 (46.7)	1 (6.7)	
DM	1 (6.7)	5 (33.3)	
Others	0	1 (6.7)	

DM, diabetes mellitus; HTN, hypertension.

Table 2 The preoperative investigations among the patients included in the study

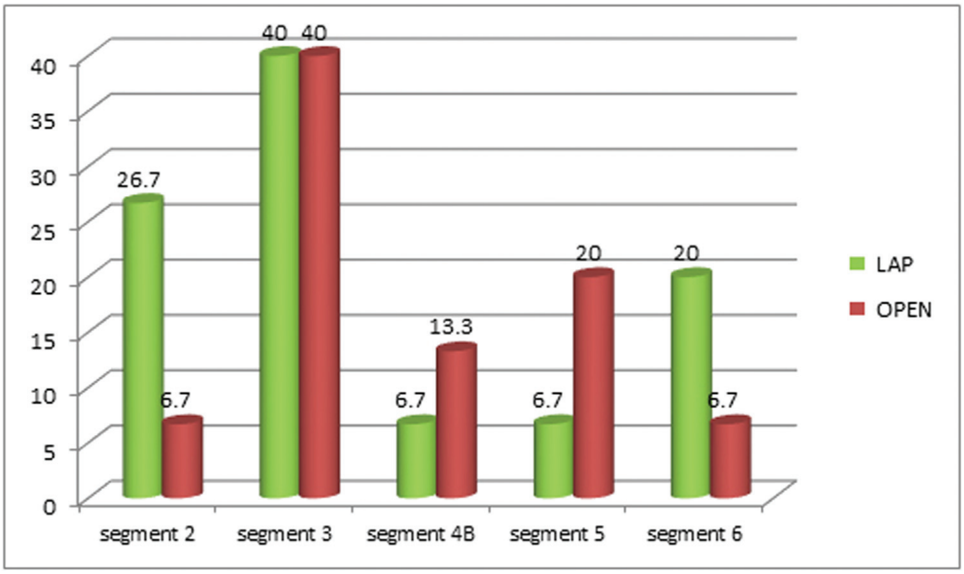
	Group A (n=15)		Group B (n=15)		
	Mean	SD	Mean	SD	P value
AST	72.1	43.4	95.9	56.2	0.187
ALT	58.9	34.7	69.5	34.5	0.412
Total bilirubin (mg/dl)	1.1	0.39	0.98	0.29	0.611
ALB (g/dl)	3.6	0.52	3.5	0.35	0.777
ALP (IU/l)	84.7	24.7	120.61	44.58	0.032*
INR	1.18	0.14	1.13	0.1	0.333
Creatinine (mg/dl)	0.89	0.14	0.77	0.19	0.211
HB (g/dl)	13.2	1.6	12.7	1.8	0.286
TLC	5.4	1.9	5.7	1.7	0.659
PLT	110.8	40.8	131.7	43.2	0.183
AFP (ng/ml)	Median=56.4	Range=10–776	Median=23	Range=5.3–652	0.163

ALB, albumin; ALT, alanine aminotransferase; ALP, alkaline phosphatase; AST, aspartate aminotransferase; HB, hemoglobin; INR, international normalized ratio; PLT, platelet; TLC, total leukocyte count.

Table 3 Characteristics of the hepatic lesions by using triphasic computed tomography and intraoperative ultrasound

	Group A (n=15) [n (%))	Group B (n=15) [n (%)]	P value
Size (cm)			
≤3	6 (40)	2 (13.3)	0.145
3–5	8 (53.3)	9 (60)	
>5	1 (6.7)	4 (26.7)	
Segment 2	4 (26.7)	1 (6.7)	
Segment 3	6 (40)	6 (40)	
Segment 4B	1 (6.7)	2 (13.3)	
Segment 5	1 (6.7)	3 (20)	
Segment 6	3 (20)	3 (20)	

Figure 9

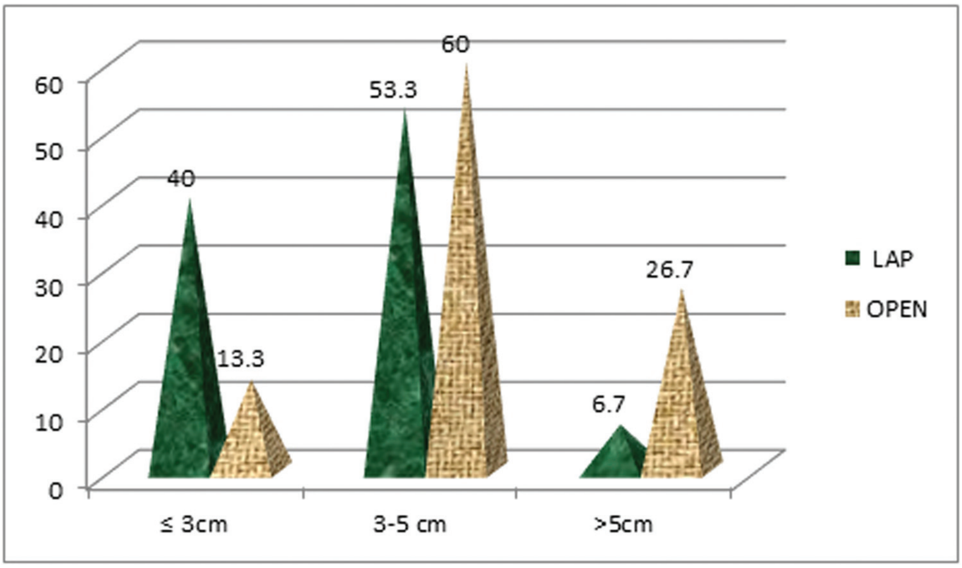


Tumor segments between the two groups.

The median AFP level in laparoscopic group was 56.4 ng/ml, ranging between 10 and 776 ng/ml, whereas the median level in open group was 23 ng/ml, ranging between 5 and 652 ng/ml, showing no statistically significant difference between both groups (Tables 2 and 3, Figs 9 and 10).

The mean operative time in laparoscopic group was 134.7±37.9 min, whereas the open group mean time

Figure 10



Tumor size in both groups.

Table 4 Difference in intraoperative data between both groups

	Group A (n=15) (mean±SD) or [n (%)]	Group B (n=15) (mean±SD) or [n (%)]	P value
Operative time (min)	134.7±37.9	166±31.1	0.002*
Blood loss (ml)	356.7±354.7	373.3±157.9	0.866
Significant bleeding	2 (13.3)	2 (13.3)	1
Conversion	2 (13.3)	0	0.143

was 166±31.1 min, with statistically highly significant difference between the two groups (P<0.002), with decreased operative time in the laparoscopic group. The mean blood loss in laparoscopic group was 356.7 ±354.7 ml, whereas the open group mean blood loss was 373.3±157.9 ml, with no statistically significant difference relations between the two groups (P=0.866). Overall, two (13%) cases in the LLR group had significant bleeding that required conversion to open; only one of them (6.7%) needed intraoperative blood transfusion. Moreover, two (13.3%) cases in the open group also had significant blood loss that required blood transfusion in both (Tables 4, 5).

Regarding the hospital stay, the mean hospital stay in LAP group was 4.2±1.01 days, ranging from 2 to 6 days, whereas the open group was 7.87±2.61 days, ranging from 6 to 12 days, with highly statistically significant positive correlation between the two groups (P<0.001), but at the same time, there was no significant difference in the ICU stay. Moreover, the drain was removed in the laparoscopic group earlier (even though there was no drain in one case), showing highly statistical difference between the two groups (P<0.001) (Table 6).

As shown in Table 7, the most frequent complication was postoperative ascites, which was seen in 12 (80%) cases in the open group and in six (40%) cases in laparoscopic group, with highly significant difference between both the groups, with much more lower incidence in laparoscopic group (P<0.03). Overall, two patients experienced bleeding in the LLR group and underwent open surgical re-exploration. However, the statistical difference between both groups was insignificant regarding postoperative bleeding.

The level of AFP at the 3-month and 6-month follow-up between two groups showed no statistically significant difference. Only one patient in each group had very mild rise in AFP after 3 months, but the PAUS was free. After 6 months, the patient in LLR group had marked rise in AFP and confirmed to have recurrence in PACT, whereas the patient in the other group had no recurrence in PACT (Table 8).

Table 9 shows the frequency of overall recurrence in both groups, either recurrence at operative site or de novo lesions, over the 6-month follow-up detected by triphasic CT. There was one (6.7%) patient in the laparoscopic group who showed recurrence, whereas none of the patients in the other group, with no statistically significance difference.

Table 5 The resection margin between the two groups (there was no statistically significant difference)

Resection margins (mm)	Group A (*n*=15)	Group B (*n*=15)	*P* value
Mean±SD	7.67±1.63	7.47±1.64	0.740
Range	5–11	5–10	

Table 6 The postoperative data of the patients included in the study

	Group A (*n*=15)		Group B (*n*=15)		
	Mean±SD	Range	Mean±SD	Range	*P* value
ICU stay (days)	1.13±0.51	0–1	1.13±0.35	1–2	0.579
Hospital stay (days)	4.2±1.01	2–6	7.87±2.61	6–12	<0.001
Drain removal (days)	3.3±0.88	0–2	4.5±0.83	4–7	<0.001

Table 7 Postoperative complications in both groups

	Group A (*n*=15) [*n* (%)]	Group B (*n*=15) [*n* (%)]	*P* value
Bleeding (>300 ml)	2 (13.3)	0	0.143
Ascites	6 (40)	12 (80)	0.03
Wound infection	1 (6.7)	1 (6.7)	1
Incisional hernia	0	1 (6.7)	0. 5
Complete liver failure	0	0	1.00
Bile leakage	0	0	1.00
Pulmonary complication	0	0	1.00

No cases of perioperative mortality occurred in any of the patients.

Discussion

Hepatic resection is a commonly performed procedure for a variety of malignant and benign hepatic tumors. Historically, liver resection, irrespective of the indication, was associated with a high morbidity and mortality rate. During the past decades, however, perioperative outcome after hepatic resection has improved, owing to the increased knowledge of liver anatomy and function, improvement of operating techniques, and advances in anesthesia and postoperative care [12]. However, laparoscopic resection, as a minimally invasive management of HCC, is still technically challenging. It requires both laparoscopic skills and advanced liver surgical skills [13].

In the current scenario of increased awareness of technical and oncological features associated with liver resections, HCC seems to be an ideal indication for laparoscopic resection. In fact, primary liver cancer currently represents the main indication for LLR among malignancies [14,15].

In this study, a comparison between laparoscopic resection and open resection was done to compare results of applicability and safety between laparoscopic hepatectomy and open hepatectomy (OH). This study focused on the perioperative period of patients undergoing minor liver resection and assessing their results if they were in line with the literature.

In this study, both groups were homogeneous regarding age, sex, etiology of liver cirrhosis, the presence of associated medical conditions, laboratory results, and AFP levels. No significant differences were found between both groups regarding demographic data, and this goes in line with the metanalysis done by Xiong *et al.* [16].

The mean operative time in laparoscopic group was 134.7±37.9 min, whereas in the open group, mean time was 166±31.1 min, with statistically significant difference between the two groups ($P<0.002$), with decreased operative time in the laparoscopic group. Operative time varies significantly between studies, influenced by the type of resection and surgeon's experience. Vigano *et al.* [18] studied three consecutive periods, each with 58 patients undergoing LLR, and observed a significant decrease in mean operative time.

Blood loss reported during laparoscopic surgery varies between series and is directly related to the type and difficulty of LLR. In several meta-analyses of comparative studies, intraoperative bleeding tends to be lower at laparoscopic approach than at open resection, resulting in decreased requirement for blood transfusion [4]. In our work, intraoperative bleeding from liver sinuses was seen in two (13.3%) cases in the laparoscopic group and converted to open technique. These results were comparable to the study by Twaji *et al.* [17], which was done in patients with cirrhosis and reported conversion rates ranged from 7 to 19.4%. The reported conversion rate is in the range of 0–20%, varying mostly according to the indication

Table 8 Level of α-fetoprotein at the three and six month

	Group A (*n*=15) [*n* (%)]	Group B (*n*=15) [*n* (%)]	*P* value
AFP			
Declining	14 (93.3)	14 (93.3)	1
Rising	1 (6.7)	1 (6.7)	

AFP, α-fetoprotein.

Table 9 Frequency of overall recurrence in both groups

Item	Group A (*n*=15) [*n* (%)]	Group B (*n*=15) [*n* (%)]	*P* value
CT			
Recurrence at operative site	1 (6.7)	0	0.391
Negative	14 (6.3)	15 (100)	

CT, computed tomography.

for LLR [19]. Good planning before an LLR operation can prevent conversion to OH.

According to the hospital stay in our study, the mean hospital stay in LAP group was 4.2±1.01days, ranging from 2 to 6 days, whereas the open group was 5.8±0.9 days ranging from 4 to 7 days, with highly statistically significant positive correlation between the two groups ($P<0.001$). These results were comparable to Rao *et al.* [20], who conducted a pooled analysis of 32 comparative studies and showed significant reduction in hospital stay (2.96 vs 3.70 days) in the laparoscopic group. The overall shorter hospital stay in laparoscopic resection is not only associated with quicker hospital discharge but also an earlier return of bowel activity and lesser requirement of analgesics. Moreover, a study done by Komatsu *et al.* [21] concluded that the laparoscopic group showed a trend toward shorter – although not statistically significant – length of postoperative hospital stay (median 10.0 vs 7.5 days, $P=0.079$). Moreover, Siniscalchi *et al.* [15] reached the same conclusion (7.6 d vs 14.3 days, $P=0.339$).

Regarding postoperative complications in our study, two (13.3%) patients in laparoscopic group required surgical intervention (owing to postoperative bleeding), whereas in the open group only one (6.7%) patient needed surgical intervention, as he developed incisional hernia.

In our study, the most frequent complication was postoperative ascites and was seen in 12 (80%) cases in the open group and in six (40%) cases in laparoscopic group with highly significant difference between both groups, with much more lower incidence in the laparoscopic group ($P<0.03$). Kanazawa *et al.* [22] also reported a reduced incidence of postoperative ascites in resected patients by laparoscopic approach. The study done by Truant *et al.* [23] showed lower rates of postoperative ascites and liver failure in the LLR group as well. Recently, Morise *et al.* [16] analyzing the subset of patients with known cirrhosis also noted a significant reduced incidence of postoperative ascites and liver failure.

The reduced incidence of postoperative complications in LLR for HCC compared with conventional approach has been clearly reported in the literature, by both single-center experiences, as investigated by Kanazawa *et al.* [22] and Cheung *et al.* [24], and meta-analysis, as investigated by Yin *et al.* [25] and Xiong *et al.* [16].

Follow-up was done after 6 months by measuring the value of the AFP, and there was no statistically significant difference between the two groups.

In our study, the frequency of overall recurrence in both groups, either recurrence at operative site or de novo lesions, over the 6-month follow-up detected by triphasic CT was seen in one (6.7%) patient in the laparoscopic group. A study was conducted on 109 patients who underwent LLR ($n=50$) or (OH) ($n=59$), and the 1-year and 3-year disease-free survival rates were 89.6 and 51.4%, respectively, for the LLR group and 84.7 and 59.6%, respectively, for the OH group ($P=0.935$). They found that tumor size, differentiation, vascular invasion, surgical bleeding, and surgical resection margin were risk factors for tumor recurrence after LLR. The study concluded that LLR for HCC did not increase the risk of recurrence compared with OH [26].

There was no mortality in our cases. However, several factors contributed to reduce mortality after hepatectomy from 5% to almost 0%. Among these factors, better knowledge of both liver anatomy and physiology, including of liver regeneration and preoperative volume modulation; better morphological assessment; advances in parenchymal transection with the selective use of vascular control; and sophisticated perioperative management have all contributed to reduction in the risks associated with liver resection [27].

Conclusion

LLR is a safe and feasible treatment option for HCC in patients needing minor resection at segments II, III, IVa, V, and VI. LLR for HCC has superior short-term and comparable oncological outcomes to open liver resection. With advances in surgical techniques and instruments, LLR has been performed more frequently, even for tumors in difficult anatomical locations. Further wider studies with long-term follow-up should be conducted.

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Conflicts of interest

There are no conflicts of interest.

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