Laparoscopic Transabdominal With Transdiaphragmatic Access Improves Resection of Difficult Posterosuperior Liver Lesions

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Objective: We describe the technical details and evaluate the safety, feasibility, and usefulness of a combined lateral and abdominal (CLA) approach for laparoscopic resection of liver segments 7 and 8.

Background: Laparoscopic resection of lesions in the posterosuperior area of segments 7 and 8 is technically challenging, and currently there is no standardized laparoscopic approach.

Methods: Through review of a prospectively maintained database, we identified 44 patients who underwent laparoscopic resection of lesions in segment 7 or 8. Twenty-five patients required the CLA approach because their lesions were more posterosuperior and intraparenchymal; 19 patients underwent resection with a regular abdominal-only approach of more accessible anteroinferior lesions. We reviewed operative details and video footage of these operations and compared the outcomes of the 2 groups.

Results: In the group treated with the CLA approach, deep location was more frequent (88% vs 42%; $P = 0.035$), median tumor diameter was larger (24.5 mm vs 15 mm; $P = 0.114$), and the median weight of the excised parenchyma was greater (56.5 g vs 23 g; $P = 0.093$). Median operative time was longer in the CLA approach group (217.5 minutes vs 165 minutes; $P = 0.046$), but blood loss, rate of conversion to open surgery, surgical margin status, morbidity, and mortality were similar between the 2 groups.

Conclusions: The CLA approach permits safe laparoscopic resection of lesions in the posterosuperior area of segments 7 and 8, allowing surgeons to overcome the difficulties of limited visualization and access to the target lesions.

Keywords: colorectal metastasis, laparoscopic liver resection, posterosuperior segment, transdiaphragmatic, transthoracic

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Compared with open liver resection, laparoscopic liver resection results in less blood loss, less postoperative pain, and shorter hospitalization without increasing morbidity or compromising oncologic outcomes.[1,2] Initially, laparoscopy was used for minor resection of easily accessible lesions in segment 2, 3, 4b, 5, or 6.[3–5] Recently, several centers around the world have reported a laparoscopic approach to major anatomic liver resections, such as right hepatectomy, initially considered unsuitable for laparoscopy.[6–9] However, an isolated resection of segment 7 or 8 is still considered a poor indication for a minimally invasive approach.[3,4,10–15] In particular, laparoscopic resection of a lesion in the cranial or deep area within segments 7 and 8 remains challenging because of the limited visualization due to the caudal view and significant interference caused by the anteroinferior segments (see Supplemental Digital Content Video, available at . . .). In contrast, laparoscopic resection of a lesion in the caudal and more superficial area within segments 7 and 8 does not have the same challenges of visualization and access.

To date, no published series have focused on the outcomes after laparoscopic resection of lesions in segments 7 and 8, and no standardized approach has been established to perform the procedure safely.[14,16,17] We have developed and used a combined lateral and abdominal (CLA) approach both to overcome challenges in visualization and to access the cranial or deep area within segments 7 and 8.[15,18,19] Here, we illustrate the technical details of our CLA approach and report the findings of a study in which we evaluated its safety, feasibility, and utility by comparing outcomes between patients who underwent resection by the CLA approach of lesions in the posterosuperior area within segments 7 and 8 and patients who underwent resection by regular abdominal-only approach of easily resectable lesions within segments 7 and 8.

PATIENTS AND METHODS

We reviewed a prospectively maintained, single-institution database of 472 patients who underwent laparoscopic liver resection between February 1994 and February 2013 at L'Institut Mutualiste Montsouris and identified 44 patients who underwent resection of lesions in segment 7 or 8 without extension of the resection to an adjacent segment (segment 4, 5, or 6). Of these 44 patients, 25 required the CLA approach because they had lesions located in the posterosuperior area of segments 7 and 8 and 19 patients were treated with the abdominal-only approach because they had lesions located in the anteroinferior area of segments 7 and 8.

The surgical approach was planned on the basis of preoperative assessment with computed tomography and/or magnetic resonance imaging. Cranial, large, or deep lesions that necessitated resection in the cranial (Figs. 1A, B) or deep area (Fig. 1C) of segment 7 or 8 were regarded as difficult to resect, and a CLA approach was planned. In contrast, small lesions located in the superficial and caudal area of segment 7 or 8 (Figs. 1D, E) were removed by wedge resection using the abdominal-only approach (Figs. 1F, G).

We examined video footage (see Supplemental Digital Content, available at . . .) of the 2 groups to evaluate the technical advantages of the CLA approach. Furthermore, we compared patient outcomes between the 2 groups in terms of operative time, blood loss, blood transfusion, conversion to open surgery, margin status, morbidity, and mortality. Procedural details such as use of the Pringle maneuver and the weight of the excised parenchyma were assessed to confirm that the lesions in the CLA-approach group were indeed more challenging to resect.

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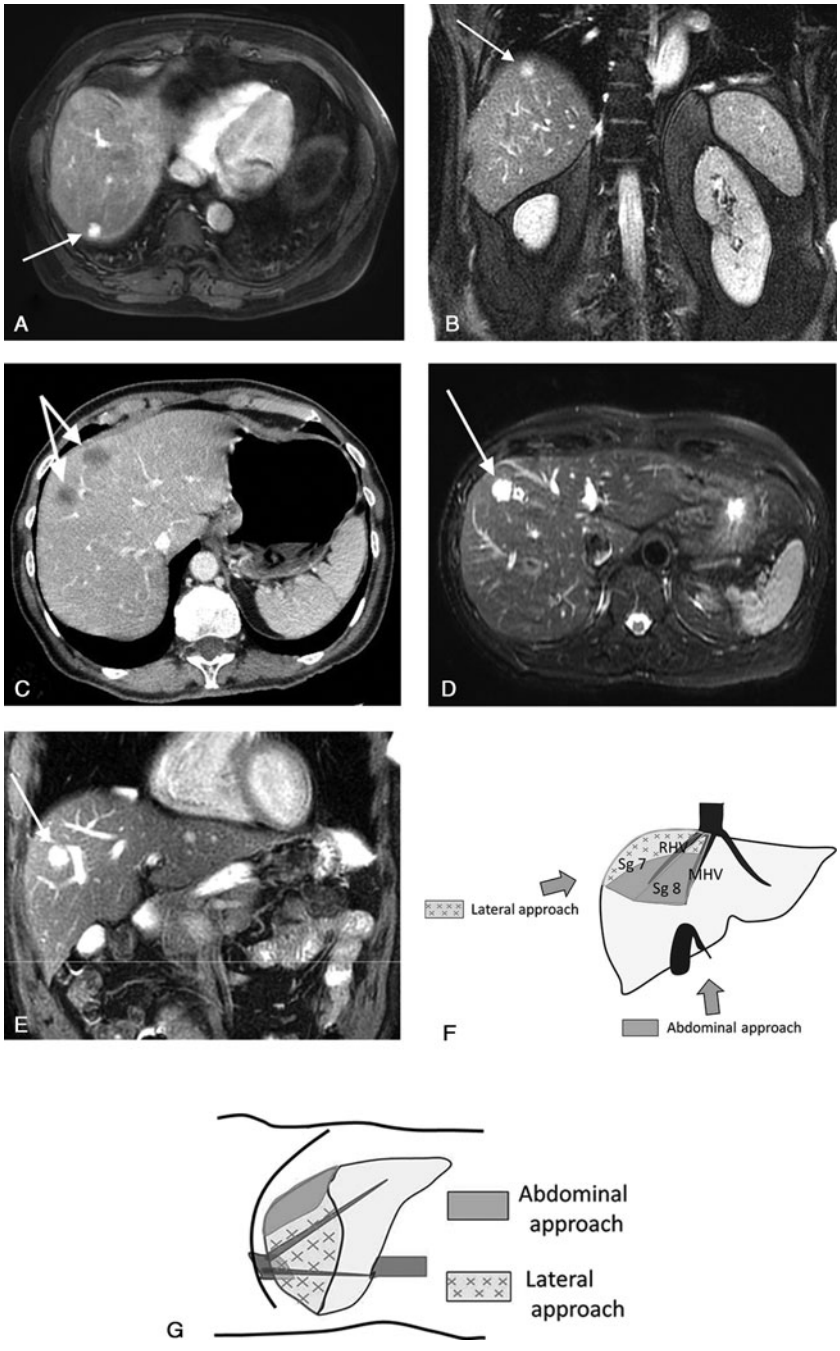

FIGURE 1. Case presentations illustrating use of the CLA approach and the abdominal-only approach. A–C, The CLA approach was used to resect the cranial area for a patient with a cranial segment 7 lesion (A, axial MR image; B; coronal MR image) and to resect the deep area for a patient with multiple segment 8 lesions (C, axial computed tomographic image). D–G, In contrast, the abdominal-only approach was used for a patient with a caudal and superficial segment 8 lesion (D; axial MR image; E; coronal MR image). Schemes of the coronal (F) and sagittal (G) liver plane show that the regular abdominal approach was used for dissection of the caudal and superficial area within segments 7 and 8 (in dark gray) and the lateral approach was used for dissection of the remaining area within segments 7 and 8 (represented by cross-hatching). MHV indicates middle hepatic vein; MR, magnetic resonance; RHV, right hepatic vein; Sg 7, segment 7; Sg 8, segment 8.

Procedure

Indication

A parenchyma-sparing laparoscopic resection of segment 7 or 8, rather than a non–parenchyma-sparing approach (eg, right hepatectomy or right posterior sectionectomy), was planned when it was anticipated that this parenchyma-sparing resection would achieve adequate surgical margins. Thus, the indications for laparoscopic resection of segment 7 or 8 included no extension of the lesion to the parenchyma of segment 4a, 5, or 6; no involvement of the portal pedicle of segment 5 or 6; and no infiltration of the main trunk of the right or middle hepatic vein.

Technical Details of the CLA Approach

For the CLA approach, the patient was placed in the left semi-lateral decubitus position with the right arm suspended (Fig. 2A); for the abdominal-only approach, the patient was placed in the low lithotomy position, the so-called "French" position.

The operation began with the abdominal approach and the operating surgeon standing between the legs or to the left side of the patient (Fig. 2B). Four or 5 trocars were placed in the right upper quadrant of the abdomen, 3 of them just below the right subcostal margin (Fig. 2C), and the intra-abdominal pressure was maintained at 10 to 12 mm Hg. The hepatoduodenal ligament was encircled with

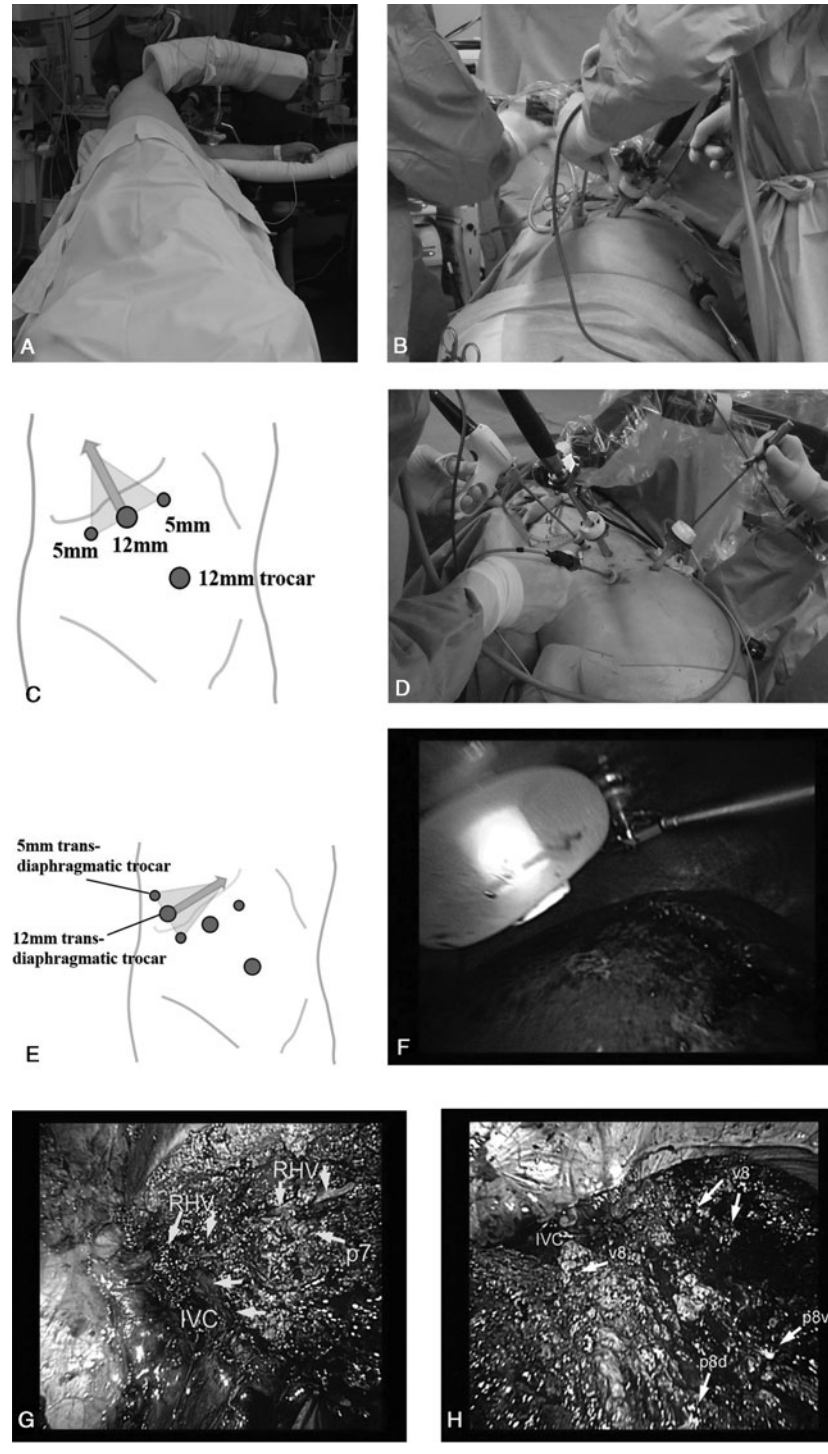

FIGURE 2. Technical details of laparoscopic resection of lesions in segments 7 and 8 via the CLA approach. A, The patient was placed in the left semilateral decubitus position with the right arm suspended. B, C, During the abdominal approach, the surgeon stood between the legs or to the left side of the patient, and 4 or 5 trocars were placed in the right upper quadrant of the abdomen, 3 of them just below the right subcostal margin. D–F, During the lateral approach, the surgeon stood to the patient's right side, and 2 additional balloon-tipped trocars were inserted through the diaphragm in the right intercostal space. G, H, For anatomic resection of lesions in segments 7 (G) and 8 (H), portal pedicles were divided close to their origins, and landmark hepatic veins were exposed on the transection plane. IVC indicates inferior vena cava; MHV, middle hepatic vein; MR, magnetic resonance; p7, portal pedicle to segment 7; p8d, dorsal branch of the portal pedicles to segment 8; p8v, ventral branch of the portal pedicles to segment 8; RHV, right hepatic vein; v8, venous branch draining segment 8.

umbilical tape for inflow occlusion (Pringle maneuver)[20–22] when needed. The right liver was fully mobilized with division of the right hepatocaval ligament for resection of segment 7 lesions but not for resection of segment 8 lesions. Before parenchymal transection, intraoperative laparoscopic ultrasonography with a flexible probe was used to evaluate the relationship between the lesion and vascular structures. Then, the dissection planes were determined to obtain adequate surgical margins. Venous branches draining segments 7 and 8 were identified to prevent inadvertent injury and subsequent hemorrhage.

After the caudal and superficial liver parenchyma was transected with bipolar forceps and ultrasonic shears via the regular abdominal approach, the operating surgeon moved to the patient's right side (Fig. 2D). Under direct visualization of the respiratory movement of the right lung via a transabdominal laparoscopic view, 2 balloon-tipped trocars were inserted through the same intercostal space and

subsequently into the diaphragm (the lateral approach) (Figs. 2E, F) to allow optimal instrument triangulation and keep eye-target and hand-target axes in line (Figs. 2D, E).[23] To achieve adequate surgical margins with good hemostasis, the corresponding portal pedicles in cases of large or deep intraparenchymal tumors were divided close to their origins and landmark hepatic veins (right hepatic vein and/or middle hepatic vein) were exposed on the parenchymal surface (Figs. 2G, H). The central venous pressure was maintained low[19] during parenchymal transection to maximize the hemostatic effect of the pneumoperitoneum on the transection surface. After completion of the parenchymal transection, the specimen was removed with an endoscopic retrieval bag through a suprapubic incision or infraumbilical port incision. Transdiaphragmatic trocars were removed after any remaining gas in the thoracic cavity was aspirated, and diaphragmatic incisions were closed via laparoscopic sutures under the transabdominal laparoscopic view. No thoracic drainage was used. Abdominal drains were placed at the transection surface of the liver only if there was concern about adequate biliostasis or hemostasis.

Statistical Analysis

Continuous variables are presented as medians and ranges and were compared using the Mann-Whitney *U* test. Categorical variables were compared using Fisher exact tests or χ^2 tests where appropriate. All analyses were performed using SPSS, version 15.0 (SPSS Inc, Chicago, IL), and significance was defined as $P < 0.05$.

RESULTS

During review of the video recordings (see Supplemental Digital Content, available at . . .), we found that the CLA approach not only was more likely to result in visualization of the operative field at the dome of the liver (Fig. 3A) and deep within the parenchyma (Fig. 3B) in the center of the laparoscopic image but also brought the operating field closer to the camera and made it more accessible to the surgeon's instruments. With the CLA approach, thin vascular branches of the right and middle hepatic veins were well recognized and bleeding was more effectively controlled than by the abdominal-only approach (Fig. 3C). Portal pedicles were well identified deep in the parenchyma of segments 7 and 8 and were clipped or sealed before their division (Fig. 3D). In contrast, during the abdominal approach, the operative field was distant from transabdominal trocars and located tangential to the laparoscopic view so that the actual line of transection could not be visualized frontally. Specifically, with the transabdominal view, the operative field in the cranial area of segments 7 and 8 was blocked by the liver parenchyma of the caudal area of segments 7 and 8 and the operative field deep in segments 7 and 8 was obstructed by the liver parenchyma of segments 5 and 6. This is also known as the "fulcrum effect."

Clinical data are summarized in Table 1. The most common indication for liver resection was colorectal liver metastasis (72% of patients treated with the CLA approach and 95% of patients treated with an abdominal-only approach). Preoperative chemotherapy, mainly FOLFOX, was administered to 12 patients (48%) in the CLA approach group and 12 patients (63%) in the abdominal-only approach group. Steatosis affected 8 patients (32%) in the CLA approach group and 2 patients (11%) in the abdominal-only approach group, and cirrhosis, classified as Child-Pugh grade A, was observed in 1 patient (4%) in the CLA approach group. Deep intraparenchymal tumor location was more common, and tumor diameter tended to be greater in the CLA approach group than in the abdominal-only approach group (88% vs 42%; $P = 0.035$ and 24.5 mm vs 15.0 mm; $P = 0.114$).

Five patients (20%) in the CLA approach group and 1 (5%) in the abdominal-only approach group had multiple tumors in segments 7 and 8. In the CLA approach group, 15 tumors (48%) were in segment 7, 1 (3%) was in both segments 7 and 8, and 15 (48%) were in segment 8. In the abdominal-only approach group, 11 tumors (55%) were in segment 7, 1 (5%) was in segments 7 and 8, and 8 (40%) were in segment 8. Eight patients (32%) in the CLA approach group and 9 patients (47%) in the abdominal-only approach group had tumors in other segments of the liver.

Operative details are summarized in Table 2. In the CLA approach group, 12 anatomic resections (43%) and 16 nonanatomic

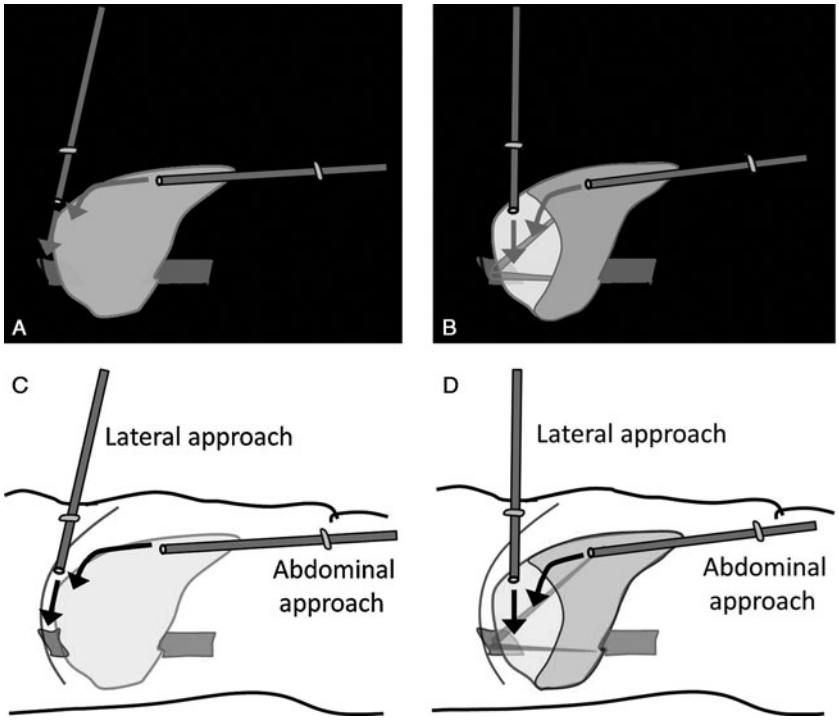

FIGURE 3. Differences in laparoscopic view and access between the lateral and abdominal approaches. A, B, The lateral approach provided a direct view and short access to the operative field around the dome (A) and in the deep parenchyma (B). C, A tear in the origin of the MHV was successfully sutured closed via the lateral approach. The tape is encircling the root of the RHV. D, The portal pedicle to segment 8 was identified and clipped before division via the lateral approach. MVH indicates middle hepatic vein; RHV, right hepatic vein.

TABLE 1. Preoperative Profiles of Patients Who Underwent Laparoscopic Isolated Resection of Liver Segments 7 and 8

	CLA Approach Group (n = 25)	Abdominal-Only Approach Group (n = 19)	*P*
Demographic factors			
Age, mean (range), yr	60 (22–85)	66 (48–79)	0.231
Gender (male/female), n (%)	16 (64)/9 (36)	9 (47)/10 (53)	0.270
Indication for liver resection, n (%)			
Colorectal metastasis	18 (72)	18 (95)	0.111
Other metastasis	6 (24)	0 (0)	0.029
Hepatocellular carcinoma	1 (4)	0 (0)	1.000
Adenoma	0 (0)	1 (5)	0.432
Preoperative chemotherapy, n (%)	12 (48)	12 (63)	0.317
Underlying liver, n (%)			
Steatosis	8 (32)	2 (11)	0.148
Cirrhosis	1 (4)	0 (0)	1.000
Normal liver	16 (64)	17 (90)	0.081
Previous liver resection, n (%)	7 (28)	3 (16)	0.474
Deep/superficial lesion, n (%)	22 (88)/3 (12)	8 (42)/11 (58)	0.035
Maximum diameter of tumors in segments 7 and 8, median (range), mm	24.5 (8–49)	15 (8–40)	0.114
Total lesions in segments 7 and 8, n (%)			
Segment 7	15 (48)	11 (55)	0.776
Extending to both segments 7 and 8	1 (3)	1 (5)	1.000
Segment 8	15 (48)	8 (40)	0.580
Patients having lesions in other segments of the liver, n (%)	8 (32)	9 (47)	0.359
Total No. lesions in the whole liver, median (range)	1 (1–4)	1 (1–4)	0.887

TABLE 2. Operative Details

	CLA Approach Group (n = 25)	Abdominal-Only Approach Group (n = 19)	*P*
Anatomic/nonanatomic resection, n	12 (43)/16 (57)	6 (32)/13 (68)	0.546
Patients undergoing concomitant major procedures, n (%)	15 (60)	10 (53)	1.000
Other laparoscopic liver procedures	11 (44)	8 (42)	0.900
Laparoscopic colorectal procedures	2 (8)	4 (21)	0.378
Other laparoscopic procedures	4 (16)	2 (11)	0.684
Inflow control (Pringle maneuver), n (%)			
Taped	16 (64)	5 (26)	0.017
Clamped	2 (8)	2 (11)	1.000
Operation time, median (range), min	217.5 (90–390)	165 (75–570)	0.046
Blood loss, median (range), mL	200 (20–2900)	100 (0–1800)	0.163
Transfusion, n (%)	1 (4)	3 (16)	0.300
Conversion, n (%)	0 (0)	1 (5)	0.432
Abdominal drainage, n (%)	9 (36)	5 (26)	0.534
Thoracic drainage, n (%)	0 (0)	0 (0)	NA

NA indicates not applicable.

resections (57%) were performed, whereas in the abdominal-only approach group, 6 anatomic resections (32%) and 13 nonanatomic resections (68%) were performed ($P = 0.546$). In the CLA approach group, 11 patients (44%) underwent an additional laparoscopic liver procedure simultaneously (8 wedge resections of other liver sites and 3 radio-frequency ablations, 2 for lesions in segments 7 and 8); in the abdominal-only approach group, 8 patients (42%) underwent an additional laparoscopic liver procedure simultaneously (10 wedge resections of other liver sites, 1 left hepatectomy, and 1 radio-frequency ablation for a lesion in segment 8). The hepatoduodenal ligament was taped in preparation for the Pringle maneuver in 16 patients (64%) in the CLA approach group and in 5 patients (26%) in the abdominal-only approach group ($P = 0.017$) and clamped in 2 patients in each group (8% and 11%, respectively; $P = 1.000$).

Median operative time was significantly longer in the CLA approach group than in the abdominal-only approach group (217.5 minutes vs 165 minutes; $P = 0.046$). There was also a trend toward greater median blood loss in the CLA approach group than in the abdominal-only approach group (200 mL vs 100 mL; $P = 0.163$), although blood loss overall was low. However, blood transfusion and conversion to open surgery were less frequent in the CLA approach group than in the abdominal-only approach group [1 patient (4%) vs 3

patients (16%); $P = 0.300$ and 0 patient vs 1 patient (5%); $P = 0.432$, respectively]. Abdominal drains were placed in 9 patients (36%) in the CLA approach group and 5 patients (26%) in the abdominal-only approach group ($P = 0.534$), and no thoracic drain was used in either group.

Postoperative outcomes are summarized in Table 3. The median weight of the excised parenchyma from segments 7 and 8 tended to be greater in the CLA approach group than in the abdominal-only approach group (56.5 g vs 23.0 g; $P = 0.093$). The median width of the tumor-free surgical margin did not differ between the 2 groups (3 mm in the CLA approach group vs 4 mm in the abdominal-only approach group; $P = 0.423$). R1 resection margins (microscopic margin involvement) were observed in 3 patients, but no patient had R2 resection margins (macroscopic residual tumor). Two of the 3 patients with R1 resection margins were in the CLA approach group. One of these 2 patients underwent resection of a tumor in contact with the middle hepatic vein, but an isolated segment 8 resection was performed to preserve the middle hepatic vein because of bilobar metastases.

Clavien-Dindo[24] grade 3 or greater complications occurred in 4 patients in each group (16% CLA approach vs 21% abdominal-only approach; $P = 0.710$), and no deaths were reported in either group. One patient in each group had a biliary fistula (4% CLA approach vs 5% abdominal-only approach; $P = 1.000$). One patient in the abdominal-only approach group had postoperative hemorrhage, which was followed by reoperation. One patient in the abdominal-only approach group developed a pleural effusion requiring drainage. An important and clinically relevant complication was the development of a diaphragmatic hernia in 1 patient in the CLA approach group a few years after resection. This required reoperation. No thoracic complications were observed in the CLA approach group. The median duration of postoperative hospitalization was similar between the 2 groups (CLA approach 7 days vs abdominal-only approach 6 days; $P = 0.765$).

DISCUSSION

This study showed that for resection of lesions in segments 7 and 8, our CLA approach produced outcomes not inferior to those seen with the regular abdominal-only approach, although the lesions in the CLA approach group were in more challenging locations.

Perioperative Parameters

In our study, the outcomes of patients in the CLA approach group were acceptable despite the added risk of the transdiaphragmatic port position. In the CLA approach group, the median value for blood loss, which is one of the greatest concerns and the main cause of conversion to open surgery during laparoscopic liver resection, was 200 mL and the incidence of blood transfusions was 4%. These results compare favorably with those reported in previous studies describing open resection of segment 8 (253–305 mL and 11.0%–35.3%, respectively)[25–28] and studies with more than 100 laparoscopic liver resections that included few segment 7 and 8 resections (98–557 mL and 2.8%–31%, respectively).[6,21,22,29–34] The highest amounts of blood loss were a single outlier case in each group: one patient in the CLA approach group lost 2900 mL of blood during multiple resections of a severely steatotic liver together with extensive adhesiolysis due to previous hepatectomies, and one patient in the abdominal-only approach group lost 1800 mL of blood during simultaneous resections of a rectal primary and a segment 8 liver lesion. In these cases, a Pringle maneuver was performed and gauze compression to control the bleeding. No patient in the CLA approach group required conversion to open surgery compared with 2.4% to 12% of patients in the aforementioned studies of laparoscopic resection.[6,21,22,29–34] Clavien-Dindo grade 3 or greater complications were observed in 16% of patients in the CLA approach group. No patients in that group died compared with 5.5% to 22% of patients in previous studies of laparoscopic liver resection.[6,21,22,29–34] Postoperative biliary fistula, which is one of the major concerns after complex liver resection[25] and may correlate with long hospital stay

TABLE 3. Postoperative Outcomes

	CLA Approach Group (n = 25)	Abdominal-Only Approach Group (n = 19)	*P*
Weight of excised segments 7–8 parenchyma, median (range), g	56.5 (10–210)	23 (5–267)	0.093
Extent of surgical margin, median (range), mm	3 (0–13)	4 (0–25)	0.423
Margin status, n (%)			
R1	2 (8)	1 (5)	1.000
R2	0 (0)	0 (0)	NA
Complication, n (%)	5 (20)	5 (26)	0.723
Clavien-Dindo classification			
I–II	1 (4)	1 (5)	1.000
III–IV	4 (16)	4 (21)	0.710
V (death)	0 (0)	0 (0)	NA
Biliary fistula	1 (4)	1 (5)	1.000
Postoperative hemorrhage	0 (0)	1 (5)	0.432
Pulmonary complication	0 (0)	1 (5)	0.432
Diaphragmatic hernia	1 (4)	0 (0)	1.000
Others	2 (8)*	2 (11)†	1.000
Reoperation, n (%)	0 (0)	1 (5)	0.432
Postoperative hospital stay, median (range), d	7 (4–22)	6 (3–49)	0.765

*Ascites and pancreatic fistula after concomitant pancreatic resection.
†Abdominal abscess and pancreatitis.
R1 indicates microscopic margin involvement; R2, macroscopic residual tumor.

and increased mortality, occurred in only 1 patient (4%) in the CLA approach group compared with 0% to 20.6% of patients in previous studies of open segment 8 resection.[25–28] In our study, there was 1 complication specifically associated with the use of the transdiaphragmatic trocars: a diaphragmatic hernia through a 5-mm port-site diaphragmatic defect. This complication developed a few years after surgery and occurred early in our experience when closure of the 5-mm suprahepatic diaphragmatic trocar defect was not part of our approach. After this observation, we revised our approach to close any diaphragmatic incisions and observed no subsequent diaphragmatic hernias. It is important that even 5-mm diaphragmatic trocar defects require closure.

In the CLA approach group, the median width of the tumor-free surgical margin was 3 mm, and 2 patients (8%) had positive resection margins (R1). This rate of R1 resection was acceptable compared with those in previous studies of heterogeneous laparoscopic resections (1.3%–6.0%).[6,21,22,29–34]

Our study showed that the CLA approach was safe, feasible, and oncologically sound as demonstrated by similar outcomes between the CLA approach and abdominal-only approach groups with respect to blood loss, blood transfusion, conversion to open surgery, postoperative complications, mortality, and surgical margin status. These noninferior results from the CLA approach lead us to conclude that cranial, large, or deep lesions within segments 7 and 8 that necessitate resection deep within the parenchyma or segmentectomy and lesions that are situated close to critical structures are resected more successfully via the CLA approach than via the regular abdominal-only approach.

Lesion Characteristics

Despite the greater technical demands on surgeons in the CLA approach group, as indicated by the higher proportion of deep tumors in this group and the trend toward higher weight of excised parenchyma in this group, the only perioperative outcome that differed significantly between the CLA approach group and the abdominal-only approach group was median operative time, which was 52.5 minutes longer in the CLA approach group.

Laparoscopic Visualization

The optimization of laparoscopic visualization and access directly affects procedural precision and efficiency.[23] Excellent visualization by the transdiaphragmatic laparoscope was helpful to identify portal pedicles and venous branches and avoid inadvertent injury. Inline working access to the operative target through transdiaphragmatic trocars allowed better control of bleeding and facilitated creation of precisely curved or angulated transection planes as planned.

Comparison With Non–Parenchyma-Sparing Approach

Laparoscopic right hepatectomy or right posterior sectionectomy, which is technically easier than laparoscopic isolated resection of segment 7 or 8, may be another choice for resection of lesions within these segments.[14,15,19] During right hepatectomy and right posterior sectionectomy, lesion-feeding portal pedicles can usually be isolated and divided at the liver hilum. In contrast to the parenchymal transection for segmental resection, the parenchymal transection for a lobectomy can be completed in a single plane and the right and middle hepatic veins are visualized in a wider operative field. Because of the lesser procedural complexity, laparoscopic right hepatectomy or right posterior sectionectomy is more frequently used for large or deeply located lesions within segment 7 or 8.[14,19,25] Nevertheless, laparoscopic resection of lesions in these segments has advantages over laparoscopic right hepatectomy and right posterior sectionectomy, mainly in terms of the preservation of greater liver parenchyma. This potentially decreases morbidity[10] in patients who undergo prolonged chemotherapy, those with cirrhotic livers, and those in whom repeat resection may be required. Isolated resection of segment 7 or 8 increases the chances of performing multiple concomitant liver resections for patients with bilobar lesions while avoiding insufficient remnant volume.[35–37] In our series, 10 patients (23%) underwent resection for bilobar and multiple lesions; of these, 2 patients underwent 2 limited resections, 7 patients underwent 3 or more limited resections, and 1 patient underwent a major resection (left hepatectomy), together with resection of segment 8. None of the patients had postoperative liver insufficiency. Isolated resection of segment 7 or 8 increases the possibility of repeated resection in the event of recurrent liver lesions,[38,39] which may positively affect long-term prognosis.[40–42] Therefore, parenchyma-sparing resection of segment 7 or 8 is important especially in the treatment of colorectal liver metastasis and hepatocellular carcinoma,[10,43] which accounted for 84% of the cases in our series.

LIMITATIONS

This study has a few limitations aside from its retrospective nature, the most significant of which is the lack of long-term oncologic outcomes of the CLA approach. Evaluating long-term follow-up and increasing sample size through pooling of data from the patients in other groups who might adapt this approach in the future are warranted.

CONCLUSIONS

Laparoscopic resection of lesions in segments 7 and 8 using the CLA approach is safe and feasible even for lesions in challenging locations. We believe this approach is helpful to expand the indications for laparoscopic resection of lesions in segments 7 and 8 and should be in the armamentarium of advanced laparoscopic liver surgeons.

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Drs Ogiso and Conrad contributed equally to this study.

REFERENCES

1. Nguyen KT, Marsh JW, Tsung A, et al. Comparative benefits of laparoscopic vs open hepatic resection: a critical appraisal. *Arch Surg.* 2011;146:348–356.
2. Croome KP, Yamashita MH. Laparoscopic vs open hepatic resection for benign and malignant tumors: an updated meta-analysis. *Arch Surg.* 2010;145:1109–1118.
3. Cherqui D, Husson E, Hammoud R, et al. Laparoscopic liver resections: a feasibility study in 30 patients. *Ann Surg.* 2000;232:753–762.
4. Gigot JF, Glineur D, Santiago Azagra J, et al. Laparoscopic liver resection for malignant liver tumors: preliminary results of a multicenter European study. *Ann Surg.* 2002;236:90–97.
5. Kaneko H, Takagi S, Shiba T. Laparoscopic partial hepatectomy and left lateral segmentectomy: technique and results of a clinical series. *Surgery.* 1996;120:468–475.
6. Dagher I, O'Rourke N, Geller DA, et al. Laparoscopic major hepatectomy: an evolution in standard of care. *Ann Surg.* 2009;250:856–860.
7. Nitta H, Sasaki A, Fujita T, et al. Laparoscopy-assisted major liver resections employing a hanging technique: the original procedure. *Ann Surg.* 2010;251:450–453.
8. Gayet B, Cavaliere D, Vibert E, et al. Totally laparoscopic right hepatectomy. *Am J Surg.* 2007;194:685–689.
9. Lin NC, Nitta H, Wakabayashi G. Laparoscopic major hepatectomy: a systematic literature review and comparison of 3 techniques. *Ann Surg.* 2012;257:205–213.
10. Edwin B, Nordin A, Kazaryan AM. Laparoscopic liver surgery: new frontiers. *Scand J Surg.* 2011;100:54–65.
11. Gagner M, Rogula T, Selzer D. Laparoscopic liver resection: benefits and controversies. *Surg Clin North Am.* 2004;84:451–462.

12. Welsh FK, Tekkis PP, John TG, et al. Open liver resection for colorectal metastases: better short- and long-term outcomes in patients potentially suitable for laparoscopic liver resection. *HPB (Oxford).* 2010;12:188–194.
13. Laurent A, Cherqui D, Lesurtel M, et al. Laparoscopic liver resection for subcapsular hepatocellular carcinoma complicating chronic liver disease. *Arch Surg.* 2003;138:763–769.
14. Cho JY, Han HS, Yoon YS, et al. Feasibility of laparoscopic liver resection for tumors located in the posterosuperior segments of the liver, with a special reference to overcoming current limitations on tumor location. *Surgery.* 2008;144:32–38.
15. Vibert E, Perniceni T, Levard H, et al. Laparoscopic liver resection. *Br J Surg.* 2006;93:67–72.
16. Ikeda T, Mano Y, Morita K, et al. Pure laparoscopic hepatectomy in semiprone position for right hepatic major resection. *J Hepatobiliary Pancreat Sci.* 2013;20:145–150.
17. Kazaryan AM, Rosok BI, Marangos IP, et al. Comparative evaluation of laparoscopic liver resection for posterosuperior and anterolateral segments. *Surg Endosc.* 2011;25:3881–3889.
18. Gumbs AA, Gayet B. Video: the lateral laparoscopic approach to lesions in the posterior segments. *J Gastrointest Surg.* 2008;12:1154.
19. Ishizawa T, Gumbs AA, Kokudo N, et al. Laparoscopic segmentectomy of the liver: from segment I to VIII. *Ann Surg.* 2012;256:959–964.
20. Torzilli G, Procopio F, Donadon M, et al. Safety of intermittent Pringle maneuver cumulative time exceeding 120 minutes in liver resection: a further step in favor of the "radical but conservative" policy. *Ann Surg.* 2012;255: 270–280.
21. Koffron AJ, Auffenberg G, Kung R, et al. Evaluation of 300 minimally invasive liver resections at a single institution: less is more. *Ann Surg.* 2007;246:385–392; discussion 392–394.
22. Bryant R, Laurent A, Tayar C, et al. Laparoscopic liver resection-understanding its role in current practice: the Henri Mondor Hospital experience. *Ann Surg.* 2009;250:103–111.
23. van Det MJ, Meijerink WJ, Hoff C, et al. Optimal ergonomics for laparoscopic surgery in minimally invasive surgery suites: a review and guidelines. *Surg Endosc.* 2009;23:1279–1285.
24. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240:205–213.
25. Dokmak S, Agostini J, Jacquin A, et al. High risk of biliary fistula after isolated segment VIII liver resection. *World J Surg.* 2012;36:2692–2698.
26. Mazziotti A, Maeda A, Ercolani G, et al. Isolated resection of segment 8 for liver tumors: a new approach for anatomical segmentectomy. *Arch Surg.* 2000;135:1224–1229.
27. Hu JX, Dai WD, Miao XY, et al. Anatomic resection of segment VIII of liver for hepatocellular carcinoma in cirrhotic patients based on an intrahepatic Glissonian approach. *Surgery.* 2009;146:854–860.
28. Kishi Y, Hasegawa K, Kaneko J, et al. Resection of segment VIII for hepatocellular carcinoma. *Br J Surg.* 2012;99:1105–1112.
29. Buell JF, Thomas MT, Rudich S, et al. Experience with more than 500 minimally invasive hepatic procedures. *Ann Surg.* 2008;248:475–486.
30. Dagher I, Belli G, Fantini C, et al. Laparoscopic hepatectomy for hepatocellular carcinoma: a European experience. *J Am Coll Surg.* 2010;211:16–23.
31. Kazaryan AM, Pavlik Marangos I, Rosseland AR, et al. Laparoscopic liver resection for malignant and benign lesions: ten-year Norwegian single-center experience. *Arch Surg.* 2010;145:34–40.
32. Cho JY, Han HS, Yoon YS, et al. Experiences of laparoscopic liver resection including lesions in the posterosuperior segments of the liver. *Surg Endosc.* 2008;22:2344–2349.
33. Chen HY, Juan CC, Ker CG. Laparoscopic liver surgery for patients with hepatocellular carcinoma. *Ann Surg Oncol.* 2008;15:800–806.
34. Topal B, Fieuws S, Aerts R, et al. Laparoscopic versus open liver resection of hepatic neoplasms: comparative analysis of short-term results. *Surg Endosc.* 2008;22:2208–2213.
35. Gold JS, Are C, Kornprat P, et al. Increased use of parenchymal-sparing surgery for bilateral liver metastases from colorectal cancer is associated with improved mortality without change in oncologic outcome: trends in treatment over time in 440 patients. *Ann Surg.* 2008;247:109–117.
36. Adam R, Laurent A, Azoulay D, et al. Two-stage hepatectomy: a planned strategy to treat irresectable liver tumors. *Ann Surg.* 2000;232:777–785.
37. Jaeck D, Oussoultzoglou E, Rosso E, et al. A two-stage hepatectomy procedure combined with portal vein embolization to achieve curative resection for initially unresectable multiple and bilobar colorectal liver metastases. *Ann Surg.* 2004;240:1037–1049; discussion 1049–1051.
38. Shafaee Z, Kazaryan AM, Marvin MR, et al. Is laparoscopic repeat hepatectomy feasible? A tri-institutional analysis. *J Am Coll Surg.* 2011;212:171–179.
39. Belli G, Cioffi L, Fantini C, et al. Laparoscopic redo surgery for recurrent hepatocellular carcinoma in cirrhotic patients: feasibility, safety, and results. *Surg Endosc.* 2009;23:1807–1811.
40. Suzuki S, Sakaguchi T, Yokoi Y, et al. Impact of repeat hepatectomy on recurrent colorectal liver metastases. *Surgery.* 2001;129:421–428.
41. Nakajima Y, Ko S, Kanamura T, et al. Repeat liver resection for hepatocellular carcinoma. *J Am Coll Surg.* 2001;192:339–344.
42. Adam R, Bismuth H, Castaing D, et al. Repeat hepatectomy for colorectal liver metastases. *Ann Surg.* 1997;225:51–60; discussion 60–62.
43. Nguyen KT, Gamblin TC, Geller DA. World review of laparoscopic liver resection—2,804 patients. *Ann Surg.* 2009;250:831–841.

