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Laparoscopic surgery section

Current position of advanced laparoscopic surgery of the liver

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With the improvement of laparoscopic techniques and the development of new and dedicated technologies, endoscopic liver surgery has become feasible. While wedge liver resections are performed more and more frequently, laparoscopic anatomical liver resections are still at an early stage of development and are somewhat controversial. In 1993 we initiated formal laparoscopic liver resections in selected patients. From 1993 to December 1995 20 patients underwent endoscopic formal resections: the procedures comprised six left hepatectomies, five right hepatectomies, one of which extended to the segment IV, three mesohepatectomy, five segmentectomies and one bisegmentectomy. The operation time ranged from 120 to 270 min (average 193 min). In 17 out of 20 cases a Pringle manoeuvre was performed (mean occlusion time 45 min). No intra-operative complications occurred and there were no conversions in the whole series. Average intra-operative blood loss was 397.5 mL and 35% of patients required intro-operative blood transfusions. Post-operative mortality rate was 5% and post-operative morbidity rate was 45% (one coagulopathy with severe trombocytopaenia, six pleural effusions, one bile collection and four hematomas of the trocar sites). Such preliminary data are comparable with those of a group of 65 patients who underwent open anatomical liver resections from 1992 and 1995. Far from being a routine technique in liver surgery, the laparoscopic approach to forma liver resections may be a promising procedure in selected patients.

Keywords: laparoscopic left hepatectomy, laparoscopic right hepatectomy, laparoscopic segmental liver resection, laparoscopic wedge liver, laparoscopy, liver resection.

Advanced liver surgery began with a left hepatic lobectomy performed in 1887 by Langenbuch.[1] The resection was accomplished by exteriorizing the liver tumour after application of a tie at its base. The resulting ischaemia caused necrosis of the exteriorized liver parenchyma including the neoplasm. This kind of resection was carried out without any knowledge of the segmental anatomy of the liver parenchyma. The first controlled liver lobectomy was reported in 1931 by Caprio.[2] Several years later, in 1939, the report by Meyer-May and Ton That Thung in *Memoires de l'Accademie de Chirurgie* on the first case of left hepatic bi-segmental dissection with ligation of the left hepatic vein, represented the technical breakthrough upon which is based modern advanced liver surgery.[3]

Laparoscopic liver resection has become feasible with the improvement of laparoscopic techniques and the development of new and dedicated technologies.[4–7] There have been several reports of wedge liver resections for single superficial benign lesions or metastases.[8–17] Furthermore, it is possible to perform major liver resections using laparoscopic assisted approaches that mirrors the steps of open procedures.[18,19]

Although there is no doubt about the benefit of endoscopic surgery for treatment of minimal or benign lesions, there is considerable concern whether the laparoscopic major resections benefit the patient, especially when performed for malignant diseases.[20]

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The rationale behind endoscopic liver surgery is based on several theoretical benefits which may be summarised as follows

(1) Minimal tissue trauma, resulting in a reduced surgical stress and post-operative immune suppression.
(2) No interruption of large abdominal wall venous collaterals with potential effect on portal pressure.
(3) No exposure of viscera which, in open surgery, causes large fluid and protein losses, resulting in a reduction of intra-operative crystalloid and colloid requirements, better haemodynamic stability and less 'third space' fluid sequestration.
(4) Less disturbance of respiratory function and reduced post-operative pulmonary complications.
(5) Decreased post-operative pain, quicker recovery and hospital discharge.

In view of its impact on quality of life, the decreased post-operative morbidity rate in patients with poor prognosis is an important consideration and the aim of advanced laparoscopic liver surgery is targeted to this potential benefit.

At present, the indications for laparoscopic formal liver resections are not well defined. For a laparoscopic procedure we consider not only eligible, selected patients with liver deposits, but also patients with cirrhosis who are developing hepato-cellular carcinoma (HCC), those with superficial tumours, tumours of any size located in the left lobe (2nd and 3rd segment) and small right intraparenchymal tumours, which do not greatly increase the overall volume of the right lobe. Intraparenchymal HCC in normal liver is considered an indication for the laparoscopic approach only when it is less than 4 cm in diameter.

In addition to the usual contraindications to liver surgery, further contraindications to advanced laparoscopic liver surgery include extensive adhesions from previous surgery, adhesion to or infiltration of the diaphragm, inability to obtain adequate views of the supramesocolic compartment due to hepato- or splenomegaly and lesions located close to the hilum, the hepatic vein and the inferior vena cava. Because of the short period of CO_2 insufflation, significant cardio-respiratory impairment although important is not necessarily a contraindication to advanced endoscopic liver surgery. Nonetheless, the techniques of patient selection are important. The early results of laparoscopic-assisted formal liver lobectomies at this institution are presented here.

PATIENTS AND METHODS

Approval of laparoscopic liver surgery was granted by the Hospital Ethics Committee and laparoscopic formal liver resections started to be performed in 1993. From January 1993 to December 1995 a total of 25 endoscopic liver procedures have been carried out. Five of these were wedge resections and twenty were formal liver lobectomies or segmentectomies. The indications for advanced endoscopic liver resections were HCC in 12 patients (11 with underlying cirrhotic liver), cystic mucous cholangioadenoma in one patient, cholangiocarcinoma in one patient, one regenerative nodule in one cirrhotic liver, and five cases of metastatic liver disease (three colorectal, one renal and one breast cancer). Table 1 shows sex and age distribution, ASA grade and disease location. Besides the routine work-up, the pre-operative work-up in all cases consisted of ultrasound scanning, colour Doppler, computerized tomography scan, liver function tests (aminotransferase, gamma glutamyltransferase, bilirubin, protein electrophoresis, PT, PTT), and platelets count, fibrinogen and fibrin split products. At present, only child-A patients are considered eligible for such procedures. A pre-operative liver biopsy is performed under sonographic guidance. The endoscopic nature and the risks of the procedure are explained to the patients when informed consent is obtained.

Six out of the 20 anatomical liver resections were left hepatectomies, five were right hepatectomy, one of which extended to the segment IV, three were hemihepatectomy, five were segmentectomies (three segment V and two segment VI resections), and one was a bisegmentectomy (segments V and VI). In two patients the formal resection was associated with another surgical procedure: a segment V resection with a gastric banding and a left hepatectomy with a right colectomy.

Patients are kept on a strict low-salt diet for 5 days and receive a full dose of vitamin K. Two days before surgery patients undergo mechanical bowel preparation and the day before they are maintained on a clear liquid diet and medication is administered to reduce intestinal gas. Anti-aldosterone therapy is reserved only for patients with clinical and laboratory signs of secondary hyperaldosteronism.

The procedure is carried out under general anaesthesia with endotracheal intubation and epidural analgesia. Central and arterial

Table 1 Patients data and diagnosis

Patient	Sex	Age (years)	ASA	Diagnosis	Location
1	M	61	II	HCC in cirrhotic liver, 4 cm	seg. VI
2	M	46	II	HCC in hemangioma in cirrhotic liver	seg. III
3	F	46	I	cystic mucous cholangioadenoma	seg. V
4	M	51	II	HCC in cirrhotic liver	seg. IV, V
5	M	71	II	HCC in cirrhotic liver	seg. III
6	F	63	II	metastasis from colon cancer	seg. VI
7	M	68	II	HCC in cirrhotic liver	seg. V
8	M	60	II	HCC 2°	seg. V
9	M	69	II	HCC in cirrhotic liver	seg. II, III
10	M	62	II	metastases from kidney cancer	seg. V, VI, VII, VIII
11	M	73	III	HCC in cirrhotic liver	seg. IV, V
12	M	71	IV	regenerative nodule in cirrhotic liver	seg. II, III
13	F	67	II	3 metastases from colon cancer	right lobe
14	M	61	III	HCC in cirrhotic liver, 4 cm	seg. IV
15	M	73	III	HCC in cirrhotic liver	seg. V
16	M	70	II	HCC in cirrhotic liver	seg. II, III
17	M	67	II	4 metastases from colon cancer	right lobe
18	M	73	II	cholangiocarcinoma, colonic lipomatosis	seg. II, III
19	M	70	II	HCC in cirrhotic liver	seg. V, VI
20	F	54	I	metastases from breast cancer	seg. IV, VIII
		63,8			

Figure in the last line of the age column is the average value.

lines are established for peri-operative cardio-vascular and arterial pressure monitoring. Continuous electrocardiogram (ECG), pulse-oximetry and end-tidal CO_2 monitoring is established as well. A single dose of metronidazole and a second generation cephalosporin are administered for antibiotic prophylaxis. Samples for blood gases analysis are obtained every 30 min to correct possible metabolic acidosis as early as possible.

Operative technique

The patient lies on the table in the supine position, with legs apart. The surgeon operates in the 'French' position with an assistant on either side (Figure 1). CO_2 pneumoperitoneum is established and four to six access ports are placed as shown on Figure 2. A 30° scope is inserted through the navel cannula and the peritoneal cavity is then inspected to assess the feasibility of the procedure, checking the absence of peritoneal deposits and the patency of the Winslow's foramen. Intra-operative ultrasonography and colour Doppler study of the vascular elements are also carried out at this stage. The operation then proceeds in a totally laparoscopic fashion in patients undergoing wedge resections or left lobectomy, alternatively conversion to a laparoscopic assisted procedure may be recommended in cases of major resections such as right hepatectomy or trisegmentectomy (extended right hepatectomy). In the latter instance, a 6-cm upper midline incision is made. A Mouret abdominal wall lifter is inserted through this incision and then retracted, allowing a suitable view of the operative field by the gasless-laparoscopy technique. The laparoscopic dissection mirrors the open procedure: the round ligament is divided by stapler while the falciform and triangular ligaments are cut with scissors. Parenchymal dissection may proceed in one of two ways; either by a transparenchymal approach to the vascular elements (Thon-That-Tung) or by preliminary dissection and control of the hilar elements of the lobe to be removed. The Pringle manoeuvre (Figure 3) to

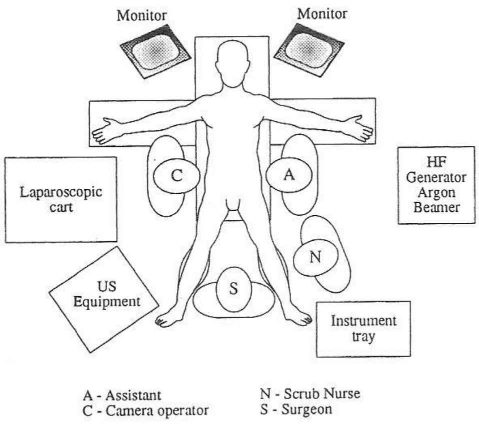

Figure 1 Patient position, position of the surgical team and equipment. The patient lays on the table with legs apart and head up tilt. The surgeon stays between the legs, with the cameraman at the patient's right and the assistant at the patient's left. Two-monitor display is recommended, argon beamer and High Frequency (HF) generator are located on the left side, behind the assistant and US equipment and the laparoscopy cart on the right side.

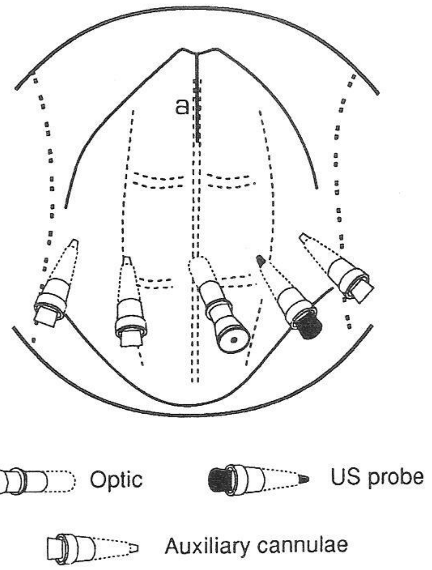

Figure 2 Position of cannulae. Five 10/12 mm cannulae are required: the cannula for the 30° telescope is positioned at the navel site, two cannulae are positioned on the right and two on the left side. The two medial operating cannulae lie on the transverse umbilical line while the lateral two are inserted in a more cephalad position. a Denotes upper midline minilaparotomy for insertion of the Mouret abdominal wall lifter and the tourniquet employed during the Pringle manoeuvre.

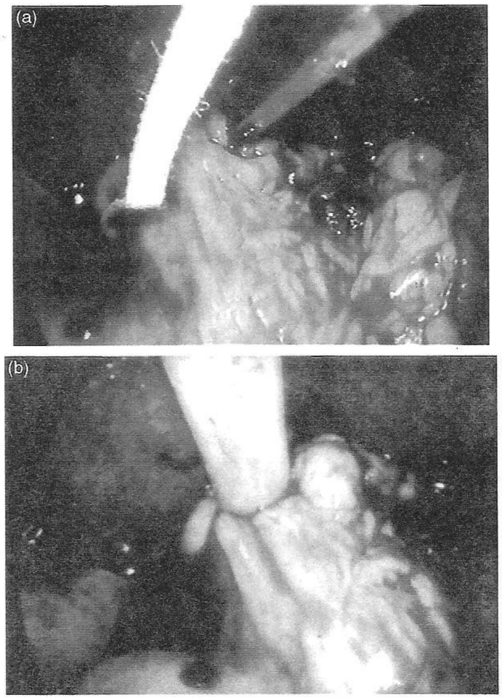

Figure 3 (a) and (b) Pringle manoeuvre. A tourniquet is applied on the portal triad.

minimize blood loss during the parenchymal dissection is used whenever possible. It is well-tolerated even in cirrhotic patients for period of up to 1 h. The Pringle manoeuvre is preferably maintained in an interrupted fashion.

Separation of the liver parenchyma is accomplished with Kelly-clamp fracture technique when the hepatic parenchyma has a normal consistency (Figure 4). Ultrasonic (US) dissection is preferred when the consistency is increased as in cirrhosis. In both cases the small intraparenchymal vessels are clipped (Figure 4) while larger vessels such as the main branches of the portal vein and the main hepatic veins are controlled with endo-linear stapler application (Figure 5).

While performing laparoscopic assisted right hepatectomies, one important difference from open surgery is that the dissection of the right lobe of the liver is carried out without forceful dislocation of the liver to the left, therefore avoiding a sudden decrease in venous return to the heart and cardiac output, which are associated with such a manoeuvre.

Once freed from all attachments, the resected specimen is inserted into a plastic retrieval bag and withdrawn through the minilaparotomy. The surface of the liver remnant is sprayed with a tissue sealant (Tissucol®, Immuno, Pisa, Italy), to deal with parenchymal oozing. During the post-operative period liver function is monitored to evaluate the efficiency of the remnant parenchyma and possible damage after prolonged Pringle manoeuvre.

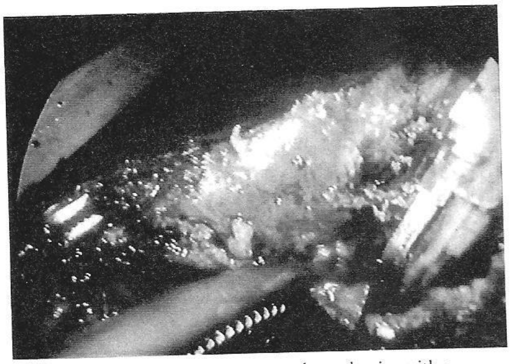

Figure 4 The dissection of the liver parenchyma begins with a preliminary application of a linear endostapler (one shot) and is continued performing a Kelly-clamp fracture. Intraparenchymal vessels are freed by the surgeon in this fashion and clipped by the assistant with a combined manoeuvre.

Figure 5 Closure-division of the right hepatic vein by stapler application.

The preliminary data regarding operative blood loss, length of Pringle manoeuvre, overall operative time, post-operative normalization of liver function tests and postoperative morbidity and mortality rates of the subjects in this feasibility study have been compared with those of a group of 65 patients (21 with liver metastases and 44 with HCC) who underwent open liver surgery from 1992 to 1995. All patients in this study have been followed up for 4 to 30 months (median follow-up 13 months).

RESULTS

The operative time ranged from 120 to 270 min (average 193 min). The operative time for left hepatectomy, with the exception of the case in which the procedure was associated with a right colectomy, ranged from 160 to 200 min, while that of right hepatectomy, included the extended right hepatectomy, ranged from 185 to 240 min.

The occlusion of the portal triad by Pringle manoeuvre was attempted in 17 of the 20 formal resections (Table 2). In all but three cases the occlusion time was less than 60 min (mean occlusion time 45 min). In prolonged cases (over 50 min of occlusion) the manoeuvre was interrupted periodically in the conventional way. The laparoscopic approach does not make the execution of the Pringle manoeuvre more difficult nor does it require more prolonged occlusion time. In patients in whom the Pringle manoeuvre was performed the liver function tests returned to normal after 1–8 days (median 5 days). No intra-operative complication occurred and there were no conversions to open surgery in the entire series. Intra-operative blood loss ranged from 100 to 1200 mL (average 397.5 mL) and seven patients (35%) required blood transfusions intra-operatively or in the early post-operative period.

One patient died (mortality rate 5%) on the first post-operative day due to uncontrollable bleeding. He was a 72-year-old man with Child-A, Hepatitis B Virus (HBV) associated cirrhosis and a module located in the left lobe which histologically was a borderline malignant lesion. The procedure lasted 195 min, some oozing from the liver parenchyma occurred but it was otherwise uncomplicated. The patient developed post-operative coagulopathy with severe trombocytopaenia. Post-operative morbidity rate was 45% and, in addition to the case of coagulopathy with severe trombocytopaenia there were six pleural effusions and/or chest infections, one bile collection and four haematomas at the trocar sites. Transient encephalopathy was noted in five cases. All complications were treated conservatively.

Hospital stay ranged from 5 to 25 days (median hospital stay 11 days). The follow-up ranged 4 to 30 months (median follow-up 13 months). Three patients died 6, 8 and 13 months respectively after the operation as a result of recurrent disease. Nine patients are alive and disease-free. Five patients are alive with recurrent disease, one patient developed a cancer of the transverse colon and another shows signs of deteriorating liver cirrhosis.

Data for the historical group of patients who underwent open formal liver resections are summarized in Table 3.

DISCUSSION

The possibility of performing advanced laparoscopic procedures, as well as the risks and poor results of conventional liver surgery for

Table 2 Operative data

Patient	Procedure	Portal triad occlusion	Type	Occlusion time (min)	Operative time (min)	Blood loss (mL)	Normal liver function (day)
1	Segmentectomy VI	No			200	100	–
2	Left hepatectomy	Pringle	Interrupted	80	200	550	6
3	Segmentectomy V, gastric banding	No			120	0	
4	Mesoepatectomy	Pringle		35	155	200	4
5	Left hepatectomy	Pringle		30	165	300	4
6	Segmentectomy VI	Pringle		40	210	100	8
7	Segmentectomy V	Pringle		40	200	1000	5
8	Right hepatectomy	Pringle		45	200	100	4
9	Left hepatectomy	Pringle		35	160	100	3
10	Right hepatectomy	Pringle		45	190	200	5
11	Mesoepatectomy	Pringle	Interrupted	50	180	100	4
12	Left hepatectomy	Pringle		20	195	100	–
13	Right hepatectomy	Pringle	Interrupted	65	240	1000	5
14	Mesoepatectomy	Pringle	Interrupted	75	285	1200	6
15	Segmentectomy V	Pringle		30	180	900	5
16	Left hepatectomy	Pringle		40	170	500	5
17	Right hepatectomy	Pringle	Interrupted	55	185	100	5
18	Left hepatectomy, right colectomy	Pringle		35	270	100	3
19	Bisegmentectomy V, VI	Pringle		40	160	100	4
20	Extended right hepatectomy	No	Separate ligation at hilum		195	1200	
				44.41	193	397.5	5

Figures in the last line of the occlusion time, operative time and blood loss columns are average values. Figure in the last line of the liver function column is median value.

Table 3 Open formal liver resections. Data from 65 patients operated on from 1992 to 1995

Liver metastases (21 patients)		
HCC (44 patients)		
Pringle manouvre (57 patients)	Mean occlusion time 16 min	(range 8–70 min)
OP time (42 patients)	Mean 179 min	(range 120–260 min)
Blood loss (65 patients)	Mean 37.5 mL	(range 100–2,500 ml)
Intra-operative blood transfusions (65 patients)	Required in 12 patients (18.5%)	
Normalization of liver function tests (42 patients)	Mean post-operative day (8th)	(range 1st–25th post-op. day)
Post-operative mortality rate (65 patients)	Three patients (4.6%)	
Post-operative morbidity rate (21 patients)	Seven patients (33.3%)	

malignancy have lead us to consider the laparoscopic approach for the treatment of either benign or malignant liver lesions and to evaluate the feasibility of endoscopic formal liver resections. The experience reported in this series has to be considered as an initial pilot phase which is aimed at establishing the feasibility of endoscopic liver surgery. During this initial phase we have standardized the technique, defined the crucial aspects and steps of the endoscopic procedure and analysed the preliminary results, comparing them with those of our historical controls who underwent open liver surgery.

Three fundamental points have to be stressed. Firstly, only experienced liver surgeons who have reached a high level of skill in endoscopic surgery should attempt advanced liver surgery via a laparoscopic route. Secondly, careful patient selection is necessary since results are strongly influenced by correct indication. Thirdly, the operation should never be attempted unless all the necessary technologies and appliances are available in the theatre.

Formal liver resections may be accomplished completely laparoscopically or by a laparoscopic-assisted approach, with no significant difference in the operation time. As previously mentioned the rationale for such an approach is the significant reduction of surgical trauma in patients with poor prognosis. Traditional surgery entails significantly long incisions which interrupt important venous collaterals in patients with liver cirrhosis and portal hypertension. With a laparoscopic operation such important vessels are spared and this may contribute to the decrease in post-operative encephalopathy. Our data are highly suggestive of this but are not yet statistically significant.

A crucial step in the laparoscopic procedure is the occlusion of the portal triad by Pringle manoeuvre. This manoeuvre is useful to reduce blood loss, is well-tolerated and is strongly recommended. In fact, the mean blood loss during laparoscopic formal liver resections does not differ significantly from that of open procedures, 397.5 vs. 279.5 mL, however, the percentage of patients who required intra-operative transfusions was higher, 35% vs. 18.5%. Blood transfusions were usually performed when intra-operative blood loss was 600 mL or higher. The average time of the Pringle manoeuvre is significantly longer than in open surgery but still does not exceed the safety limits (45 min, ranging from 20 to 80 min, median value = 40 min).[21,22] Despite these figures the occlusion of the portal triad does not seem to affect the normalization of liver function tests. Data from the group of patients who underwent open liver resections show that there is no correlation between the average occlusion time (16 min) and the post-operative interval required for the return of the liver function tests to normal in the laparoscopy group (average: eighth postoperative day).

The laparoscopic approach avoids the extraparenchymal dissection of the right hepatic vein, which is considered one of the most difficult and dangerous steps during hepatic resections and has been reported by Belghiti as the cause of serious intra-operative haemorrhage in 5% of 93 hepatectomies (personal report at the congress of the SFCG, Paris, December 1995). The laparoscopic approach to liver resection minimizes the dislocation of the liver and the distension of the hepatic veins required for securing the right hepatic vein during open hepatic resection. Overall operative time is higher than in open liver surgery, but the difference is not significant.

Post-operative mortality is similar in both group of patients, 5% after laparoscopic liver resection and 4.6% after open liver resections. Post-operative stay is significantly shorter after laparoscopic liver surgery. The day of discharge was most often delayed because of further diagnostic assessment (study purposes) or for patient convenience and not for clinical reasons.

Use of sophisticated technologies is often mandatory in laparoscopic liver surgery.[23–27] Ancillary equipment employed during liver resections were laparoscopic US probe, argon beamer and US dissector. Contrary to other reports, no real need for laser or water-jet dissection was found. Laparoscopic US was performed in all cases at the beginning of the operation to define location and spread of tumours and to guide the resections.[28] Also the availability of linear endostaplers is mandatory. Their use in open liver surgery has been described and is considered safe.[29] The instrument is employed for closure and division of the hepatic veins and to commence the parenchymal division. In most cases, tissue sealant was sprayed over the surface of the divided liver parenchyma at the end of the procedure to control residual oozing and minimize bile leaks.

The treatment of liver metastases and HCC is multimodal. Various techniques have been described for treatment of liver lesions, with the aim of minimizing trauma, above all in high-risk patients. Some techniques are performed under the laparoscopic guidance.[30] Laparoscopy may also have a role in reducing the invasive nature of major liver surgery. Our preliminary data show that the laparoscopic approach to formal liver resections is feasible and safe. However it must not be considered as a routine technique in liver surgery, but as a promising new approach in selected patients.

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