

Anatomic resection of liver segments 6-8 for hepatocellular carcinoma

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Abstract

AIM: To report the devised anatomic liver resection of segments 6, 7 and 8 to improve the resection rate for patients with right liver tumors.

METHODS: We performed anatomic liver resection of segments 6, 7 and 8 to guarantee the maximum preservation of the remaining normal liver tissue. Segment 5 was determined by two steps of Glissonean pedicle occlusion. And a "┐" shaped broken resection line was marked upon the diaphragmatic surface of the liver. Selective right hemihepatic inflow occlusion was used to reduce blood loss during parenchymal transection between segments 6 and 5 and between segments 8 and 5. If needed, total hepatic Glissonean pedicle occlusion was used during parenchymal transection between segment 8 and the left liver.

RESULTS: Compared to right hemihepatectomy, the percentage of future liver remnant volume was increased by an average of 13.9% if resection of segments 6, 7 and 8 was performed. Resection of segments 6, 7 and 8 was completed uneventfully. After

hepatectomy, the inflow and outflow of segment 5 were maintained. There was no perioperative mortality, postoperative abdominal bleeding or bile leakage in this group. Alpha-fetoprotein (AFP) returned to the normal range within 2 mo after the operation in all the patients. One patient died 383 d postoperatively due to obstructive suppurative cholangitis. One patient suffered from severe liver dysfunction shortly after surgery and had intrahepatic recurrence 4 mo postoperatively. Postoperative lung metastasis was found in one patient. No tumor recurrence was found in the other patients and the parameters including liver function and AFP level were in the normal range.

CONCLUSION: Anatomic liver resection of segments 6, 7 and 8 can be a conventional operation to improve the overall resection rate for hepatocellular carcinoma.

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Key words: Anatomic hepatectomy; Hepatocellular carcinoma; Selective occlusion; Alpha-fetoprotein; Liver tumor

Core tip: Hepatic resection is the only curative treatment for patients with huge and multifocal tumors. However, patients with huge or multifocal tumors in the right liver and with a small volume of left liver cannot undergo right hemihepatectomy because of the possibility of postoperative liver failure, thus leading to a low overall resection rate for hepatocellular carcinoma. To increase the number of resectable patients and improve the overall resection rate, we devised anatomic liver resection of segments 6, 7 and 8 in patients with right liver tumors.

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INTRODUCTION

Hepatic resection is the only curative treatment for patients with huge and multifocal tumors. These patients are less likely to benefit from liver transplantation or local ablative therapy^[1-4]. In many such cases, complete resection of hepatocellular carcinoma (HCC) can only be achieved by hepatectomy that removes a significant proportion of the liver parenchyma. Recent advances in preoperative imaging, understanding of liver anatomy, surgical techniques, and anesthetic monitoring have increased the safety of liver resection^[5-7]. Unfortunately, in some cases, hepatic failure occurs after major liver resection and carries poor prognosis due to the lower remnant liver volume^[8]. So it restrains those patients who have much less remnant liver volume from radical operations. For example, patients with huge or multifocal tumors in the right liver and with a small volume of left liver cannot undergo right hemihepatectomy because of possible postoperative liver failure. To increase the number of resectable patients, we devised anatomic liver resection of segments 6, 7 and 8 using the technique of selective occlusion of hepatic inflow in patients with right liver tumors. This is a radical operation and benefits patients with huge or multifocal tumors in the right lobe.

MATERIALS AND METHODS

Patients

Six patients undergoing anatomic liver resection of segments 6, 7 and 8 from December 2011 to November 2013 in our department were included in this study. All these patients were male with a mean age of 55 years (range: 43-61 years), and had a history of hepatitis B virus infection. All the tumors were located in the right liver with multifocal tumors in two patients and huge tumors in four (Table 1). Preoperative imaging showed that segment 5 was free of tumor in all patients (Figure 1). Serum α -fetoprotein (AFP) level was elevated in all patients. Conventional follow-up was done, ranging from 6 to 23 mo.

Preoperative assessment

Liver function, hepatic functional reserve and hepatic imaging, including ultrasound B and computed tomography (CT), were carried out preoperatively. Liver function was classified by Child-Pugh score and hepatic functional reserve was evaluated by the indocyanine green retention at 15 min (ICG-R15) test. Contrast-enhanced CT scans were generated with a helical scanner. Manual 3D reconstructions of the liver were made using reconstructed 5-mm-thick axial slices from 2-3-mm original slices. The total liver, left liver and segment 5, as well as the tumors were manually outlined using portal and

hepatic veins as landmarks for segmental division^[9]. The volumes of the total liver, left liver, segment 5 and tumor were calculated. The percentage of future liver remnant volume (%FLRV) was expressed using the formula: $\%FLRV = (\text{remnant liver volume} \times 100) / (\text{total liver volume} - \text{tumor volume})$ ^[10]. If right hemihepatectomy was performed, %FLRV would be < 40% in all of the patients. The risk of postoperative liver failure would be high due to insufficient remnant functional liver because all these cases had liver cirrhosis. However, if resection of segments 6, 7 and 8 was performed, %FLRV would increase by an average of 13.9% (Table 1). The risk of postoperative liver failure would be low due to sufficient remnant functional liver. Therefore, we designed anatomic resection of liver segments 6, 7 and 8, with retention of segment 5, to guarantee the maximum preservation of remnant functional liver tissue.

Surgical procedures

Selective occlusion of hepatic inflow was the key to complete anatomic liver resection of segments 6, 7 and 8. Segment 5 was determined by two steps of Glissonean pedicle occlusion. After cholecystectomy, the porta hepatis was dissected based on Glissonean pedicle anatomy^[11-13]. The right hemihepatic Glissonean pedicle and the segment 6 and 7 Glissonean pedicle were sequentially divided (Figure 2A). After occlusion of the right hemihepatic Glissonean pedicle, the right liver developed obvious ischemia. So, the demarcation between the right and left liver could be easily determined (Figure 2B). After demarcation, the right hemihepatic Glissonean pedicle was left unoccluded. Then the segment 6 and 7 Glissonean pedicle was dissected and ligated, and segments 6 and 7 showed obvious ischemia (Figure 2C). The interface between segments 6 and 5 could be easily demarcated. Intraoperative ultrasound B was used to form the demarcation between segments 8 and 5, with a transverse marked line upon the diaphragmatic surface of the liver. This line was located 1-2 cm below the tumor in segment 8. Finally, segment 5 was determined and a “┐” shaped broken resection line was marked upon the diaphragmatic surface of the liver (Figure 2D). Short hepatic veins were dissected, isolated and ligated. Parenchymal transection was performed along the broken resection line using an ultrasonic scalpel and cavitron ultrasonic surgical aspirator. Selective right hemihepatic inflow occlusion was used to reduce blood loss during parenchymal transection between segments 6 and 5 and between segments 8 and 5. If needed, total hepatic Glissonean pedicle occlusion was used during parenchymal transection between segment 8 and the left liver.

Postoperative treatment

Postoperative follow-up was done with conventional liver function tests and measurement of serum AFP level. Abdominal ultrasonography and CT were performed at intervals of 30 d in the first 3 mo postoperatively, and at intervals of 2-3 mo thereafter. Chest X-ray, whole-body

Table 1 Clinical features and postoperative outcomes

| No. | Sex | Age (yr) | Diagnosis | ICG-R15 | Child-Pugh liver function grade | %FLRV for right hemihepatectomy | %FLRV for 6-8 segmentectomy | Survival period (d) |
|-----|------|----------|-------------------------------|---------|---------------------------------|---------------------------------|-----------------------------|-------------------------------------|
| 1 | Male | 61 | Multifocal tumors | 6.8% | A | 29.8 | 44.7 | 690, DFS |
| 2 | Male | 43 | Huge tumor, 12.2 cm × 9.3 cm | 5.5% | A | 34.5 | 46.2 | 383, dead |
| 3 | Male | 59 | Huge tumor, 11.5 cm × 10.7 cm | 13.8% | B | 32.6 | 46.9 | 270, intrahepatic recurrence, alive |
| 4 | Male | 54 | Huge tumor, 13.2 cm × 10.6 cm | 8.3% | A | 31.8 | 48.6 | 256, lung metastasis, alive |
| 5 | Male | 53 | Multifocal tumors | 2.6% | A | 37.5 | 50.3 | 239, DFS |
| 6 | Male | 60 | Huge tumor, 13.5 cm × 11.6 cm | 7.9% | A | 33.4 | 46.5 | 181, DFS |

DFS: Disease-free survival; FLRV: Future liver remnant volume.



Figure 1 Preoperative imaging showed that segment 5 was free of tumor in all patients. A: Multiple tumors were found in segments 6, 7 and 8 by contrast-enhanced computed tomography scans (arrows) in Case 1; B: Huge tumor located in the right liver in Case 4. Arrow: Middle hepatic vein; Arrowhead: Right anterior portal vein; Triangular arrow: Right posterior portal vein; Curved arrow: Gallbladder.

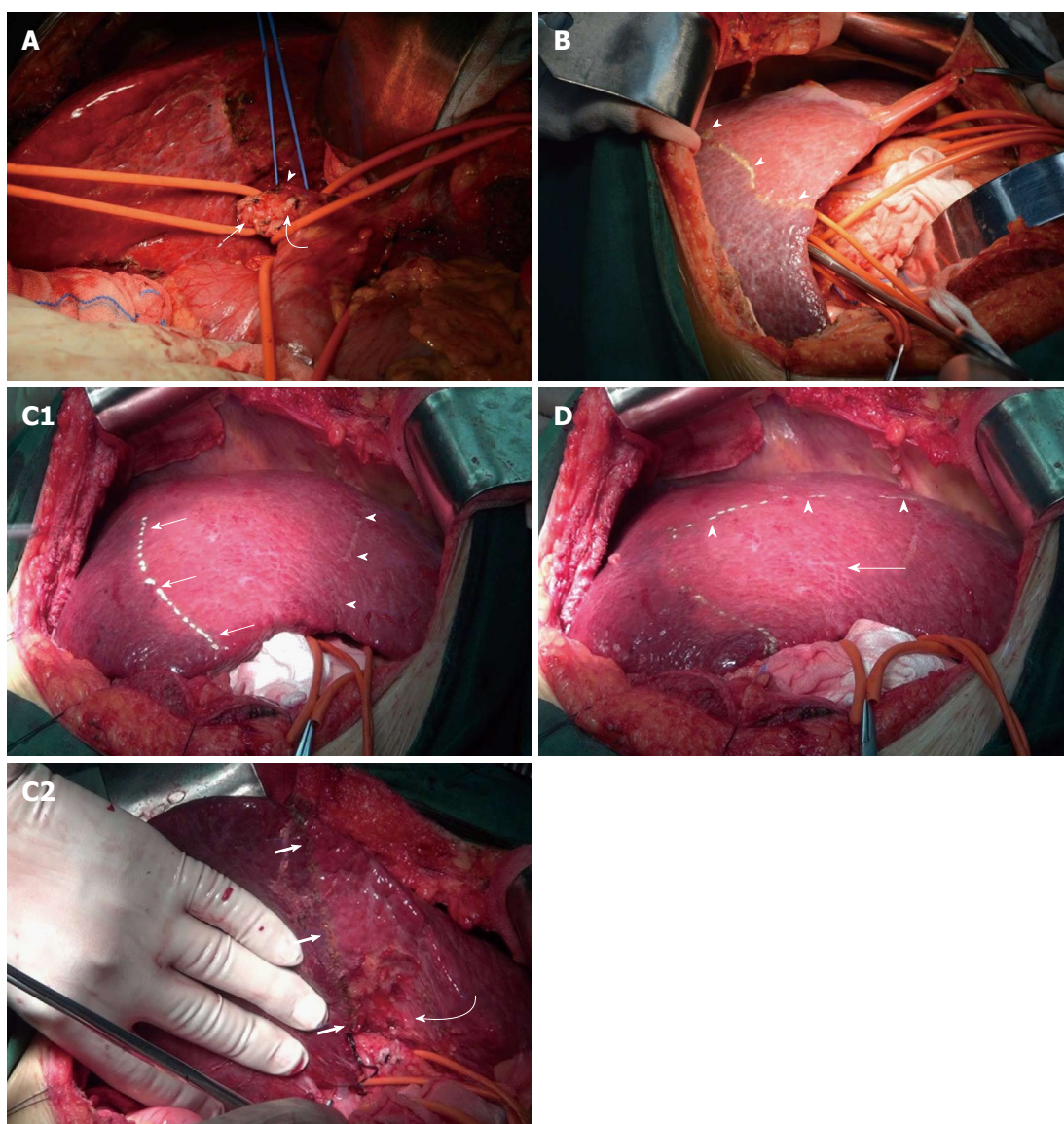


Figure 2 Surgical procedures. A: Right hemihepatic Glissonean pedicle and segment 6 and 7 Glissonean pedicle in Case 4 were sequentially divided. Arrow: Segment 6 and 7 Glissonean pedicle; arrowhead: Segment 5 and 8 Glissonean pedicle; curved arrow: Right hemihepatic Glissonean pedicle; B: After occlusion of the right hemihepatic Glissonean pedicle in Case 4, the right liver showed obvious ischemia. The demarcation between the right and left liver could be easily determined (arrowheads); C: After the segment 6 and 7 Glissonean pedicle of Case 4 was ligated, segments 6 and 7 showed obvious ischemia. The interface between segments 6 and 5 could be easily demarcated. Arrow: Demarcation between segments 6 and 5 upon the diaphragmatic surface of the liver; Arrowheads: Demarcation between the right and left liver; Bold arrows: Demarcation between segments 6 and 5 on the visceral surface of the liver; Curved arrow: Fossa of gallbladder (C1, C2); D: Segment 5 was determined and a “┐” shaped broken resection line was marked upon the diaphragmatic surface of the liver in Case 4. Arrowheads: Demarcation between segments 5 and 8; Arrow: Segment 5.

bone scan, or other imaging studies were undertaken in patients who had suspected metastasis. All the patients received three sessions of postoperative transcatheter arterial chemoembolization (TACE). If affordable, sorafenib, a multi-targeted tyrosine kinase receptor inhibitor was used for metastatic or recurrent cases.

RESULTS

All hepatectomies were uneventfully completed with an average operation time of 326 min (range: 260-470 min) and average blood loss of 758 mL (range: 400-1800 mL). After hepatectomy, the inflow and outflow of segment 5

were maintained (Figure 3A). Gross specimens showed that tumors were completely resected and postoperative pathology verified a diagnosis of HCC (Figure 3B). There was no perioperative mortality, postoperative abdominal bleeding, or bile leakage. Serum AFP decreased to the normal range within 2 mo postoperatively.

Case 2 survived well with normal AFP level and liver function for about 12 mo postoperatively. However, he was hospitalized 381 d postoperatively due to fever and 15 d progressive elevation of jaundice at home without any treatment. CT and ultrasound B showed no tumor recurrence and metastasis inside or outside the liver. Serum total bilirubin was 193.4 $\mu\text{mol/L}$ (normal range: 1.7-20 $\mu\text{mol/L}$)

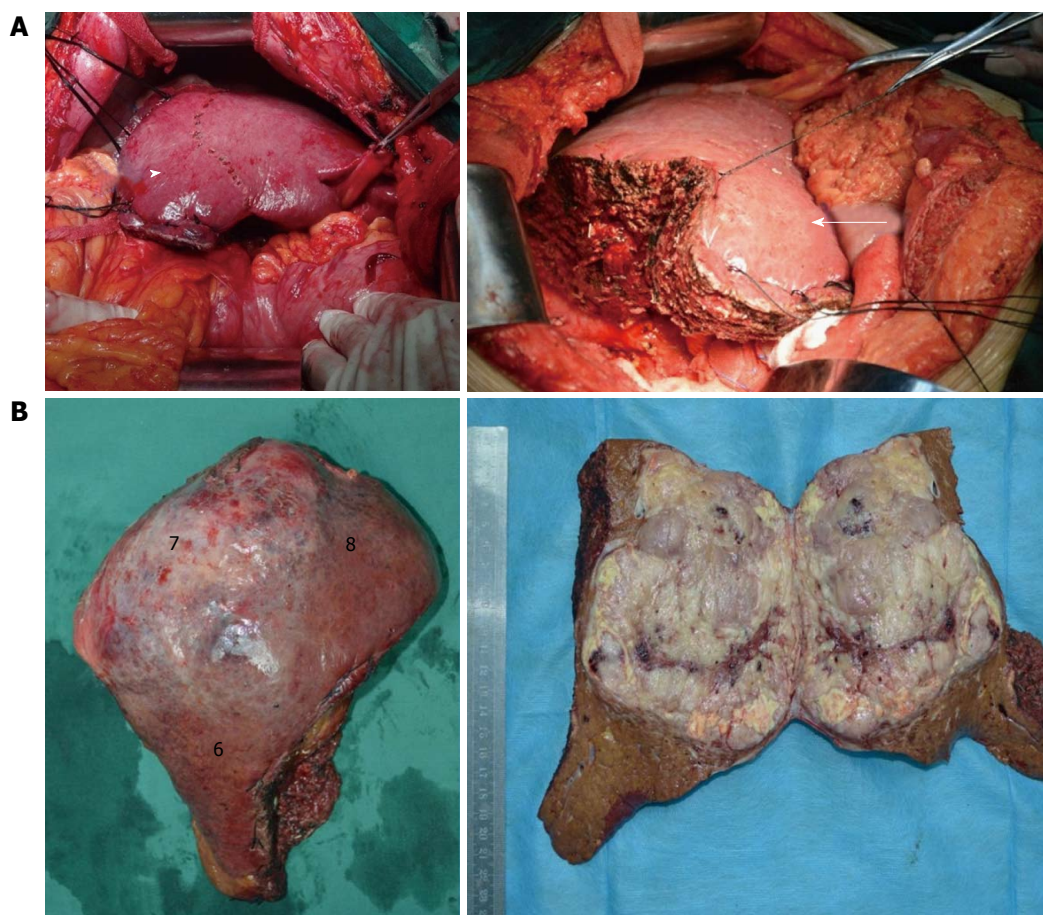


Figure 3 Surgical results. A: After hepatectomy, the inflow and outflow of segment 5 were maintained. Triangular arrow: remnant segment 5 in Case 1; arrow: Remnant segment 5 in Case 4; B: Gross specimen showed that tumors in Case 4 were completely resected. Segments 6, 7 and 8 are indicated.

at admission with direct bilirubin being 129.1 $\mu\text{mol/L}$ (normal range: 0-6 $\mu\text{mol/L}$). Two days after admission, this patient died from obstructive suppurative cholangitis.

Case 3 had Child-Pugh score 7 and 13.8% ICG, which indicated severe postoperative liver dysfunction. His serum total bilirubin increased constantly and peaked at 142.5 $\mu\text{mol/L}$ on postoperative day 8. Ascites and hepatoencephalopathy occurred consecutively due to liver dysfunction. These symptoms resolved gradually as liver dysfunction improved. However, intrahepatic recurrence was found by CT and digital subtraction angiography 4 mo postoperatively. Although AFP level increased to 219.9 ng/mL at that time, it decreased to the normal range after two sessions of TACE. To date, this tumor-bearing patient has had > 6 mo survival.


Lung metastasis was found by CT 5 mo postoperatively in Case 4. Sorafenib was administered to this patient. To date, this patient has had > 4 mo tumor-bearing survival with AFP in the normal range.

No tumor recurrence was found in the other patients and the parameters including liver function and AFP level were in the normal range. Postoperative outcome and quality of life are summarized in Table 1.

DISCUSSION

Inadequate future liver remnant may not meet the he-

patic metabolic demands after major hepatectomy^[14,15]. Therefore, patients with huge or multifocal tumors in the right liver and a small volume of left liver cannot undergo right hemihepatectomy because of possible postoperative liver failure. These patients are excluded from radical operations. In the present study, all %FLRV would have been < 40% if right hemihepatectomy was performed. The risk of postoperative liver failure would have been high because of liver cirrhosis and insufficient remnant functional liver. However, if resection of segments 6, 7 and 8 was performed, %FLRV would increase by an average of 13.9%. The risk of postoperative liver failure would be low because of sufficient remnant functional liver. Therefore, all patients underwent anatomic liver resection of segments 6, 7 and 8, with retention of segment 5. The patients underwent radical surgery with tumor-free margins and maximum preservation of remnant functional liver tissue^[16-19]. This technique could improve the resection rate in patients with huge or multifocal tumors in the right liver. No remnant tumor was found on imaging shortly after the operation and AFP decreased to the normal range within 2 mo postoperatively. The tumors were completely resected by anatomic liver resection of segments 6, 7 and 8. These six patients have survived > 6 mo with satisfactory quality of life postoperatively. We demonstrated that this operation had a good therapeutic efficacy.

It is worth mentioning that the hepatectomies were performed with a “” shaped broken resection line. This naturally increased the resection length, area, operation time and blood loss. However, the blood loss in our study (mean: 758 mL) was no more than that previously reported for huge HCC (*e.g.*, 1015^[20] and 780 mL^[21]).

There were no severe complications such as perioperative mortality, postoperative abdominal bleeding, and bile leakage. We demonstrated that liver resection of segments 6, 7 and 8 is safe and effective for the treatment of HCC. Anatomic liver resection of segments 6, 7 and 8 could become a conventional operation for patients whose tumors do not involve segment 5, to enable maximum preservation of remaining normal liver tissue. It may be an alternative modality for maximal hepatectomy in the treatment of HCC.

Finally, selective occlusion of right hemihepatic inflow was applied during parenchymal transection between segments 6 and 5 and between segments 8 and 5. If needed, total hepatic inflow occlusion was used during parenchymal transection between segment 8 and the left liver. Selective right hemihepatic Glissonean pedicle occlusion enables blood inflow to the left liver and avoids splanchnic stasis during hepatectomy^[22-24]. Thus, liver ischemia-reperfusion injury and hemodynamic instability were reduced during the operation. It particularly benefits patients with cirrhosis^[25-27].

COMMENTS


Background

Hepatic resection is the only curative treatment for patients with huge and multifocal tumors. However, patients with huge or multifocal tumors in the right liver and a small volume of left liver cannot undergo right hemihepatectomy because of possible postoperative liver failure, thus making the overall resection rate for hepatocellular carcinoma (HCC) low. To increase the number of resectable patients, we devised anatomic liver resection of segments 6, 7 and 8 in patients with right liver tumors.

Research frontiers

Anatomic liver resection of segments 6, 7 and 8 has not been reported previously. By the techniques of selective occlusion of hepatic inflow and anatomic liver resection, complicated hepatectomy can be performed. Anatomic liver resection of segments 6, 7 and 8 could be a conventional technique for patients whose tumors do not involve segment 5, to enable maximum preservation of remaining normal liver tissue, thus improving the overall resection rate for HCC.

Innovations and breakthroughs

Compared to right hemihepatectomy, the percentage of future liver remnant volume (%FLRV) was increased by an average of 13.9% when resection of segments 6, 7 and 8 was performed. Segmentectomy was completed uneventfully in this group. Segment 5 was determined by two steps of hepatic inflow occlusion. A “” shaped broken resection line was marked upon the diaphragmatic surface of the liver. Selective right hemihepatic inflow occlusion was used to reduce blood loss during parenchymal transection between segments 6 and 5 and between segments 8 and 5. If needed, total hepatic Glissonean pedicle occlusion was used during parenchymal transection between segment 8 and the left liver. Thus, liver ischemia-reperfusion injury and hemodynamic instability were maximally reduced during the operation. It particularly benefits patients with cirrhosis.

Applications

Patients with huge or multifocal tumors in the right liver and with a small volume of left liver cannot undergo right hemihepatectomy because of the possibility of postoperative liver failure. To improve the overall resection rate for HCC, anatomic resection of segments 6, 7 and 8 can be performed in these cases. This

operation is radical and benefits these patients because it avoids postoperative liver failure.

Terminology

%FLRV is an important measure for patients undergoing major liver resection. Selective occlusion of hepatic inflow was the key procedure for anatomic liver resection.

Peer review

Partial hepatectomy is a powerful tool for HCC patients. Selective resection of right anterior/posterior segments often requires an experienced surgeon. The procedures may involve a unique technique. Surgical technique of parenchyma-sparing liver resection for right liver HCC (huge or multiple) developed on liver cirrhosis. This is a description of an atypical technique of anatomic liver resection.

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