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Ex vivo liver resection followed by autotransplantation in radical resection of gastric cancer liver metastases: A case report

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Abstract

BACKGROUND

Radical resection of gastric cancer liver metastases (GCLM) can increase the 5-year survival rate of GCLM patients. However, patients may lose the theoretical feasibility of surgery due to the critical location of liver metastasis in some cases.

CASE SUMMARY

A 29-year-old woman had a chief complaint of chronic abdominal pain for 1 year. Abdominal computed tomography and magnetic resonance imaging examinations suggested a mass of unknown pathological nature located between the first and second hila and the margin of the lower segment of the right lobe of the liver. The anterior wall of the gastric antrum was unevenly thickened. The diagnosis of (gastric antrum) intramucosal well-differentiated adenocarcinoma was histopathologically confirmed by puncture biopsy with gastroscopy guidance. She underwent radical resection (excision of both gastric tumors and *ex vivo* liver resection followed by autotransplantation simultaneously) followed by XELOX adjuvant chemotherapy. Without serious postoperative complications, the patient was successfully discharged on the 20th day after the operation. Pathological examination of the excised specimen indicated that gastrectomy with D2 lymph node dissection for primary gastric tumors and R0 resection for liver metastases were achieved. The resected mass was confirmed to be poorly differentiated gastric carcinoma (hepatoid adenocarcinoma with neuroendocrine differentiation) with liver metastases in segments VIII. No recurrence or metastasis within the liver was found during a 7.5-year follow-up review that began 1 mo after surgery.

CONCLUSION

Application of *ex vivo* liver resection followed by autotransplantation in radical resection for GCLM can help selected patients with intrahepatic metastases located in complex sites obtain a favorable clinical outcome.

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INTRODUCTION

The incidence of gastric cancer liver metastases (GCLM) ranges from 9.9% to 18.7% among gastric cancer patients[1,2], and GCLM patients have a median survival time of 11 mo and a 5-year survival rate < 20%[3]. Some retrospective studies have declared that radical resection (excision of both gastric tumors and liver metastases simultaneously) can increase the 5-year survival rate of GCLM patients, but the timing and ideal surgical type remain controversial. Based on the likelihood of a surgical treatment being successful, Chinese type for-GCLM has been proposed by the Chinese consensus on the diagnosis and treatment of GCLM[4]. While we acknowledge that a tumor-free margin is the predictor of a better outcome for GCLM patients, an unavoidable question may emerge: What if liver metastases meet all the surgical qualifications judged by size and scope according to the aforementioned classification criteria, but their location is so critical that the technical risk of surgery significantly increases? It would be regretful to give up the chance of radical resection because of the limited number of eligible patients. The application of *ex vivo* liver resection followed by autotransplantation (ELRA) may provide an alternative solution to this problem. Here, we present a case pertaining to the treatment procedures and prognosis of a young female patient with GCLM, which showed that the application of ELRA in radical resection for GCLM can help patients with intrahepatic metastases located in complex sites obtain a favorable clinical outcome.

CASE PRESENTATION

Chief complaints

A 29-year-old woman had a chief complaint of chronic abdominal pain for one year and she experienced continuous weight loss of 5 kg over 2 mo prior to her admission.

History of present illness

The patient had chronic abdominal pain for 1 year and she experienced continuous weight loss of 5 kg over 2 mo prior to her admission.

History of past illness

The patient had undergone ovarian cystectomy, appendectomy, and subtotal hysterectomy for uncontrollable hemorrhage according to her past medical history.

Personal and family history

No special family history was provided except that her mother was diagnosed with squamous cell carcinoma of the vulvar epithelium and the disease was cured according to her description.

Physical examination

Upon physical examination, a round mass approximately 7 cm in diameter could be palpated in the right upper abdomen and the mass was smooth, pushable, hard, and indistinguishable from adjacent tissue. Other detailed basic information is displayed in [Table 1](#).

Laboratory examinations

Laboratory data demonstrated normal liver function and routine blood test results ([Table 2](#)). The tumor marker results showed that the level of alpha-fetoprotein was 9850 ng/mL and that of carcinoma embryonic antigen was 0.55 ng/mL.

Imaging examinations

Abdominal computed tomography (CT) and magnetic resonance imaging examinations suggested a mass of unknown pathological nature located in segment VIII and it was between the first and second hila and the margin of the lower segment of the right liver lobe ([Figure 1](#)). The anterior wall of the gastric antrum was unevenly thickened. Positron emission tomography/CT (whole body) examination showed two main points: (1) The anterior wall of the gastric antrum was unevenly thickened, and fluorodeoxyglucose uptake was increased, which was consistent with the manifestations of gastric cancer; and (2) A mass shadow was located at the first and second hepatic hila and the lower right lobe of the liver. As increased fluorodeoxyglucose uptake is a sign of malignancy, whether the mass was liver metastasis or primary liver cancer remained to be identified. Electrocardiograph, chest digital radiography, and CT of the lower abdomen and pelvis showed no obvious abnormalities.

MULTIDISCIPLINARY EXPERT CONSULTATION

Due to the unknown nature and special location of the mass in the liver, it was considered to be a liver metastatic focus of gastric cancer after consultation by general and hepatobiliary surgeons.

FINAL DIAGNOSIS

The results of puncture biopsy with gastroscopy guidance supported the pathological diagnosis of gastric antrum intramucosal well-differentiated adenocarcinoma.

TREATMENT

A tumor protruding through the liver capsule with unclear borders and an uneven surface was found in the right liver during abdominal exploration. It was hard and pale and was tightly adhered to the surrounding omentum. Consistent with the preoperative imaging findings, the tumor extended to the junction of the left and right liver lobes and was adjacent to the vena cava. Intraoperative frozen biopsy of the liver mass was performed and the results supported a poorly differentiated malignant tumor. The presence of intrahepatic microlesions was ruled out by intraoperative ultrasound. The results of intraoperative exploration led us to perform ELRA combined with radical resection for gastric cancer as the original plan.

Hepatectomy was accomplished by using standard technique[5] with extensive lymph node dissection around the superior mesenteric artery and celiac trunk. The common bile duct was completely removed up to the head of the pancreas. Preservation and perfusion of the removed isolated liver were performed with ice-cold solution at 4 °C and UW solution *via* the intact portal vein (PV). At the same time, a temporary channel was established between the superior hepatic inferior vena cava and inferior hepatic inferior vena cava with an internal diameter of 2 cm and Geo-Text artificial vessel. The PV was also anastomosed to the vessel to construct a portacaval shunt. After the intrahepatic tumor and target liver segment (VIII) were completely resected and the repairment of the middle and right hepatic vein was done, the aforementioned temporary venous channel was removed. The remnant of the liver was implanted similar to orthotopic liver transplantation, which was followed by anastomosis of the superior hepatic inferior vena cava, inferior hepatic inferior vena cava, PV, hepatic artery, and bile duct. The total anhepatic period was 245 min,

Table 1 Detailed basic information of the patient

Item	Value
Height	158 cm
Weight	48 kg
BMI	19.2 kg/m ²
Obstructive jaundice	No
Zubrod-ECOG-WHO	1
Hypertension	No
Diabetes	No
Heart disease	No
Kidney disease	No
Liver disease	No
Breast disease	No
Genitourinary diseases	No
Infectious disease	No
Respiratory function	Good
Mental state	Good
Neoadjuvant chemotherapy	No

BMI: Body mass index; Zubrod-ECOG-WHO: Zubrod-Eastern-Cooperative Oncology Group-World Health Organization (An indicator of the general health status and treatment tolerance of patients from their physical strength).

including 180 min of cold ischemia time (CIT) for extracorporeal tumor resection and vein repair, 40 min of vena cava anastomosis, and 25 min of PV anastomosis. Observation of the normal liver surface color after reperfusion was commonly performed, and the surgeons usually confirmed bile outflow before bile duct anastomosis. Some of intraoperative photos are presented in [Figure 2](#). As we performed *ex vivo* liver resection on the back table, radical surgery for gastric cancer was accomplished simultaneously by general surgeons on the operating table. The stomach and duodenum were respectively transected at 15 cm from the distal end of the cardia and 2 cm from the distal end of the pylorus with a disposable linear cutting closure. After the lymph nodes around the PV were resected, the digestive tract was reconstructed by gastrojejunal anastomosis and a gastric tube was inserted into the jejunum for input loop.

OUTCOME AND FOLLOW-UP

Our medical team provided the patient with symptomatic treatment after surgery such as gastrointestinal decompression, abdominal drainage, anti-infection medication, and nutritional support. She underwent bile leakage drainage on the fifth day after the operation. Fluid accumulated in the liver section and caused symptoms of gastric compression. The effusion was completely drained out after CT-guided puncture and catheter drainage 1 wk later. No other postoperative complications such as small-for-size syndrome, acute liver failure, vascular embolism, intra-abdominal infection, or hemorrhage occurred. She was successfully discharged on the 20th day after the operation. Postoperative pathological examination of the excised specimen indicated that gastrectomy with D2 lymph node dissection for primary gastric tumors and R0 resection for liver metastases were achieved. The resected mass was confirmed to be poorly differentiated gastric carcinoma (hepatoid adenocarcinoma with neuroendocrine differentiation) with liver metastases in segments of 6 and 8 ([Figure 3](#)). The patient began her first follow-up 1 mo after the operation, and received six courses of XELOX chemotherapy every 21 d since then, during which no serious adverse reactions or treatment discontinuation occurred. The patient also insisted on oral Tegafur Gimeracil and Oteracil Potassium Capsules for 1 mo after intravenous

Table 2 Preoperative laboratory data of the patient

Item	Value
WBC	$6.77 \times 10^9/L$
RBC	$3.62 \times 10^{12}/L$
Hgb	111 g/L
PLT	$168 \times 10^9/L$
Neu	$4.88 \times 10^9/L$
Neu%	(Neu%) 72.1%↑
ALT	34 IU/L
AST	32 IU/L
ALP	37 IU/L
GGT	12 IU/L
ALB	38 g/L
PALB	0.15 g/L
TBA	16.2 umol/L
DBIL	6.1 umol/L
IDBIL	10.1 umol/L
PT	12.50 s
INR	0.95
AFP	9850 ng/mL
CEA	1.46 ng/mL

WBC: White blood cells; RBC: Red blood cells; Hgb: Hemoglobin; PLT: Platelets; Neu: Neutrophile granulocyte; ALT: Alanine aminotransferase; AST: Aspartate amino transferase; ALP: Alkaline phosphatase; GGT: Gamma-glutamyl transpeptidase; ALB: Serum albumin; PALB: Pre-albumin; TBA: Total bile acid; DBIL: Direct bilirubin; IDBIL: Indirect bilirubin; PT: Prothrombin time; PT-INR: International standardized ratio of prothrombin time; AFP: Alpha-fetoprotein; CEA: Carcinoma embryonic antigen.

chemotherapy. She went back to the hospital on time for follow-up every 3 mo after the end of chemotherapy. Routine blood, liver and kidney function, and tumor markers tests, as well as abdominal CT are routine examination items. No obvious signs of tumor recurrence or metastasis within the abdomen or liver were recorded during a 7.5-year follow-up period. The patient had a good overall condition and did not undergo a second operation. Selected pre- and post-operative abdominal CT images of the patient are displayed in [Figure 1](#). Postoperative laboratory data of the patient are displayed in [Table 3](#).

DISCUSSION

GCLM is usually transglobally, multifocally, or even diffusely spread. It is always complicated by peritoneal, extensive lymph node and organ metastases due to its highly malignant and rapidly invasive oncologic nature. Poor prognosis and deadly surgical complications make the resection rate so low that there is no multicenter clinical trial with large samples on the significance of liver resection for GCLM. No well-established criteria exist except for a few retrospective studies with a limited number of cases[4]. What is worth noting is that the results of these limited studies almost indicate that patients with GCLM can benefit from radical resection[6-9].

According to the Chinese type for-GCLM, the definitions of both type I and II include the same criterion: "Technological resectability of liver metastases judged by a hepatobiliary surgeon". It emphasizes the principle that surgery should be performed only when R0 resection is anticipated[4]. Then the aforementioned question arises: What if the size and scope of liver metastases comply with this standard, but the anatomical complexity puts the hepatobiliary surgeon into a dilemma? The most

Table 3 Postoperative laboratory data of the patient

Item	Value
WBC	$5.66 \times 10^9/L$
RBC	$4.07 \times 10^{12}/L$
Hgb	121 g/L
PLT	$154 \times 10^9/L$
Neu	$4.00 \times 10^9/L$
Neu%	(Neu%) 70.6%↑
ALT	53.3 IU/L↑
AST	53.5 IU/L↑
ALP	113 IU/L
GGT	17 IU/L
ALB	42 g/L
PALB	0.18 g/L
TBA	17.3 umol/L
DBIL	4.32 umol/L
IDBIL	12.98 umol/L
PT	11.40 s
PT-INR	0.85
AFP	2.8 ng/mL
CEA	3.56 ng/mL

WBC: White blood cells; RBC: Red blood cells; Hgb: Hemoglobin; PLT: Platelets; Neu: Neutrophile granulocyte; ALT: Alanine aminotransferase; AST: Aspartate amino transferase; ALP: Alkaline phosphatase; GGT: Gamma-glutamyl transpeptidase; ALB: Serum albumin; PALB: Pre-albumin; TBA: Total bile acid; DBIL: Direct bilirubin; IDBIL: Indirect bilirubin; PT: Prothrombin time; PT-INR: International standardized ratio of prothrombin time; AFP: Alpha-fetoprotein; CEA: Carcinoma embryonic antigen.

common situation is that the tumor is located deeply within the liver and has extensive involvement of the main hepatic veins or retrohepatic vena cava. These types of tumors are usually deemed unresectable by conventional surgery because it is extremely hazardous due to the potential risk of uncontrollable hemorrhage and long ischemia time[10,11].

We can infer that ELRA may overcome this issue from our case report[4,12]. It effectively alleviated the technical bottleneck in traditional hepatectomy and allowed the hepatobiliary surgeons to perform precise liver tumor resection and effective vascular repairment by enabling them to operate with bloodless vision and access to critical structures easily since the first report of *ex vivo* hepatectomy by Pichlmayr *et al*[13] in 1988. What is more, full exposure of the surgical area can help reduce the risk due to vascular or bile duct variation that may not be detected before the operation.

ELRA is a challenging and time-consuming surgery with cumbersome procedures and complex operations. The theoretical basis and detailed surgical procedures that have been reported systematically in many studies will not be repeated here[14]. The most valuable experience that our team has summarized from this case is that accurate preoperative evaluation for specific patients based on detailed medical examination is of great importance. Strict patient selection and precise assessment of the size and quality of the remnant liver are pivotal to the decision-making process[14]. Although experiences gained from previous studies have indicated that after extended hepatectomy involving 70% to 75% of the liver, the remnant liver can still function well in non-cirrhosis patients[15,16], the strategy may need to be adjusted in the application of ERLA. A major feature of endoscopic retrograde appendicitis treatment (ERAT) is the longer CIT compared with ordinary liver transplantation (LT)[17]. In addition, procedures of ERAT are more complex than common LT and hepatectomy so a longer operative time and more intraoperative blood loss seem inevitable[10]. These

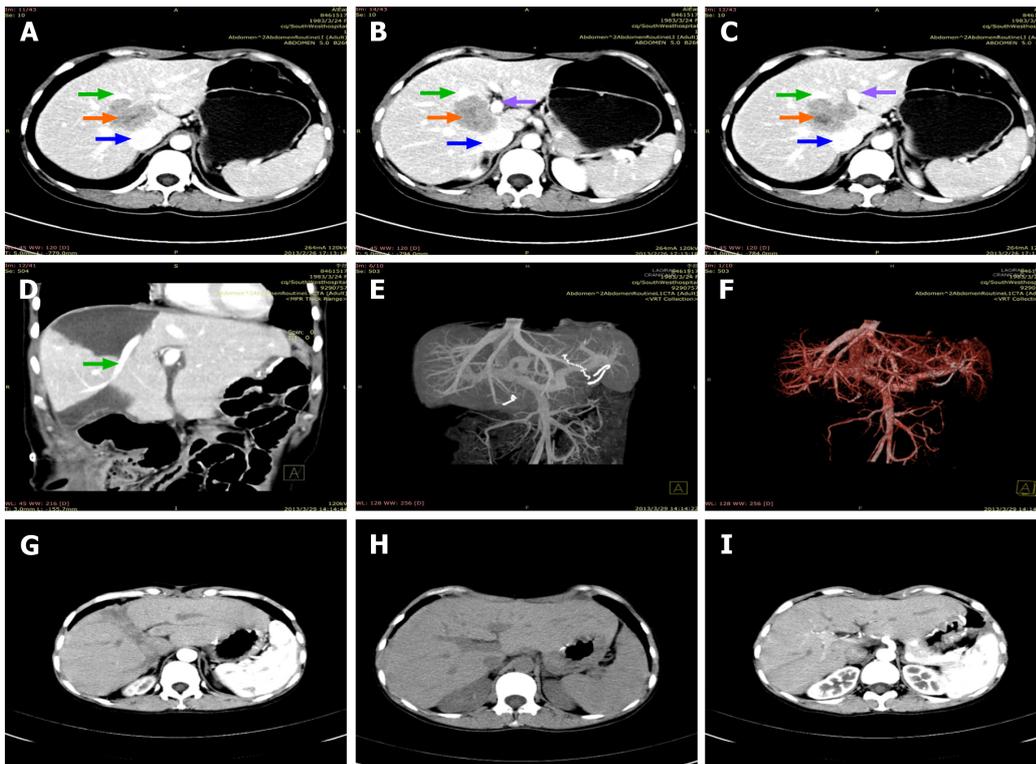


Figure 1 Abdominal computed tomography and magnetic resonance imaging examinations. A-C: The tumor (pointed by the orange arrow) was located between the first and second hila and it was adjacent to the middle hepatic vein (pointed by the green arrow), inferior R vena cava (pointed by the blue arrow), and the right branch of portal vein (pointed by the purple arrow); D-F: Postoperative imaging examination and upper abdominal angiography showed that the left hepatic vein, middle hepatic vein, right hepatic vein, inferior R vena cava, hepatic artery, and portal vein were intact and blood flow was unobstructed; G-I: Computed tomography results in the first, second, and third year after operation showed that there were no obvious signs of tumor recurrence.

are two poor prognostic indicators for LT recipients and hepatectomy patients because they may lead to graft loss due to the high incidence of postoperative biliary and arterial complications or severe hepatic dysfunction[18]. Based on the above theory, the liver function, liver quality, and estimated Rauscher leukemia virus of ELRA patients need to meet higher requirements. Livers with poor quality are less tolerant to cold ischemia-reperfusion injury. In addition, sufficient preoperative preparations, such as biliary drainage in patients with obstructive jaundice and nutritional support in malnourished patients, are indispensable once the doctor and patient reach a consensus to perform the surgery. Without exaggeration, it can be considered that half the success will be achieved if suitable GCLM patients are screened out, but inaccurate preoperative assessments will force surgeons to discontinue the operation or will even cause fatal postoperative complications such as small-for-size syndrome or acute liver failure[19]. Aji *et al*[14] described the largest case series of 69 patients with end stage hepatic alveolar echinococcosis who underwent ELRA. The detailed methods and procedures applied to select patients preoperatively are explicitly described in the literature. We also adopted the same issues to evaluate the patient in this case report.

A longer anhepatic period can lead to circulatory and metabolic disorders. Hepatobiliary surgeons must pursue more accurate and rapid surgical techniques to shorten the CIT and anhepatic phase. This is also a major test for the monitoring and intraoperative management of the anesthesiology department. So launching this type of major surgery can help improve the overall medical level of institutions and optimize the multidisciplinary diagnosis and treatment model. The lack of consensus and guidance on the application of ELRA drives us to accumulate more successful cases and precious experiences. Once successful, it will bring great significance in two aspects. For patients, the painful clinical symptoms caused by the tumor will be controlled, and the quality of their lives will be dramatically improved. It is our responsibility and obligation to create an opportunity for patients who never give up on themselves to extend their lives to fulfill their unfinished wishes. From a medical point of view, an increased survival rate may provide a longer time for more postoperative treatment options and promote the progress of clinical research. For instance, Qiu *et al*[20] proposed their vascular infiltration-based classification as a tool to improve anatomic comprehension and facilitate surgical planning for ELRA.

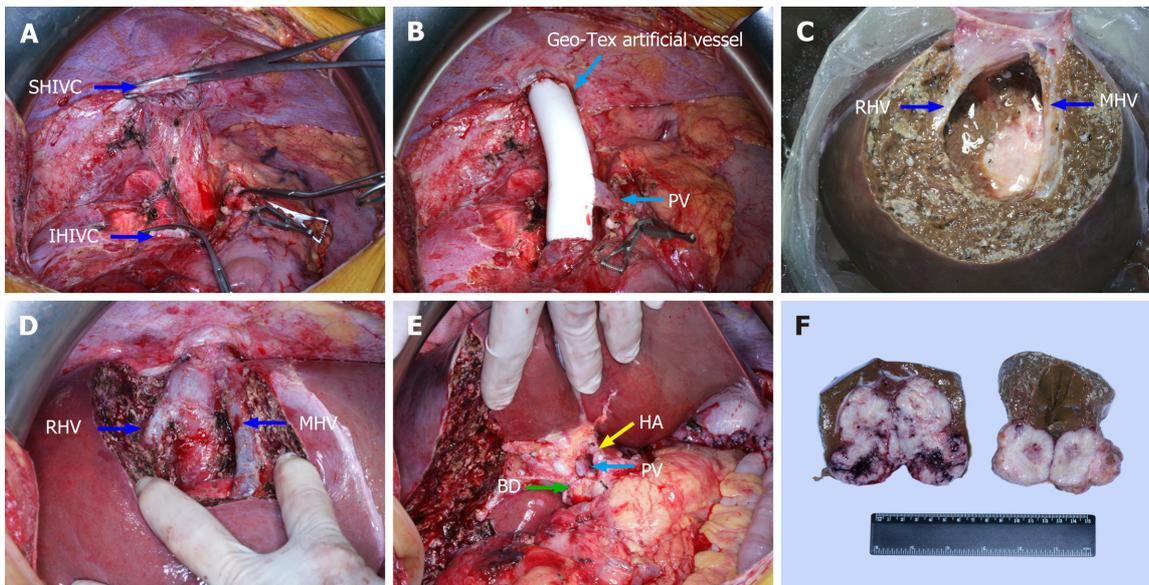


Figure 2 Intraoperative photos. A: The liver was removed from the abdominal cavity; B: The portal vein was anastomosed to the Geo-Tex artificial vessel to construct a portacaval shunt; C: The tumor has been completely resected from the isolated liver. Right hepatic vein and middle hepatic vein were intact; D: The remnant of the liver was implanted similar to orthotopic liver transplantation. After reconstruction, the right hepatic vein, middle hepatic vein, and inferior R vena cava had unobstructed blood flow; E: The first hepatic hilum after reconstruction; F: The first hepatic hilum after reconstruction. PV: Portal vein; RHV: Right hepatic vein; MHV: Middle hepatic vein; IHIVC: Infrahepatic inferior vena cava; SHIVC: Suprahepatic inferior vena cava; HA: Hepatic artery; BD: Biliary dilatation.

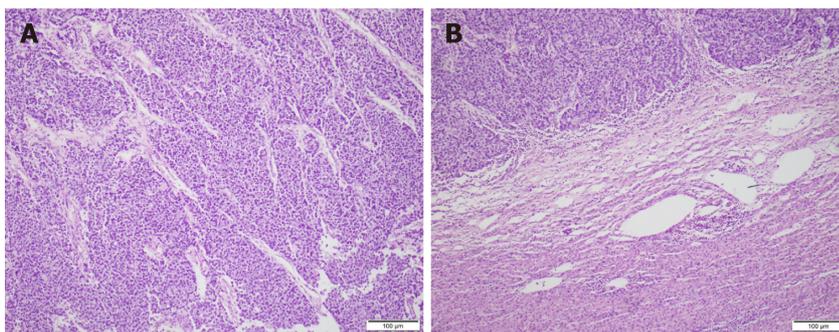


Figure 3 Microscopic images. A: Poorly differentiated gastric carcinoma (hepatoid adenocarcinoma with neuroendocrine differentiation) with liver metastases; B: Tumor tissue and adjacent liver tissue.

CONCLUSION

In conclusion, the application of ELRA in radical resection of GCLM could provide an alternative for selected patients. Strict patient selection and careful perioperative management guaranteed by an experienced multidisciplinary team could contribute to favorable clinical outcomes[21,22].

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