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Preoperative segmental embolization of the proper hepatic artery prior to pylorus-preserving pancreaticoduodenectomy: A case report

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ABSTRACT

INTRODUCTION: Radical resection of bile duct carcinoma may require resection of hepatic arteries. Preoperative segmental embolization of the hepatic artery for resection of hilar cholangiocarcinoma has been reported. We report a patient with bile duct carcinoma infiltrating the proper hepatic artery.
PRESENTATION OF CASE: A 66-year old male with jaundice was diagnosed with mid-distal bile duct carcinoma. A replaced left hepatic artery originated from the left gastric artery. Pylorus-preserving pancreaticoduodenectomy (PPPD) with combined resection of hepatic artery was planned. To promote the development of collateral blood flow after excision of the hepatic artery, preoperative segmental embolization of the proper hepatic artery was performed. The patient underwent PPPD with concurrent resection of the common hepatic, right hepatic, and middle hepatic arteries without arterial reconstruction. He received adjuvant chemotherapy with gemcitabine for six months and is alive three years after surgery without tumor recurrence.
DISCUSSION: The growth of collateral vessels after selective embolization of the proper hepatic artery has been used for hilar lesions and bile duct lesions. Resection of the hepatic artery without the need for complex arterial reconstruction, allowing a radical resection, may have contributed to this patient's relatively unremarkable recovery and long-term survival. Retroperitoneal mobilization of the pancreatic head and duodenum must be limited as important collaterals may originate in that area.
CONCLUSION: Preoperative segmental embolization of the hepatic artery before PPPD for a patient with a replaced left hepatic artery encouraged the growth of collateral blood supply, allowing radical resection including the vessels and obviated the need for arterial reconstruction.
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1. Introduction

A radical resection by pancreaticoduodenectomy (PD) or pylorus-preserving PD (PPPD) is the only way to achieve a complete cure of mid-distal bile duct carcinoma. Bile duct carcinoma often infiltrates surrounding tissues with invasion of hepatic arteries and the surrounding neural plexus [1]. In this situation, a combined resection of hepatic arteries is needed to perform a radical resection [2]. The need for hepatic artery reconstruction is a source of controversy, which greatly complicates the operative procedure, in part because anomalies of the hepatic arteries are common [3,4]. There are many patterns of tumor infiltration to the hepatic arteries and many patterns of hepatic collateral vessels.

We report a patient with bile duct carcinoma, which was suspected to infiltrate the proper hepatic artery with a replaced left hepatic artery. We have previously reported the efficacy of preoperative segmental embolization of the proper hepatic artery for the resection of hilar cholangiocarcinoma with left hepatectomy [5]. Applying this strategy, the patient underwent preoperative segmental embolization of the proper hepatic artery to encourage the development of collateral pathways and then performed a PPPD with concurrent resection of the proper hepatic artery.

2. Presentation of Case

The patient is a 66-year old male who previously underwent cholecystectomy secondary to cholecystitis. He presented to an outside clinic with jaundice and was diagnosed with bile duct carcinoma after evaluation. He underwent endoscopic retrograde biliary drainage and was referred to our institution. Physical examination showed a generally healthy appearing man with jaundice. There were no significant findings on the physical examination.

Abbreviations: CT, computed tomography; PPPD, pylorus preserving pancreaticoduodenectomy; PD, pancreaticoduodenectomy.

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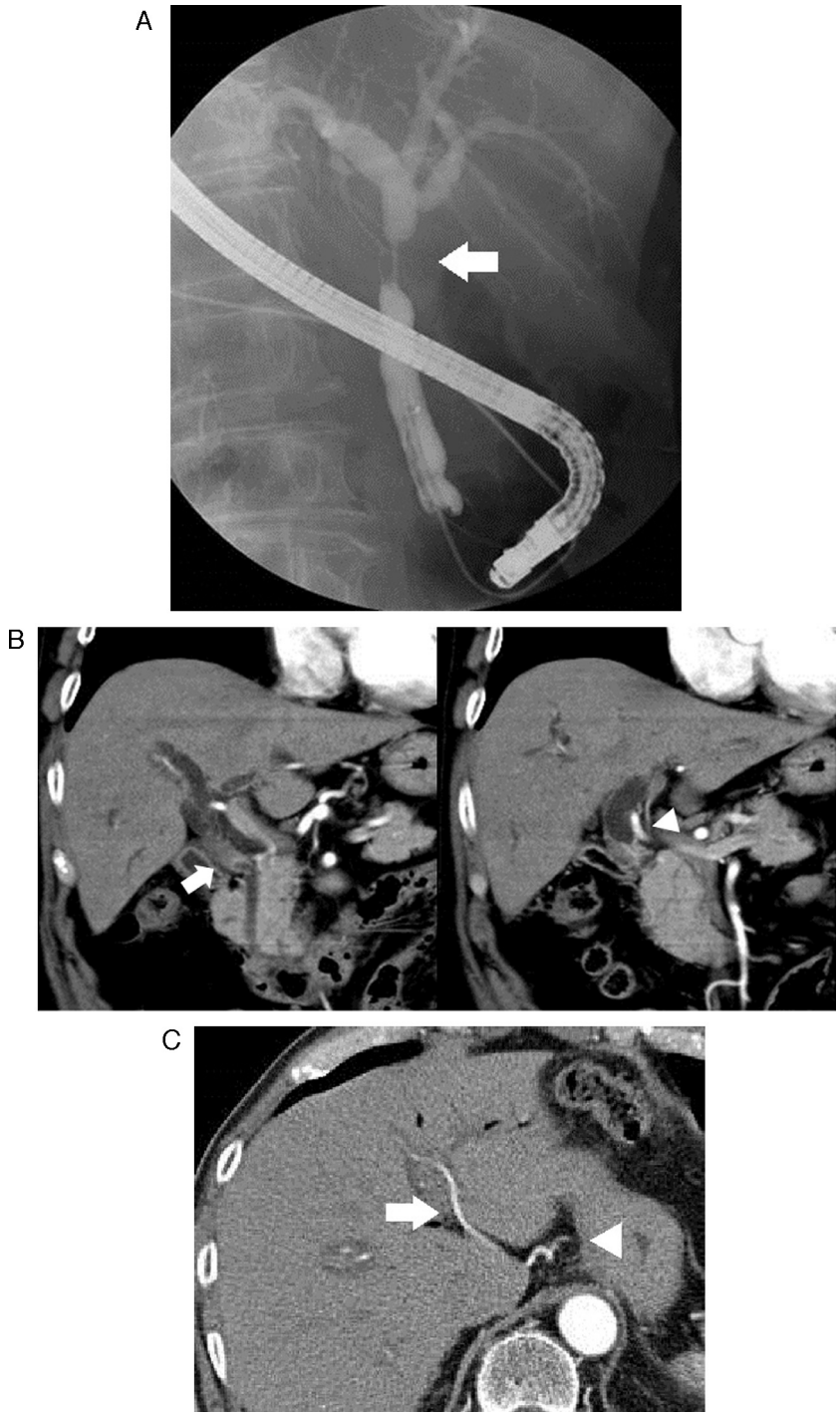

Fig. 1. Preoperative imaging studies.
(A) Endoscopic retrograde cholangiopancreatography showed an approximately 2 cm stricture of the common bile duct (arrow).
(B) The tumor is seen to be infiltrating the upper pancreas (arrow) and is very close to the proper hepatic artery (arrowhead).
(C) Axial image of contrast-enhanced CT scan showed that the left hepatic artery (arrow) originated from the left gastric artery (arrowhead).

Serum chemistries showed a total bilirubin 3.2 mg/dl, alanine transaminase 150 mU/ml, aspartate transaminase 80 mU/ml, carbohydrate antigen 19–9 130 U/ml, and carcinoembryonic antigen 2.7 ng/ml. Endoscopic retrograde cholangiopancreatography showed an approximately 2 cm stricture in the mid-distal bile duct (Fig. 1A). Contrast-enhanced CT scan revealed existence of tumor in mid-distal bile duct infiltrating to upper pancreas and the distance between tumor and the proper hepatic artery was as close as 3 mm and infiltration was suspected (Fig. 1B). A replaced left hepatic artery originated from the left gastric artery (Fig. 1C). Bile duct biopsy showed well differentiated adenocarcinoma.

We planned to perform PPPD with combined resection of the hepatic artery, rather than hepatectomy, as a radical resection due to the invasion of the pancreas seen on imaging studies. In order to promote the development of collateral blood flow from the replaced left hepatic artery to the right side of the liver after excision of the hepatic artery, preoperative segmental embolization of the proper hepatic artery with coils was performed (Fig. 2A). There

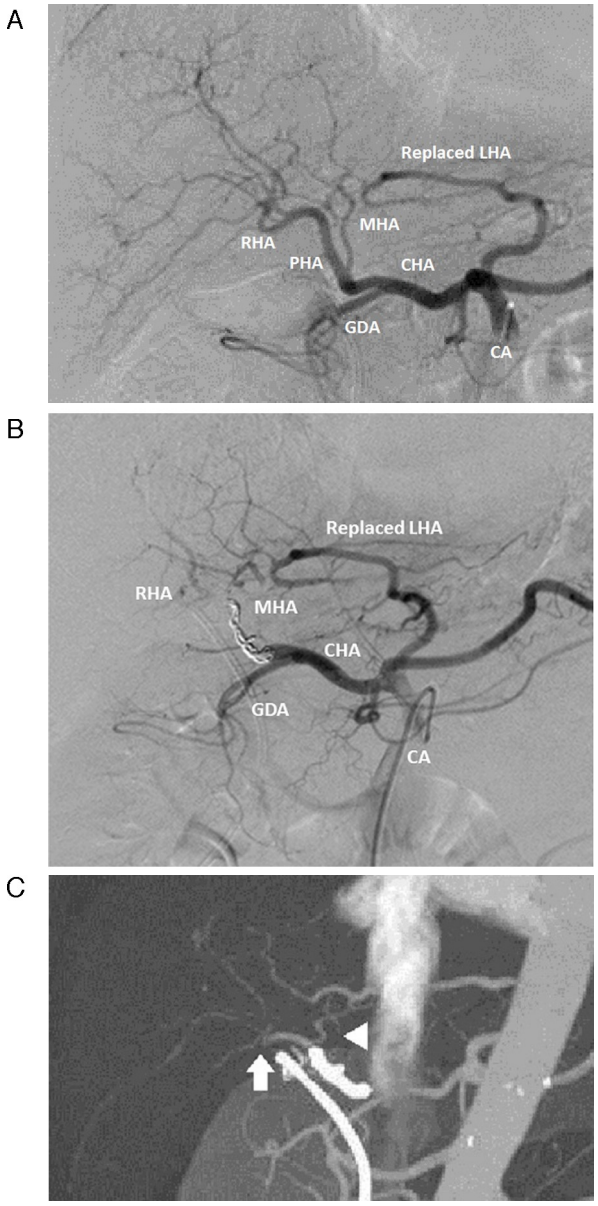

Fig. 2. Vascular imaging studies before and after embolization.
(A) Celiac angiography revealed that the replaced left hepatic artery originated from the left gastric artery.
(B) Following embolization of the proper hepatic artery (coils seen on this study), celiac arteriography shows that the replaced left hepatic artery now provides flow to the middle and right hepatic arteries. There are no obvious shunts seen from the retroperitoneum or pancreaticoduodenal vessels.
PHA, proper hepatic artery; MHA, middle hepatic artery; RHA, right hepatic artery; CHA, common hepatic artery; GDA, gastroduodenal artery; CA, celiac artery, LHA left hepatic artery
(C) Three dimensional CT scan image shows blood flow through an intra hepatic shunt to the middle hepatic artery (arrowhead) and right hepatic artery (arrow).

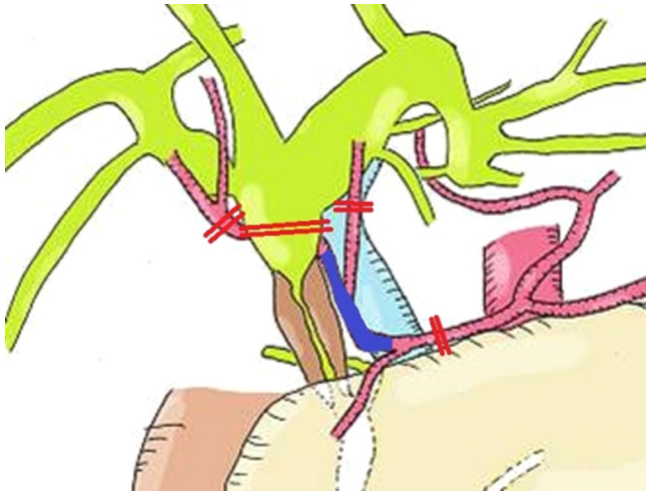

Fig. 3. The transection lines of the right, middle and common hepatic arteries and the common bile duct are shown. The position of the coils is shown in blue.

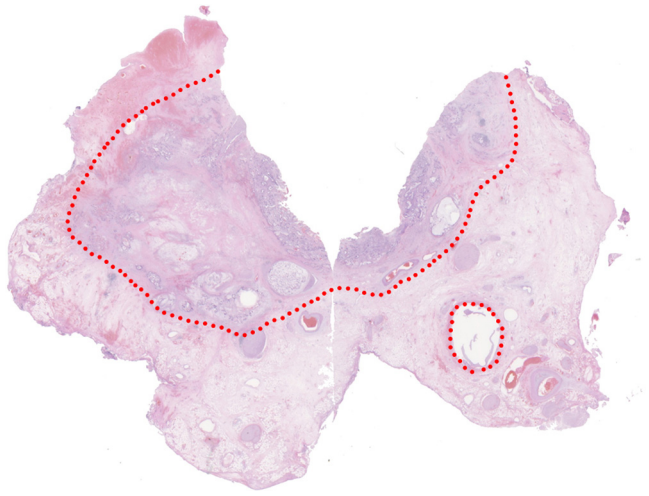

Fig. 4. Microscopic findings in the resected specimen show a moderately differentiated adenocarcinoma of the bile duct (above the dotted line), with very close approximation to the proper hepatic artery (circled dotted line).

were no complications from the arterial embolization. One day after embolization serum alanine transaminase was 21 mU/ml, and the aspartate transaminase was 18 mU/ml. Following embolization, flow is seen from the left hepatic artery to the right and middle hepatic arteries (Fig. 2B). Thirteen days after embolization, enlargement of the replaced left hepatic artery and blood flow through an intra-hepatic shunt to the middle hepatic artery and the right hepatic artery was observed (Fig. 2C). At 23 days after embolization, cholangitis occurred due to obstruction of the biliary stent, so we changed the stent tube.

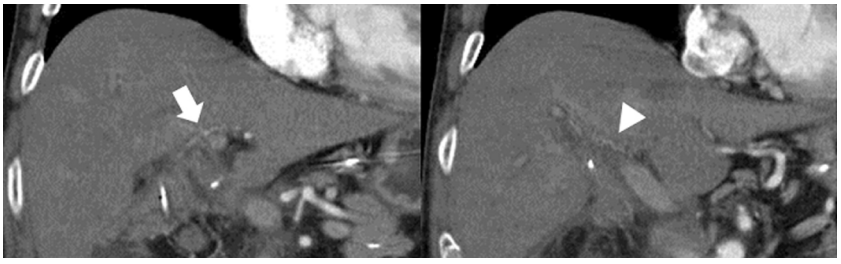

Fig. 5. Computed tomography scan of the liver seven days postoperatively shows flow from the left hepatic artery (arrow) to the distal right hepatic artery (arrowhead).

PPPD was performed at 33 days after embolization (Fig. 3). The tumor was adherent to surrounding tissues due to invasion or inflammation, and it was impossible to identify the proper hepatic artery. The tumor infiltrated near the hilum of the liver so combined resection of the right hepatic artery was needed. There was no infiltration of the portal vein by the tumor. Intraoperative pathologic evaluation showed a clear margin on the hepatic side of the duct. The middle hepatic, proper hepatic, and common hepatic arteries were divided without reconstruction. Pathologic findings after resection showed very close approximation of the tumor to the proper hepatic artery (Fig. 4). Seven days postoperatively, a CT scan was obtained which showed flow in the replaced left hepatic artery and the distal portion of the right hepatic artery (Fig. 5), which is similar to the flow shown in Fig. 2B, after embolization.

On postoperative day one, aspartate transaminase and alanine transaminase were 729 mU/m, 665 mU/ml, respectively, but normalized by postoperative day 14. CT scan on postoperative day seven showed mild hepatic ischemia in the right posterior liver. On postoperative day 25, the ischemic area in the liver had resolved on CT scan. There were no postoperative hepatobiliary complications.

The patient suffered a small pulmonary embolism, treated with anticoagulation therapy. Pathological findings showed a moderately differentiated adenocarcinoma of the bile duct and the tumor and the proper hepatic artery were separated by 4 mm. Perineural invasion was seen and 1/10 lymph nodes was positive for metastases. He was discharged on postoperative day 29 and underwent adjuvant chemotherapy with gemcitabine for six months. He is alive three years after surgery, without evidence of recurrence.

3. Discussion

This patient underwent a radical PPPD for bile duct carcinoma after preoperative segmental embolization of the proper hepatic artery. There were no hepatobiliary complications despite the fact that the hepatic artery was not reconstructed. We have extensive experience with preoperative segmental embolization of the proper hepatic artery in patients with hilar cholangiocarcinoma and applied this strategy for this patient with mid-distal bile duct carcinoma [5].

If the proper hepatic artery is divided and not reconstructed during PD/PPPD in a patient without an hepatic arterial anomaly, there can be severe hepatobiliary complications. Manjo et al. reported liver necrosis and breakdown of the biliary-enteric anastomosis with sepsis after PPPD after ligation of the proper hepatic artery without reconstruction [6]. Adequate blood flow in the proper hepatic artery is important after PD/PPPD. Reconstruction is generally needed after arterial resection, and arterial reconstruction techniques have advanced in recent years [2]. In the present patient, reconstruction of the right hepatic artery was complicated because the graft would have to be very long, and the distal right hepatic artery for reconstruction was very small, so it was technically demanding. Preoperative segmental embolization of the proper hepatic artery before PPPD was performed, allowing the development of collateral pathways. The proper hepatic artery was then resected without reconstruction.

This patient had a replaced left hepatic artery from the left gastric artery, which facilitated blood flow after arterial embolization and increased the flow in the right hepatic artery, and the middle hepatic artery via the hilar plate arterial plexus. The right hepatic artery is a very important feeding artery not only for the right liver, but also the bile duct after PD/PPPD [7–9], which helps prevent liver necrosis and breakdown of the biliary-enteric anastomosis. To perform preoperative embolization of the hepatic artery, fine caliber embolization material such as gelfoam powder or lipiodol should be avoided, as these materials may occlude the peribiliary vascular plexus [10] which could lead to bile duct necrosis and liver infarction. The hepatic arteries should be embolized segmentally to maintain hepatic hilar arterial perfusion. Metal coils were used in this patient to preserve the intrahepatic vascular plexus.

There are previous reports of fifteen patients, reporting the usefulness of preoperative embolization of the hepatic arteries before PD/PPPD (Table 1) [8,11–17]. The embolized artery and collateral pathways varied in each of these patients. No complications occurred after embolization. PD/PPPD was performed 12–28 days after embolization, and every patient underwent radical resection. No hepatobiliary complications occurred after surgery in all patients reported. Serum transaminases transiently increased in four patients, including the present patient. The reason for elevated transaminases in this patient was likely the ischemic changes seen in the right posterior liver seen on CT scan at seven days after surgery.

There are two further explanations possible for the area of liver ischemia including: (1) A small portal vein thrombus developed during the PPPD. This patient had a small pulmonary thromboembolism, which may reflect a hypercoagulable state. (2) Destruction of hepatic collateral pathways during the resection, in an area where collateral blood flow originates from the retroperitoneum. According to our experience and a previous report [18], collateral pathway to the right hepatic area arises from the superior mesenteric artery via the retroperitoneum after occlusion of the proper hepatic artery. The development of the collateral pathway after embolization of the proper hepatic artery is highly individual, and this retroperitoneal pathway does not develop in all cases. But we should recognize that PD/PPPD may destroy one of the collateral pathways which goes through the retroperitoneum or pancreaticoduodenal arcade [19]. It is necessary to minimize dissection of the retroperitoneum during mobilization of pancreatic head and duodenum.

Simultaneous resection of the hepatic artery may contribute to long-term survival of a patient with bile duct carcinoma [2]. Although pathological findings showed that the tumor and the proper hepatic artery were close without actual arterial invasion, perineural invasion was present which supports the need for combined resection of the artery. It may be difficult to preoperatively judge the necessity of combined arterial resection when the tumor is close to the artery. Inflammation around the tumor can mimic invasion of the hepatic artery.

4. Conclusions

This patient underwent preoperative segmental embolization of the proper hepatic artery and a radical PPPD with combined arterial resection for bile duct carcinoma. In a patient with a replaced left hepatic artery, this strategy is very effective for well developing collateral flow which may limit hepatobiliary complications that would likely occur without reconstruction of the hepatic artery. Preoperative segmental embolization of the hepatic artery may increase the possibility to achieve an R0 resection. Preoperative segmental embolization of the hepatic artery is very effective strategy to achieve a safe radical resection without reconstruction of the artery when performing PD/PPPD. This radical resection, made possible by preoperative embolization, has resulted in an excellent clinical outcome with the patient alive three years after resection without evidence of recurrence.

Conflict of Interest

None.

Table 1
Previous reports of PD/PPPD after preoperative embolization of the hepatic arteries.

Number (Ref.)	Author (year)	Age/Gender	Tumor	Replaced artery	Embolized artery	Time after Embolization to Surgery (days)	Operative procedure	Peak AST after surgery (IU/l)	Peak ALT after surgery (IU/l)	Complications after surgery	Outcome
1 (11)	Inokuchi 2000	55/M	Bile duct cancer	LHA (from LGA)	PHA	28	PPPD RPV	505	No Data	None	NED
2 (12)	Miyamoto 2004	73/M	Pancreatic head cancer	CHA (from SMA)	Same as left	12	PD	No Data	No Data	None	NED
3 (13)	Sasaki 2011	69/M	Bile duct cancer	CHA (from SMA)	Same as left	No Data	PD Right hepatic lobectomy	No Data	No Data	None	NED
4 (14)	Cloyd 2012	62/M	Bile duct cancer	RHA (from SMA)	Same as left	22	PD RPV	No Data	No Data	None	Liver metastases at 6 months
5		59/M	Pancreatic head cancer	RHA (from CA)	Same as left	28	PD RPV	No Data	No Data	Pancreatic fistula Bleeding	9 months alive without recurrence
6 (15)	Sergeant 2013	64/F	Pancreatic head cancer	None	CHA	14	PPPD RPV	4809	5444	DGE SSI	Local recurrence after 45 days and death after 83 days
7 (16)	Ichida 2014	65/M	Pancreatic neuroendocrine tumor	RAHA (from SMA)	CHA	18	PD Partial hepatectomy	638	561	No Data	Liver metastases after 16 months
8 (8)	El Amrani 2014	53/M	Pancreatic head cancer	RHA (from SMA)	Same as left	22	PD RPV	No Data	No Data	No Data	NED
9 (17)	Yoshidome 2014*	49/M	Pancreatic head cancer				PD				
10		74/F	Pancreatic head cancer				PD				
11		67/M	Pancreatic head cancer				PD				
12		59/M	Pancreatic head cancer				PD				
13		70/M	Pancreatic head cancer				PD				
14		53/M	Pancreatic head cancer				PD				
15		69/F	Pancreatic head cancer				PD				
This Report		66/M	Bile duct cancer	LHA (from LGA)	PHA	33	PPPD	729	665	PTE	Alive at 3 years without recurrence

LHA, left hepatic artery; CHA, common hepatic artery; RHA, right hepatic artery; RAHA, right anterior hepatic artery; PHA, proper hepatic artery; NED, no evidence of disease; PPPD, pylorus-preserving pancreatoduodenectomy; RPV, resection of the portal vein; PD, pancreatoduodenectomy; DGE, delayed gastric emptying; SSI, surgical site infection; PTE, pulmonary thromboembolism.

* Individual patient data for patients 9–15 are not available as they were published in aggregate (17).

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Ethical approval

None.

Author's contribution

Masanobu Taguchi: Data collection and writing the manuscript.Naohiro Sata: Study design and revision of the manuscript.Yuji Kaneda: Data collection.Masaru Koizumi: Data collection.Masanobu Hyodo: Data collection.Alan Kawarai Lefor: Critical revision of the manuscript.Hirotoshi Kawata: Confirming the pathological diagnosis.Yoshikazu Yasuda: Study design and revision of the manuscript.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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