# EFFICIACY OF APPLIED CARDIOVASCULAR SURGERY TECHNIQUES FOR EXTENDED RESECTION IN HEPATO-BILIARY-PANCREATIC MALIGNANCIES

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# EFFICACY OF APPLIED CARDIOVASCULAR SURGERY TECHNIQUES FOR EXTENDED RESECTION IN HEPATO-BILIARY-PANCREATIC MALIGNANCIES

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## INDEXING WORDS

hepato-biliary-pancreatic malignancies; veno-venous bypass; autologous vein graft; centrifugal pump

## SYNOPSIS

The application of extracorporeal circulation (ECC) and vascular surgery techniques provide the possibility to resect severely advanced hepato-biliary-pancreatic (HBP) malignancies that had been adjudged unresectable hitherto. In this paper, recent two successful cases are reported for the purpose of indicating the efficacy of ECC and vascular surgery techniques in HBP surgery.

Two patients had a cholangiocellular carcinoma and a carcinoma of the pancreatic head, those metastatic lymph nodes invaded to the portal veins and the hepatic arteries. These tumors could be resected en bloc with these Glissonian vessels using a centrifugal pump through veno-venous bypass. Reconstruction of these portal veins was performed with autologous external iliac vein graft. Postoperative angiographies showed no anastomotic leakage or occlusion on vascular anastomotic sites in both cases, and they have gone on uneventful postoperative courses.

Application of cardiovascular techniques in the field of HBP surgery might expand surgical indication for advanced malignancies.

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## INTRODUCTION

The application of extracorporeal circulation (ECC) and vascular surgery techniques provide the possibility of concomitant portal vein (PV) and/or hepatic artery (HA) resection, and increases the resectability rate of advanced malignancies that had been hitherto adjudged unresectable in the hepato-biliary-pancreatic (HBP) field.[5,11,18,22]

The ECC system basically requires systemic heparinization for its establishment. Therefore, the application of conventional ECC for HBP surgery has a disadvantage of massive intra- and postoperative bleeding. Recently developed ECC apparatus,[1] the heparin-coated centrifugal pump system, can be utilized without intravenous heparinization. Furthermore, with this system, it is easy to get the optimal blood flow depending on the portal circulation in order to prevent the intestinal congestion during PV clamping.

Malignancies in the HBP field easily invade to the neighboring important vessels, i.e. PV and/or HA. So it is occasionally necessary to resect these Glissonian vessels in the hepato-duodenal ligament (HDL) en bloc with advanced malignancies. In these cases, meticulous techniques of vascular surgery are indispensable to reconstruct the resected vascular portions without torsion, tension, stenosis, and occlusion.[18]

Recently we have operated on two cases of advanced HBP malignancies en bloc with PV and HA using ECC and vascular surgery techniques. In this paper, our successful cases are reported and the efficacy of basic techniques of cardiovascular surgery for resection of HBP malignancies is discussed.

Table 1. Characteristics of operated cases in Hepato-biliary-pancreatic fields.

| 1) lesion of HBP field | | | 2) applied cardiovascular surgery techniques | |
|---|---|---|---|---|
| Hepatic | HCC | 68 | ECC (+) | 6 |
| | CCC | 11 | | |
| | metastatic | 27 | ECC (-) | 6 |
| Bile tract | | 22 | | |
| Pancreatic | | 18 | | |
| Others (benign) | | 17 | | |
| Total | | 163 | Vascular reconstruction | 12 |

HBP; hepato-biliary-pancreatic, HCC; hepatocellular carcinoma,
ECC; extracorporeal circulation, CCC; cholangiocellular carcinoma.

## CASE REPORTS

During the past 10 years, 163 patients were aggressively operated on for malignant or benign HBP lesions in our institute. Of 163 patients, 68 were hepatocellular carcinoma, 11 cholangiocellular carcinoma, 27 metastatic carcinoma from colorectal cancers, 22 cancer of the bile duct,18 cancer of the head of the pancreas, and the remained 17 were benign and miscellaneous lesions (Table 1). Concomitant vascular resection in the HBP surgery was performed in 12 patients. Six patients were operated on with ECC, the other 6 were done without ECC.

### Case 1:

A 51-year-old-man admitted to our institute in December 1995 with complaints of general fatigue and jaundice. Computed tomography (CT) and endoscopic retrograde cholangiopancreatography (ERCP) revealed an abnormal low density area in subsegment IV-V of the liver, a swollen gallbladder, a severe stenosis of the common bile duct (CBD), and dilatation of the intrahepatic bile ducts. Magnetic resonance imaging (MRI) more clearly revealed the tumor in subsegment IV-V of the liver (Fig.1a). Percutaneous transhepatic biliary drainage (PTBD) was immediately performed for the purpose of decreasing jaundice. Cholaniography through PTBD tube revealed the obstructed hilar bile duct (Fig.1b), which was suspected to be induced by lymph nodes' metastasis into the HDL. Angiogram showed that the proper HA, the right HA, and the PV in the HDL were encased by metastatic lymph nodes (Fig.1c,d).

Followed by these findings, the patient was diagnosed as an advanced cholangiocellular carcinoma with involved Glissonian vessels in the HDL. Although he had an advanced hepatic malignancy, his liver function has been well preserved.

In February 1996, after serum bilirubin level has returned within normal range, the operation was carried out. In order to resect the original tumor in the liver and the invaded Glissonian vessels in the HDL completely, we selected hepato-ligamento-pancreato-duodenectomy (HLPD). This procedure was of extreme, so that we selected the extended left hepatic lobectomy to decrease the resected liver volume and preserve the residual liver function.

At first, pancreatoduodenectomy (PD) was done, and consecutively extended left hepatic lobectomy was performed with the resection of the right HA involved into the tumor. The remnant right HA was directly anastomosed to the stump of the common HA while the blood flow of the PV was maintained. After the reconstruction of the HA for the purpose of preventing a warm ischemic disturbance of the remnant liver, the PV was clamped under the ECC working. To avoid the splanchnic congestion, the ECC was established from the superior mesenteric vein (SMV) to the left femoral vein through a centrifugal pump system (Biopump® with Medtronic/Cameda Bio-Active Surface; Medtronic Bio-Medics Inc., Eden Prairie, USA). PV with tumor invasion was resected, and en bloc resection of the malignant lesions was prudently

carried out.

During the ECC running, the reconstruction of PV was also done with interposition of the autologous external iliac vein (EIV) graft of 7cm in length. The gap of the EIV was interposed with 8 mm in diameter expanded-polytetrafluoloethylene (e-PTFE) graft.

The mesenteric venous pressure was maintained from 17 to 22cmH2O during the ECC and the splanchnic congestion was not observed. The flow rate of the centrifugal pump was stabilized between 1.3-1.5 l/min and the duration of ECC was 33 minutes.

Reconstruction of alimentary tracts was carried out with Imanaga's fashion[8] after weaning the ECC.

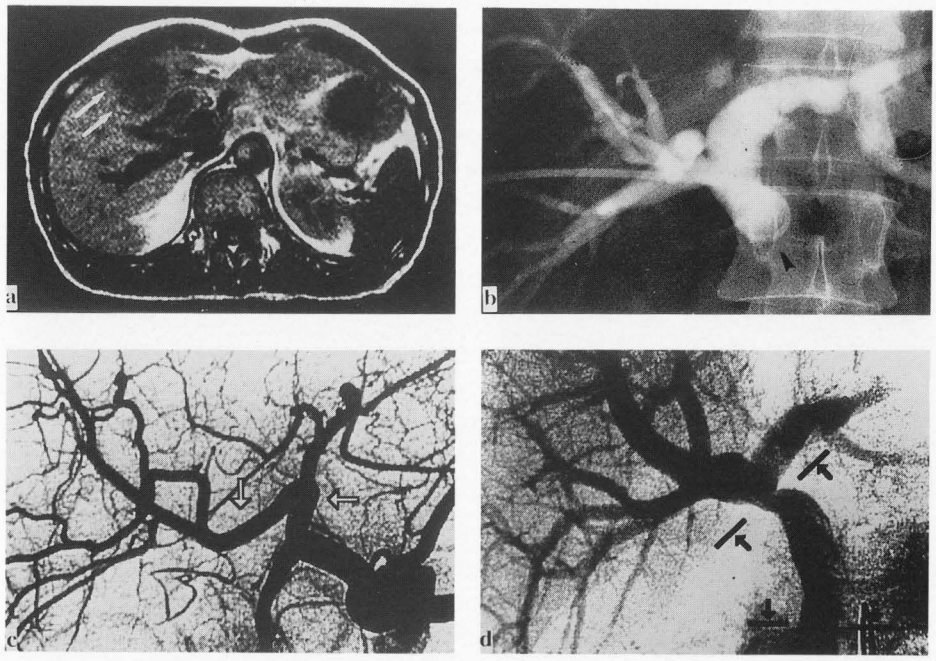

Fig.1. Radiological diagnostic findings in Case 1.

a: Magnetic resonance imaging (MRI) shows low intensity mass (arrows) between medial and anterior segment (subsegment 4-5) in the liver and dilatation of the intrahepatic bile ducts.

b: Cholangiogram via percutaneous transhepatic biliary drainage (PTBD) tube demonstrates complte obstruction of the proximal bile duct (arrowhead).

c: Celiac arteriogram shows smooth encasement (open arrows) between the proper hepatic artery (PHA) and the right hepatic artery (RHA).

d: Transarterial portogram shows irregular encasement (black arrows) of the portal vein (PV).

## Case 2:

A 54-year-old-woman visited her local hospital with jaundice, and was detected a mass in the head of the pancreas by the imaging examinations such as CT and ERCP. Then percutaneous transhepatic gallbladder drainage (PTGBD) tube was immediately inserted in order to decrease jaundice. Cholangiography through PTGBD tube revealed a complete obstruction of the common bile duct (Fig.2a,b).

In January 1996, she was referred to our hospital. Arteriogram revealed the encasement of the gastroduodenal artery and the proper HA (Fig.2c). On the transarterial portogram, the lowest margin of the pancreatic mass invaded to the peripheral branches of the SMV and collateral circulation was developed remarkably instead of the SMV interruption (Fig.2d). Gastrofiberscopy also revealed the invasion to the second portion of the duodenum. From these findings, she was diagnosed as an advanced cancer in the head of the pancreas with invasion to the gastroduodenal artery, the proper HA, and the SMV.

In February 1996, after the serum bilirubin level was decreased from 8.0 mg/dl to 1.7 mg/dl, the operation was performed.

Laparotomy was done through the Benz incision. A mass in the head of the pancreas involved the second portion of the duodenum, the middle colic artery, and its vein. At first, the middle colic artery and its vein were sheared after ligation. Thereby, on lifting the transverse colon, the mesenteric root was opened and the distal portion of the superior mesenteric artery (SMA) and the SMV were encircled with a tape.

Following cholecystectomy, the HDL was dissected and Glissonian vessels were divided into the common hepatic duct, the proper HA, and the proximal PV, and each of them was encircled with a tape. The distal portion of the common HA and the gastroduodenal artery branched from the common HA were involved by the tumor. Fortunately, metastasis of lymph nodes could not be observed at the porto hepatis and cephalad portion of the HDL.

After partial gastrectomy, vessels of collateral circulation were meticulously ligated and sheared, and then pancreatic resection was started on the top of the SMA. Because it was difficult to control hemorrhage from the excisional surface of the pancreas, heparinless bypass was established from the peripheral SMV to the reopened umbilical vein in the round ligament.

Under the ECC running, PD with the excision of the peripheral common HA and the PV was carried out. Approximately 10cm segment of the PV was excised en bloc with the specimen, and also the gap of the HA resected with the specimen was approximately 10cm in length. A vein graft harvested from the EIV was inserted to bridge the gap in the PV and anastomosed with a continuous suture of 5-0 polypropylene. The gap of the EIV was also interposed with 8 mm in diameter e-PTFE graft. After reconstruction of the PV, the ECC came off. The duration of ECC was 116 minutes. During the ECC, the venous pressure of the SMV was controlled between 22 and 23cmH2O, and the flow rate of ECC varied between 0.2 and 0.3 l/min. No congestion of the portal bed was observed. Then, the hepatic artery was immediately reconstructed with an autologous great saphenous vein graft. This anastomotic fashion was

carried out with interrupted sutures of 7-0 polypropylene.

After completion of all vascular reconstruction, alimentary tracts were aligned by Imanaga's fashion.[8)]

## Peri- and postoperative courses:

Their ECC data were summarized in Table 2. To establish the ECC support, a centrifugal pump (Biopump®) system was used in both cases. Veno-venous bypass worked satisfactory without systemic heparinization, and the splanchnic congestion was not observed during the operation.

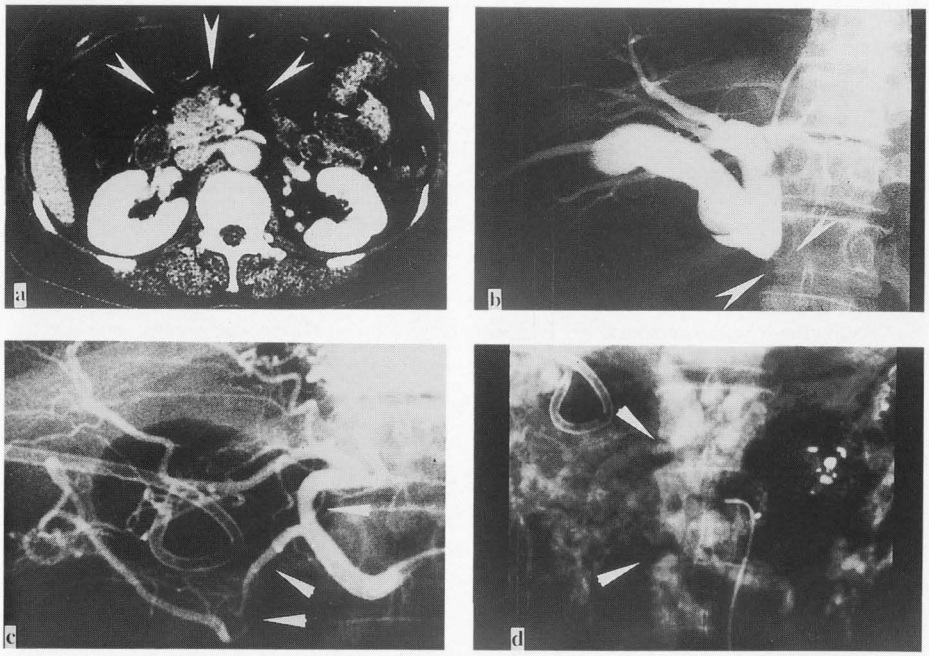

Fig. 2. Radiological disgnostic findings in Case 2.

a: Contrast enhanced computed tomogram (CE-CT) shows a mass (arrowheads) in the head of the pancreas with collateral circulations in the surrounding tissue.

b: Cholangiogram via percutaneous transhepatic gallbladder drainage (PTGBD) tube shows complete obstruction (arrowheads) of the common bile duct (CBD).

c: Selective hepatic arteriogram shows narrowing of the gastroduodenal artery (GDA) (arrowheads) and encasement of the proper hepatic artery (PHA) (arrowhead).

d: Transarterial portogram demonstrates complete obstruction (arrowheads) of the superior mesenteric vein (SMV) and well developed collateral circulations in the neighboring tissue.

Although these aggressive operations took 12 hrs 33 mins in Case 1 and 14 hrs 22 mins in Case 2, respectively, we did not encounter the procedure-related complications.

Histological findings of the resected specimen revealed cholangiocellular carcinoma (moderately differentiated tubular adenocarcinoma) in Case 1, and invasive pancreatic ductal carcinoma (moderately differentiated tubular adenocarcinoma) in Case 2, respectively, and the surgical margins were free of cancer in both cases. The preformed operations were pahtologically estimated as a relative curative operation in both cases.

Their postoperative courses were shown in Fig.3. The levels of GOT and GPT gradually decreased after the peak value on the operative day and restored on the 14th post operative day (POD) in both cases. The level of total-bilirubin in Case 1 increased to 2.7 mg/dl on the 7th POD, and gradually decreased after this peak. In Case 2, the maximum level of total-bilirubin was 5.5 mg/dl on the 1st POD, and gradually decreased to 1.2 mg/dl on the 14th POD and subsequently restored to within normal limits on her discharge.

Table 2. Operative procedures and ECC data of reported two cases.

| Case | 1 | 2 |
|---|---|---|
| Age/sex | 51/M | 54/F |
| Gross Pathology | liver tumor in S4 involving HDL | pancreas head tumor involving PV&GDA |
| Surgical Procedure | HLPD | extended PD |
| Management of PV & HA | PV: reconstruction of a gap of PV with a EIV graft<br>HA: end to end anastomosis | PV: reconstruction between PV and SMV with a EIV graft<br>HA: interposition with a GSV graft |
| ECC data | | |
| type | Biopump | Biopump |
| running time | 33 min | 116 min |
| flow rate | 1.3-1.5 l/min | 0.2-0.3 l/min |
| V-V bypass | SMV to left FV | SMV to the opened round lig. |
| PV pressure | 17-22 cm$H_2O$ | 22-23 cm$H_2O$ |
| Postop. course | uneventful | uneventful |
| Outcome | dead, 15 months after operation | dead, 9 months after operation |

PV: portal vein, HA: hepatic artery, EIV: external iliac vein, GDA: gastroduodenal artery,
SMV: superior mesenteric vein, GSV: greater saphenous vein,
HLPD: hepatoligamentopancreatoduodenectomy, PD: pancreatoduodenectomy,
FV: femoral vein, HDL; hepatoduodenal ligament, ECC; extracorporeal circulation

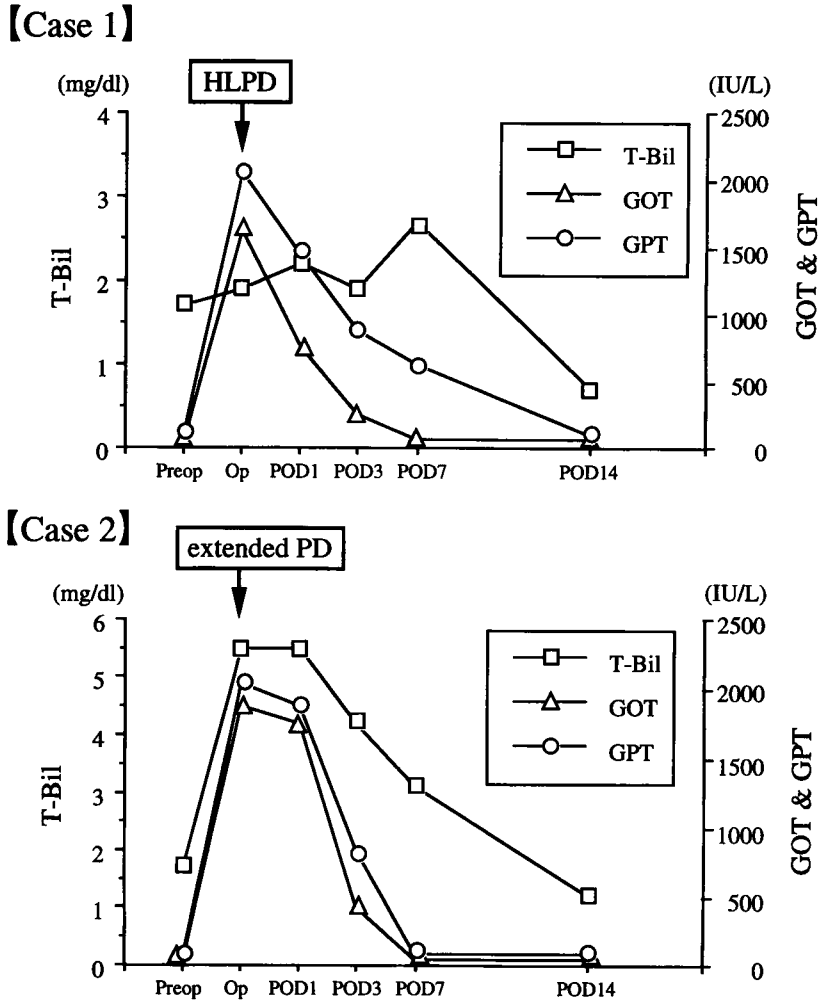


Fig. 3.Changes of the perioperative liver function in Case 1 (top) and Case 2 (bottom).
HLPD; hepato-ligamento-pancreato duodenectomy
extended PD; extended pancreatoduodenectomy

CA 19-9 decreased from 640 ng/ml of the preoperative value to 12 ng/ml in 4 weeks after the operation in Case 1, and from 130 ng/ml preoperatively to 12 ng/ml in 3 weeks after the surgery in Case 2, respectively. Other tumor markers were within normal limits throughout their clinical courses.

The postoperative radiographic studies showed no anastomotic insufficiency on the reconstructive sites of alimentary tracts in both cases. Early postoperative angiographies revealed the reconstructed hepatic artery and PV were patent in both cases. On the postoperative course, both patients had not shown any unpleasant symptoms, and they returned to a normal work and social life.

## DISCUSSION

Advanced malignancies in the HBP fields easily invade to the great vessels of the neighboring tissue, particularly to PV and/or HA. Therefore, the resection of such tumors has been beyond the limits of conventional surgical procedures.[10] With the use of the ECC support and techniques in the cardiovascular surgery, it has become possible to resect en bloc such advanced HBP malignancies.

The purposes of using ECC in HBP surgery are to prevent the congestion of the splanchnic organs and to carry out the operation with safety.[17,21] It has been reported that the allowable period of total clamped PV without ECC was desirably within approximately 30 minutes on normal body temperature.[19] There are many reports concerning about techniques to avoid the splanchnic congestion during PV clamping, such as a veno-venous bypass tube,[14] total hepatic vascular exclusion technique.[2,4,7] However, we prefer to use a centrifugal type pump (Biopump®) for veno-venous bypass in the operation of HBP malignancies. The reasons are as follows; 1) it does not require systemic heparinization, 2) it is not necessary to worry about venous clamping time, 3) it is quite easy to control the venous pressure of PV or SMV in order to prevent the splanchnic congestion and stabilize the hemodynamics.

During Biopump® working, the venous pressure of SMV was maintained between 17-23cmH2O, respectively. The running time of Biopump® in Case 2 was longer than that in Case 1, because Biopump® had been started in early stage of the operation to control the bleeding out of remarkably developed collateral pathways. The flow rate of Biopump® in Case 2 was less than that in Case 1, but no congestion of the portal bed was recognized. We believe that Biopump® should be controlled by the pressure and not by the flow rate, because the flow rate is easily influenced by the degree of individual collateral pathways.

If the gap of resected segmental PV is longer than 7 cm, a venous graft would be required.[5,20] However some authors reported e-PTFE may be suitable for a vascular prosthesis in such cases,[9,15] thrombosed occlusions of the interposed e-PTFE graft actually

occurred more frequently. Therefore, we have selected autologous EIV graft for PV reconstruction. The diameter of EIV is very similar to that of PV, and the harvested EIV has enough length for PV reconstruction. The portion of the harvested EIV may be interposed by e-PTFE graft, because graft thrombosis in EIV lesion is not fatal.

The blood supply to HA would be essential to prevent an anastomotic insufficiency between intrahepatic or hilar bile ducts and a loop of the jejunum.[12] However, anastomotic technique in the reconstruction of the hepatic artery is still difficult for general surgeons.[6] So lately, various fashions are recommended for the reconstruction of HA such as vascular anastomosis under microscope,[13] preoperative embolization of hepatic artery for development of the collateral blood supplies,[6] and so on. In this series, reconstruction of HA was carried out with vascular surgery technique, and leakage or thrombosis at the anastomotic sites was not detected on postoperative radiographic studies.

In 1985, Boerma et al.[3] reported that the radical block resection of the HDL with an anastomosis between the round ligament and the splenic vein was possible according to their postmortem investigations. And the first clinical case of HLPD was performed by Hanyu et al.[6] in 1986. However we well know that HLPD is of extreme procedure in gastro-enterological surgery and still poor as to the results, [6,12] HLPD was indispensable for our patient because of the existence of severe lymph nodes' metastasis in the HDL. Serious complications, such as anastomotic insufficiencies or liver failure, were not found in the postoperative stage fortunately, and the patient was discharged from our institute.

Conventional PD is a popular operative fashion in pancreatic surgery, and lately PD with concomitant resection of PV is undergoing frequently as a prevention to avoid cancerous microinvasions into the surrounding tissue.[16] On the other hand, controversy still exists as to the significance of concominant PV resection with PD, because the improvement of their survival and quality of life have not been fully obtained yet.

Although such extended operations for advanced HBP malignancies described above has raised the resectability rate, the surgical prognosis in patients with such diseases was not improved satisfactorily. However, we surgeons should make an effort to obtain better surgical prognosis and overcome malignancies from now on.

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