REVIEW ARTICLE

Radical surgery: vascular and pancreatic resection for cholangiocarcinoma

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Abstract
Recent progress in vascular surgical techniques has made it possible to combine liver and portal vein and/or hepatic artery (HA) or retrohepatic inferior vena cava (IVC) resection and reconstruction in cases of locally advanced cholangiocarcinoma. Reports of the success of this difficult surgery have been published. Aggressive Japanese surgeons have applied hepatopancreatoduodenectomy (HPD) not just in cases of advanced gallbladder cancer, but also in locally advanced cholangiocarcinoma with or without superficial spread. The above extended surgeries were associated with high postoperative morbidity and mortality, but recent progress in perioperative management and surgical techniques has improved the outcome of these types of surgery. Combined portal vein and liver resection provides R0 resection and contributes to longer survival in resected patients with locally advanced cholangiocarcinoma than in unresected patients. Portal vein invasion is a strong prognostic factor of cholangiocarcinoma and the actual number of 5-year survivors is limited. The number of clinical cases of liver resection combined with IVC or HA resection and reconstruction is still limited, and therefore the long-term survival benefit from these procedures has not been clarified. HPD carried high morbidity and mortality rates in the 1990s, but the outcome has been improving and an increasing number of 5-year survivors has been reported. Although the clinical value of the above extended surgeries has not been evaluated prospectively, with the increasing number of retrospective studies it has been concluded that combined liver and portal vein and/or HA or IVC resection or HPD could be indicated for selected patients with locally advanced cholangiocarcinoma.

Introduction
Recent improvement in operative techniques and perioperative management have enabled hepatopancreato-biliary surgeons to perform extended hepatobiliary and surrounding organ resection using fine vascular surgical techniques. As these aggressive surgeries are associated with considerable postoperative morbidity and mortality, however, continuous efforts are being made to improve the outcome of resected patients.

Indications
Combined portal vein resection in pancreatoduodenectomy has been performed in locally advanced carcinoma of the pancreatic head. Combined portal vein and liver was resected successfully on 6 August 1965 by Dr. Kajitanai at the Cancer Institute Hospital in Tokyo for locally advanced hilar cholangiocarcinoma [1]. Right hepatectomy with extrahepatic bile duct resection and reconstruction was performed. Although portal vein was resected en bloc, a proximal end-to-side portocaval shunt was made for portal vein reconstruction. The patient survived this extended surgery but died from peritoneal cancer recurrence 3 years and 11 months postoperatively [2]. Since the 1970s, surgeons from both the West [3,4] and East [5,6] have attempted to perform hepatobiliary and vascular resection and reconstruction for locally advanced cholangiocarcinoma. Recent progress in microvascular techniques in digestive organ surgery and in visceral organ transplantation has made it possible to perform combined liver and hepatic artery resection and reconstruction in locally advanced cholangiocarcinoma [7,8]. On the other hand, Japanese surgeons aggressively applied combined liver and pancreas resection, HPD, not only in cases of locally advanced...
advanced gallbladder cancer [9], but also in locally advanced cholangiocarcinoma [10–12].

**Surgical strategies and techniques**

**Combined portal vein resection**

Combined portal vein and liver resection has been applied in locally advanced cholangiocarcinoma, and several types of liver resection and concomitant portal vein resection and reconstruction have been reported. These strategies clearly demonstrate that combined resection of the portal vein contributes to negative surgical margins and to radical hepatobiliary resection for cholangiocarcinoma, and significantly prolongs survival of the resected patients compared to non-resected patients [13–18].

The portal vein is usually resected during the final step of hepatic hilar resection and is reconstructed after the tumor is removed. In cases of right-sided hepatectomy, Kondo recommends that portal vein resection and reconstruction should be carried out prior to liver resection in order to establish the non-touch resection of hilar hepatobiliary cancer [19].

Several techniques can be used for portal vein reconstruction. Although end-to-end anastomosis is commonly used, a graft interposition using the iliac vein [6] or an hepatic venous segment [20] or a saphenous vein or a left renal venous patch [21] are used for difficult portal vein reconstruction.

**Combined inferior vena cava resection**

Although combined liver and retrohepatic inferior vena cava (IVC) resection and reconstruction is a challenging procedure, some surgeons attempt to apply this procedure aggressively in cases of advanced primary or metastatic liver tumors, and recent progress in surgical techniques in visceral organ transplantation has encouraged them to accumulate the surgical experience with this procedure for advanced cholangiocarcinomas [22–27]. Most use an artificial graft of Dacron or ePTFE for IVC reconstruction, but in cases of partial resection of the IVC wall a venous patch from the great saphenous vein or from the left renal vein can be used [28].

**Hepatopancreatoduodenectomy for cholangiocarcinoma**

Although HPD has been used as aggressive surgical treatment of advanced gallbladder cancer, recent development of diagnostic modalities has increased the number of patients with locally advanced cholangiocarcinoma, for which HPD is indicated [29–31]. Common bile duct cancer with superficial spread to intrahepatic segmental duct or intrahepatic cholangiocarcinoma with superficial spread to distal bile duct is also indicated for HPD [32–34].

Actually, pancreatoduodenectomy is carried out as the first step of this surgery, and the hepatoduodenal ligament is dissected upward to skeletonize the vascular structures at the hepatic hilum. Hepatectomy is performed depending on the preoperative diagnosis of the extent of the cancer [10].

**Results**

Combined portal vein and liver resection has been associated with high postoperative morbidity and mortality. However, recent progress in perioperative management and surgical techniques has improved the outcome of this difficult surgery, which provides radical R0 resection and contributes to longer survival in resected patients with locally advanced cholangiocarcinoma. Portal vein invasion is a strong prognostic factor of cholangiocarcinoma and the actual number of 5-year survivors is limited [16]. Liver resection combined with IVC resection and reconstruction is a newly developed surgical technique and the number of clinical cases is still limited. Therefore, the long-term survival benefit of this difficult procedure has not been clarified. As this surgery has been carried out at experienced centers, postoperative morbidity and mortality have been reported in an acceptable range. HPD has been performed mainly in Japan, with postoperative morbidity and mortality high in the 1990s [13]. According to recent progress in perioperative management of difficult patients, the outcome has been improving and an increasing number of 5-year survivors has been reported [30,35]. This surgery was actually carried out in the USA [36]. It is expected that an increasing number of patients with locally advanced cholangiocarcinoma will be indicated for difficult surgeries with combined vascular resection or HPD followed by improved outcome.

**Conclusions**

Prospective studies evaluating surgical treatments with advanced techniques, i.e. using vascular resection and reconstruction or combined liver and surrounding organ resection for locally advanced cholangiocarcinoma, have not been published. In addition, several retrospective studies have concluded that combined liver and portal vein and/or IVC resection or HPD could be indicated for locally advanced cholangiocarcinoma.

**References**


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