NOTE *Surgery*

En Block Resection of a Large Hepatocellular Carcinoma Involving the Caudal Vena Cava in a Dog

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(Received 11 May 2010/Accepted 10 December 2010/Published online in J-STAGE 24 December 2010)

ABSTRACT. A 13-year-old neutered female Shih Tzu was referred for investigation of a cranial abdominal mass. Investigations including conventional radiography, abdominal ultrasonography and computed tomography confirmed the mass in the caudate lobe of the liver. As a collateral vein originating from the caudal vena cava (CVC) communicated with the azygos vein, the CVC was ligated and transected cranial to the right renal vein and cranial to the mass under temporary occlusion of the thoracic descending aorta and posthepatic CVC. The mass combined with the CVC was excised. The mass was confirmed as hepatocellular carcinoma (HCC). This report describes the first case with successful en bloc resection of a large HCC involving the CVC in a dog.

KEY WORDS: canine, caudal vena cava, hepatocellular carcinoma.

J. Vet. Med. Sci. 73(5): 693–696, 2011

Hepatocellular carcinoma (HCC) is the most common primary hepatic tumor in dogs [4, 11, 15]. Canine HCC is classified into three morphologic types, massive, nodular and diffuse, and the most common pattern is a massive lesion that involves a single liver lobe [11]. Therefore, liver lobectomy is the recommended treatment, and the prognosis after surgical resection is good in dogs [7, 8]. However, in cases of large or right-divisional hepatic tumors involving the CVC, surgical resection has a risk of large hemorrhage. Partial resection or reconstruction of the CVC may be require when the vessel wall is invaded.

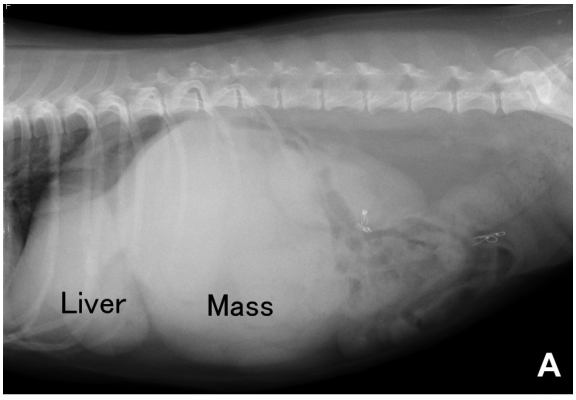
A 13-year-old neutered female Shih Tzu (weight 6.6 kg) was referred to the Animal Medical Center of Nihon University for investigation of a cranial abdominal mass. In a physical examination, an enlarged abdomen was observed. Complete blood cell count revealed mild leukocytosis (18,300/m*l*); other hematological and coagulation parameters were within the normal range. The serum biochemical profile was normal, except for increases in the concentrations of serum alanine aminotransferase (684 U/*l*), alkaline phosphatase (559 U/*l*) and aspartate aminotransferase (732 U/*l*). Radiography revealed a large mass in the caudal side of the liver, displacement of the stomach and intestine (Fig. 1A. B) and a small mass in the left caudal lobe of the lung. In an abdominal ultrasound, a large mixed echogenic mass in the right-divisional hepatic lobe and several splenic nodules were confirmed.

Computed tomography (CT) showed a large mass in the caudate lobe occupying the abdominal cavity and displacing the right kidney to the caudal side and the portal vein to the left. In CT angiography, a little contrast medium was detected in the CVC, as blood flow through the CVC was interrupted by the mass (Fig. 2). A collateral vein originating from the CVC caudal to the right renal vein communicated with the azygos vein through a lumber vein (Fig. 3A, B). Further, a single congenital extrahepatic portacaval shunt via the left gastric and phrenic veins was confirmed.

The hepatic mass was surgically resected 24 days after the initial presentation. After 0.04 mg/kg atropine (Atropine sulfate; Mitsubishi Tanabe Pharma Corporation.) was administered subcutaneously, general anesthesia was induced with intravenous injection of 0.1 mg/kg midazolam (Dormicum; Astellas) followed by 4 mg/kg propofol (Rapinovet; Schering-Plough Animal Health K.K.). After endotracheal intubation, the dog was mechanically ventilated with a mixture of sevoflurane (SevoFlo; Maruishi Pharmaceutical) and pure oxygen. During the operation, 5% glucose in acetate Ringer's solution (1–10 m*l*/kg/h, Veen-D; Kowa Co., Ltd.) and whole blood (1–5 m*l*/kg/h) were infused. Dopamine (3 μg/kg/min, Dominin; Nippon Shinyaku Co., Ltd.) and dobutamine (5 μg/kg/min, Dobutrex; Shionogi) were also infused to maintain intraoperative hemodynamic stability. For intra- and postoperative analgesia, remifentanil (5–40 μg/kg/h, Ultiva; Janssen Pharmaceutical K.K.) was infused.

The dog was placed in dorsal recumbency and celiotomy extending from the xiphoid process to the pubis and caudal median sternotomy were performed. The hepatic mass originated from the caudate process of the caudate lobe of the liver and adhered to the mesentery of the descending duodenum (Fig. 4). The adhesions to the mesentery were released by electrocautery, and the CVC was ligated and transected cranial to the right renal vein (Fig. 5). Following partial incision of the diaphragm, the thoracic CVC and descending aorta were isolated cranial to the diaphragm. As the portal vein and hepatic arteries were close to the mass, these ves-

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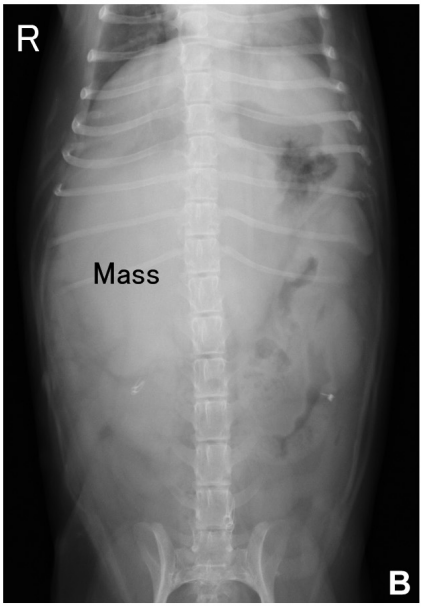


Fig. 1. Radiographic findings of the abdominal complications. (A) Lateral view, (B) ventral view. A large hepatic mass displaced the stomach and intestine to the caudal side and left.

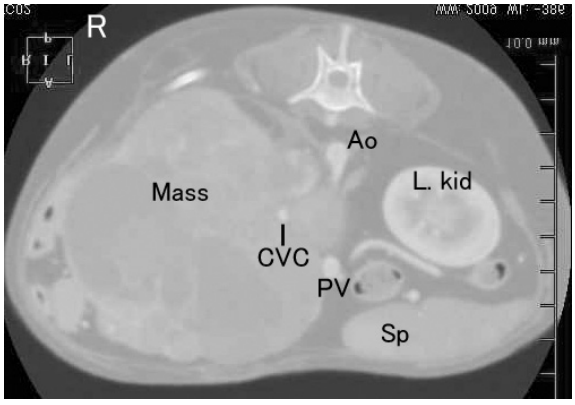


Fig. 2. Axial computed tomographic findings of the abdomen (angiography). Ao: descending aorta. CVC: caudal vena cava. PV: portal vein. L. Kid: left kidney. Sp: spleen. A large hepatic mass in the caudate lobe was detected in the abdominal cavity. The CVC was compressed by the mass, and some amount of contrast medium flowed into the CVC.

sels were not exposed. Umbilical tapes were placed around the thoracic CVC and descending aorta and passed through Rummel tourniquets. Vascular occlusion was accomplished by tightening the tourniquets to reduce hepatic blood flow and prevent hemorrhage during hepatic resection. Vascular occlusion was performed 3 times, for 17, 16 and 11 min, and reperfusion was performed for 6 and 13 min. Antebrachial systolic arterial pressure measured by an oscillometer increased from 120 to 175 mmHg, and the heart rate decreased from 120 to 60 bpm during the first occlusion. Hemodynamic status was stable during the second and third occlusions. Under the vascular occlusion, tributaries of the portal vein and hepatic artery and the hepatic vein into the caudate lobe were separated using an ultrasonic aspirator. After these vessels were ligated and transected, the CVC was ligated and transected caudal to the hepatic vein into the remaining liver lobes. Thereafter, hepatic resection including the CVC was performed. The Rummel tourniquets were loosened after resection of the mass. The spleen was removed, and the portacaval shunting vessel was attenuated by an ameroid constrictor (4 mm in internal diameter). The resected hepatic mass was 9.6 × 9.0 cm in size, and presence of the narrow CVC was confirmed within the mass. The mass was confirmed to be an HCC, and the splenic mass was confirmed to be a nodular hyperplasia.

Postoperatively, transient edema of the pelvic limb was observed, and the patient was discharged on the 11th postoperative day. After that, the patient appeared to be well; however, abdominal ultrasonography revealed a small mass-like lesion near the resected area on the 76th postoperative day. Because the owner did not approve of additional surgical treatment, adoptive immunotherapy (intraperitoneal infusion of lymphokine-activated killer cells) was performed at intervals of 2–3 weeks from the 107th postoperative day. On the 167th postoperative day, jaundice of unknown origin was detected and improved by fluid therapy. On the 298th postoperative day, the patient was treated with fluid therapy and blood transfusion, as anemia resulting from gastrointestinal hemorrhage was confirmed. The patient recovered as a result of treatment but eventually died on the 394th postoperative day. Unfortunately, necropsy was not acceptable to the owner.

Surgical resection is the recommended treatment, but the major complication following hepatic resection is hemorrhage in dogs with a massive HCC [7, 8]. Surgical resection of right-divisional hepatic tumors involving the CVC, in particular, has a risk of large hemorrhage as a result of injury to the CVC. It has been reported that dogs with left-sided tumors live significantly longer than dogs with right-sided tumors [8]. Partial resection or reconstruction of the CVC may be required when the vessel wall is invaded. In our case, the HCC in the caudate lobe invaded the CVC, and a collateral vein had already been established between the

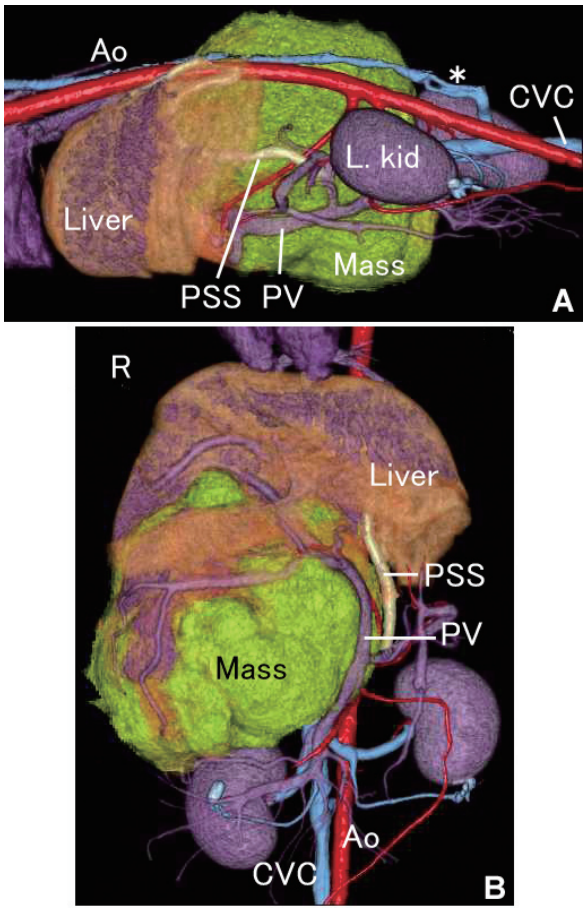


Fig. 3. Three-dimensional CT angiographic reconstruction. (A) Lateral view, (B) ventral view. Ao: descending aorta. CVC: caudal vena cava. PV: portal vein. PSS: congenital portosystemic shunt. L. Kid: left kidney. ∗: acquired collateral vessel. A large hepatic mass displaced the right kidney to the caudal side and the portal vein to left. The CVC was interrupted by the mass, and an acquired collateral vessel had been formed communicating between the CVC and the azygos vein. A single congenital extrahepatic portosystemic shunt (PSS) via the left gastric and phrenic veins was confirmed.

CVC and the azygos vein through the lumber vein. Therefore, reconstruction of the CVC was not required, and en block resection of the HCC with the CVC was possible. Gradual occlusion of the CVC cranial to the renal vein have been reported to cause development of collateral veins from the renal capsules and the CVC to the lumber veins, vertebral veins and azygos vein in dogs [12]. In humans, combined liver and inferior vena cava resection for tumors has been reported [5, 10]. En bloc resection including the suprarenal CVC has been reported in a dog with pheochromocytoma [9]. This is the first report about en block resection of a large HCC of the caudate lobe involving the CVC in a dog. However, if an available collateral vessel has not been formed, en bloc resection of a tumor involving the CVC might not be feasible without reconstruction of the CVC.

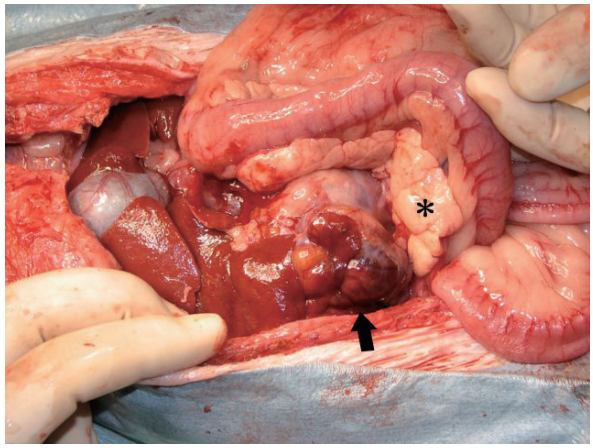


Fig. 4. Photograph during the surgery. The large hepatic mass (arrow) originated from the caudate process of the caudate lobe of the liver and adhered to the mesentery of the descending duodenum. ∗: Pancreas

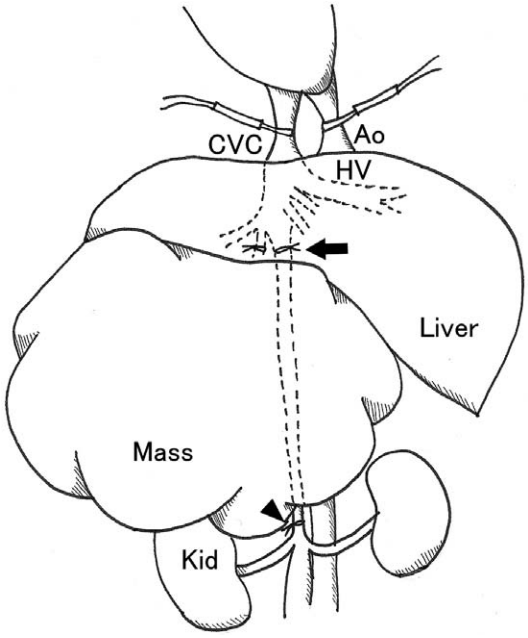


Fig. 5. Illustration of the operation. Ao: descending aorta. CVC: caudal vena cava. HV: hepatic vein. The CVC was ligated and transected cranial to the right renal vein (arrow head). Under vascular occlusion of the thoracic CVC and descending aorta, some vessels into the caudate lobe and the CVC were ligated and transected (arrow).

In our cases, we used a method of vascular occlusion to reduce hepatic blood flow and prevent hemorrhage during hepatic resection. In human medicine, hepatic vascular occlusion during hepatic resection is effective in reducing intraoperative bleeding, and various techniques for vascular occlusion have been reported [1, 3, 14]. In veterinary medicine, two methods of hepatic vascular occlusion have been reported in dogs; one is occlusion of the celiac artery, cra-

nial mesenteric artery, portal vein and the prehepatic and posthepatic CVC [2, 16], and the other is occlusion of the thoracic aorta, hepatic artery, portal vein and prehepatic and posthepatic CVC [6]. In a previous study, we compared 2 methods, occlusion of the celiac artery, cranial mesenteric artery, hepatic pedicle (the hepatic artery and portal vein) and the prehepatic and posthepatic CVC versus occlusion of the thoracic aorta, hepatic pedicle and prehepatic and posthepatic CVC for 20 min [13]. As a result, the influence on the hemodynamic status was lesser for occlusion of the thoracic aorta, hepatic pedicle and prehepatic and posthepatic CVC than occlusion of the celiac artery, cranial mesenteric artery, hepatic pedicle and the prehepatic and posthepatic CVC. In our case, occlusion of only the thoracic CVC and descending aorta were performed to prevent bleeding. We should perform occlusion of the portal vein and hepatic artery to interrupt hepatic blood flow completely. However, we performed vascular occlusion partly to reduce hepatic blood flow because separation of these vessels had a risk of bleeding.

In our case, except for transient edema of the pelvic limb, no other complications were observed, and the patient lived more than a year after the operation. En bloc resection of the tumor and CVC was an effective method for the HCC that involved the CVC and collateral veins had already been established.

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