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Central and left division hepatectomies in two dogs

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OBJECTIVE
To describe the management of extensive hepatectomy in 2 dogs.

ANIMALS
A 10-year-old female intact mixed-breed dog (case 1) and an 11-year-old male castrated mixed-breed dog (case 2) were presented for surgical evaluation following diagnosis of a hepatic mass.

CLINICAL PRESENTATION, PROGRESSION, AND PROCEDURES
16 months before presentation, case 1 had undergone a left lateral liver lobectomy, which resulted in an incomplete resection of hepatocellular carcinoma. Both dogs underwent surgical excision of the liver mass.

TREATMENT AND OUTCOME
In case 1, surgery consisted of the removal of the remaining left medial lobe, as well as the central division. Case 2 received a complete left and central division hepatectomy. Histopathology confirmed a diagnosis of hepatocellular carcinoma in both dogs. Liver enzyme resolution and lack of tumor recurrence were confirmed with chemistry panel and abdominal ultrasonography in both dogs.

CLINICAL RELEVANCE
This case report describes, for the first time, the clinical management and outcome of extensive hepatectomy in 2 dogs. We propose that extensive hepatectomy, staged or synchronous, is possible in a clinical setting.

History

Case 1

A 10-year-old female intact mixed-breed dog weighing 12.3 kg was presented to The Ohio State University (OSU) Veterinary Medical Center Integrated Oncology Service for evaluation for recurrence of hepatocellular carcinoma (HCC). Sixteen months before presentation, the dog underwent a left lateral liver lobectomy for HCC with incomplete surgical margins, at a different tertiary facility. Following surgical resection, the dog was presented to the same tertiary facility for staging with abdominal CT scanning every 6 months. One month before presentation, CT was used to identify a large, mixed attenuating mass arising from the left medial liver lobe. A fine-needle aspiration of the mass was performed under sedation, and cytology was consistent with recurrence of HCC. There was no evidence of pulmonary metastatic disease on 3-view thoracic radiographs.

Case 2

An 11-year-old male castrated mixed-breed dog weighing 34.5 kg was presented to OSU Veterinary Medical Center Integrated Oncology Service for a newly diagnosed hepatic mass. One month prior to presentation, increases in ALT, ALP, and AST were found during routine preanesthetic blood work for a prophylactic dental procedure. An abdominal ultrasound was recommended at that time, and a left-sided hepatic mass measuring approximately 8 to 12 cm was identified. There was no evidence of pulmonary metastatic disease on 3-view thoracic radiographs.

Diagnostic Findings and Interpretation

Case 1

At OSU presentation, physical examination results and CBC values were within normal limits. Serum chemistry abnormalities included increased concentrations of ALT (987 IU/L; reference range, 18 to 108 IU/L) and AST (333 IU/L; reference range, 16 to 51 IU/L) as well as hypoglycemia (31 mg/dL; reference range, 67 to 127 mg/dL). Tho-

racic and abdominal CT were performed for presurgical planning and staging. The previous liver lobectomy site was identified with multiple metallic staples. Ventral to the staples, a lobular, hypoattenuating soft tissue mass (5.5 X 5.5 cm) with heterogeneous contrast enhancement was identified involving the left medial liver lobe **(Figure 1)**.

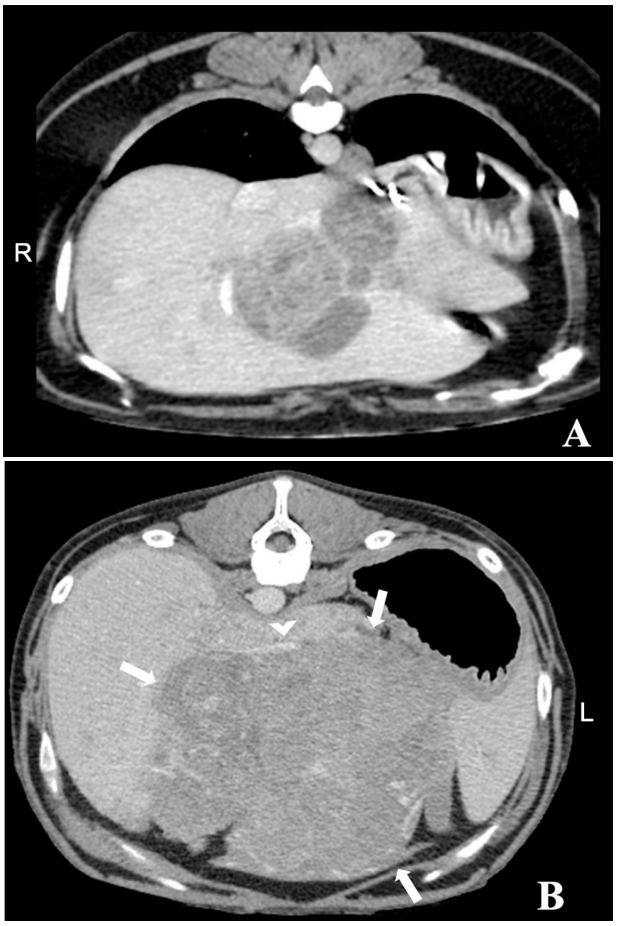

Figure 1—A—Transverse plane CT image of case 1's hypoattenuating soft tissue mass with heterogeneous contrast enhancement. Note the metal attenuating staples along the left dorsal margin of the mass from the previous surgical resection. B—Transverse plane CT image of case 2's hypoattenuating soft tissue mass with heterogeneous contrast enhancement (white arrows), occupying most of the liver at this level. Note the dorsal displacement and compression of the portal vein (chevron) by the mass. The caudal vena cava is not easily identified in this image due to compression. Window width, 400 HU; window level 40 HU; 1.25-mm slice thickness; acquired with 120 kVp.

Two ill-defined nodules, measuring 1.3 and 1.4 cm, were identified in the right liver. Based on these imaging findings, tumor recurrence was suspected. No evidence of metastasis or structural abnormalities were identified within the thoracic cavity.

Case 2

At OSU presentation, the dog was noted to have bilateral lenticular sclerosis and exhibited moderate stridor during physical examination. An abdominal CT was performed for presurgical planning. A lobular, heterogeneous, hypoattenuating soft tissue mass with contrast enhancement, measuring 12 X 15 X 14 cm, was identified. The mass was highly vascular, compressing and causing dorsal displacement of the intrahepatic caudal vena cava and the portal vein at the porta hepatis within the liver (Figure 1). The mass was identified as being centered in the region of the right medial lobe and expanding centrally. Additionally, a hypoattenuating, rim-enhancing soft tissue nodule, measuring 1.5 cm, was in the left liver. The thoracic cavity was not evaluated with CT. Based on these imaging findings, primary hepatic tumor occurrence was suspected. Ultrasound-guided fine-needle aspiration of the larger mass was performed under sedation, and cytology was suggestive of HCC.

Complete blood count results revealed a nonregenerative anemia (Hct, 35% [reference range, 40% to 59%] MCV, 68 fL [reference range, 62 to 77 fL]; MCHC, 33.8 g/dL [reference range, 33.0 to 36.1 g/dL]) and stress leukogram (absolute neutrophils, 7.79 X 10^9/L [reference range, 2.6 X 10^9 to 10.8 X 10^9/L]; absolute lymphocytes, 0.31 X 10^9/L [reference range, 0.7 X 10^9 to 3.2 X 10^9/L]; absolute monocytes, 1.64 X 10^9/L [reference range, 0.1 X 10^9 to 1.1 X 10^9/L]). Serum chemistry abnormalities included increased concentrations of liver enzymes ALT (3,587 IU/L; reference range, 18 to 108 IU/L), ALP (699 IU/L; reference range, 12 to 133 IU/L), and AST (317 IU/L; reference range, 16 to 51 IU/L).

Treatment and Outcome

Case 1

A standard ventral midline celiotomy approach was made. The abdominal exploration revealed a large mass associated with the left medial liver lobe extending into the hilus of the central division. Following intraoperative visualization, it was determined that to completely resect the recurrent mass, the central division and left medial liver lobe would need to be removed en bloc. Some dissection of the fat overlying the right divisional hepatic duct was performed to identify this structure before positioning the stapler. The right medial lobe, gallbladder, quadrate lobe, and left medial lobe were removed en bloc at their respective hilus with a vascular loading unit (TA-30 Vascular Loading Unit with DST Series Technology; Covidien LLC). Additional hemostasis was achieved with hemoclips. Following resection, bile leakage from the right lateral hepatic duct near the junction to the common bile duct was noted and subsequently repaired with a simple interrupted suture using 5-0 polypropylene suture. Prior to closure, the abdomen was lavaged with warm, sterile saline solution. The abdomen was closed in routine fashion via 3-layer closure. The dog recovered uneventfully from the procedure. Histological examination

confirmed a diagnosis of HCC, indicative of local recurrence. Neoplastic cells extended to 2 mm of the surgical margin, which consisted of adjacent liver tissue, and were considered narrow but complete. The dog was seen for recheck examination 6 months following surgery by the referring veterinarian. Liver enzyme elevation improvement (ALT, 88 IU/L [reference range, 8 to 65 IU/L]; ALP, 113 IU/L [reference range, 7 to 92 IU/L]) and lack of tumor recurrence were identified following chemistry panel and abdominal ultrasonography recheck diagnostics.

Case 2

A standard ventral midline celiotomy approach was made. The abdominal exploration revealed a large mass associated with the right medial liver lobe. A small diaphragmatic incision was made to enable caudal retraction of the liver mass and permit improved visualization of adhesions to the diaphragm. The gallbladder and cystic duct were dissected from the right medial liver lobe using a combination of blunt dissection and a precise vessel-sealing system (LigaSure and ForceTriad Energy Platform; Medtronic). During dissection, the cystic bile duct was torn and was subsequently ligated using 4-0 polydioxanone suture. The left and central division, along with the gallbladder, were removed en bloc at the hilus with a vascular loading unit (TA-55 Vascular Loading Unit with DST Series Technology; Covidien LLC). The papillary process of the caudate lobe was removed en bloc with a TA-30 due to congested appearance and concern for a compromised blood supply. During surgery, significant blood loss resulted in hypotension (mean noninvasive blood pressure, 40 mm Hg; reference range, 60 to 100 mm Hg) that warranted an intraoperative transfusion of 2 units of packed RBCs. The diaphragm was closed with 4-0 polydioxanone suture in a simple continuous pattern. Air was evacuated from the thorax with a red rubber catheter, 3-way stopcock, and 60-mL syringe until negative pressure was achieved. The abdomen was closed in routine fashion via 3-layer closure. The dog recovered uneventfully from the procedure. Histopathology of the liver sample confirmed a diagnosis of HCC. Neoplastic cells extended to the margins of the excised hepatic mass, and monitoring for recurrence was recommended. The dog was reportedly seen for recheck examination 6 months following surgery by the referring veterinarian. Liver enzyme elevation improvement (ALT, 150 IU/L [reference range, 18 to 121 IU/L]; ALP, 357 IU/L [reference range, 5 to 160 IU/L]; and AST, 47 IU/L [reference range, 16 to 55 IU/L]) and lack of tumor recurrence were identified following chemistry panel and abdominal ultrasonography recheck diagnostics.

Comments

This report describes surgical treatment for HCC via central and left division hepatectomies in 2 dogs. Massive HCC are typically treated with liver lobectomy, but these cases involved multiple lobes, due to either recurrence of disease or simply size and location of the primary tumor. Left and central divisional hepatectomies were required to remove all tumor-bearing segments in these dogs. Prolonged survival times (> 1,460 days) are reported in dogs undergoing surgical resection of affected liver lobes.[1] Reported recurrence rates of HCC are low, about 0% to 5.4%; therefore, surgical resection via liver lobectomy is the treatment of choice to remove tumor-bearing segments in their entirety.[1] In comparison, dogs whose owners elect to pursue medical management, as opposed to pursuing surgery, for HCC have a median survival time of only 270 days.[1] While case 2 had an incomplete resection, the overall survival times in both dogs are expected to be similar.[1]

When multiple liver lobes are found to be involved, preoperative planning is required before surgical resection. The liver's 3 subdivisions—left, central, and right—make up 44%, 28%, and 28% of the liver's total volume, respectively.[2] Both the volume and functionality of the liver remnant need to be considered to prevent posthepatectomy liver failure (PHLF). While no uniform definition for PHLF exists, it is generally considered to include failure in 2 or more of the liver's synthetic or excretory functions or clinical evidence of hepatic encephalopathy following hepatectomy.[3] Neither dog in this report showed signs of PHLF, as both had normal postoperative chemistry panels with resolved elevated liver enzymes. In case 1, only 1 excretory function (total bilirubin) was impaired preoperatively, but the hyperbilirubinemia resolved following surgical intervention.

When performed as separate procedures, both left and central hepatectomy have been proven to provide successful clinical outcomes at both removing the tumor and preserving patient liver function.[4] Experimentally, young dogs, between the ages of 8 and 12 months, have tolerated massive hepatectomy, with up to 90% of hepatic mass resection, but no clinical cases have been reported with resection > 50% of total liver volume.[3] Using previously reported liver lobe volumes, the total liver volume removed in case 1 and 2 was about 72%.[2]

Extensive hepatic resections increase the risk of PHLF. Neither dog in this report showed signs of PHLF based on postoperative liver enzyme elevation resolution and normal chemistry panel values. The limits for how much liver can be resected at 1 time are debated. When experimental extensive hepatectomy was performed in dogs by performing staged surgical procedures, resection of 95% of the dog's total hepatic mass was possible because liver regeneration occurred during the waiting period of 6 to 8 weeks between procedures.[5] It should be noted that most of the resected liver consisted of the neoplastic mass in both dogs; therefore, it can be assumed that the amount of functional liver volume resected was far < 70%.

Successful clinical outcome following both single-session central and left division hepatectomies has not been reported in small animals prior to this case report. Further studies are necessary to deter-

mine the largest hepatectomy limit achievable without inducing PHLF in a dog with and without preexisting liver disease.

Acknowledgments

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References

1. Lapsley JM, Wavreille V, Barry S, et al. Risk factors and outcome in dogs with recurrent massive hepatocellular carcinoma: a Veterinary Society of Surgical Oncology case-control study. *Vet Comp Oncol*. 2022;20(3):697–709.
2. Boothe HW. Current concepts in hepatobiliary surgery. *Vet Clin North Am Small Anim Pract*. 2015;45:463–475.
3. Steen S, Conway C, Guerra C, Kargozaran H, Gagandeep S. 90% hepatectomy with a porto-hepatic shunt in a canine model: a feasibility study. *ILAR J*. 2012;53(1):E1–E8.
4. Linden DS, Liptak JM, Vinayak A, et al. Outcomes and prognostic variables associated with central division hepatic lobectomies: 61 dogs. *Vet Surg*. 2019;48(3):309–314.
5. Szawlowski AW, Saint-Aubert B, Gouttebel MC, Astre C, Joyeux H. Experimental model of extended repeated partial hepatectomy in the dog. *Eur Surg Res*. 1987;19(6):375–380.