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**Anatomic Rationale for Arterial Bleeding from the Liver Bed
During and/or after Laparoscopic Cholecystectomy: A
Postmortem Study**
[Articles]

Bergamaschi, Roberto M.D., Ph.D.; Ignjatovic, Dejan M.D., M.M.S.

From the Institute of Surgery, University of Bergen, SSSF Hospital, Forde, Norway (R.B.); and KBC Dr. Dragisa Misovic University Hospital, Belgrade, Yugoslavia (D.I.).

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Address correspondence and reprint requests to Dr. R. Bergamaschi, National Center for Advanced Laparoscopic Surgery, Trondheim University Hospital, Trondheim, Norway.

Abstract

Summary: The aim of this study was to establish an anatomic rationale for liver bed arterial bleeding during laparoscopic cholecystectomy. Fifty consecutive human cadavers were dissected. A corrosion cast method was used. Six anastomotic branches (12%) of the cystic artery to the right or left hepatic artery ran underneath the gallbladder serosa surface and entered liver parenchyma after crossing the medial or lateral edge of the liver fossa without passing through the areolar tissue of the liver bed. Their mean length was 18.3 mm (range 4–60), and the mean diameter was 0.38 mm (range 0.2–0.8). Two cystic arteries that ascended in the midline between the gallbladder and liver bed were identified in 50 (4%) casts. Their lengths were 16 and 18 mm, and their diameters were 1.9 and 2.2 mm. Five and seven branches encircling the gallbladder arose radially. These two arterial branching patterns can cause arterial bleeding from the liver bed during and/or after laparoscopic cholecystectomy. Major vascular injuries aside (1), enforced conversion rates due to arterial bleeding during laparoscopic cholecystectomy have been reported to range between 0.18% and 2% (2–9). Although arterial bleeding from the liver bed might occur in 7% of patients (7), conversion rates vary from 0.09% to 1.3% (3,5,6,10,11). Secondary laparotomy due to bleeding from the liver bed following laparoscopic cholecystectomy has been reported in 0.1% to 0.5% of patients (2,8,9,12). Postoperative arterial bleeding resulted in fatal outcome rates of 0.01% (9) and 0.02% (13). Anatomy textbooks do not provide sufficient data to account for bleeding from the liver bed when the gallbladder is removed without dissecting into liver tissue (14).

The aim of this postmortem study is to establish an anatomic rationale for liver bed bleeding during and/or after cholecystectomy.

MATERIALS AND METHODS

Fifty consecutive fresh (<24 hours old) autopsy specimens from patients (27 men and 23 women; mean age 54 years, range 26–83) were obtained from Belgrade City Hospital from January to June 1997. Five cadavers with macroscopic pathologic changes of the liver [metastatic disease (n = 2), cirrhosis (n = 1), echinococcus cyst (n = 1), and trauma (n = 1)] were excluded from the study. The liver and hepatoduodenal ligament were removed en bloc through a midline incision of the anterior abdominal wall. The inferior vena cava was divided cranial to the mobilized liver. The duodenum was dissected free from retroperitoneum and the hepatic artery proper, common bile duct, and portal vein were transected close to the head of the pancreas. The inferior vena cava was divided caudal to the liver. Specimens were placed into a 0.9% NaCl normotonic solution (37°C). The hepatic artery proper was identified, a 10-Fr polyethylene catheter placed into it, and it was secured with a suture. The artery was irrigated with 0.9% saline solution to wash out all blood clots and to identify collateral vessels. Branches of the artery were identified and ligated to prevent leakage of cold polymerizing methyl acrylate during injection. The common bile duct was prepared in a similar manner. After placement of a 10-Fr catheter, irrigation was performed to remove sludge from the bile ducts, particularly the cystic duct. Ligation of bile duct branches was not performed. All blood clots were removed with forceps from the portal vein lumen, which then was irrigated thoroughly through a polyethylene catheter until clear saline solution was derived from the inferior vena cava. Identification and ligation of collateral vessels (right gastric vein, umbilical veins, and other small veins) were performed during portal vein irrigation.

Corrosion casting was carried out injecting cold polymerizing methyl acrylate (dyed with different colors) through the catheters. During injection, specimens were immersed in water to regain their original shape. Acrylate was first injected into the hepatic artery proper and then into the portal vein. Once solidification occurred in the arteries and veins, the cystic duct was identified and ligated at the gallbladder neck to prevent filling of the gallbladder, which otherwise would have broken the specimen because of the weight of the gallbladder cast. The bile ducts were injected. Corrosion was performed in a heated 35% potassium hydroxide solution to accelerate saponification. The casts were rinsed in water until all remnants of organic tissue disappeared and then mounted on stands.

Photographs and measurements of corrosion casts were made during September 1998 at the University of Bergen SSSF Hospital at Forde, Norway. The size and length of the arteries were measured by a nonius scalable ruler and flexible copper wire, respectively. If the location of an artery was deep in the cast, surrounding vessels were shaved off to allow

measurement. Only inner diameters were measured; outer diameters were assumed to correspond to a 20% increase of the inner values due to the methodology used.

RESULTS

Anastomotic branches of the cystic artery to intrahepatic branches of the right or left hepatic artery were identified in 6 (12%) of 50 corrosion casts. The length of these anastomotic vessels varied between 4 and 60 mm (mean 18.3). Their inner diameter ranged from 0.2 to 0.8 mm (mean 0.38). These vessels arose either from the superficial or the deep branch of the cystic artery and ran underneath the serosa surface of the gallbladder. Before entering the liver parenchyma they crossed either the medial or lateral edge of the liver fossa and penetrated the hepatic parenchyma without passing through the areolar tissue of the liver bed. Of 6 anastomotic vessels, 1 was located between the superficial branch of the cystic artery and the right hepatic artery, 4 were between the deep branch of the cystic artery and a segmental branch of the right hepatic artery (Fig. 1), and 1 was between the deep branch of the cystic artery and a segmental branch of the left hepatic artery (Fig. 2). Four anastomotic vessels were located in the gallbladder fundus (66%) and two in the gallbladder neck (33%).



FIG. 1. Anastomosis (a) between a segmental branch of the right hepatic artery (b) and cystic artery (c).

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FIG. 2. Deep branch of cystic artery (a) anastomosing (b) with a segmental branch of left hepatic artery (c).

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A cystic artery that arose from the right hepatic artery and ran through the most cranial part of Calot's triangle and reached the liver bed (without giving a superficial and a deep branch) was identified in 2 (4%) of 50 corrosion casts. The two arteries ascended longitudinally and approximately in the midline through the areolar tissue between the gallbladder and the liver surface. Their lengths from the right hepatic artery to the liver bed was 16 and 18 mm, and their diameters were 1.9 and 2.2 mm. Five and seven branches encircling the gallbladder arose radially from the two cystic arteries (Fig. 3). No anastomotic communications were found between the right and left hepatic arteries and the branches of these two cystic arteries, which were completely extrahepatic.



FIG. 3. Cystic artery (a) arising from the right hepatic artery and giving rise to branches encircling the gallbladder. B, cystic duct.

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DISCUSSION

Bleeding is not an infrequent occurrence during dissection of the gallbladder from the liver bed. In most cases, it is due to dissection inadvertently entering the liver tissue and/or the gallbladder wall. Usually it is easily controlled. However, two uncommon branching patterns of the cystic artery can occasionally cause bleeding from the liver bed. 1) Although intrahepatic anastomotic branches of the cystic artery to the right or left hepatic arteries have been described (15,16), their clinical significance for surgeons performing laparoscopic cholecystectomy is not yet fully understood. When divided, these vessels will bleed from both ends: the cystic artery and the right or left hepatic artery. The

magnification of the laparoscope usually allows identification of these branches as vessels of a small diameter crossing either the medial or lateral liver bed edge from underneath the serosa surface of the gallbladder and entering the liver parenchyma without passing through the areolar tissue of the liver bed (Fig. 4). Due to the seemingly insignificant caliber of these anastomotic branches, hemostasis may appear to be adequately achieved, but secondary bleeding still can occur postoperatively. When identified along either the medial or lateral liver bed edge, arterial anastomotic branches should be individually clipped on the liver side or divided using ultrasonic scissors. The use of a hook instrument should be avoided. 2) When the cystic artery is not identified during dissection of Calot's triangle, the chance that this artery is running through the most cranial part of the triangle should be borne in mind. At this point, the artery should be expected to run approximately in the midline through the areolar tissue between the gallbladder and the liver surface. The surgeon should identify this unusually located cystic artery and divide it after clipping. Failure to do so entails that having to deal with five or seven arterial branches radially embracing the gallbladder (Fig. 4). Enforced conversion may be the end result of poor control of this radial pattern of branching. On the other hand, when the procedure is not converted, postoperative bleeding might occur as long as the cystic artery is not ligated.

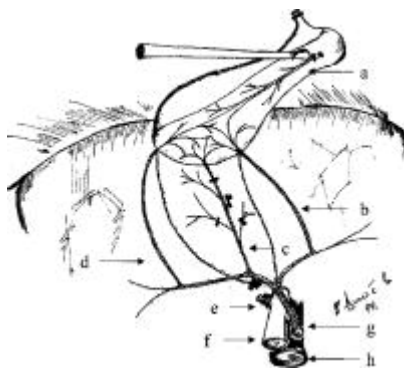


FIG. 4. Two arterial branching patterns of the cystic artery. a, gallbladder b, anastomosis between cystic artery and segmental branch of left hepatic artery; c, cystic artery running through the most cranial part of Calot's triangle; d, anastomosis between cystic artery and segmental branch of right hepatic artery; e, cystic duct; f, common bile duct; g, hepatic artery proper; h, portal vein.

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This postmortem study identified two arterial branching patterns of the cystic artery that, if not dealt with adequately, could cause arterial bleeding from the liver bed during and/or after cholecystectomy.

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