CASE REPORT

Replaced right and left hepatic arteries: a variation in origin and course

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SUMMARY

In ~60% of cases, hepatic artery anatomy is of the normal variant. However, in 40% of cases, anomalies can exist. Preserving the hepatic blood supply is paramount in hepatobiliary procedures. We report an aberrant right hepatic artery coursing retroportally, with an aberrant left hepatic artery originating directly from the coeliac artery in a patient who underwent an elective pancreaticoduodenectomy (Whipple procedure).

BACKGROUND

The hepatic artery most commonly originates from the coeliac trunk, coursing anterior to the portal vein and branching into right and left before entering the liver. Albrecht von Haller first described this normal variant of the coeliac artery branches in the 18th century.¹ Since then, anatomic variants of the hepatic artery have been researched and studied due to its importance in identification during surgical procedures of the foregut. In 1955, NA Michels described his classification of hepatic artery variants and their frequency, which is commonly referenced today. The most common variations from the standard include a left hepatic artery (LHA) originating from the left gastric artery, or the right hepatic artery (RHA) originating from the superior mesenteric artery (SMA) occurring at 10% and 11% frequencies in the population, respectively.² There is a significant risk in iatrogenic injury to replace the RHA during surgical procedures such as a pancreaticoduodenectomy and cholecystectomy, and other types of hepatobiliary hilar surgery. Moreover, there is evidence of increased incidence of hepatic artery stenosis and thrombosis in liver transplant recipients with an aberrant right hepatic artery.³ For reasons such as these, it is important to be aware of any anatomical variants prior to conducting procedures in the region of the pancreas and hepatic hilum.

CASE PRESENTATION

A 62-year-old woman with a history of irritable bowel syndrome, diabetes mellitus, coronary artery disease, gastrointestinal bleed, paroxysmal atrial fibrillation, chronic obstructive pulmonary disease and hypertension, status post hysterectomy presented to our office after being referred to us for extrahepatic cholangiocarcinoma. This was diagnosed via endoscopic retrograde cholangiopancreatography performed by our gastroenterologist. The patient's CT scan including the angiogram and tumour marker results were reviewed; aberrant right and left hepatic arteries were evident. There

was no evidence of metastatic disease. Therefore, the patient was advised to undergo pancreaticoduodenectomy as a curative procedure. Subsequently, the patient underwent an elective pancreaticoduodenectomy.

A standard chevron incision was carried out to expose the epigastric region and bilateral upper quadrants. Abdominal cavity exploration was negative for any gross metastatic disease or tumour burden. Therefore, we proceeded with the operation. An open dome down cholecystectomy procedure was performed first. The common hepatic duct and the proximal common bile duct were noted to be in normal anatomical position. Next, the Kocher manoeuvre was performed to mobilise the entire duodenum. The retroperitoneum structures were exposed, including the head of the pancreas, which was found to be firm with no specific palpable mass noted. The gastroduodenal artery (GDA) and the RHA were not present in the usual supraduodenal location. Instead, a retroportal aberrant RHA and an abnormally large GDA (4 mm) was noted coming off the SMA (figure 1). The GDA was clamped and the hepatic hilum was evaluated with an intraoperative Doppler device. The Doppler signals were very strong; however, the RHA was not entirely visualised due to its retroportal course. The GDA was ligated at its root. Subsequently, the distal stomach, the entire duodenum including the ligament of Treitz, the common

Figure 1 CT angiogram demonstrates both the GDA and the replaced RHA retroportal course after arising from the SMA. GDA, gastroduodenal artery; RHA, right hepatic artery; SMA, superior mesenteric artery.

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bile duct and the pancreas head and uncinate process were resected using a Harmonic scalpel device without any major issues. All specimens were sent for pathology.

Prior to proceeding with the anastomosis, a repeat Doppler was performed to evaluate the hepatic hilum. The Doppler signals, which were very strong initially, now suddenly were weak. The GDA root stump was explored and noted to have significant brisk back bleeding. It was then realised that the RHA was inadvertently transected. It was now evident that the RHA, from which the GDA branched off, had an aberrant origin from the SMA and coursed retroportally into the right lobe of the liver (figures 1 and 2). In addition, a replaced LHA was noted to be coming directly off the coeliac trunk, with absence of a common hepatic artery (figure 3).

TREATMENT

When the transection of the RHA was noted, a segment of the saphenous vein of the left thigh was immediately harvested and used for bypass grafting. The saphenous vein jump graft was anastomosed to the infrarenal abdominal aorta and then the proximal end of the saphenous vein was anastomosed to the

Figure 2 CT angiogram demonstrates the retroportal PV course of the replaced RHA. PV, portal vein; RHA, right hepatic artery.

Figure 3 CT angiogram demonstrates the replaced LHA and splenic artery arising from the CA. CA, coeliac axis; LHA, left hepatic artery; SA, splenic artery.

GDA stump. After verification, there was good pulsatile flow with strong Doppler signals present in the hepatic hilum and the remainder of the pancreaticoduodenectomy was performed. A pancreaticojejunostomy, hepaticojejunostomy, gastrojejunostomy and Braun jejunostomy were carried out without complication.

Postoperatively, the patient was kept intubated and monitored overnight in the intensive care unit (ICU). On postoperative day 1, a liver ultrasound demonstrated a lack of flow in the RHA. There was a moderate elevation in the transaminases as well. A CT angiogram was further obtained to assess the RHA and the graft flow across the anastomosis. It showed occlusion of the RHA and thrombosis of the distal jump graft near the GDA anastomosis.

Given the current findings, the patient was brought back to the operating room for graft revision. The bypass graft was fully exposed from the infrarenal attachment and up to the GDA anastomosis. The Doppler signals in the hepatic hilum remained weak. After further meticulous dissection, it was noted that there was a complete RHA transection and the jump graft was looping back into the SMA, which supplied the RHA and GDA originally. The transected RHA within the hepatic hilum was dissected free from surrounding attachments and opened; however, no flow was evident. There was a thrombus within the artery, which was removed using a 3 French Fogarty catheter. After this, a good pulsatile back bleeding was observed from the RHA stump. A side branch of the saphenous vein graft was anastomosed to the RHA stump easily and without tension. Excellent pulsatile flow was appreciated along with strong Doppler signals. The patient had an abdominal washout and closure and subsequently was taken back to the ICU in stable condition.

OUTCOME AND FOLLOW-UP

The patient was maintained on a heparin drip for several days postoperatively and was then transitioned to baby aspirin therapy. Liver transaminases and other laboratory tests returned normal. A diet was started and advanced without issues. The patient was transferred out of the ICU to surgical floors. Subsequently, the patient was discharged to a skilled nursing facility for physical therapy and rehabilitation.

DISCUSSION

Interest in hepatobiliary arterial variants has existed since major pancreatic and hepatic hilar surgical procedures have been routinely conducted. However, the importance of recognising these variances is no longer limited to invasive surgical procedures, as in our case of a pancreaticoduodenectomy. Newer techniques to approaching hepatic tumours including transhepatic arterial chemoembolisation (TACE) and hepatic arterial perfusion scintigraphy are of increasing popularity.⁴ Therefore, it is important to interventional radiologists and surgeons alike to be aware of rare anomalies in this region. Knowing the arterial distributions prior to any intervention can change our approach and also greatly decrease the chance of complications during the procedure.

Vascular aberrancies of the hepatobiliary anatomy may occur due to deviations from standard embryological development. During development, three hepatic arteries exist. The RHA arises from the SMA, the LHA originates from the left gastric and the middle hepatic originates from the coeliac axis. Eventually, these embryonic right and left hepatic arteries are obliterated and only the middle hepatic artery remains. The middle hepatic artery becomes the proper hepatic artery, which goes on to give off the right and left hepatic branches that

usually occur in adult anatomy.⁵ However, anomalies can occur when these embryonic RHA and LHAs persist from their initial origins into adulthood.

Knowing the embryonic origins of the hepatic vessels, we can appreciate why Michels found the most common variations to be the RHA branching from the SMA, and the LHA branching from the left gastric artery.² In our case, however, these were not the exact variants found. In a retrospective study carried out at Mayo Clinic, which looked at aberrant right hepatic arterial anatomy in pancreaticoduodenectomy procedures, it was found that the most common RHA variant branched from the SMA and coursed lateral to the portal vein.⁶ In our case, the RHA originates from the SMA but coursed posterior to the portal vein rather than lateral to it (figures 2 and 4). In addition, the GDA branched off from the RHA. The LHA was also a replaced variant, coming directly off the coeliac trunk rather than the left gastric artery. Michels described a replaced RHA and replaced LHA occurring together at ~1% frequency.² To the best of our knowledge, however, there are no reported cases of right and left replaced hepatic arteries simultaneously occurring with the specific origins we observed in our case (figure 5).

Compromise to the RHA can cause ischaemia to the right liver lobe and to the bile ducts. This is because the RHA and the GDA provide supply to the biliary ducts. Normally, the GDA arises from the common hepatic artery.^{7 8} In our case, since the GDA came from the RHA and SMA, there was increased risk of compromise to the hepatic duct arterial supply. In retrospect, the RHA was most likely transected during dissection of the enlarged periportal lymph node using the Harmonic scalpel. This was not immediately recognised because the RHA was sealed at the point of harmonic transection, therefore, haemostasis was falsely reassuring. The Doppler signals were initially strong due to arterial back flow, most likely from the LHA supplying portions of the right lobe of the liver. In order to avoid this in the future, a different approach can be taken to this procedure.

In a case report by Lapascu *et al* in 2011, it was observed that the posterior approach to pancreaticoduodenectomy is best in patients with hepatic artery variants. In this approach, the SMA, portal vein and retroportal pancreatic lamina are dissected prior to transection of the pancreas and gastrointestinal tract. They concluded that the posterior approach avoids arterial injuries

Figure 4 CT angiogram demonstrates replaced RHA arising from the SMA. The AO is also displayed. AO, abdominal aorta; RHA, right hepatic artery; SMA, superior mesenteric artery.

Figure 5 CT angiogram demonstrates both the SMA and CA giving rise to the replaced hepatic arteries. CA, coeliac axis; GDA, gastroduodenal artery; RHA, right hepatic artery; SMA, superior mesenteric artery.

that may compromise the liver.⁹ In another study carried out in Japan, looking at this posterior approach to the procedure, they described dissecting the SMA and superior mesenteric vein in a clockwise manner. They found that this method aids in understanding the anatomy of the vessels and that accidental transection is more likely to be avoided.¹⁰ This strategy can be used when aberrant arterial anatomy is observed in preoperative radiographic imaging. The findings in this case have implications for living-related transplants, particularly in living-related donors. The variation in the anatomy needs to be addressed at the time of donor harvest.

Learning points

- ▶ It is important to be aware of any anatomical variants prior to conducting procedures in the region of the pancreas and hepatic hilum.
- ▶ CT angiograms are helpful in delineating the hepatic arterial blood supply quite accurately.
- ▶ When there is a replaced hepatic artery, a posterior approach to pancreaticoduodenectomy is recommended.
- ▶ Dissect the replaced right hepatic artery from the superior mesenteric artery to the hepatic hilum to prevent any inadvertent injury.
- ▶ If the replaced hepatic artery injury is recognised intraoperatively, saphenous vein interposition graft with inflow from the infrarenal aorta is recommended.

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