



Replaced gastroduodenal artery: Added benefit of the “artery first” approach during pancreaticoduodenectomy—A case report

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ARTICLE INFO

Article history:

Received 22 January 2016

Received in revised form 6 April 2016

Accepted 7 April 2016

Available online 13 April 2016

Keywords:

Replaced gastroduodenal artery

Artery first

Pancreaticoduodenectomy

ABSTRACT

INTRODUCTION: Variations in hepatic arterial anatomy are frequently encountered in pancreas and liver surgery. These aberrancies add technical complexity to the procedure and can result in significant patient morbidity if these vascular nuances are not recognized.

PRESENTATION OF CASE: We report a case whereby a superior mesenteric artery first approach was used to locate and preserve an aberrant left hepatic artery arising from a replaced gastroduodenal artery emanating from the SMA during pancreaticoduodenectomy. The procedure was done for resection of a large duodenal adenoma.

DISCUSSION: High-quality preoperative imaging and mastery in surgical expertise are requirements for identification and preservation of aberrant hepatic arterial anatomy during procedures involving vital intra-abdominal organs.

CONCLUSION: Our aim is to provide awareness of rare vascular anomalies encountered during pancreaticoduodenectomy and provide a unique method for successful management.

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1. Introduction

Hepatic arterial anomalies occur in up to 40–45% of the population [1,2]. Successful surgical resection of lesions in the head of the pancreas requires high quality preoperative imaging to define aberrant vascular anatomy and the surgical expertise to identify and preserve relevant blood supply to vital intra-abdominal organs. Herein we report a case of aberrant hepatic arterial anatomy where the left hepatic artery (LHA) arose from the gastroduodenal artery (GDA) which in turn, arose from the SMA. We completed the pancreaticoduodenectomy (PD) using a superior mesenteric artery (SMA) “artery first” approach to preserve the left hepatic artery (LHA). To our knowledge, this is the first description of this particular vascular anomaly managed during PD.

2. Presentation of case

This 55 year old woman with a long-standing history of gastroesophageal reflux disease and Barrett’s esophagus, was incidentally found on surveillance endoscopy to have a fungating, friable mass in the second portion of her duodenum encompassing the ampulla

of Vater (Fig. 1a). Biopsy of this mass was consistent with duodenal adenoma. Endoscopic retrograde cholangiopancreatography (ERCP) revealed a four centimeter multilobulated mass extending at least one cm into both the common bile duct (CBD) and the pancreatic duct (PD) causing partial obstruction of both ducts (Fig. 1b). Magnetic Resonance Cholangiopancreatography (MRCP) confirmed these findings and she was therefore referred for surgical resection (Fig. 1c). The patient denied jaundice, icterus or pruritus and was borderline diabetic. She had no evidence of pancreatic exocrine insufficiency, nor any history of pancreatitis. She had undergone a laparoscopic cholecystectomy for symptomatic cholelithiasis a few years prior. Family history was significant for esophageal cancer in several first degree relatives resulting in their deaths. Liver functions, amylase, lipase and tumor markers including carcinoembryonic antigen (CEA) and carbohydrate antigen 19-9 (Ca 19-9) were all normal.

The patient was counseled about her pathology, the indications for surgical resection, and the risks and benefits of PD, a written consent form was signed and documented in the medical record. A preoperative computed tomography (CT) scan of the chest, abdomen and pelvis with CT angiogram and reconstruction of the visceral arterial anatomy was obtained (Fig. 2). The scan revealed that her common hepatic artery (CHA) arose directly from the celiac artery (CA) and continued to form the right hepatic artery (RHA), which travelled posterior to the portal vein and coursed superiorly to supply the right lobe of the liver. More importantly,

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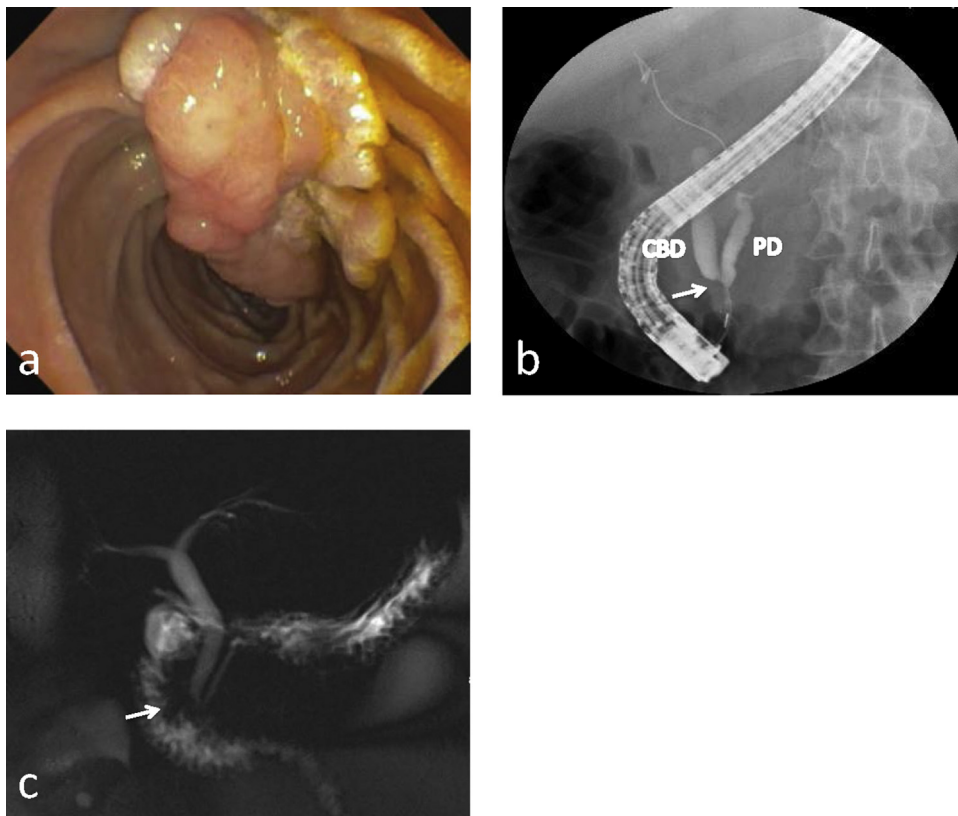


Fig. 1. (a) is an Esophagogastroduodenoscopy (EGD) image showing the major papilla with a bulky growth consistent with villous adenomatous changes. Endoscopic retrograde cholangiopancreatography (ERCP) in (b) illustrates partial narrowing of the CBD and PD (arrow). Magnetic resonance cholangiopancreatography (MRCP) in (c) suggests narrowing of the distal CBD by the ampullary mass (arrow points towards the mass).

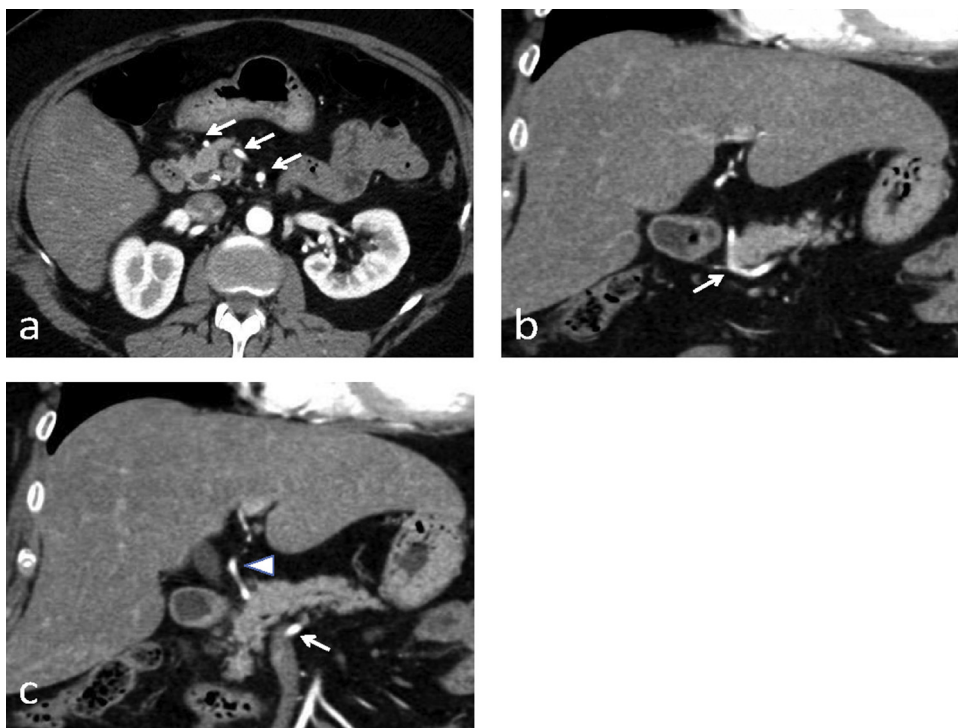


Fig. 2. Computed tomography axial images of the abdomen and pelvis showing the replaced gastroduodenal artery (GDA) arising from the superior mesenteric artery (SMA) in (a), then hugging the neck of the pancreas in (b) and continuing on to become the left hepatic artery (LHA) indicated by the arrowhead in (c).

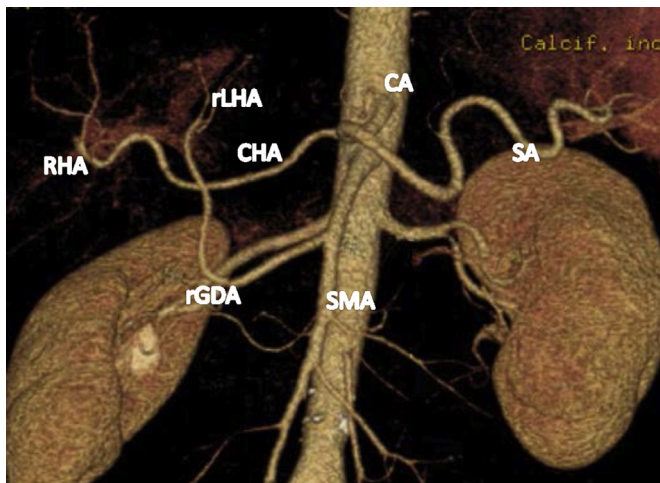


Fig. 3. CT angiogram reconstruction of the extrahepatic mesenteric arterial system showing the aberrant arterial anatomy. rGDA = replaced gastroduodenal artery, rLHA = replaced left hepatic artery, CHA = common hepatic artery, SMA = superior mesenteric artery, SA = splenic artery, RHA = right hepatic artery.

the GDA arose from the SMA and travelled from the inferior border of the pancreas over the anterior surface of the pancreatic neck before it terminated as the left hepatic artery (LHA) supplying the left lobe of the liver (Fig. 3).

The patient was taken to the operating room for PD with the intent of dissecting and preserving the GDA and its LHA tributary as it was the major arterial blood flow to the left lobe of the liver. The PD was initiated as we previously published, however, with a few exceptions required to preserve the GDA [3]. In brief, after having entered the lesser sac and identified the infrapancreatic superior mesenteric vein (SMV), a Kocher maneuver was completed. The portal dissection revealed the aberrant GDA on the anterior surface of the pancreatic neck. The supra-pancreatic portal vein (PV) was then identified. We then directed our attention to the SMA, performing an “artery first” approach [4]. Exposing the SMA on the medial side of the SMV allowed localization of the origin of the aberrant GDA. Proximal and distal control of this artery allowed safe ligation of multiple branches of the GDA going to the head of the pancreas. An SMA first approach also helped differentiate the aberrant GDA (which was to be preserved) from the nearby inferior pancreaticoduodenal arteries arising from the SMA and supplying the uncinate process of the pancreas. The bile duct and the stomach were divided in the usual fashion. Once the GDA branches to the pancreas were divided, the pancreas was transected at the neck directly overlying the PV-SMV-SV confluence (Fig. 4). Post-operatively, the patient recovered uneventfully and was discharged home on day seven. Final pathology revealed a duodenal adenoma. CARE guidelines were used in the preparation of this case report [5].

3. Discussion

Following introduction of the cholecystectomy procedure in the late nineteenth century, Western surgeons began to realize potential complications resulting from failure to recognize and understand complex biliary and vascular anatomy. Variations of the extra-hepatic arterial anatomy added complexity to what was considered to be a new and difficult procedure. The past two decades have witnessed significant changes and improvements in surgical technique, as well as regional and systemic therapies. Pancreatic and liver tumors previously considered unresectable due to vascular abutment or encasement are now being resected, once again bringing these anatomic anomalies to the forefront of attention

of surgeons, radiologists, and interventionalists conducting procedures on mid- and fore-gut organs [6]. Many attempts have been made to classify variations in extrahepatic arterial anatomy throughout the past century. Lipshutz in 1917, Adachi in 1928 and Morita in 1935 are a few such authors [7,8]. However, the most commonly used and internationally recognized classification remains that of Michels published in 1955. Michels found that standard extrahepatic arterial anatomy occurs in 55–60% of individuals based on results of 200 autopsies. Recent meta-analyses and large volume surgical, radiological, and post-mortem anatomical studies including up to 12,000 cases each, reported an extrahepatic arterial anatomic variation ranging from 10% to 42% [8–13].

Our patient had a CHA arising from the usual location in the CA. The proximal course of the CHA was suprapancreatic in location travelling posterior to the PV then emerging superiorly to enter the hilum of the liver. Therefore, the artery arising from the SMA and giving off multiple branches to the head of the pancreas could not be anything other than a replaced GDA. This artery looped around the anterior border of the pancreas, caudal to cephalad in a crescent-like course, supplying multiple pancreaticoduodenal arcade branches that needed to be ligated during our dissection of the head and neck of the pancreas. The replaced GDA continued superiorly and laterally terminating as a LHA before it entered the left side of the liver hilum. To our knowledge, this rare anatomic variation of the GDA and the LHA has not been previously described. A “replaced” artery is a totally replaced variant artery in the absence of the normal artery that has the same name. Thus, the GDA in this case can technically be called a replaced GDA and the overall description of the patient’s anatomical variant is a replaced LHA originating from a replaced GDA arising from the SMA.

To emphasize the rarity of this arterial anomaly, we reviewed multiple studies in the anatomic, radiologic, and transplant literature and could not find a description that matched these findings. Panagouli et al. published a meta-analysis of 36 studies including more than 12,000 cases talking about arterial variations [8,14]. Whereas a CHA arising from the SMA was found in 1.13% of cases, there was no mention of a GDA arising from the SMA in the presence of a standard CHA origin from the CA. Song et al. found a replaced CHA arising from the SMA in 3% of 5002 patients studied [13]. The GDA in the above series was a branch of the replaced CHA and thus could not be considered a replaced GDA. In addition, the replaced CHA, after giving off the GDA, bifurcated into a RHA and a LHA. None of these reports are similar to the description of our patient’s anatomical variant of the GDA. Similarly, Hiatt et al. reported 1000 patients who underwent hepatectomy prior to orthotopic liver transplantation [10]. Standard arterial anatomy was found in 55% of patients and a CHA arising from the SMA was found in 1.5%. However, once again, there was no mention of an arterial variation that matched our case.

From a technical perspective, we used an “artery first” approach in order to safely dissect the GDA off of the pancreatic head and neck region and ligate all of the pancreaticoduodenal branches [3,4,15]. After identifying the aberrant GDA coursing anterior to the neck of the pancreas, we began the dissection of the SMA margin along the medial aspect of the SMV cephalad to the first jejunal vein branch, which was travelling posterior to the SMA in its usual location. We identified the takeoff of the aberrant GDA on the lateral (patient left) aspect of the SMA caudal to the neck of the pancreas. That allowed total control of that vessel prior to identification and ligation of the pancreaticoduodenal branches. With the aberrant artery freed from surrounding tissues, we proceeded to our last step of the resection which was transection of the pancreas (Fig. 4). The reconstruction was then done as previously described [3].

Knowledge of both common and rare variations of the extra-hepatic arterial anatomy is a prerequisite for safe and successful clinical care in multiple domains. Hepatopancreatobiliary surgeons

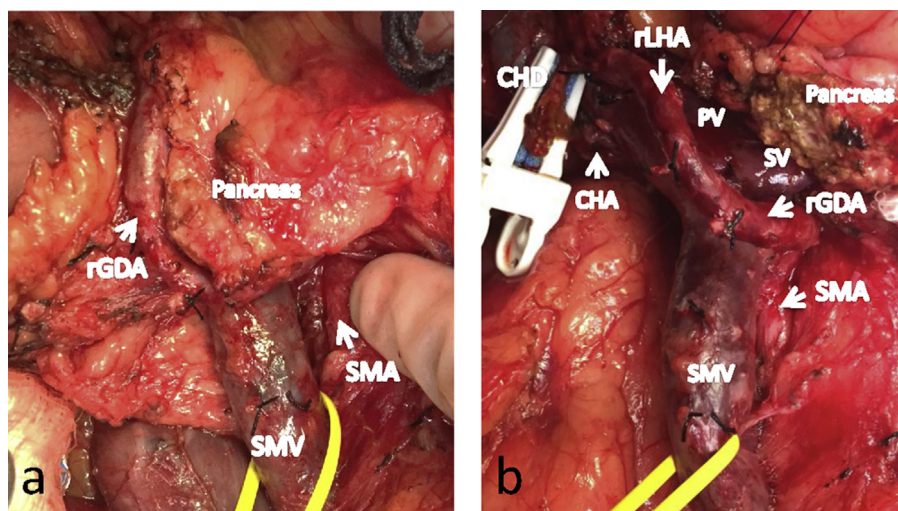


Fig. 4. Intraoperative photograph showing the replaced gastroduodenal artery (rGDA) and its relation to the pancreas and the end result after the specimen was removed. (a) shows the tumor attached to the lateral wall of the PV. (b) shows the final anatomy after removal of the tumor. rLHA = Replaced left hepatic artery, CHA = common hepatic artery, SMA = superior mesenteric artery, SMV = superior mesenteric vein, PV = portal vein, SV = splenic vein, CHD = common hepatic duct.

need to be aware of variant anatomy during hepatectomy and pancreatectomy, with the aim of preserving adequate blood supply to the liver and biliary tree to prevent acute and chronic sequelae of organ ischemia. Placement of arterial pumps for chemotherapy infusion should be carefully planned in cases of aberrant anatomy in order to prevent pump-related complications [16]. Involvement of aberrant arterial anatomy by tumors might preclude a curative resection in certain cases [6]. In organ transplantation, a high index of suspicion is needed during both procurement and transplantation, in order to identify and preserve adequate arterial anatomy to perfuse transplanted organs. In a study of 4200 transplant recipients, aberrant arterial anatomy requiring complex reconstruction was a significant risk factor for hepatic artery thrombosis and graft loss after orthotopic liver transplantation [17]. Interventional radiologists utilize multiphasic multidetector CT scans with high definition three-dimensional reconstruction for intravascular interventions during cases of gastrointestinal hemorrhage or transarterial chemo- or radio-therapy for liver tumors [18]. Emphasis is currently on standardized reporting of axial imaging studies, thus adapting standard terminology for aberrant arterial anatomy and raising awareness in an effort to prevent unnecessary complications in all of these domains [19].

4. Conclusion

We report a rare arterial anomaly documented by preoperative imaging that was managed by an “artery first” approach during PD. Arterial anomalies need to be identified and managed appropriately during surgical resection or interventional radiology procedures to prevent end organ ischemia. Standardized image acquisition, reporting, and preoperative/preinterventional “time outs” combined with physician/surgeon expertise are critical features of success.

Conflict of interest

None.

Funding

None.

Ethical approval

NA.

Consent

NA.

Author contribution

Writing the paper: George Younan, Munyaradzi Chimukangara, Susan Tsai, Douglas B. Evans, Kathleen K. Christians.
Study concept and design: George Younan, Kathleen Christians.

Guarantor

Kathleen K. Christians.

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