



Pancreaticoduodenectomy: how to handle a replaced right hepatic artery

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Hepatobiliary pancreatic surgeons sometimes encounter an aberrant (or replaced) right hepatic artery (a-RHA, Hiatt types III–VI) during pancreaticoduodenectomy (PD). Arterial flow cutoff to the a-RHA may be associated with a biliary leak or stenosis at the choledocho-jejunostomy and liver ischemia, resulting in ischemic cholangitis, liver abscess, and sepsis (1). Pyras and colleagues reported successful preservation of all 80 a-RHAs among 353 consecutive PDs during a 5-year period by paying particular attention to avoid damage to the a-RHA during dissection and division of the common bile duct (2). Critically, they did not focus on selected a-RHA cases but rather focused on a cohort of consecutive PDs during a long 5-year period. In that cohort, they demonstrated that a-RHA had no adverse effects on safety or oncologic radicality in PD cases, including those with various malignant (n=224, 63%) and benign (n=129, 37%) tumors located in the pancreatic head.

Exploration of the PubMed database revealed a debate regarding the handling of an a-RHA that until recently was overlooked for almost half a century after the first classic PD reported in 1945 (1,3). Since then, preservation of the a-RHA has been highlighted as one of the potential reasons for the further reduction in the total morbidity and mortality rates. In a recent article, the Japanese National Clinical Database Study reported Clavien-Dindo classification \geq grade III morbidity rate and a 30-day

mortality rate of PD of 24.2% and 1.0%, respectively, in 2019, by analysis of 11,813 cases, due to remarkable advances in surgical and perioperative management (4).

When a surgical team cuts open a patient's body to remove a tumor, careful individual anatomy-based surgical planning with various imaging modalities is crucial during the preoperative team meeting, similar to the planning required for a mountaineering expedition. Nowadays, the majority of hospitals can acquire multidetector-row computed tomography (CT) images as a "climbing map", which is also recommended in the National Comprehensive Cancer Network (NCCN) guideline for evaluating pancreatic ductal adenocarcinoma (PDAC) (5). Pyras and colleagues report that they were able to accurately diagnose a-RHA before surgery using multidetector-row CT as the current standard (2).

The a-RHA remains a surgical pitfall during PD. Asano and colleagues reported that 1 of 9 (11%) patients undergoing concomitant resection of an a-RHA was accidentally injured during PD. The a-RHA is not a rare anatomic variant; Hiatt types III–VI account for 12.9% (6), ranging from 12% to 22% according to various reports (6,7). Pyras and colleagues reported a 19.3% rate, which means that hepatobiliary pancreatic surgeons not uncommonly encounter an a-RHA. A rarer case, an a-RHA arising from the gastroduodenal artery (3.6%, 19/532) was

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reported in 2021 (7). Before performing a PD, the team of hepatobiliary pancreatic surgeons should share information regarding the specific hepatic arterial and gastroduodenal arterial anatomy observed on multidetector-row CT and other imaging modalities. As an additional safety measure, Yamaguchi and colleagues further suggest intraoperative liver Doppler ultrasonography examination to confirm bilateral intrahepatic artery flow in both the right and left hepatic arteries before cutting and clamping the gastroduodenal artery (7). The Japanese Society of Hepato-Biliary-Pancreatic Surgery recommends the hepatic artery flow confirmation to be a board-certified expert hepatobiliary-pancreatic surgeon (8).

The incidence of all types of pancreatic cancer ranges from 1 to 10 cases per 100,000, 85% with PDAC, PDAC is the eighth leading cause of death from cancer in men and the ninth leading cause of death from cancer in women throughout the world (9). Resectable or borderline-resectable PDAC is evaluated by detailed multidetector-row CT assessment with a multidisciplinary team (10). With regard to PDAC and a-RHA, safe surgical management has not yet been established because of the small number of reported cases. In the current NCCN, Version 2.2022, clinical practice guidelines in oncology define PDAC in contact with an a-RHA as a borderline-resectable tumor as it may affect surgical planning. Miura and colleagues, however, reported that upfront resection was safely performed with a 32.8% morbidity rate and an 89.7% R0 resection rate in tumors with a-RHA-contact patients (n=15) (11). The overall survival of patients with a-RHA-contact, however, was significantly worse than that of patients with borderline-resectable tumors (median survival time, 14.6 *vs.* 35.3 months, $P=0.048$). A tumor contacting the a-RHA should be regarded as technically resectable but oncologically borderline-resectable. Miura and colleagues concluded that upfront surgery may not be appropriate for patients with a-RHA contact (11).

When PDAC involves an a-RHA, detailed technical strategies are needed. Generally, combined arterial resection and reconstruction are necessary to maintain the blood supply to the right liver. In a recent report, when an a-RHA was resected without reconstruction, 3 of 9 (33%) patients had Clavien-Dindo classification \geq grade IIIa complications, including liver abscess during the postoperative course (12). Before PD, interventional radiology was attempted to make surgery easier for PDAC involving a-RHA. Marichez and colleagues reported that embolization was successful with

sufficient development of an intrahepatic arterial shunt, without complications (n=18) (13). In their report, serum aspartate and alanine transaminase levels on day 1 after the a-RHA embolization remained low compared with the baseline level (aspartate transaminase 55.5 ± 52.63 and alanine transaminase 69.75 ± 87.53 UI/L). The mean hospital stay duration for embolization was only 1 ± 0.5 days. The median waiting period between embolization and PD was 8 days. The overall morbidity, however, was 44%, including 1 patient (6%) that developed a hepatic abscess after hepatic ischemia with better patent intrahepatic arterial flow, resulting in mortality. Surprisingly, Takeuchi and colleagues reported a similar case series (14). They performed preoperative embolization of a-RHA before the scheduled PD for combined resection in 5 cases. Although a better-communicating arcade was observed from the left hepatic artery via the hilar plate in all cases, 1 patient (20%) had multiple liver infarctions during the postoperative course. According to these reports, preoperative embolization of the a-RHA could not completely prevent postoperative liver infarction or abscess. The reason for this is unknown, but hepatic hilum lymphadenectomy may diminish the communicating arcade from the left hepatic artery. Further studies are needed to evaluate preoperative embolization of the a-RHA before the scheduled PD.

The a-RHA also came into the limelight in minimally invasive PD following laparoscopic and robotic PD. Chierici and colleagues reported a systematic review on dealing with a-RHA in minimally invasive PD (15), which included 5 studies with 118 patients. The most commonly reported management of a-RHA was careful isolation without ligation and resection (96.9%, n=116); 2 patients undergoing a-RHA resection without reconstruction did not develop liver or biliary complications. No differences in the postoperative morbidity and long-term oncological-related overall survival were reported in all the included studies when comparing minimally invasive PD in patients with standard anatomy to those with a-RHA.

In summary, we agree that hepatobiliary pancreatic surgeons should have a particular surgical strategy for a-RHA in PD. First, the surgical team should perform a detailed evaluation using multidetector-row CT before PD to determine the presence of a-RHA and other hepatic artery variants, and tumors involving a-RHA. Second, when tumors do not involve the a-RHA, the a-RHA should be carefully preserved by gentle dissection, as recommended, and described by Pyras. To achieve R0 resection, however,

the following should be considered: when the tumor involves a-RHA, there are at least 2 other options: a-RHA reconstruction during PD or removal of the tumor involving a-RHA under careful management during the postoperative course. Although preoperative a-RHA embolization without reconstruction is another option, 6% to 20% of patients had hepatic ischemia despite better patent hepatic flow. Thus, the postoperative course of those patients should also be carefully monitored.

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