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ORIGINAL ARTICLE

# Robotic pancreaticoduodenectomy in the presence of aberrant or anomalous hepatic arterial anatomy: safety and oncologic outcomes

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## Abstract

**Background:** Hepatic arterial anomalies (HAAs) are not infrequently encountered during pancreatic resections. In view of the current emergence of the robotic platform as a safe alternative to open surgery in experienced centres, this study sought to determine the implications of HAAs on the safety and oncologic outcomes of robotic pancreaticoduodenectomy (RPD).

**Methods:** A prospectively maintained database of patients with HAAs who underwent RPD (RPD + HAA) at a single institution between 2008 and 2013 was retrospectively reviewed. Demographic information and perioperative outcomes of RPD were compared for patients with and without HAAs.

**Results:** A total of 142 patients underwent RPD; 112 (78.9%) did not have and 30 (21.1%) did have HAAs. The majority (90.0%) of RPDs in patients with HAAs were performed for malignant indications and all aberrant vessels were preserved without conversion to laparotomy. There were no statistically significant differences between RPD patients with and without HAAs with respect to preoperative demographics, tumour characteristics, operative metrics (operative time, estimated blood loss, conversion) and postoperative outcomes, including complications, length of stay and readmissions. Negative margin (R0) rates were similar in both groups.

**Conclusions:** Robot-assisted pancreaticoduodenectomy is safe and feasible in patients with HAAs and has outcomes similar to those in patients with normal arterial anatomy.

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## Introduction

Hepatic arterial anomalies (HAAs) are not unusual and are encountered in 20–45% of pancreaticoduodenectomies (PDs), adding to the difficulty of an already technically challenging operation.[1–7] The variations in hepatic arterial blood supply were classically delineated by Michels in 1966 and updated by Hiatt *et al.* in 1994 (Table 1).[3,5] The most common anomaly according to the Hiatt *et al.* system of classification is a type III variant: a replaced or accessory right hepatic artery (RHA) that arises from the superior mesenteric artery (SMA).[4] This variant is of great concern during PD because the anomalous vessel can course near or through the pancreatic head and posterior to the common bile duct.[6,8] Similarly, the less common type V variant, in which the common hepatic artery (CHA) arises from the SMA, can also impede dissection of the pancreatic head, common bile duct and gastroduodenal artery (GDA) during PD.[2] Injury to the hepatic arteries can lead to liver ischaemia and also affect bilioenteric anastomosis because the RHA provides the chief blood supply to the common bile duct.[1,9,10]

Several series from experienced centres have demonstrated that the emerging use of the robotic platform for PD can be a safe alternative to the open surgery approach.[11–14] The technical advantages of the robotic platform (three-dimensional visualization, magnification and dexterity) may be useful for

This paper is associated with a video titled 'Robotic Pancreaticoduodenectomy with Anomalous Hepatic Arterial Anatomy', presented at the Annual Meeting of the AHPBA, 20–24 February 2013, Miami, Florida.

 

**Table 1** Hepatic anatomy according to the classifications of Michels[5] and Hiatt *et al.*[3]

| Michels | Anatomy | Hiatt *et al.* |
|---|---|---|
| I | Normal (RHA and LHA arise from the proper hepatic artery) | I |
| II | Replaced LHA from the LGA | II |
| III | Replaced RHA from the SMA | III |
| IV | Replaced LHA from LGA and replaced RHA from SMA | IV (Combination of accessory and/or replaced LHA and RHA) |
| V | Accessory LHA from LGA | II |
| VI | Accessory RHA from the SMA | III |
| VII | Accessory LHA and accessory RHA | IV |
| VIII | Replaced RHA and accessory LHA or Replaced LHA and accessory RHA | IV |
| IX | Replaced CHA from SMA | V |
| X | Replaced CHA from the LGA | |
| | Replaced CHA from the aorta | VI |

LGA, left gastric artery; LHA, left hepatic artery; RHA, right hepatic artery; SMA, superior mesenteric artery.

the meticulous dissection required in PD in the presence of HAAs.[15–17] However, the method is disadvantaged by the lack of haptic feedback, which can potentially cause vascular injury and compromise margins.[15,18] Although several reports have established outcomes equivalent to those of open PDs in patients with normal versus aberrant hepatic arterial anatomy (particularly Hiatt *et al.* type III variants), the safety and outcomes of robotic PD (RPD) in the presence of anomalous hepatic arterial anatomy remain unknown.[8,19–21]

## Materials and methods

Following University of Pittsburgh Institutional Review Board approval, a retrospective review of a prospectively collected database of patients submitted to RPD between 2008 and 2013 was performed. Patients who underwent RPD with HAAs (RPD + HAA group) were identified based on operative reports and electronic medical records. Outcomes in this group were compared with those in RPD patients without HAAs (RPD − HAA group). All outcomes were followed to 90 days. Pancreatic fistulae were graded according to International Study Group of Pancreatic Fistula (ISGPF) criteria.[22] Postoperative complications were graded based on the Clavien–Dindo system of classification.[23] The pancreatic and bile duct margins were the only margins routinely assessed intraoperatively.

At the study institution, all RPD patients undergo a preoperative triphasic computed tomography (CT) scan. Hepatic arterial anomalies considered relevant to a PD were a replaced or accessory RHA or CHA, and arteries that arose in a classic (non-aberrant) fashion but had an anomalous course similar to that of a replaced RHA or CHA (Fig. 1).

Statistical analysis was performed using STATA Version 12.0 (StataCorp LP, College Station, TX, USA). The distribution of continuous variables was checked for normality. The two-tailed Student's *t*-test was used to compare normally distributed variables between the normal and anomalous arterial anatomy groups. The Wilcoxon rank-sum test was used for continuous variables that were not normally distributed. The two-tailed Fisher's exact test was used to compare categorical variables. Values are presented as the mean ± standard deviation (SD) or median with interquartile range (IQR) as appropriate. *P*-values of $<0.05$ were considered to indicate statistical significance.

## Results

### Prevalence of anomalous hepatic arterial anatomy

Robotic PD was performed in 142 patients, of whom 30 (21.1%) harboured HAAs (RPD + HAA group). The most common vascular anomaly encountered was a replaced RHA ($n = 15$, 50.0%) followed by a replaced CHA ($n = 9$, 30.0%) (Table 2). All of the replaced RHAs and CHAs arose from the SMA except in one case, in which the replaced CHA arose directly from the aorta. There was a single case of an accessory RHA coming off the GDA. Another patient had a GDA arising from an aberrant RHA deep in the neck of the gland. In both cases, the GDA was transected while the accessory and aberrant RHAs were preserved. Additionally, in four patients either the RHA ($n = 3$) or CHA ($n = 1$) took an anomalous path, coursing posterior and lateral to the portal vein.

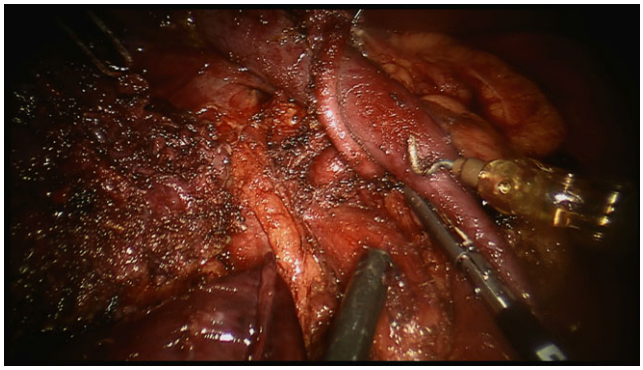

**Figure 1** Intraoperative view of a resection bed in a robotic pancreaticoduodenectomy in a 42-year-old patient with pancreatic head adenocarcinoma. Note the anomalous common hepatic artery arising from the coeliac trunk and coursing posterior to the portal vein. The tip of the suction lies on the superior mesenteric artery, which has been skeletonized in 180 ° fashion in order to maximize the R0 outcome. The resected specimen is shown on the far left aspect of the field.