Implications of the presence of an aberrant right hepatic artery in patients undergoing pancreatoduodenectomy

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Abstract

AIM: To analyze the differences in outcomes and the clinical impact following pancreatoduodenectomy (PD) in patients with and without aberrant right hepatic artery (aRHA).

METHODS: All patients undergoing PD between January 2008 and December 2012 were divided into two groups, one with aRHA and the other without. These groups were compared to identify differences in the intraoperative variables, the oncological clearance and the postoperative morbidity, mortality and hospital stay.

RESULTS: A total of 225 patients underwent PD, of which 43 (19.1%) patients were found to have either accessory or replaced right hepatic arteries (aRHA group). The aRHA was preserved in 79% of the patients. There was no significant difference in the intraoperative blood loss but operative time was prolonged, reflecting the complexity of the procedure [420 ± 44 (240-540) min vs 480 ± 45 (300-600) min, P < 0.05]. There were no differences in the incidence of postoperative complications (pancreatic leak, pancreatic fistula, delayed gastric emptying and mortality) and hospital stay. Oncological clearance in the form of positive resection margins [13 (7.1%) vs 3 (6.9%)] and lymph node yield were also similar in the two groups.

CONCLUSION: An aRHA is found in approximately one fifth of patients undergoing PD. Preservation is technically possible in most patients and can increase the operative complexity but does not negatively affect the safety or oncological outcomes of the procedure.

Key words: Pancreatodudodenectomy; Aberrant right hepatic artery; Arterial anomalies; Outcomes

Core tip: Appreciation and study of hepatic arterial anatomical variability is essential to the successful performance of complex pancreatobiliary procedures. An aberrant right hepatic artery (aRHA) represents the vascular anomaly encountered most frequently during pancreatoduodenectomy (PD) and, because of its course, is most susceptible to intraoperative damage and tumor involvement. When an aRHA is present, the challenge in peri-pancreatic malignant disease is to balance its preservation and the need to achieve oncological clearance. In this study, we analyzed the incidence of aRHA and its relationship with the operative complexity, occurrence of complications and oncological clearance in a large cohort of patients undergoing PD.
INTRODUCTION

Even although well described in the literature, the surgical anatomy of the hepatic arteries is notoriously variable. Appreciation and study of hepatic arterial anatomical variability is essential to the successful performance of complex pancreaticobiliary procedures, such as the pancreaticoduodenectomy (PD). Although anatomically interesting, the presence of aberrant hepatic arterial anatomy raises the surgical complexity and increases the potential risk of injury to the hepatic arterial supply during a PD\[4\]. The two most widely accepted classifications of hepatic arterial variations are those by Michels\[2\], based on 200 autopsies, and Hiatt, based on 1000 donor livers\[3\, 4\]. In both series, the most commonly reported vascular anomaly is an aberrant right hepatic artery (aRHA)\[2\, 3\].

An aRHA represents the vascular anomaly encountered most frequently during PD. It may have a suprapancreatic, intrapancreatic or rarely transpancreatic course, and, because of its course, it is most susceptible to intraoperative damage and tumor involvement\[2\, 3\]. The incidence of an aRHA identified in patients undergoing PD varies from 11%–26.5%\[1, 4\]. When an aRHA is present, the challenge in peripancreatic malignant disease is to balance between its preservation and the need to achieve oncological clearance, which represents the only chance for prolonged survival\[2, 3\]. The presence of an aRHA leads not only to an alteration in the surgical approach, but may also adversely affect the outcomes of the surgical procedure\[2\, 3\]. In this study, we analyzed the incidence of aRHA and its relationship with the operative complexity, occurrence of complications and oncological clearance in a large cohort of patients undergoing PD.

MATERIALS AND METHODS

The study was conducted over a five year period (2008-2012) which included all patients who underwent a PD by a single surgical team in a tertiary care center. Detailed information regarding their demography, characteristics, imaging, intraoperative findings and operative details were maintained on a prospective database. Demography and patient characteristics were carefully recorded. The details of the arterial anatomy, variations and the operative complexities, including duration of surgery and blood loss, were noted. In the specimen, the arterial margin was inked in addition to the resection margins. Postoperative course was recorded, with death during the same hospital stay or within 30 d of surgery being considered as operative mortality. Histopathology, along with resection margin status and lymph nodal yield, was also documented.

Definitions

Normal anatomy was defined as when the celiac axis trifurcated into the left gastric artery, the splenic artery and the common hepatic artery, with the common hepatic artery continuing as a hepatic artery proper after the branching off of the gastroduodenal artery, finally bifurcating into the right and left hepatic arteries. The term anomalous or aberrant encompassed both the “accessory” and the “replaced” vessels. An extra right hepatic artery that supplied the liver, which also received blood supply from a normally located right hepatic artery, was termed an accessory right hepatic artery. If the liver received its primary blood supply from the aberrant right hepatic artery, it was called a replaced hepatic artery.

Statistical analysis

Data are reported as frequencies or mean ± SD and ranges. SPSS version 20.0 (SPSS, Inc., Chicago, IL, United States) software was used for data analysis. The Student t test was used to test significance for continuous variables and the Fisher’s exact test was used for categorical variables. P values less than 0.05 were considered significant.

RESULTS

Between January 2008 and December 2012, two hundred and twenty-five consecutive patients who underwent PD were included in the study. No significant differences were noted in terms of age, gender, American Society of Anesthesiologists class and indication for pancreaticoduodenectomy (Tables 1 and 2). The most common indication for surgery was ampullary adenocarcinoma, followed by distal cholangiocarcinoma. There were 43 (19.1%) arterial anomalies detected during the procedure. The spectrum of arterial anomalies is shown in Table 3. Replaced RHA from superior mesenteric artery (SMA) was the most common anomaly noted. The artery could be preserved in 79% of the cases (Table 4). In eight patients (6%) with an aRHA, the aberrant vessel was sacrificed for oncological (n = 6) or technical (n = 2) reasons. While in 6, the aberrant artery was found to be accessory and was ligated. In two patients, there was an inadvertent
ligation which did not result in any ischemia of the liver; following an intraoperative Doppler confirmation, no re-
construction was undertaken. In one patient, the replaced right hepatic artery was resected for oncological reasons
and a primary Anastomosis was performed. Apart from
an increase in operating time by approximately an hour, there were no other significant differences in intraopera-
tive variables between the two groups (Table 5). There were also no differences in the overall rates of postpan-
createctomy hemorrhage, postpancreatectomy fistula, de-
layed gastric emptying, positive resection margin, length
of hospital stay and mortality between the two groups (Table 5). Seven point one percent of the patients un-
dergoing PD had positive resection margins, 10 of them
with their SMA margin positive for tumor. None of the
arterial margins were positive for tumor (Table 5).

**DISCUSSION**

The significance of the aberrant arterial anatomy is enor-
mous during surgery, especially PD. The artery could
necessitate altering the surgical approach by interfering
with the resection and/or lymphadenectomy. These anom-
alous vessels may interfere with reconstruction of the
pancreatic remnant, precluding safe pancreatic stump
drainage. Aberrant anatomy increases the risk of injury to
the hepatic arterial supply, leading to unexpected bleed-
ing (intra- or postoperative) and ischemia[4,15]. The extrahepatic biliary tree receives a substantial portion of
its blood supply from the RHA. Any ischemia secondary
to hepatic artery injury will lead to ischemia of the biliary
anastomosis, resulting in a biliary anastomotic leak. Isch-
emic liver dysfunction may also manifest in the form of
elevations in hepatic enzymes [3,5,7,9,10]. During dissection
of these arteries, excessive handling of the vessel should
be avoided as it may damage the vessel adventitia, thereby
increasing the chances of pseudoaneurysm. This can lead
to catastrophic complications in the event of pancreatic
anastomotic leak[4,15,16].

A precise knowledge of normal hepatic arterial
anatomy is necessary to appreciate abnormal anatomy.
Preoperative imaging can detect up to 60%-80% of all
arterial anomalies. If the anomaly is detected preopera-
tively, embolization of the vessel can be performed with
microcoils[12,14]. It also helps to forewarn the surgeon,
thereby preventing inadvertent injury to the RHA[1,7].
Multidetector row computed tomography (CT) (MDCT)
scan shows enhanced delineation of the pancreatic le-
sion and vascular structures along with the benefit of
CT angiography in preoperative delineation of the arterial
anatomy[4,10]. A visceral angiography is recommended only
when very rare or complex visceral arterial anomalies
are encountered on noninvasive imaging[15,16]. Although
advance planning is ideal, extemporaneous decisions may
be required intraoperatively[1,7,10]. In our series, imag-
ing picked up the anomalies preoperatively in 58% of
the cases. Interestingly, Perwaiz et al[11] have shown that
the duration of the surgery did not differ significantly
between those patients whose arterial anomalies were
detected preoperatively compared to those detected in-
traoperatively. A recent study from The Netherlands has
shown that preservation of an aRHA is technically pos-
sible in most patients and does not negatively impact on
outcomes in patients undergoing PD. Surgical morbid-
ity is also not higher in patients with an aRHA[8]. Another
study, a series from India, has shown that while oncolo-
gical outcomes and safety of the procedure are not com-
promised, there is an increased operative complexity[11].
This is in concurrence with our study results. A report by
Jah et al[17] showed a trend towards prolonged operative

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### Table 2 Underlying disease in patients with and without arterial anomaly n (%)

| Indication               | No arterial anomaly n = 182 | Arterial anomaly n = 43 | P value |
|--------------------------|-----------------------------|-------------------------|---------|
| Ampullary adenocarcinoma | 99 (54.4)                   | 23 (53.5)               | NS      |
| Distal cholangiocarcinoma| 43 (23.6)                   | 10 (23.2)               | NS      |
| Pancreatic adenocarcinoma| 25 (13.7)                   | 6 (13.9)                | NS      |
| Duodenal carcinoma       | 15 (8.2)                    | 3 (7.0)                 | NS      |
| GIST                     | 0                           | 1 (2.3)                 | -       |

GIST: Gastrointestinal stromal tumor.

### Table 3 Hepatic arterial variations observed during pancreaticoduodenectomy n (%)

| Arterial variations               | n = 43        |
|-----------------------------------|---------------|
| Replaced RHA from SMA             | 31 (72.1)     |
| Accessory RHA from SMA            | 10 (23.2)     |
| Replaced CHA from SMA             | 1 (2.3)       |
| Accessory RHA from GDA            | 1 (2.3)       |

RHA: Right hepatic artery; SMA: Superior mesenteric artery; GDA: Gateway design automation.

### Table 4 Intraoperative management of aberrant artery n (%)

| Management                      | n = 43 |
|---------------------------------|--------|
| Dissection and preservation     | 34 (79) |
| Ligation                       | 8 (18.6) |
| Dissection and primary anastomosis| 1 (2.3) |

### Table 5 Intraoperative and postoperative comparison in patients with or without arterial anomalies n (%)

| Variables                  | No arterial anomaly n = 182 | Arterial anomaly n = 43 | P value |
|----------------------------|-----------------------------|-------------------------|---------|
| Duration of surgery (min)  | 420 ± 44 (240-540)          | 480 ± 45 (300-600)      | <0.05   |
| Blood loss (mL)            | 360 ± 52 (200-630)          | 390 ± 45 (300-650)      | NS      |
| Postpancreatectomy         | 4 (2.1)                     | 1 (2.3)                 | NS      |
| Hemorrhage                 |                             |                         |         |
| Postpancreatectomy fistula | 9 (4.9)                     | 2 (4.65)                | NS      |
| Delayed gastric emptying   | 98 (53.8)                   | 23 (53.4)               | NS      |
| Length of hospital stay    | 13.6 ± 6.0                  | 13.1 ± 5.1              | NS      |
| Mortality                  | 3 (1.7)                     | 1 (2.3)                 | NS      |
| Positive margin            | 13 (7.1)                    | 3 (6.9)                 | NS      |
| Lymph node yield           | 12 ± 4                      | 12 ± 5                  | NS      |
times and blood loss but these did not reach statistical significance. This is mirrored in a study by Yang et al[7], whose incidence of postoperative complications, operating time and blood loss is similar to ours.

Prevention of the injury is the best policy. Hence, an early step in every PD should be a conscious attempt to define the vascular anatomy. After a complete Kocherisation and opening of the pars flaccida, the porta hepatitis should be palpated to determine the location of the arterial pulsation[1,5,7,10,11,19-24]. Any variation in the normal location of the proper hepatic artery pulsations should raise the suspicion of an aberrant artery. Performing intraoperative liver Doppler ultrasonography is recommended to ensure the results of the arterial sacrifice or reconstruction and to prevent postoperative complications[1,5,7,10,11,25,26]. Surgical expertise is a key factor in reducing morbidity so these patients should be managed in high volume centers where arterial reconstructions are routinely performed[19,27].

An all-important factor in the management of vascular anomalies is its recognition. There are multiple approaches to deal with an anomalous vessel interfering with the pancreatic resection. These include avoidance, ligation, dissection and traction away from the site of dissection, and division and anastomosis. Preservation is technically possible in most patients; this increases the operative complexity but does not negatively affect the safety or oncological outcomes of the procedure. A high index of suspicion in every patient along with an awareness of the normal and aberrant anatomy is a sine qua non to the performance of a safe pancreaticoduodenectomy.

**COMMENTS**

**Background**

An aberrant right hepatic artery (aRHA) is the most frequently encountered vascular anomaly during pancreaticoduodenectomy (PD) which necessitates control of various arcades of the upper gastrointestinal tract. When an aRHA is present, the challenge in peripancreatic malignant disease is to balance its preservation and the need to achieve oncological clearance which represents the only chance for prolonged survival. The presence of an aRHA leads not only to an alteration in the surgical approach, but may also adversely affect the outcomes of the surgical procedure. This study was performed to analyze the differences in outcomes and the clinical impact following PD in patients with and without aRHA.

**Research frontiers**

Although well described in the literature, the surgical anatomy of the hepatic arteries is notoriously variable. Appreciation and study of hepatic arterial anatomy and the whipple procedure: lessons learned. Am J Surg 2011; 11: 161-167 [PMID: 21309932 DOI: 10.1111/j.1477-2574.2010.00258.x]

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**Terminology**

The term anomalous or aberrant artery encompasses both the “accessory” and the “replaced” vessels. An extra right hepatic artery that supplies the liver, which also receives blood supply from a normally located right hepatic artery; is termed an accessory right hepatic artery. If the liver receives its primary blood supply from the aberrant right hepatic artery, it is called a replaced hepatic artery.

**Peer review**

This is a brief article that analyzed 225 patients who had a pancreaticoduodenectomy during the last 5 years. The content is interesting and it implies that aberrant right hepatic artery can be handled with no adverse consequences when treated in high volume centers.

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