Pancreatology 19 (2019) 781–785

Contents lists available at ScienceDirect

Pancreatology

journal homepage: www.elsevier.com/locate/pan

Arterial blood supply to the pancreas from accessary middle colic artery

Kyoji Ito, Nobuyuki Takemura, Fuyuki Inagaki, Fuminori Mihara, Toshiaki Kurokawa, Norihiro Kokudo*

Hepato-Biliary-Pancreatic Surgery Division, Department of Surgery, National Center for Global Health and Medicine, 1-21-1 Toyama, Shinjuku-ku, Tokyo, 162-8655, Japan

ARTICLE INFO

Article history:
Received 28 March 2019
Accepted 17 May 2019
Available online 18 May 2019

Keywords:
Accessary middle colic artery
Dorsal pancreatic artery
Inferior pancreaticoduodenal artery

ABSTRACT

Background: An accessory middle colic artery (AMCA) is an aberrant artery feeding the splenic flexure of the colon. Little is known about the branching pattern of an AMCA. We aimed to evaluate the branching pattern of the AMCA from the superior mesenteric artery (SMA) with special reference to the pancreatic artery using multidetector-row computed tomography (MDCT) before surgery.
Methods: We investigated 112 patients who underwent contrast-enhancement MDCT before surgical resection of the pancreas between January 2015 and July 2018. The pancreatic branch from the AMCA was divided into the dorsal pancreatic artery (DPA) and the inferior pancreaticoduodenal artery (IPDA). The branching level and angle of the AMCA from the SMA were also evaluated.
Results: The AMCA was present in 27.7% of patients (n = 31/112). The AMCA branching pattern was classified into four types: type A, no branch from the AMCA (n = 20); type B, a common trunk with the DPA (n = 6); type C, a common trunk with the IPDA (n = 3); and type D, a common trunk with the DPA and IPDA (n = 2). The AMCA with the IPDA (types C and D) branched more proximally compared to the AMCA without the IPDA (P = 0.04). The AMCA branched vertically from the SMA in most cases (n = 24/31, 77.4%).
Conclusions: The AMCA had a pancreatic branch in 8.9% (10/112) of cases. Special attention should be paid to its branching pattern in pancreatic and colon surgery.

Introduction

Accurate identification of the vascular anatomy before surgery is crucial for a safe and curative procedure. Identification of the branching pattern of arteries associated with target organs in surgery is especially important to decide the extent of lymph node dissection and to preserve the arterial supply to residual organs. Recent advances in multidetector-row computed tomography (MDCT) has enabled precise preoperative assessment of the arterial anatomy related to a surgical resection [1,2].

An accessory middle colic artery (AMCA) has recently been identified preoperatively because of recent advances in imaging modalities [3–6]. An AMCA usually originates from the superior mesenteric artery (SMA), more proximally than the middle colic artery, running along the inferior border of the pancreas and supplying the colon around the splenic flexure [5]. Although an AMCA has no branch in the majority of cases, it occasionally has a common trunk with the pancreatic artery [3], which indicates the importance of an AMCA in pancreatic and colon surgery. In this context, the branching artery from an AMCA should be identified before pancreatic surgery for complete lymph node dissection and preservation of arterial flow to the residual pancreas and colon. However, little is known about the branching pattern of an AMCA, especially around its root, with regards to its common trunk with the pancreatic artery.

The purpose of the present retrospective study was to evaluate the branching pattern of an AMCA from the SMA using MDCT, with special reference to the pancreatic artery.

Materials and Methods

Patients

Consecutive 113 patients, who underwent pancreatic resection

* Corresponding author. Department of Surgery, National Centre for Global Health and Medicine, 1-21-1 Toyama, Shinjuku-ku, Tokyo, 162-8655, Japan.
E-mail address: nkokudo@hosp.ncgm.go.jp (N. Kokudo).

https://doi.org/10.1016/j.pan.2019.05.458
1424-3903/

at the National Center for Global Health and Medicine between January 2015 and July 2018, were retrospectively investigated. All patients had been preoperatively evaluated using MDCT. Of these, one patient who underwent CT without contrast enhancement because of poor renal function was excluded. The remaining 112 patients were included in the analysis.

The hospital medical records of these patients were retrieved. Patient characteristics and radiologic data were collected, entered into a database, and retrospectively reviewed. The National Center for Global Health and Medicine Research Ethics Committee/Institutional Review Board approved this study (approval number: 3125). The study was conducted in accordance with the Declaration of Helsinki 1975, as revised in 1983.

Definition of the artery

An AMCA was defined as a branch of the SMA towards the left side, which originates more proximal to MCA, running along the inferior border of the pancreatic body and supplying the splenic flexure of the colon [3]. The AMCA was distinguished from the left branch of the MCA, which branches independently from the SMA and supplies the left side of the transverse colon. The pancreatic branch of the AMCA was also investigated. A branch from the AMCA, which courses upwards to the posterior aspect of the pancreatic body was defined as the dorsal pancreatic artery (DPA) [7], and another branch, which supplies the uncinate process of the pancreas was defined as the inferior pancreaticoduodenal artery (IPDA) [8]. The representative branching 3D CT (Synapse Vincent; Fujifilm Corporation, Tokyo, Japan) image of the AMCA, including its common trunk with the DPA and IPDA, is shown in Fig. 1.

MDCT protocol and the assessment of the artery

Phase contrast-enhanced dynamic CT scans of the arterial and portal phases of the AMCA were performed using a 64-detector row scanner with a section thickness of 1–1.5 mm. The branching level of the AMCA was assessed by measuring the distance between the root of the AMCA and the inferior border of the pancreas on the coronal section of the MDCT. The branching angle of the AMCA from the SMA was evaluated on the transverse section of the MDCT. The branching pattern of the AMCA was evaluated on the transverse and coronal images. Two surgeons (KI and NT) retrospectively interpreted the MDCT images.

Statistical analysis

Continuous variables are expressed as means ± standard deviation. The statistical significance of the association of the distance of the AMCA from the inferior pancreatic border with the branching pattern was determined using Mann-Whitney U-tests.

Statistical analyses were performed using JMP® version 10 (SAS Institute, Cary, NC, USA). P-values were derived from two-tailed tests. A P-value of <0.05 was considered statistically significant.

Results

Patient characteristics

The patients were 62 men and 50 women. Their mean age was 68.2 ± 13.5 years and their mean BMI was 21.6 ± 3.3 kg/m^2. Indications for pancreatic resection included pancreatic cancer (n = 44), intraductal papillary mucinous neoplasms (n = 16), bile duct cancer (n = 14), duodenal cancer (n = 13), benign tumor (n = 13), neuroendocrine tumor (n = 9), and others (n = 3). The surgical procedures included pancreaticoduodenectomy (n = 81), distal pancreatectomy (n = 27), and total pancreatectomy (n = 4).

Frequency of the AMCA and branching patterns

An AMCA was present in 27.7% of patients (n = 31/112). We classified the branching pattern of the AMCA into four types (Fig. 2): type A, AMCA without a pancreatic branch (n = 20); type B, AMCA with the DPA (n = 6); type C, AMCA with the IPDA (n = 3); and type D, AMCA with both the DPA and IPDA (n = 2) (Table 1). Pancreatic AMCA branches were found in 11 of 31 AMCAs (35.6%).

The branching level and angle of the AMCA from the SMA

The branching level of the AMCA from the SMA is shown in Fig. 3. The distance between the root of the AMCA and the inferior border of the pancreas ranged from 16 mm proximally to 40 mm distally, and 10/31 AMCAs branched from the level proximal to the inferior border of the pancreas. The AMCA with the IPDA (types C and D) branched more proximally from the SMA compared to the

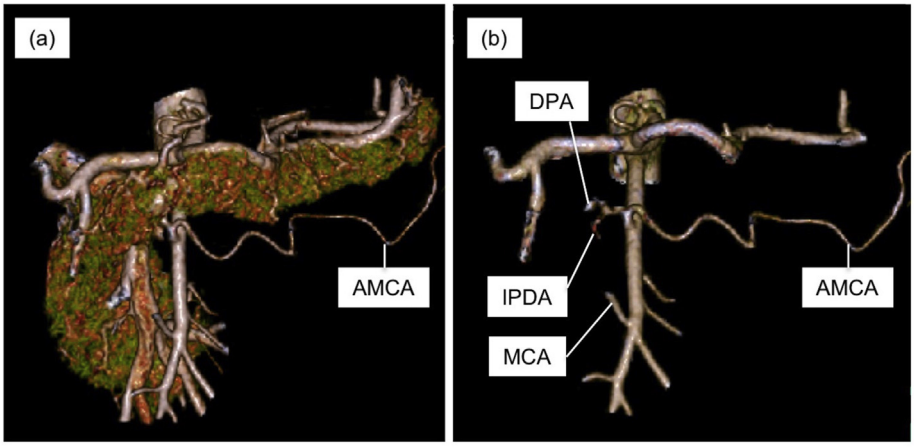

Fig. 1. Representative branching pattern of the AMCA, DPA, and IPDA using 3D computed tomography imaging (a) 3D image of the pancreas, portal system, and arterial system. The AMCA originated from the SMA, running along the inferior border of the pancreatic body to the splenic flexure of the colon. (b) 3D image of the arterial system. The DPA branched from the AMCA, and the IPDA branched from the DPA.
AMCA, accessory middle colic artery; DPA, dorsal pancreatic artery; IPDA, inferior pancreaticoduodenal artery; SMA, superior mesenteric artery.

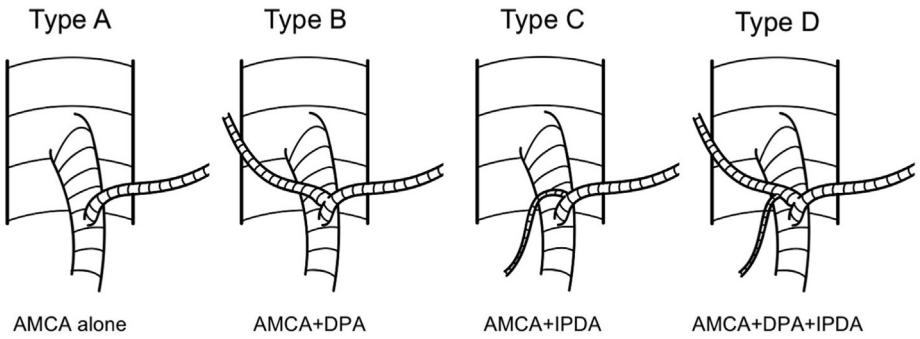

Fig. 2. Branching pattern of the AMCA
The branching pattern of the AMCA was classified into four types. Type A, no branch from AMCA; type B, common trunk with DPA; type C, common trunk with IPDA; type D, common trunk with DPA and IPDA.
AMCA, accessory middle colic artery; DPA, dorsal pancreatic artery; IPDA, inferior pancreaticoduodenal artery.

Table 1
Clinicopathological factors in 32 patients evaluated by MDCT performed before biliary drainage and mapping biopsy.

Variables	Value
Presence of AMCA	31/112 (27.7)
Branching pattern of AMCA	
Type A	20/31 (64.5)
Type B	6/31 (19.4)
Type C	3/31 (9.7)
Type D	2/31 (6.5)

Abbreviations: AMCA, accessary middle colic vein.

AMCA without the IPDA (P = 0.04). The branching angle of the AMCA from the SMA is summarized in Fig. 4. The majority of AMCAs (n = 24/31, 77.4%) branched vertically from the SMA. The AMCA branches from the right and left sides of the SMA were three and four branches, respectively. No significant difference was noted between the branching angle of the AMCA and the branching pattern.

Discussion

The present study revealed the branching pattern of an AMCA focusing on its common trunk with the pancreatic arteries.

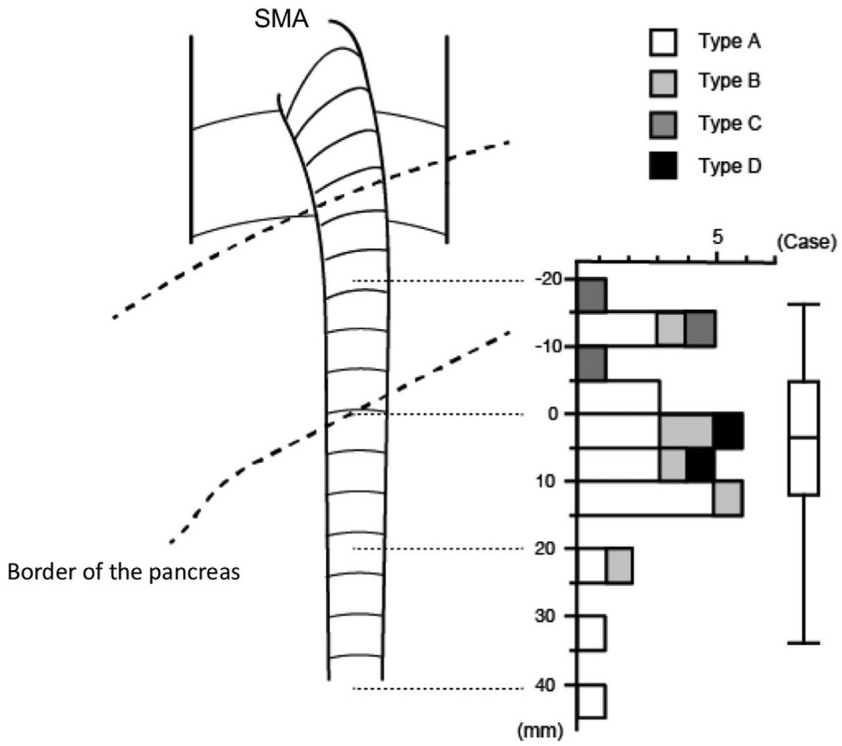

Fig. 3. Branching level of the AMCA from the SMA
The distance between the root of the AMCA and the inferior border of the pancreas ranged from −16 to 40 mm. The AMCA with the IPDA (types C and D) branched more proximally compared to the AMCA without the IPDA (P = 0.04).
AMCA, accessory middle colic artery; DPA dorsal pancreatic artery; IPDA, inferior pancreaticoduodenal artery; SMA, superior mesenteric artery.

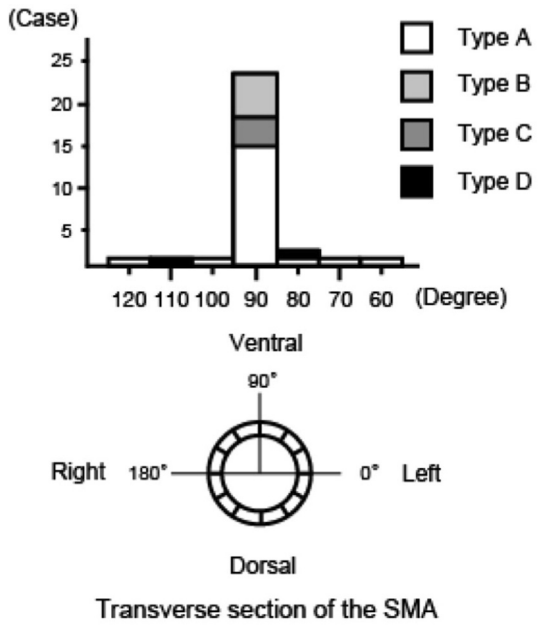

Fig. 4. Branching angle of the AMCA from the SMA.
The majority of AMCAs branched vertically from the SMA without a significant difference between the branching angle of the AMCA and the branching pattern.
AMCA, accessory middle colic artery; SMA, superior mesenteric artery.

Pancreatic branches of the AMCA were found in 11 of 31 AMCAs, and we classified the branching pattern into four types. We also demonstrated the branching level and angle of the AMCA from the SMA. The majority of AMCAs branched vertically from the SMA, and 10/31 of AMCAs branched from a level proximal to the inferior border of the pancreas. In addition, the AMCA with its common trunk with the IPDA branched more proximally compared to the AMCA without the IPDA. To the best of our knowledge, this is the first report to investigate an AMCA in patients who underwent pancreatic surgery and to assess the pancreatic artery that branched from the AMCA.

An AMCA [3] has also been called the accessory left colic artery [9], left accessory aberrant colic artery [5,10,11], and superior left colic artery [6]. AMCAs were evaluated mainly by dissecting cadavers [6,9–11]. However, recent advances in MDCT [3] and intraoperative fluorescence imaging using indocyanine green [5] have enabled the detection of AMCAs before and during surgery. The detection rate of an AMCA was 7.4–49.2% via cadaveric evaluation [6,9], while MDCT [3] and intraoperative fluorescence imaging [5] detected an AMCA in 36.4% and 38.7% of cases, respectively. In the present study, an AMCA was observed in 27.7% ($n = 31/112$) of cases, which is consistent with previous reports.

Miyake et al. [3] revealed that the AMCA had a common trunk with the transverse pancreatic artery in 20.2% of cases. However, the transverse pancreatic artery may be considered a secondary branch rather than a major artery of the pancreas [12]. Therefore, we classified the pancreatic branch from the AMCA using the primary branch of the pancreas, including the DPA and IPDA, and demonstrated the branching pattern of the AMCA. In the present study, pancreatic branches were found in 35.6% of AMCAs, including the common trunk with the DPA, the common trunk with IPDA, and the common trunk with DPA and IPDA. Both DPA and IPDA were involved in pancreatic resection procedures, including pancreaticoduodenectomy, distal pancreatectomy, and total pancreatectomy; therefore, special attention should be paid to the AMCA with pancreatic branches in pancreatic surgeries.

One of the surgical relevance of the AMCA with pancreatic branches is SMA nerve plexus dissection in pancreatic resection. During surgery for a pancreatic tumor, which is located close to the SMA, half of the SMA nerve plexus should be dissected to secure the surgical margin from the tumor both in pancreaticoduodenectomy and distal pancreatectomy [13,14]. Therefore, accurate preoperative evaluation of the branch from the SMA is crucial to achieve a safe and curative hemicircumferential resection of the SMA nerve plexus. In addition, pancreatic arterial branches, including the DPA and IPDA, should be divided in the course of SMA nerve plexus dissection when the resecting side of the pancreas is supplied by the arteries. The AMCA is one of the branches from the SMA and we showed that it could have pancreatic branches, including the DPA and IPDA. The AMCA should be identified and preserved during SMA nerve plexus dissection to secure colonic blood supply although the pancreatic branch from the AMCA to the resecting side of the pancreas should be divided. Therefore, the presence of an AMCA and the branching pattern of the AMCA should be assessed preoperatively in pancreatic surgeries to avoid unexpected bleeding during SMA nerve plexus dissection and to preserve the blood supply to the residual organ.

The branching level and angle of the AMCA from the SMA could be another concern for safe SMA nerve plexus dissection. The AMCA was reported to have branched at the level of the inferior border of the pancreas [3]. However, the present study showed that the distance between the root of the AMCA and the inferior border of the pancreas ranged widely from −16 to 40 mm, and that 10/31 of all AMCAs branched from the level proximal to the inferior border of the pancreas. The identification of pancreatic arteries, which branch from the proximal SMA during SMA nerve plexus dissection could be technically demanding because the surgical field might be deeper and more confined, indicating that preoperative assessment of the branching level of the AMCA was required for safe dissection of the SMA nerve plexus. In addition, the branching angle of the AMCA from the SMA has hardly ever been reported. We showed that the AMCA majorly branched vertically from the SMA, indicating that the AMCA might be useful as a landmark of the ventral dissection border of the SMA nerve plexus to avoid excess SMA nerve plexus resection leading to refractory diarrhea [13].

Another surgical importance of the AMCA is related to the resection of colon cancer located in the transverse or descending colon. Surgical treatment for colon cancer should include resection of the affected segment of the bowel and en bloc resection of the associated draining lymph nodes to the level of the origin of the primary blood supply to that segment of the bowel [15]. Watanabe et al. revealed that lymph flow from the tumor located at the splenic flexure was detected in the lymph node along the AMCA using indocyanine green fluorescence [5]. In this context, the AMCA, which predominantly feeds the tumor, should be resected at its root for lymph node dissection, although the preservation of its pancreatic branches should be considered in colon surgeries to maintain arterial supply to the pancreas. Contrarily, if the AMCA is not the main feeding artery to the tumor, it should be preserved because securing the arterial flow to the residual colon is crucial to prevent anastomotic leakage [16].

This study has some limitations. First, we did not investigate the branching pattern of the left colic artery, which is reported to be associated with the presence of the AMCA, because the arterial phase of MDCT in the lower abdomen was not performed in patients who underwent pancreatic resection. Second, although we focused on the AMCA from the SMA, AMCAs could branch from other arteries, including the hepatic artery and the first jejunal artery [3]. These types of AMCAs could have a pancreatic branch, and further study is required to evaluate the branching pattern of

these types of AMCAs. Finally, the relatively small number of patients may have weakened the analyses.

In conclusion, an AMCA occasionally has a pancreatic branch, and special attention should be paid to the branching pattern of the AMCA in colon and pancreatic surgery to perform curative dissection of the lymph nodes and to preserve the blood supply to residual organs.

Financial support

None.

Conflicts of interest

The authors disclose no conflicts.

Statement of informed consent

Informed consent was obtained in the form of opt-out on the hospital web-site.

Statement of human and animal rights

The National Center for Global Health and Medicine Research Ethics Committee/Institutional Review Board approved this study (approval number: 3125).

Acknowledgments

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pan.2019.05.458.

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