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Angioarchitecture of the major duodenal papilla and its relevance for endoscopic sphincterotomy

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Abstract

Background: The advantages of endoscopic retrograde cholangiopancreatography (ERCP) over traditional surgery for correction of various biliary and pancreatic pathologies became apparent immediately after its introduction into large clinical practice and today are also not in doubt. ERCP and endoscopic sphincterotomy (EST) are characterized by efficacy similar to open surgery, but significantly less traumatic, relatively easy, a decrease in the degree of perioperative surgical and anesthetic risk, and a reduction in the time of in-hospital treatment and postoperative recovery. However, therapeutic ERCP with EST can be complicated by gastrointestinal bleeding, the degree of which can range from mild to very severe and even life-threatening. Although the greatest risk for the development of bleeding after EST is caused by preexisting coagulopathy, the anatomical features of the arterial blood supply to the pancreaticoduodenal region and major duodenal papilla should also be taken into account during the endoscopic procedure.
Conclusions: The communicating artery, directly vascularizing the area of the major duodenal papilla, usually originates from the posterior superior pancreaticoduodenal artery, and entering in the anterior pancreaticoduodenal arcade. The smallest number of papillary arteries, distributed in potential accessibility to the sphincterotomy incision, are located in the zone between 10 and 11 o'clock of the papilla Vater circumference. Hence, the preferred performance of EST in this area can be accompanied by a significant reduction in the risk of arterial bleeding after ERCP.
Key words: major duodenal papilla, bleeding, arterial supply, endoscopic retrograde cholangiopancreatography, endoscopic sphincterotomy.

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Introduction

The advantages of endoscopic retrograde cholangiopancreatography (ERCP) over traditional surgery for correction of various biliary and pancreatic pathologies became apparent immediately after its introduction into large clinical practice and today are also not in doubt. ERCP and endoscopic sphincterotomy (EST) are characterized by efficacy similar to open surgery, but significantly less traumatic, relatively easy, a decrease in the degree of perioperative surgical and anesthetic risk, and a reduction in the time of in-hospital treatment and postoperative recovery. Unfortunately, both therapeutic and diagnostic ERCP can be accompanied by various and sometimes very serious complications, such as acute pancreatitis, bleeding, duodenal perforation, cholangitis, cholecystitis, and sepsis. However, the majority of gastrointestinal intraluminal hemorrhages are associated primarily with the performance of EST, and not diagnostic ERCP [1].

There are several classifications of bleeding after ERCP / EST based on time of the onset (immediate or delayed), endoscopic and clinical significance, and severity [2]. Immediate or intraprocedural bleeding is defined by most authors as an episode of hemorrhage that occurs at the time of EST, i.e. during or just after the electrosurgical tissue incision is performed [2, 3, 4]. Delayed bleeding after EST is considered any bleeding that occurs after completion of ERCP, manifested as melena, hematemesis or hematochezia, with a decrease in hemoglobin level from the baseline [2]. Delayed bleeding can become evident from few hours to several days [1, 2, 4] and even 2-3 weeks [3, 5] after the initial EST.

The incidence of EST-related bleeding ranges from 2% to 3% [5], but in some studies it reaches up to 48% [4]. A certain degree of immediate active bleeding (from oozing to pulsating) is observed during EST in 10-30% of cases [3, 4]. The overall prevalence of delayed bleeding after EST is between 4% and 10% [4].

Risk factors for the post-EST bleeding have been divided traditionally into patient-related, anatomy-related, and technical-related to endoscopic therapeutic procedure [5]. Although the greatest danger for the development of bleed-

ing after EST are factors associated with the patient's comorbidities, primarily coagulopathy (liver cirrhosis, thrombocytopenia, and the use of anticoagulants), anatomical factors also play a significant role.

In case of the correctly positioned duodenoscope in the second part of the duodenum and just below the papilla, biliary EST is performed by stepwise incisions oriented between 11 and 1 o'clock [6, 7]. The length of the sphincterotomy is variable, but usually between 1 and 1.5 cm and not extending beyond the intramural segment of the bile duct. This direction and length of incision correspond to the anatomical location of biliary sphincter and the lumen of overlying common bile duct. The segment of the papilla circumference between 11 and 1 o'clock has even been designated by some authors as a "safety zone" referring to duodenal perforation [8]. However, patients with anatomical variants of the papillary vessels may be at increased risk of post-EST bleeding [9].

Arterial blood supply to the pancreaticoduodenal zone

It is well known that the main blood supply to the pancreaticoduodenal region is provided by anterior and posterior arterial pancreaticoduodenal arcades. Further vascular configuration of the pancreaticoduodenal region is comprised of a series of the marginal vessels, and their *vasa recta* [10]. In an anatomical study, W. Kimura found that the artery in the direction of the papilla Vater branches from the posterior superior pancreaticoduodenal artery and then passes along the right side of the common bile duct [11]. He did not find any other such large artery going in the direction of the major duodenal papilla. Therefore, the author considered this artery to be the main and extremely important for the blood supply to the papilla Vater and the distal part of the common bile duct (fig. 1).

Later, the communicating arteries that directly vascularize the region of major duodenal papilla were thoroughly studied and classified by H. Yamaguchi into two types [12]. The first type, or "typical" communicating artery usually originates from the posterior superior pancreaticoduodenal artery, runs posterior to the common bile duct, then passes anteriorly between the main and accessory pancreatic ducts before terminating in the anterior pancreaticoduodenal arcade. The communicant artery of the second type runs in a similar postero-anterior direction, but inferior to the main pancreatic duct.

A total of 70 of the nearly 100 papillary arteries studied by the author arose directly or indirectly from communicating arteries, with 50 directly from a "typical" artery. The posterior pancreaticoduodenal arcade was the source of 26 papillary arteries, and the anterior pancreaticoduodenal arcade – of only two. The average external diameter of the papillary arteries ranged from 0.75 mm to 0.6 mm [12]. Thus, dorsal-ventral blood flow along the communicating arteries is dominant. In other words, the major duodenal papilla is located on the "dorsal vascular territory" of the pancreatic head [12].

The assumption about predominantly "posterior" direction of blood supply to the papilla region was confirmed in the studies of W. Kimura [11] and H. Furukawa [13]. The latter established an angiographic border in the pancreatic head between the arterial areas of the celiac trunk and the superior mesenteric artery. As expected, the border between two sources of arterial blood supply, on the whole, corresponded to the embryonic line of junction of the ventral and dorsal pancreas buds. The main pancreatic duct runs along the border of two vascular areas, while the common bile duct with a major duodenal papilla belonged to the celiac arterial territory [13].

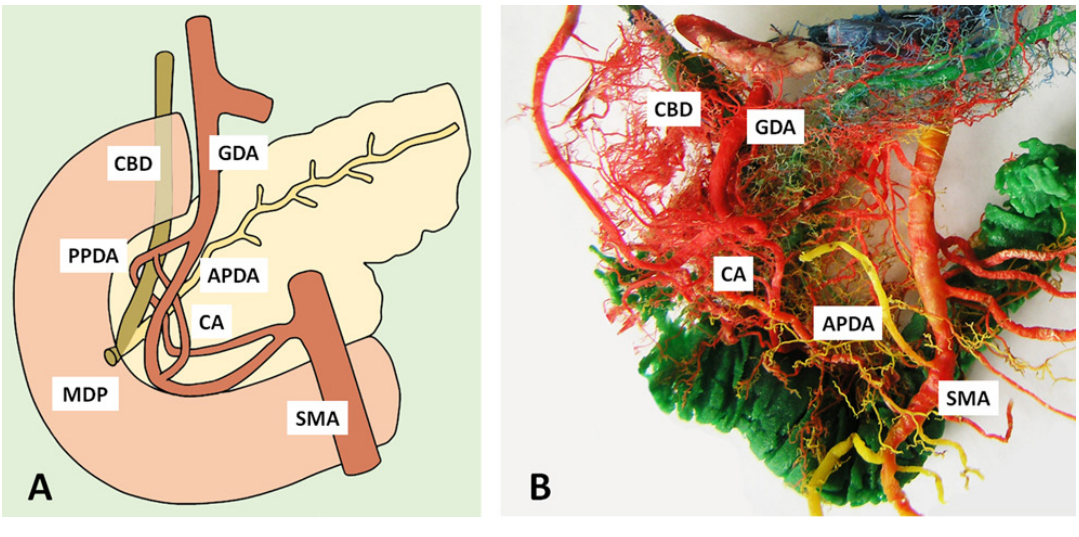

Fig. 1. Arterial supply of the pancreaticoduodenal region and the zone of the major duodenal papilla

(A) The communicating artery, which directly supplies with blood the major duodenal papilla, as well as other main arteries of the pancreaticoduodenal zone (GDA – gastroduodenal artery, SMA – superior mesenteric artery, APDA – anterior pancreaticoduodenal arcade, PPDA – posterior pancreaticoduodenal arcade, CA – communicating artery, CBD – common bile duct, MDP – major duodenal papilla).

(B) Polychromatic vascular corrosion cast of a fresh cadaver pancreaticoduodenal specimen demonstrating the pancreaticoduodenal arterial arcades and a typical communicating artery from which papillary arteries originate.

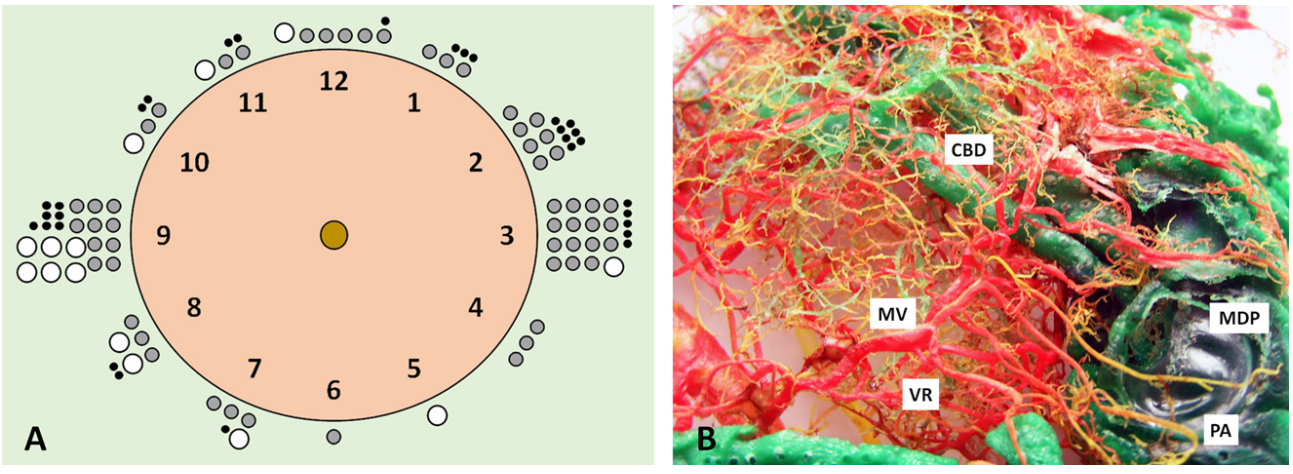

Fig. 2. Distribution of the papillary arteries

(A) Distribution of papillary arteries entering within 5 mm of the major duodenal papilla in typical endoscopic orientation, seen from the duodenal lumen during ERCP. Arterial diameters: <0.50 mm (small black dots); 0.51-0.75mm (medium gray dots); and 0.76-1.0 mm (large white dots) (Adapted with permission from Mirjalili SA, Stringer MD. The arterial supply of the major duodenal papilla and its relevance to endoscopic sphincterotomy. Endoscopy. 2011 Apr;43(4):307-311 [16]).

(B) Polychromatic vascular corrosion cast of the peripapillary zone including the terminal portion of common bile duct (CBD) and major duodenal papilla (MDP), showing the marginal vessels (MV), their *vasa recta* (VR), and a number of papillary arteries (PA).

The origin of arterial branches supplying the papilla Vater zone, mainly from the posterior pancreaticoduodenal artery, was also noted in clinical studies described selective endovascular embolization to arrest gastroduodenal bleeding [14, 15].

Papillary arteries

A noteworthy original study by S. A. Mirjalili and M. D. Stringer was addressed to arterial blood supply directly to the major duodenal papilla [16]. It should be noted right away that the study has two limitations. First, received by the authors findings are related only to arterial bleeding after EST. Although arterial bleeding is potentially more serious, damage to the veins surrounding papilla during intervention with the further venous bleeding is also possible. Second, specimens of the pancreaticoduodenal complex were harvested *en bloc* from 26 cadavers, none of which had known pancreaticobiliary or duodenal diseases. At the same time, inflammatory or neoplastic pathological conditions can change the normal anatomical relationships, including the topography of arteries in the papilla Vater region.

The study of S. A. Mirjalili and M. D. Stringer documents for the first time the distribution of papillary arteries around the circumference of the major duodenal papilla. Generally, there is no such anatomical definition as a "papillary artery". However, this study meant papillary arteries that could be damaged during therapeutic ERCP. They included two options: (1) An artery that penetrates the duodenal wall within 5 mm from the circumference of the entrance of the common bile duct and main pancreatic duct; or (2) an artery that penetrates the wall of the common bile duct or main pancreatic duct within 5 mm of their insertion into the duodenal wall [16].

The results of the study suggest that most of the papillary arteries are located in the region at 3 and 9 o'clock (fig. 2). The data that the area between 10 to 12 o'clock contained only about 15% of the arteries are of the greatest theoretical and practical importance, and if the segments of 10 and 11 o'clock are considered together, then only 10% of the papillary arteries were located here. Moreover, in almost half of observations, there were no arteries in this area at all [16].

Thus, a decreasing risk of arterial bleeding after ERCP can be achieved by performing EST preferentially in the area corresponding to 10-11 o'clock of the papilla circumference [1, 6, 16].

Conclusions

Therapeutic ERCP with EST can be complicated by gastrointestinal bleeding of various degree, which can range from mild to very severe and even life-threatening. Although the greatest risk for the EST-related bleeding have patients with preexisting coagulopathy, the anatomical features of the arterial blood supply to the pancreaticoduodenal region and major duodenal papilla should also be considered during the endoscopic procedure. The communicating artery, directly vascularizing the region of the major duodenal papilla, usually originates from the posterior superior pancreaticoduodenal artery and ends in the anterior pancreaticoduodenal arcade. The smallest number of papillary arteries distributed in the potential accessibility of a sphincterotomy incision are located in the zone corresponding to 10-11 o'clock of the papilla circumference. As a result, the preferred performance of EST in described area can be associated with decreasing risk of arterial bleeding after ERCP.

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Authors' contribution

EP drafted the first version of the manuscript; SS collected data and examined the specimens; EG conceptualized the project and contributed to the final version of the manuscript. All the authors revised the manuscript critically and approved the final version of the manuscript.

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Ethics approval and consent to participate

No approval was required for this study.

Conflict of Interests

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