Arterial supply of gastric fundus in human – final results

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ABSTRACT

Background: General scheme of stomach arterial supply is well known and was repeatedly described but there are only few reports about gastric fundus arterial supply. The aim of the study is to describe the anatomy of the gastric arterial fundic branches with special reference to their selected morphometric and morphologic features, determination of the relationship between certain gastric arterial fundic branches and the selected gastric ligaments and indication of the exact site of the arterial fundic branches perforation in relation to its quadrants (defined vascular areas). Material and methods: The study was performed on 50 samples taken during post-mortem autopsy. In the whole material, a total 304 gastric arterial fundic branches were identified and measured. Statistical analysis was performed. Conclusions: The splenic artery almost always participates in gastric fundus arterial supply and other arteries inconstantly participate in the process. There are three morphological types of arterial fundic branches. The branches occurring in the superior part of gastro-splenic ligament usually supply posteromedial quadrant. Sequence of quadrants in terms of number of arterial branches supplying them is as follows: the postero-lateral, postero-medial, antero-medial and antero-lateral. There were no differences in gastric fundus arterial supply between males and females.
BACKGROUND

Knowledge of the gastric fundus arteries anatomy is very important in the diagnosis and treatment of patients with gastrointestinal tract or vascular system disease. This knowledge makes it easier to perform many surgical procedures and minimizes the risk of complications. Only few authors dealt with the topic of the gastric fundus arterial supply. Most publications relate to the posterior gastric and the splenic artery fundic branches. There is no work that would treat the topic as a whole. Most authors are focused on one or only few source arteries involved in supplying gastric fundus. They hardly ever mentioned specific details concerning the incidence, number, length and the diameter of gastric arterial fundic branches and their place of perforations in the different quadrants of the gastric fundus. Their analysis did not relate to lengths and diameters of arterial fundic branches either.

Arterial supply of stomach derives mainly from celiac trunk, both from its direct branches (left gastric artery, splenic artery, common hepatic artery) and from vessels, it derives indirectly from celiac trunk (right gastric artery, right gastro-epiploic artery, left gastro-epiploic artery, additional left hepatic artery, posterior gastric artery, gastro-splenic artery, superior polar artery) [5].

Only few of the above mentioned vessels are a potential source of blood supply of gastric fundus. Arterial supply of gastric fundus derives mainly from two arteries branching from celiac trunk: the left gastric artery and splenic artery [6]. The left superior suprarenal artery and left inferior phrenic artery may also function as additional arterial supply. A group of arteries deriving from splenic artery: posterior gastric artery, gastro-splenic artery, superior polar artery, left gastro-epiploic artery and short gastric arteries should also be mentioned. Some of these vessels are not always present. All the above mentioned vessels (source arteries) can branch off arterial fundic branches to gastric fundus and directly perforate its individual quadrants. Despite their importance in planning and certain surgical procedures, their anatomy and topographic relations are not sufficiently described.

Nowadays, there are a lot of possible non-invasive radiological methods of imaging blood supply of every human organ but sound knowledge of anatomy is necessary for the correct interpretation.

There are a lot of diseases that affect the area supplied by the gastric fundus arteries, which often require surgical treatment. The most important are the conditions requiring gastrectomy e.g. gastric cancer, gastric ulcer or obesity. Hiatus hernia is also very important because surgical treatment of this disorder is sometimes recommended. The most popular and most frequently used technique is called Nissen fundoplication can sometimes cause very serious complications. Other important diseases are visceral artery aneurysms which are more frequent than abdominal aortic aneurysm [1]. Splanchnic artery aneurysms could be single or multiple and may be complicated by rupture associated with high mortality [2]. There is a large group of conditions the only effective treatment of which is splenectomy e.g. ruptured spleen, a lot of hematological diseases, cysts and tumors of the spleen. For the treatment of hematological disorders laparoscopic splenectomy is becoming the gold standard method [3]. In that procedure proper hemostasis and adequate exposure of the splenic hilum are crucial. The next very important condition is median arcuate ligament syndrome, also known as Dunbar syndrome. This rare disorder is caused by extrinsic compression and narrowing celiac trunk [4]. Patients with this syndrome, in most cases need surgery to achieve celiac trunk decompression. In treatment of all these conditions, knowledge of anatomy is of utmost importance.

The aim of the study is to describe the anatomy of the gastric arterial fundic branches with special reference to their selected morphometric and morphologic features, determination of the relationship between certain gastric arterial fundic branches, the selected gastric ligaments and indication of the exact site of the arterial fundic branches perforation in relation to its quadrants (specific vascular areas).

MATERIAL AND METHODS

The study was performed on 50 samples taken during post-mortem autopsy. The content of the specimens were as follows: a fragment of the abdominal aorta with the departure of the inferior phrenic arteries, coeliac trunk, the proximal segment of superior mesenteric artery and splenic artery; part of the pleura; the abdominal part of esophagus; stomach; duodenum; pancreas; spleen and left suprarenal gland.

All cut vessels were selectively tied. The next step was to flush the arterial system of the test preparation with 1000ml 0,9% NaCl solution at a temperature of 40°C. Thus prepared arteries were injected at a pressure of 120 mmHg with a mixture of 15% gelatin solution with universal Mixol 10 red pigment concentrate. In some specimens Foley catheter was placed in a portal vein. Through the catheter, the venous system was flushed with 1000ml 0,9% NaCl solution at a temperature of 40°C and next it was injected at a pressure of 120 mm Hg with a mixture of 15% gelatin solution with universal Mixol 10 blue pigment concentrate.

Such prepared research material was solidified in 10% formaldehyde for about three weeks. Then the landmarks described the boundaries of each quadrant of gastric fundus and parts of the selected gastric ligaments. Then began the preparation of source arteries and its fundic branches using an OPM1 operating microscope and a set of microsur-
gical instruments. The particular stages of preparation, tested morphological features and relations were photographically documented by EOS 350D DIGITAL Canon camera and G600 Konica Minolta Dimage. The photos were processed using GIMP 2.6.8. All measurements were made using electronic Topex calipers and the data obtained was reported in the pre-prepared forms of research. The base was created using Excel on which the data from 50 preparations was summarized. The program was also used in some cases to prepare graphs showing dependency tests. Statistical analysis was performed using STATISTICA 6.0.

RESULTS

After the measurements, 272 correlation tests were performed.

The percentage of individual source arteries involved in arterial vascularization of gastric fundus is as follows: splenic artery – 96%, the superior polar artery – 69.2%, an accessory left hepatic artery – 55.6%, the posterior gastric artery – 44%, the left gastric artery – 36%, the left inferior phrenic artery – 30%, the left gastro-epiploic artery – 8% and the left superior suprarenal artery – 2%. Left gastric artery and splenic can originate in several different ways but there is no correlation between that and diameters of arteries. There are two morphological types of splenic artery: single vessel and bifurcate. There is no statistically significant correlation between size of splenic artery and morphological type.

There is statistically a significant correlation between average diameter of splenic artery and average diameters of splenic artery fundic branches but there is no correlation between average diameter of splenic artery and the number of artery fundic branches.

In whole material total 304 gastric arterial fundic branches was identified, of which 154 perforated postero-lateral quadrant, 108 - postero-medial quadrant, 28 – antero-medial quadrant and 13 – antero-lateral quadrant.

The longest gastric arterial fundic branches abandoned the left gastro-epiploic artery. The shortest ones originated from the posterior gastric artery. The average length of branches was 36 mm. As many as 41.31% of arterial fundic branches ranged in the length between 10 and 25 mm. Compared to the test done on the the least significant differences, between the average length of the arterial fundic branches in relation to the place of their perforation the findings showed that the average length of gastric arterial fundic branches perforating the antero-lateral quadrant is significantly longer than average length of gastric arterial fundic branches supplying postero-medial quadrant. Secondly: the average length of arterial fundic branches perforating postero-medial quadrant is significantly shorter than the average length of arterial fundic branches perforating the posterior-lateral quadrant. Comparison of average lengths of arterial fundic branches originating from different source arteries revealed that average diameter of the fundic branches departing from the left inferior phrenic artery, left gastric artery, accessory left hepatic artery, splenic artery and the left gastro-epiploic artery is statistically significantly longer than the average diameter fundic branches deriving from the posterior gastric and the superior polar arteries.

Evaluation of gastric arterial fundic branches diameters showed the widest diameter in the left gastric artery fundic branches and the narrowest in the accessory left hepatic artery fundic branches. Examination of a number of distributions of all arterial fundic branches diameters revealed that the diameter of two thirds of them ranges between 0.5 and 1.5 mm.

There are three morphological types of posterior gastric artery and superior polar artery: single vessel, bifurcate and with perforators. Detailed examination of the morphology of the arterial branches of the stomach fundus showed that 47.68% reflect perforates, the 36.09% are a single vessels and 16.23% just before the perforation of the stomach bifurcate. Furthermore, statistically significant correlation between the length and the diameter of fundic branches originated from the left inferior phrenic artery, left gastric artery, accessory left hepatic artery and the left gastro-epiploic artery was found.

DISCUSSION

Recently The anatomy of the gastric arteries was described for the first time in 1847 by Arnold [7] and updated by many further authors. The stomach is arterial supplied by four well-anastomosed arteries [8]. Only a few authors dealt with the topic of the gastric fundus arterial supply.

Morphometric and morphologic features of celiac trunk were repeatedly described. Generally the trunk gave rise to left gastric, common hepatic and splenic arteries but there is a lot of their possible origin [9]. The most common type is truncus hepatospennogastricus (84% in our study, comparable in other studies [10-16]). Other types are truncus hepatospesnicus, truncus hepatospennomesentericus, truncus hepatoaergastricus, truncus splenogastricus, truncus celiacomomesentericus. The average diameter of the most common type of celiac trunk was 7.22mm and the average length was 26.35mm there were no differences between male and female gender.

In our study left gastric artery originates from celiac trunk in 83.33%, directly from aorta in 8.33%, from truncus splenogastricus in 6.25% and from truncus hepatogastricus in 2.08%. Theset results are comparable to the most of the results of the other autors. In our material there was accessory left hepatic artery in 16% cases (in literature from 5.95% to 43%). [17]
CONCLUSION

The studies led to the following conclusions. The splenic artery almost always participates in gastric fundus supply (in 48 of 50 examined cases). The left inferior phrenic, left gastric, accessory left hepatic, posterior gastric, superior polar and the left gastro-epiploic artery inconstantly take part in gastric fundus arterial supply. There are three morphological types of arterial fundic branches. Arterial fundic branches occurring in the superior part of gastro-splenic ligament usually supply postero-medial quadrant. Sequence of quadrants in terms of numbers of arterial branches supplying them is as follows: the postero-lateral, postero-medial, antero-medial and antero-lateral. There were no differences in gastric fundus arterial supply between male and female gender.

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FIG. 1. SCHEME OF STOMACH ARTERIAL SUPPLY

FIG. 2. THE SPECIMEN

FIG. 3. SPLENIC ARTERY – SINGLE VESSEL

FIG. 4. SPLENIC ARTERY – BIFURCATE

1 - aorta
2 - left inferior phrenic artery
3 - left superior suprarenal artery
4 - posterior gastric artery
5 - gastro-splenic artery
6 - superior polar artery
7 - accessory left hepatic artery
8 - celiac trunk
9 - left gastric artery
10 - splenic artery
11 - short gastric arteries
12 - gastroduodenal artery
13 - right gastric artery
14 - common hepatic artery
15 - right gastro-epiploic artery
16 - left gastro-epiploic artery
A - fundus
B - spleen
C - pyloric part of stomach
D - corpus of stomach
E - short gastric arteries
F - left inferior phrenic artery
G - left superior suprarenal artery
H - posterior gastric artery
I - gastro-splenic artery
J - superior polar artery
K - accessory left hepatic artery
L - celiac trunk
M - left gastric artery
N - splenic artery
O - pyloric part of stomach
P - corpus of stomach
Q - celiac trunk
R - splenic artery
S - posteriori gastric artery
T - stomach
U - superior branch of splenic artery
V - inferior branch of splenic artery


**FIG. 5. ARTERIAL FUNDIC BRANCHES**

1 - posterior gastric artery fundic branches
2 - splenic artery fundic branches
3 - left gastro-epiploic artery fundic branches
4 - left inferior phrenic artery fundic branches
5 - left gastric artery fundic branches

**FIG. 6. CELIAC TRUNK BY MICHAELIS CLASSIFICATION**

1 - aorta
2 - left gastric artery
3 - common hepatic artery
4 - splenic artery
5 - superior mesenteric artery

**BIBLIOGRAPHY**