ANEURYSM OF SPLENIC ARTERY. INCIDENCE, CLINIC, DIAGNOSIS, TREATMENT. REVIEW AND CASES FROM PRACTICE

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ABSTRACT
Aneurysms of splenic artery are the most common visceral aneurysms. There are true aneurysms and pseudoaneurysms. True aneurysms develop against the background of artery wall weakness. Pseudoaneurysms result from a rupture of the intima of the vessel wall with subsequent dissection of blood into a false lumen and formation of a periarterial hematoma. They are detected as an incidental finding without any clinical manifestation.

The aim of this article is to present two clinical cases of a ruptured aneurysm of the splenic artery in our practice.

The mortality rate after rupture of the splenic artery aneurysm varies from 25% to 40%. Under emergency conditions, the time for diagnosis is scarce and limited by the hemodynamic status of the patient.

With increasing the possibilities of diagnostic imaging, the chances for minimally invasive treatment of incidentally detected pseudoaneurysms of the splenic artery improve.

The conditions for successful management of this pathology include organization of emergency surgical care and collaboration between surgical teams.

Keywords: splenic artery aneurysm, clinical diagnostic approach

INTRODUCTION
The diameter of the splenic artery varies from 0.43 cm to 0.49 cm. A focal dilation of the splenic artery diameter greater than 50% of the normal vessel diameter is defined as an aneurysm. True aneurysms involve all layers of the vessel wall, as these are intact but thin. True aneurysms develop against the background of artery wall weakness. Pseudoaneurysms result from a rupture of the intima of the vessel wall with subsequent dissection of blood into a false lumen and formation of a periarterial hematoma. As a rule, they are secondary, lack a real wall, which makes them more susceptible to rupture. Risk factors for the development of splenic artery aneurysm are: portal hypertension; pregnancy; atherosclerosis; acute necrotic pancreatitis; liver transplantation; Marfan syndrome; Ehlers Danlos syndrome; polyarteritis nodosa, and Wegener’s granulomatosis [1]. Pseudoaneurysms of the splenic artery occur in up to 21% of the patients diagnosed with chronic pancreatitis. They may be associated with a blunt or penetrating trauma, as well as iatrogenic lesions during instrumentation [2]. Pancreatic enzymes may cause necrotizing arteritis by destroying the structure of the vessel wall and fragmenting elastic tissues, leading to an aneurysm or pseudoaneurysm [3]. A long-term pseudocyst of the pancreas may cause a pseudoaneurysm resulting from vascular erosion by enzymes in the pseudocyst, direct compression or ischemia [4].

True splenic artery aneurysms (SAAs) are more common than pseudoaneurysms. Splenic artery aneurysms are the third most common aneurysms after these of the abdominal aorta and iliac vessels [5, 6, 7, 8] and the most common aneurysms of visceral arteries, accounting for 60% to 70% of the patients diagnosed with aneurysms of the visceral arteries [9, 10, 11].

According to literature data, the incidence of aneurysmal dilations of the splenic artery varies widely, from 0.2% to 10.4% [7, 8]. Rare in the past, with the advent of modern diagnostic imaging, the incidence of splenic artery aneurysms is increasing. They are detected as an incidental finding, without clinical manifestation, which explains their low incidence in the general population - less than 1% [12]. In a 2015 publication, Veluppillai C. et al. reported a higher incidence of SAAs in women - 78% [13]. The mortality rate after rupture of the splenic artery aneurysm in non-pregnant patients ranges from 25% to 40%. Maternal mortality due to aneurysmal rupture reaches 75% and fetal mortality - up to 95% [13. 14].

Clinical case I:
A 58-year-old woman with arterial hypertension, two normal births, presented with complaints of pain in the right hypochondrium with a duration of 1 week, vomiting and fever of up to 38.2°C, and lack of defecation for 2 days. No previous surgical interventions or abdominal injuries were reported. On the ultrasound examination of abdominal organs, there was evidence of hydronephrosis of the gallbladder, with double wall contouring and perivesical effusion. We performed conventional cholecystectomy with intraoperative cholangiography, transcystic drainage
and subhepatic drainage. We found no other pathological changes during the exploration of the abdominal cavity. The histological result was phlegmonous cholecystitis with areas of necrosis. In the third postoperative hour, arterial blood started to flow through the subhepatic drain, and a collapse of the patient’s hemodynamics occurred. Within 30 minutes, a relaparotomy was performed, and 2 units of erythrocyte mass and plasma were provided. During the exploration, we found a massive retroperitoneal hematoma pushing the stomach and the colon into the surgical field and a flow of arterial blood from the hilum of the spleen. We performed a splenectomy, but arterial blood continued to flow along the tail of the pancreas. We mobilized the left flexure and opened the omental bursa completely by cutting the gastrocolic ligament. We found a ruptured aneurysm in the middle third of the splenic artery, which we sewed with several z-shaped sutures. We evacuated the blood and clots and tamponaded the bursa with 3 Mikulicz compresses, forming a laparostoma with mesh for re-examination after the patient’s stabilization.

Our conduct, in this case, was in line with the principles of Damage control surgery (DCS). We revised the abdomen at 72 hours, exposing the celiac trunk and ligating the splenic artery into its orifice. We removed the tamponade, lavaged the abdominal cavity, and closed it definitively after draining the Douglas pouch and the left lateral canal. We removed the drains on the third and fourth day. The patient was discharged on the 10th postoperative day without complications.

**Clinical case II:**
A 64-year-old woman, in satisfactory general condition, was referred to our surgical department for emergency hospitalization, after examination by a gastroenterologist and ultrasound evidence of an hourglass-type collection behind the stomach and in the right iliac fossa, measuring 23 mm and 145 x 56 mm, respectively, with a suspected posterior perforation of the stomach wall for 6-7 days (Fig. 1).

One week before hospitalization, the patient reported that she had sharp pain in the epigastrium, radiating to the scapula and lower back, without dyspeptic syndrome. The pain lasted for about 2 hours, after which it subsided with the help of analgesic therapy. There were severe comorbidities: polycythemia vera, Class III NYHA heart failure, Hashimoto’s thyroiditis, seropositive rheumatoid arthritis, bilateral nephrolithiasis, severe mitral, moderate aortic and mild tricuspid regurgitation; condition after COVID-19 infection 1 month ago, without scanning data for a ground-glass type of interstitial pneumonia.

Upon admission to the emergency department, the patient had stable hemodynamic and hematological parameters. She was prepared and operated under the conditions of delayed emergency. Intraoperatively, about 300 ml of blood was found in the small pelvis and right lateral canal, as well as an old hematoma with a diameter of 5 cm in the area of the gastrocolic ligament wall-tangent to the uncinate process and the right gastroepiploic artery. After aspiration of the free blood, the wall of the hematoma was torn in a blunt manner, whereby extravasation of arterial blood along the upper edge of the pancreas was observed. The splenic artery was exposed in its middle third, and a ruptured pseudoaneurysm was detected within the borders of its proximal-middle third. Resection of the aneurysm in her neck and end-to-end anastomosis of the splenic artery with 5/0 was performed. The abdominal cavity was lavaged to clear lavage fluid. Three tubular drains were placed - in Winslow’s foramen, subhepatically and in the small pelvis, respectively. Layer by layer, the abdominal wall was restored with its own tissues. The postoperative period went smoothly, with good hemodynamics and without complications. On the 5th postoperative day, CAT angiography was performed without evidence of extravasation and with normal imaging of the branches of the ciliary trunk without aneurysmal dilations (Fig. 2). On the 6th postoperative day, the patient was discharged with anticoagulant therapy at home, as recommended by the supervising hematologist.
DISCUSSION

The course of the splenic artery is along the upper edge of the pancreas, but variations are possible. Aneurysms are usually saccular and located in the middle or distal third of the vessel [15]. True SAAAs are usually smaller than 3 cm (range: 2-9 cm), can be multiple, and are most frequently located in the distal third of the artery [16]. The mean size of pseudoaneurysms of the splenic artery is 4.8 cm (range: 0.3-17 cm), and in 41% of the cases, there is also a pseudocyst of the pancreas [17]. Bleeding from a ruptured pseudoaneurysm may involve the pseudocyst, pancreatic duct, peritoneum, retroperitoneum and adjacent organs such as the stomach and the colon [16, 17].

According to the Mayo Clinic, 97% of the SAAs, confirmed by diagnostic imaging methods, are asymptomatic [18]. The risk of a rupture of the splenic artery aneurysm varies between 10% [19] and 2-3% in more recent studies [20,21]. The increase in the incidence of aneurysmal ruptures of the splenic artery is associated with portal hypertension, pregnancy and liver transplantation [22]. Clinical manifestations include abdominal pain and hemodynamic failure [22]. Temporary stabilization of hemodynamics with subsequent sudden collapse is possible, which is associated with a two-moment rupture of the aneurysmal dilation. Initially, blood accumulates in the soft tissues adjacent to the formation of a hematoma, which subsequently ruptures with the formation of a hemascos [23].

Pseudoaneurysms of the splenic artery have more frequent clinical symptomatology and the associated risk of a rupture, according to the literature, reaches 37%, with up to 90% mortality in the absence of treatment [24, 25]. The most common clinical manifestations are: abdominal pain (29.5%) hematochezia or melena (26.2%), pancreatic hemorrhage (20.3%) and hematemesis (14.8%) [26].

The possible causes for creation of splenic artery aneurysms include: trauma, hormonal and local hemodynamic changes during gravidity, portal hypertension, arterial degeneration, infection and splenectomy. Factors leading to rupture of aneurysms could be: sudden increase of intraabdominal pressure during direct or indirect trauma, compartment syndrome, retroperitoneal or intraperitoneal miniinvasive procedures with gas insufflation or sudden decrease of intraabdominal pressure during laparotomy like it is with the first clinical case.

Direct catheter angiography is now considered the gold standard in the diagnosis of aneurysm and pseudoaneurysm of the splenic artery, and a treatment procedure can be applied at the same time [27].

The use of Doppler sonography with is limited due to such compromising factors as the patient’s high body mass index and atherosclerotic changes in the vessels. Small vascular lesions may be omitted due to the limited spatial resolution of the method [28, 29, 30]. The use of MRI and MR is a good choice, but it is not an applicable method in patients with pacemakers, metal clips, claustrophobia or the patient’s inability to hold breath for long periods of time [30]. The use of CT angiography is contraindicated in renal failure, poor intravenous access and allergy to contrast media. Modern MDCT scanners are capable of high spatial resolution and short breath holding times. The high temporal resolution facilitates data collection during the purely arterial phase and leads to a reduced movement artifact [27,31].

Treatment tactics for incidentally detected SAAs include stenting, aneurysmal resection with or without splenectomy, or dynamic monitoring in the absence of complications. Aneurysms located in the proximal or middle third of the splenic artery can be treated with simple excision, proximal and distal ligation of the artery, and preservation of the spleen. In the case of aneurysms located in the distal third, resection with splenectomy is most frequently performed [32]. Transcatheter embolization is performed with a success rate of 85% and is accompanied by low morbidity and lethality [33,34].

Pseudoaneurysms of the splenic artery are subject to priority treatment due to the high risk of rupture and the associated high mortality. Splenectomy with or without partial pancreatectomy is the method of choice. The mortality and morbidity rate with this surgical intervention is between 1.3% and 9%. (35) Endovascular techniques are successful in 75-85% [35].

Risk groups to be assessed for emergency surgical treatment include: pregnant women or women of childbearing potential, as well as liver transplant patients or patients with cirrhosis and portal hypertension.

In the presence of SAA rupture, the diagnostic possibilities are limited to the extreme due to the hemodynamic instability and the immediate danger to the patient’s life. The diagnosis is made by intraoperative exploration of the hematoma.

The mortality rate after rupture of the splenic artery aneurysm varies from 25% to 40% [35, 36]. Under emergency conditions, the time for diagnosis is scarce and limited by the hemodynamic status of the patient. The diagnosis is made during the intraoperative exploration of the hematoma. The main priority is to save the patient’s life, which is the principle of DCS. The lack of an exact preoperative diagnosis puts the surgical team to the test.
case of a ruptured aneurysm, the presence of a vascular surgeon is crucial. Aneurysms located in the proximal or middle third of the splenic artery can be treated with simple excision, proximal and distal ligation of the artery, and preservation of the spleen. Upon exposure of the pseudoaneurysmal neck, resection may be performed to restore the integrity of the vessel. Ruptured aneurysms in the splenic hilum end in splenectomy and partial resection of the tail of the pancreas[37, 38].

In an emergency, volume replacement therapy and the availability of blood and blood products are essential. In the first clinical case presented by us, the delivery of isogroup blood was performed within 30 minutes due to the availability of a blood bag on the territory of the medical institution, which together with the adequate behavior of the surgical team under the DCS protocol - split of the surgical intervention, stabilization of the patient and final hemostasis in the second stage, led to a successful clinical outcome [39].

In the second case, the presence of a vascular surgeon in the team led to organ-sparing surgical treatment. Knowledge of this pathology allows adequate behavior in an emergency.

Incidentally detected pseudoaneurysms of the splenic artery are subject to priority treatment due to the high risk of rupture and the associated high mortality. Treatment tactics include stenting, aneurysm resection with or without splenectomy, or dynamic monitoring in the absence of complications. With increasing the possibilities of diagnostic imaging, the chances for minimally invasive treatment of incidentally detected pseudoaneurysms of the splenic artery improve, in accordance with the risk groups and the world consensus on this case. Splenectomy with or without partial pancreatectomy is the method of choice. The mortality and morbidity rate with this surgical intervention is between 1.3% and 9%. Endovascular techniques are successfully applied in 75-85% [40].

**CONCLUSION**

Despite the progress of medicine and the introduction of new diagnostic and treatment methods, the competence of the surgical team and the work organization in emergency departments is crucial for the favorable outcome of splenic artery aneurysm-associated complications.

The real aneurysms could be asymptomatic but the pseudoaneurysms always produce symptoms. The abdominal pain could be explained with existing inflammatory process in the ventral cavity but the exact diagnostic imaging could be informative about existing aneurism of splenic artery and spare the risk and complications of a subsequent rupture when such pathology is considered especially if there are predisposing factors.

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