Laparoscopic treatment of splenic artery aneurysms

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Objectives
The purpose of this study was to report a series of 16 consecutive patients who underwent laparoscopic treatment of splenic artery aneurysms.
Methods
Over a period of 8 years, patients were selected for the laparoscopic option by a team of specialists that included the vascular surgeon, the interventional radiologist, and the laparoscopic surgeon. The mean size of the aneurysm was 32 mm and most was located at the splenic hilum. They were twice as common in females as in males. Ultrasonography with color Doppler function was used to define intraoperative strategy.
Results
The laparoscopic treatment entailed excision of the aneurysm or its exclusion, usually reserved for distally located lesions. In one patient, laparoscopic resection and robotic anastomosis of the splenic artery was performed to re-establish flow to the spleen. In two patients, the intraoperative decision was added to combine a laparoscopic splenectomy due to insufficient residual arterial flow to the spleen. There was no conversion, or need for re-operation or related mortality. Analysis of intraoperative arterial flow data avoided unnecessary splenectomy following noncritical reduction of flow to the spleen.
Conclusions
The use of intraoperative color Doppler ultrasonography is essential in deciding the appropriate procedure and whether the spleen should be removed or saved. Early control of the splenic artery proximal to the aneurysm can limit the risk of conversion due to intraoperative bleeding. Distally located aneurysms are more difficult to manage and entail a higher risk of associated splenectomy. The laparoscopic option offers some advantages over the endovascular treatment in selected patients. A multidisciplinary approach is the key to a successful treatment of this uncommon disease.

Splenic artery aneurysms are today diagnosed more frequently due to the wide diffusion of medical imaging. They are often nonsymptomatic and indication for treatment depends on several factors, the most important of which is a diameter exceeding 2 cm.[1,2 3 and 4] Endovascular management is a very attractive option, since the procedure can be done under local anesthesia with minimal trauma to the patient. However, only selected aneurysms are suitable for this procedure; the post-treatment splenic flow can be compromised with related splenic malfunction and infarction, and imaging follow-up is required to confirm permanent exclusion of the aneurysm.[5]

A laparoscopic management of a splenic artery aneurysm was originally reported in 1993.[6] The aneurysm can be excluded to vascular flow by ligating or clipping the afferent and efferent vessels, or it can be resected. Reconstruction of vascular continuity of the splenic artery is usually not necessary due to the collateral circulation provided by the short gastric vessels, but occasionally an end-to-end anastomosis is the only way to avoid a concomitant splenectomy. Nonetheless, splenectomy is sometimes unavoidable to complete the treatment. The intraoperative strategy varies depending on the localization of the aneurysm along the splenic artery and on the changes of flow to the spleen that are observed throughout the procedure.

In this article, we report our experience with 16 patients with aneurysms of the splenic artery treated with laparoscopy and comment on the management strategy of this uncommon condition.

Materials and methods

From January 2000 to December 2008, 16 patients with aneurysms of the splenic artery were treated by laparoscopy at our institution. Patients were usually referred to the vascular surgeon (M.F.) but the management was the result of a collegial decision taken with the interventional radiologist and the laparoscopic surgeon (A.P.). In the time interval of this study, 10 additional patients were selected for endovascular treatment, resulting in seven coil embolization and three placements of covered stents; two more patients with aneurysms exceeding 10 cm in diameter were treated with an open surgery approach. The preoperative planning of the surgical strategy was based on the three-dimensional (3D) reconstruction of the vascular anatomy of the splenic vessels, segmented from the dataset of a multidetector angio-CT.[7 and 8] In this selected series of patients treated with laparoscopy, the endovascular treatment was excluded to avoid potential splenic complications in seven patients aged less than 55 years, in whom preservation of the splenic function was considered a priority, or to obviate postoperative imaging follow-up in three cases, or finally, for the technical difficulty to achieve a satisfactory endovascular exclusion of the aneurysm in six. The general data of our patients are depicted in the Table. One patient presented with a symptomatic splenic abscess caused by spontaneous thrombosis of a 4 cm splenic artery aneurysm, which demanded a laparoscopic splenectomy.

Table.

Data of the 16 patients with splenic artery aneurysms treated laparoscopically

	Proximal	**Middle**	**Distal**	**Total**
Number of patients	4	2	10	16
Mean age	52	66	54	58
Males	0	0	5	5
Females	4	2	5	11
Mean size (mm)	28	42	32	32

Intraoperative management

Aneurysms of the distal third of the splenic artery were approached with the patient in the left lateral decubitus; a supine position was the preferred option for proximal aneurysms and a semi-lateral position was used for those occurring in the middle third. A 30° optic was introduced at the umbilicus and three additional ports were placed in the left subcostal area. After opening the lesser sac and retracting the stomach to expose the pancreas and the aneurysm, the first step always consisted in providing vascular control of the splenic artery proximal to the aneurysm by looping this vessel with an umbilical tape.[9] Special care was used not to interrupt the short gastric vessels while opening the lesser sac, as this collateral circulation is crucial in maintaining spleen perfusion.[10] Laparoscopic color Doppler ultrasonography on the aneurysm and on the splenic parenchyma provides at this stage flow information before vascular exclusion of the aneurysm. Both measurements are then repeated after exclusion of the aneurysm. All ultrasonographic examinations were performed with Acuson Aspen TM ultrasound scanners (Acuson Corporation, Oceanside, Calif) with 4-10-MHz linear laparoscopic-array transducer. The filter and pulse repetition frequency settings were kept low to maximize the sensitivity to slow flow. Gain settings were adjusted for optimal signal detection without artifacts. The ultrasonographic assessment on the aneurysm started with a preliminary real-time morphologic evaluation. Color Doppler mapping of the arterial signal was now used to assess the flow inside the aneurysm and then to detect small intrasplenic arteries on three different areas: upper pole, middle area, and lower pole. The insonation angle ranged from 40° to 60° during this phase of the examination. The color scale was set at the lowest possible level to obviate aliasing with maximal gain without background noise. When an arterial signal was detected, the Doppler gate was applied. A small (2–5 mm) Doppler gate was used to exclude signals originating from veins; the Doppler velocity scale was initially set as low as possible and then increased as needed. For the purposes of this study, we analyzed each sonogram for the presence or absence of blood flow inside the splenic aneurysm and for measurements inside the splenic parenchyma of the resistance index (RI) and systolic acceleration time (SAT). A single operator performed all ultrasonographic examinations (L.M.). An RI lower than 0.30 and a SAT ≥ 80 ms were considered indicators of insufficient arterial perfusion.[11 and 12] Power Doppler sonography was also used for signal enhancement and detection of slow flow.

Most of the dissection of the aneurysm was accomplished with the use of a laparoscopic monopolar hook. Proximal and distal legation was generally achieved by a combination of extracorporeal and intracorporeal knotting technique.[13] When we encountered evidence of persistence of flow within the aneurysm, we continued the dissection along the adventitial plane until the whole aneurysm was removed. Small feeding vessels were identified and clipped during this phase.

In two patients, a hand-assisted approach was employed to overcome the technical difficulty posed by a post-thrombotic splenic abscess firmly attached to the diaphragm in the first one and a retropancreatic hilar aneurysm in the second.

Postoperative follow-up

Patients were seen in the outpatient clinic 6 weeks after surgery and then at 3 months, 6 months, and 1 year; imaging follow-up was based on ultrasonography, and color Doppler ultrasound (US) was used to measure splenic flow and to check on residual flow inside excluded aneurysms.

Results

As expected in our series there was a prevalence of females (11 over 16) (Table). The mean size of the aneurysm was 32.3 cm (range 20–60 cm). Four were located in the proximal third, in the vicinity of the celiac trunk; two were of the middle third of the splenic artery, along the superior border of the pancreatic body, and 10 were located near to the hilum of the spleen. Notably, all the five young females (aged less than 55) were included in the last subgroup. Mean operative time was 143 minutes (range 64–187). Intraoperative blood loss was usually minimal (less than 100 mL) and no patient received blood transfusion, including two cases in which the aneurysm ruptured during the dissection. There was no conversion to open surgery. Mean postoperative stay was 3 days, which extended to 8 days in patients who also underwent a splenectomy. No patient required additional surgery. There was no mortality. Postoperative serum amylase was always within the normal range, and no patient developed clinical sign of pancreatitis or of pancreatic leak.

In five cases, in which the aneurysm was located in the distal third, simple exclusion of the aneurysm was the final treatment; in the remaining 11 cases, the aneurysm was excised. Rupture of the aneurysm during its dissection occurred in two cases: previous isolation of the splenic artery proximal to the aneurysm allowed in both cases a quick control of the resulting bleeding, thus obviating conversion. A splenectomy had to be performed in three cases, due to critical loss of flow signal to the spleen at intraoperative contact color Doppler ultrasonography in two and to pre-existing splenic infarction/abscess in the other. In four cases, the intraoperative color Doppler after exclusion of the aneurysm indicated a RI between 0.3 and 0.5. with a SAT > 80 ms. The spleen was left in place, despite the change of color that had occurred to its surface. In one case, a robotic procedure with the Da Vinci system allowed end-to-end re-anastomosis of the splenic artery and re-establishment of a normal splenic flow, thus avoiding a splenectomy. This patient had a distal aneurysm that was resected with a consequent drop of intrasplenic flow below the set threshold. The end-to-end anastomosis was performed with two running 6-0 polypropylene sutures and with the aid of laparoscopic bulldog clamps. In case of associated splenectomy, this was performed with a hand-assisted technique in the patient with the splenic abscess and with pure laparoscopic technique in the other two, using an endobag to retrieve the specimen with morcellation. Mean blood loss in these patients was 150 mL. No patient was lost to follow-up. The interval of follow-up was recorded and averaged 43 months (range, 1 to 92 months).

No patient developed postoperative splenic infarction and an arterial pattern of flow to the spleen could be assessed in all cases at US postoperative control. In the four patients in whom the intraoperative color Doppler had shown a reduction of flow parameters after exclusion of the aneurysm, a progressive recovery of this data was observed postoperatively, reaching a plateau 6 months after surgery.

Discussion

Many authors have reported on the laparoscopic treatment of splenic artery aneurysms. Most of these articles are single case reports and usually have only proved the feasibility of this approach with few having also offered management advice.[1,9 and 14] In the last 8 years, we have been able to collect a series of 16 patients thanks to the synergic collaboration of different specialists: the interventional radiologist, the vascular surgeon, and the laparoscopic surgeon. This multi-disciplinary approach proved very effective in offering the patient the optimal treatment for any given visceral aneurysm, be this endovascular, laparoscopic, or open. At our University Center for Computer Assisted Surgery “ENDOCAS” we have also developed a dedicated software to achieve 3D reconstruction of the vascular anatomy of the splenic vessels, segmented from the dataset of a multidetector angio-computed tomography (CT), that provides the interventionist with preoperative visual information he or she can “fly through” to plan and simulate the procedure[8] (Fig.). This is particularly useful before and during a laparoscopic case, where the lack of tactile feed-back limits our capability to identify pulsating arteries. We believe that the laparoscopic management is to be preferred in young patients where it is advisable to preserve the splenic function, or when the endovascular treatment is technically not feasible or the patient is not willing to undergo the imaging control protocol that follows this procedure. Although the reported results of endovascular treatment of visceral aneurysms are generally good, no data is available to compare this method with the laparoscopic approach. The weak points of the endovascular treatment are the primary success rate, reported between 75% and 98%,[15, 16, 17 and 18] the possible refilling of the aneurysm at some time after the procedure and the post embolization syndrome.[18] Both anatomy and morphology of the aneurysm can determine the technical success of endovascular treatment. A long and tortuous splenic artery with a distal aneurysm or a wide neck of the aneurysm has a reduced potential success rate. Also, a large amount of thrombus within any aneurysm may lead to midterm coil migration and recanalization.[19] The occurrence of post-treatment endoleak has been reported as high as 9%.[20] Chiesa[21] also reported three cases of aneurysm recanalization, suggesting a selective approach when choosing the endovascular treatment. Saltzberg[20] reported 22.2% of patients with major endovascular procedure-related complications, including one late recurrence requiring open repair. Since these complications always occurred with distally located aneurysms, Salzberg concluded that traditional surgical treatment may be preferred in these cases.[20] With stent-assisted treatment, prolonged antiplatelet medication is usually necessary. Image artifacts after coil embolization also limit the use of TC during follow-up.[22] After selective coiling, angiographic follow-up is mandatory because reopening of some feeding vessel can occur.[20 and 21] If reopening results in partial aneurysm filling, additional coiling or surgery can be considered. When successful embolization is confirmed at 1 year after endovascular treatment, further follow-up is probably no longer needed, although a wide range of opinions can be found in the literature.[22 and 23] However, in view of the reported occurrence of late recanalization,[20] careful consideration of the appropriate time to discontinue follow-up for the single patient should be made.

Postembolization syndrome is related to insufficient flow to the spleen and can lead to partial infarction and occasional development of splenic abscess. This event occurs more frequently after exclusion of aneurysms of the hilum of the spleen. A postembolization syndrome was reported in about one third of patient by Piffaretti[18] and McDermott.[24] Although only few patients will need additional surgery after a postembolization syndrome, since this is correlated to a variable degree of splenic infarction, nonetheless, it is possible that in some of them, the splenic function will result permanently compromised. The capability of laparoscopy to combine the management of the splenic aneurysm with a concomitant laparoscopic splenectomy in case of need, obviates the syndrome caused by insufficient flow to the spleen and its sequaele.[25]

The low invasiveness of the laparoscopic approach and the absence of specific morbidity in our series with a mean postoperative stay in patients who did not require a splenectomy of 3 days, compares favorably with the results of the endovascular treatment.[5]

The laparoscopic approach with the combination of contact ultrasonography, as opposed to endovascular treatment, allows intraoperative recognition of deficient residual flow to the spleen, after aneurysm exclusion. In this situation, reported in two patients in our series, a laparoscopic splenectomy shall prevent subsequent splenic infarction, and the possible evolution of this into a splenic abscess that in turn demands additional percutaneous treatment or surgery.[18 and 20]

For a successful laparoscopic treatment of splenic artery aneurysms, it is essential to be proficient in advanced laparoscopy, since the dissection of the aneurysm can be very difficult and risky. Most of the dissection of the aneurysm was accomplished with the use of a laparoscopic monopolar hook. This device allows gentle and careful separation of tissue around the adventitia that can be elevated and inspected by the surgeon before being cut with the activation of the electrocautery foot-control and passage of current. Sudden rupture of the thin wall of the aneurysm should always be feared during its dissection off the surrounding tissue. It is good practice to isolate the artery proximal to the aneurysm early during the procedure to allow subsequent vascular control, should this need arise.[9] Distally located aneurysms are more difficult to dissect, and special attention should be paid to avoid damaging the splenic vein in this area, where it can be in close contact with branches of the artery. As a consequence of this anatomical relationship, it can be advisable in these patients to limit the procedure to simple exclusion of the aneurysm without attempt at its excision. The risk of pancreatic injury during the laparoscopic dissection of a splenic artery aneurysm is more theoretical than real, since the splenic artery runs separate from the pancreatic parenchyma, and a plane can always be found between the two. In addition, the gentle exposure of the laparoscopic approach, with avoidance of retractors and of direct manipulation of the pancreas accounts for possible less pancreatic injury with this technique when compared to open surgery. In our series, no clinical or laboratory evidence of pancreatitis was recorded postoperatively, and no patient developed a pancreatic leak. The use of a laparoscopic stapler seems to be the most popular method to interrupt the splenic artery.[10, 26, 27, 28 and 29] Some[14] have also advocated a tangential stapler resection of sacciform aneurysms, to preserve splenic flow. We, as others,[30] think that this type of laparoscopic treatment leaves behind part of the aneurismal artery and therefore might contribute to recurrence. To exclude the aneurysm, we prefer simple ligation using various laparoscopic knotting techniques. Once the aneurysm is excluded, opening of its wall, which will represent the usual step in open surgery, exposes to the potential severe blood loss from back bleeding vessels, which would be difficult to dominate with the laparoscopic technique. In case of persistent flow within the aneurysm, we found simpler and safer to continue the dissection along the adventitia plane, till the whole aneurysm is removed. Additional feeding vessels will be encountered and clipped during this dissection.

The laparoscopic equipment should also include a laparoscopic ultrasonographer with a color Doppler function. Arterial flow signal inside the spleen should be checked before and after exclusion of the artery. This is particularly useful to manage aneurysms located in the distal third of the splenic artery. In this situation, in fact, a drop in the flow to the spleen is more likely to occur following exclusion of the aneurysm, whereas interruption of the splenic artery close to the celiac trunk or in the middle third of the vessel will usually be bypassed by the short gastric arteries or by the intrapancreatic network producing no significant change in the splenic perfusion. The simple darkening of the surface of the spleen does not necessarily imply that the spleen will develop an infarction. In our experience, this is unlikely to occur if the US color Doppler can still detect an arterial flow signal with an RI > 0.30 and a SAT > 80 ms. inside the splenic parenchyma, despite any change of color that might have occurred after exclusion of the aneurysm. Some evidence was provided that after surgery the collateral circulation is capable to re-establish flow to the spleen improving the splenic perfusion.[10] Also, in our patients with intraoperative reduction of flow, some progressive improvement could be detected up to 6 months after surgery. If no arterial signal is detected, or if this is found below the above threshold, the possibility to re-establish the flow with a robotic anastomosis should also be considered, particularly in young patients were preservation of the spleen is advisable.

The low morbidity of the laparoscopic treatment of splenic artery aneurysms combined with the satisfactory definitive results compares favorably with the less invasive endovascular treatment, nonetheless, still responsible of a significant complication rate. The choice between these two options should be based on the patient's vascular anatomy, on concurrent risk factors and on informed motivation to undergo one treatment or the other. Again, such a decision is best taken within a multidisciplinary environment, where each specialist can contribute different experience, knowledge, and skill.

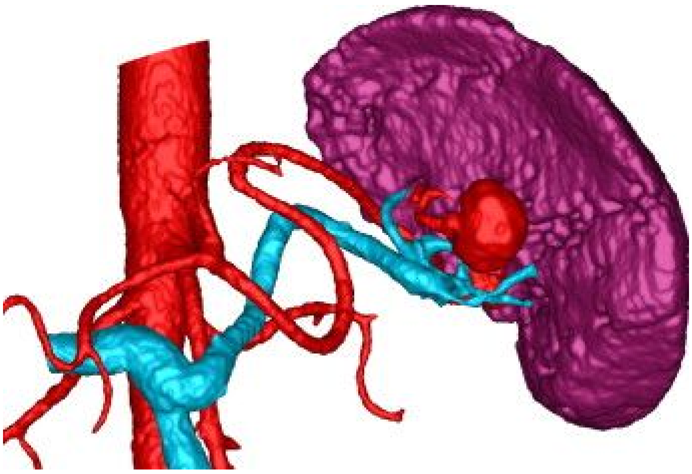

Figure :Three-dimensional reconstruction of the vascular anatomy of a patient with a splenic artery aneurysm. The dedicated software allows navigation inside the virtual landscape to plan the laparoscopic procedure.

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