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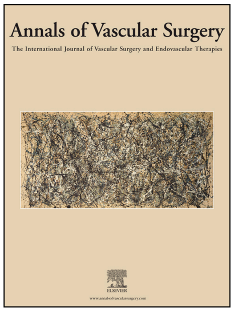

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PII: S0890-5096(18)30856-2

DOI: https://doi.org/10.1016/j.avsg.2018.08.088

Reference: AVSG 4094

To appear in: *Annals of Vascular Surgery*

Received Date: 11 February 2018

Revised Date: 4 June 2018

Accepted Date: 8 August 2018

Please cite this article as: Zhu C, Zhao J, Yuan D, Huang B, Yang Y, Ma Y, Xiong F, Endovascular and surgical management in intact splenic artery aneurysm, *Annals of Vascular Surgery* (2018), doi: https://doi.org/10.1016/j.avsg.2018.08.088.

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Endovascular and surgical management in intact splenic artery aneurysm

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Conflict of interests: None

Abstract

Objective

This study aims to reveal the experience with endovascular and surgical management of intact splenic artery aneurysms in our single center.

Method

Between January 2011 and June 2017, 42 patients with intact splenic artery aneurysm were enrolled in this study. Twenty patients undergoing surgical intervention were classified as the surgical group, and twenty-two patients who received endovascular repair were categorized as the endovascular group. Demographic data, preoperative comorbidities, and aneurysm anatomical characteristics were collected and analyzed. Details of interventions, perioperative outcomes, and follow-up results were evaluated and compared between the two groups.

Results

Forty-two patients with a mean age of 53.4±11.6 years were enrolled in this study, and 44 aneurysms were repaired. Thirty-nine (92.9%) patients were asymptomatic, and three (7.1%) patients were symptomatic. The diameter of splenic artery aneurysms was 3.3±1.6 cm, and the shape was mostly saccular. In the surgical group, the common methods used were splenic artery aneurysm resection (nine patients), followed by splenic artery aneurysms resection and splenectomy (six patients), splenic artery aneurysm resection and arterial reconstruction with end-to-end

anastomosis (three patients), and laparoscopic splenic artery aneurysm resection coexisting with splenectomy (two patients). In the endovascular group, the exclusive means was embolization with coils. The technical success rates in open repair and endovascular repair were both 100%. The 30-day mortality was nil, and no severe complication was found in early time except that one patient suffered multiple splenic abscess in the endovascular group after embolization. Endovascular repair had significantly shorter surgery time (82.5±27.6 vs 191.9±62.7 min, p <0.001) and hospital stay (5.6±3.1 vs 10.8±5.2 days, p <0.001) compared with open repair. The median follow-up time in this study was 34.5 (IQR 16.8-60.8) months. Two sac reperfusions were detected during the follow-up in the endovascular group, and patients needed new embolization. No late deaths were found in the follow-up time, and the freedom from reintervention in the endovascular group at 1 and 3 years postoperatively was 95.5% and 82.4%, respectively. In addition, the freedom from reintervention in the surgical group at 1 and 3 years postoperatively were both 100%. No significant differences were observed in late survival and reintervention between the open repair and endovascular repair.

Conclusion

Open repair and endovascular repair were equally feasible, safe, and effective for intact splenic artery aneurysm. Endovascular repair is less invasive accompanied with an obvious decrease in surgery time and rapid recovery with a short hospital time.

Keywords splenic artery aneurysm, open surgery , endovascular repair

Introduction

Visceral artery aneurysm is a rare disorder with an incidence rate of 0.1% to 2%[1], carrying the lethal consequence of aneurysm rupture. Splenic artery aneurysm is the most common type of visceral artery aneurysm, ranking the third-common abdominal aneurysm, followed by aortic and iliac artery aneurysms[2-3]. The majority of splenic artery aneurysm is asymptomatic and unexpectedly continues to increase as detected by imaging examinations. Clinical evidence in the management of splenic artery aneurysm is not optimal due to small size and retrospective nature of sample. In the past, surgical intervention is the standard management in splenic artery aneurysm, obtaining good long-term outcome[4]. In recent years, with the development of endovascular technology and devices, endovascular repair is becoming an alternative option for splenic artery aneurysm, possessing the advantage of low perioperative morbidity and mortality[5-6]. Previous studies usually mixed other types of visceral aneurysms and pseudoaneurysms[7-9], and clinical research concentrating on splenic artery aneurysm was lacking. This study aimed to reveal the experience with endovascular and surgical management of intact splenic artery aneurysms in our single center.

Patients and method

Patients

Patients diagnosed with splenic artery aneurysm admitted in West China Hospital between January 2011 and June 2017 were selected and reviewed. Patients with splenic artery pseudoaneurysm, rupture splenic artery aneurysm or receiving conservative treatment were excluded in this study. This study was approved by the Review Board of West China Hospital, and the informed consent was waived due to retrospective nature.

Demographic data of patients, preoperative comorbidities, and aneurysm anatomical characteristics were collected and analyzed. Preoperative assessments of comorbidities contained hypertension, diabetes mellitus, renal insufficiency, malignancy, aortic aneurysm, and portal hypertension. Prior to elective intervention, patients received elaborate assessment of aneurysm characteristics by computed tomographic angiography (CTA) or magnetic resonance angiography (MRA). Women at child-bearing age accepted pregnancy testing upon admission. Details of endovascular or

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surgical procedures were collected. Postoperative incidents, such as mortality, complications, and reintervention, were also collected.

Definition

Intact splenic artery aneurysm was defined as that three layers of arterial wall were integrated in preoperative CTA or MRA. Symptomatic patient presented with positive symptoms attributed to splenic artery aneurysm, such as abdominal pain. However, asymptomatic patient was incidental identifications during imaging techniques and referred for other disorders. Measurements of diameter characteristics were applied by the method of central line from adventitia to adventitia in CTA or MRA. The location of splenic artery aneurysm was categorized into four groups, namely, proximal, middle, distal, and hilum. Thirty-day mortality was defined as all causes of death incidence occurring in 30 days after intervention or during initial hospital time.

Intervention

The indication for intervention was that the diameter of splenic artery aneurysm was equal or greater than 2.0 cm in asymptomatic patients, or symptomatic patients without the diameter limitation. The option of intervention method relied on aneurysm anatomy, patient’s general condition, and surgeon preferences. Recently, the advantage of endovascular management on low perioperative morbidity and mortality is widely accepted[5,7,10]. In general, endovascular interventions have become the first choice in suitable anatomical condition in our institution, which aneurysms present with adequate neck and limited tortuosity. If young patients possess with good general status or maintaining blood supply for end organ is crucial, surgical repair will be a considerable option. Common femoral artery was the preferred access approach, and left brachial artery was the alternative option when the iliac artery was severe tortuous or celiac trunk took off the aorta at a steep angle. All patients received intraoperative heparinization (sodium heparin 75IU/kg, intravenous). If splenic artery aneurysm was tortuous, a long sheath was advanced in celiac trunk or further into splenic artery. The endovascular intervention was applied occluding the outflow tract, aneurysm itself, and inflow tract in proper order with coils. The technical success in endovascular repair was defined as aneurysmal occlusion in final angiography, satisfactory deployment of coils in planed location without migration, and no conversion to laparotomy. Open surgery usually employs median abdominal incision to entirely remove the aneurysm. If possible, revascularization splenic artery was performed by end-to-end anastomosis or bypass with graft or autologous saphenous vein. If patients were found to accompany with megalosplenia or aneurysm located in the hilum or intrasplenic, splenectomy was simultaneously performed.

Follow-up

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All patients with splenic artery aneurysm received strict follow-up. Patients receiving endovascular repair were advised abdominal computed tomography (CT) angiography 1 and 6 months postoperatively and annually. Outpatients were followed up thereafter. Duplex ultrasound (DU) was suggested to patients with surgical repair at 1 and 6 months postoperatively and annually, and outpatients were also followed up thereafter. When presented with good clinical outcome, all patients selected DU follow-up after the first year. Moreover, when a suspicion of complication or adverse events is observed, CTA or MRA would be performed. Data on complications, reinterventions, and mortality were collected and analyzed in the follow-up period. The last follow-up period was closed on October 30, 2017.

Statistical method

Data analysis was performed using SPSS (Version 22.0, IBM Corp, USA). Continuous variables were recorded as mean±standard deviation, and categorical variables were accounted as N%. According to the nature of characteristics, suitable statistical methods were selected to compare the differences between the endovascular repair group and the surgical repair group. Freedom from reintervention adopted the means of Kaplan–Meier analysis, and log-rank test was used to compare the differences between the two groups. Statistical significance was defined as p value<0.05 with two-sided test.

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Results

Baseline and aneurysm anatomical characteristics

According to the criteria in this study, 42 patients diagnosed with intact splenic artery aneurysm were enrolled. Among them, 20 patients receiving surgical repair were classified as the surgical group, whereas 22 patients treated with endovascular repair were categorized as the endovascular group. In total, the mean age was 53.4±11.6 years, and 61.9% (26) of this study were females. The mean age of the surgical group was 50.7±13.9 years, whereas that in the endovascular group was 55.9±8.5 years. The details of baseline and preoperative comorbidities in this cohort and its subgroups are shown in Table □. Thirty-nine (92.9%) patients were asymptomatic, and three (7.1%) patients were symptomatic presenting with abdominal pain. Pregnancy tests in females at child-bearing age in the study were all negative. No significant differences were found between the surgical group and the endovascular group in baseline and preoperative comorbidities.

The diameter of splenic artery aneurysms was 3.3±1.6 cm, and the shape was mostly saccular (88.6%). In this cohort, 44 aneurysms were repaired, and two patients presented double splenic artery aneurysm. The locations of splenic artery aneurysms in proximal, middle, and distal or hilum were found in 12 (27.3%), 10 (22.7%), and 22 (50.0%) patients, respectively. An anomalous splenic artery origin was observed from superior mesenteric artery in the endovascular group. Abdominal aorta diameter at the celiac trunk level was 2.0±0.2 cm in these patients. The descriptions of anatomical characteristics in splenic artery aneurysms are demonstrated in Table □. Differences of these indexes between the surgical group and endovascular group were not significant.

Data of surgical repair and endovascular repair

In the surgical group, the common methods used were splenic artery aneurysm resection (nine patients), followed by splenic artery aneurysms resection and splenectomy (six patients), splenic artery aneurysm resection and arterial reconstruction with end-to-end anastomosis (three patients), and laparoscopic splenic artery aneurysm resection+ splenectomy (two patients). All patients in this group were under general anesthesia. The technical success was 100% in the surgical group, and no adverse incidents were detected in these procedures. The mean surgery time was 191.9±62.7 min.

In the endovascular group, the exclusive means was embolization with coils. All patients in this group were under local anesthesia. The majority of approach access was femoral artery (21 patients, 95.5%), followed by brachial artery (1 patients, 4.5%). The technical success in the endovascular group was 100%. The mean intervention time was 82.5±27.6 min. The details of surgical and endovascular repair are summarized in Table □. Compared with surgical repair, endovascular

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repair has significant advantages of shorter surgery time (p<0.001) .

Early and late follow-up outcomes

No early death case was found, and 30-day mortality was nil. The mean hospital stay was 8.1±5.0 days. Endovascular repair showed significant shorter hospital stay compared with open repair (5.6±3.1 vs 10.8±5.2 days, p<0.001). In the surgical group, two patients suffered pulmonary infection with prolonged hospital time, and no severe wound complications, pancreatitis, and reinterventions were found. In patients with splenectomy, no serious infections were observed during hospital time. In the endovascular group, five (22.7%) patients suffered from post-embolization syndrome (PSE). They presented light fever, abdominal pain, and elevated leukocyte level. In addition, their serologic test and blood cultures results were negative. They underwent antibiotic and analgesia therapy and soon recovered without sequelae. One patient showed multiple splenic abscess with severe abdominal pain and fever. Percutaneous splenic drainage was performed in this patient with the guide of an ultrasound. Meanwhile, this patient received strict antibiotic treatment. Fourteen days later, he fortunately recovered and was discharged with strict follow-up. No percutaneous complications were observed in the endovascular group. Vaccinations were offered if patients underwent splennectomy or suffered severe splenic infraction. The early and late outcomes in this study are summarized in Table 4.

The median follow-up time was 34.5（IQR 16.8-60.8）months, and one patient lost in 30-month follow-up in the endovascular group. No difference was observed in the follow-up time between the surgical group and the endovascular group (*p*=0.504). Late death was not detected in the follow-up time. No late complications and re-interventions in the surgical group were found. In addition, no overwhelming post-splenectomy infection (OSPI) occurred in patients with splenectomy. Three patients showed asymptomatic splenic infraction in the endovascular group, and no damage was found in the spleen function. Two sac reperfusions were detected in the 1 and 18 months after operation. All patients received re-endovascular repair of embolization with coils. No sac reperfusion was observed in subsequent follow-up time. No migration and rupture were found in the endovascular group during the follow-up time. According to the latest CT examination, the majority of splenic artery aneurysm was stable in the endovascular group (12 patients), and remaining aneurysm diameter decreased by 2.1 mm (10 patients). No enlargement was also detected. The freedom from reintervention in the endovascular group by the method of Kaplan–Meier statuses at 1 and 3 years postoperatively were 95.5% and 82.4%, respectively. In addition, the freedom from reintervention in the surgical group at 1 and 3 years postoperatively were both 100%. The endovascular group tended to have more reintervention than surgical repair with no significant difference (Fig 1, Log rank test

p=0.114).

Discussion

In our study, splenic artery aneurysm was dominantly confirmed in females, mostly asymptomatic and located in the distal or hilum. Open repair and endovascular repair were equally feasible, safe, and effective therapeutic methods. This result was concordant with previous studies[2-4,11-12].

Owing to the rarity of this disease, relevant studies were limited. The natural history of splenic artery aneurysm was undefined. Atherosclerosis, fibromuscular dysplasia, collagen weakness, and media degeneration might be involved in its pathogenesis[12]. Splenic artery aneurysm held a majority of female gender. Female dominance was relatively rare in aneurysm diseases, while the commonest aneurysm of abdominal aortic aneurysm owned male dominance[13]. Therefore, the influence of female hormone was highly skeptical[14], lacking solid evidence to support this finding. With the lack of high-quality evidence, such as randomized controlled trial or multiple center prospective studies, the management of splenic artery aneurysm still needs further studies. The worst consequence of this disability was rupture, leading to mortality of more than 20%[7]. Specific mechanism of aneurysm rupture was unclear. Preventing aneurysm rupture relied mainly on the management of

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aneurysm diameter. Symptomatic splenic artery aneurysm, pseudoaneurysm, and rupture cases reached an agreement of positive intervention[8]. However, management of asymptomatic splenic artery aneurysm was still controversial. The widely accepted criteria of cutoff was 2.0 cm[12,15-16]. Recently, because of the huge progress of less invasive and effective endovascular therapy, some researchers proposed to cut down the cutoff in selected patients[17]. Moreover, other investigators were inclined to raise the standard to 2.5 cm because of the very low rupture risk in aneurysm below the standard, supported by their retrospective studies[7]. In our perspective, the threshold of aneurysm diameter was still 2.0 cm, needing sufficient solid and high-quality evidence to modify it. Previous investigations demonstrated that patients with pregnancy or after liver transplantation have high-rupture risk. Thus, patients with above risks may benefit in positive intervention regardless of aneurysm size[14,18-19]. Preventing aneurysm rupture is always our primary goal, wherein future investigations are needed to certify the real cause of rupture to attain patient-tailed suggestion for elective intervention.

Before the invention of endovascular techniques, open repair is the sole surgical option, which obtained good longtime outcome[4]. In previous studies, open repair for visceral artery aneurysm tended to link with relatively high mortality and surgical risks[3]. However, because of the

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overwhelming majority of perioperative deaths owing to rupture individuals, the safety of open repair for intact splenic artery aneurysm was very satisfactory. Skukla et al. demonstrated that intact aneurysms had the significant lower mortality than rupture aneurysms, and the perioperative mortality in intact aneurysm was 0%[7]. In this study, the 30-day mortality was 0%, and no serious complications and reinterventions in follow-up time were found. The role of open repair is irreplaceable in the current endovascular era. Laparoscopic and robot-assisted techniques were invented to offset the shortage of open repair. The samples undergoing laparoscopic techniques were limited. Comparing between laparoscopic techniques and traditional open repair were also not performed in this study. The relative studies concentrating on splenic artery aneurysm was insufficient. Tiberio and his colleagues found the advantage of reducing postoperative complications in laparoscopic repair compared with open repair for splenic artery aneurysm[20]. Additionally, Giulianotti et al. found that robot-assisted treatment of splenic artery aneurysm is an effective method[21]. The invasiveness of these methods mainly draws from experiences of other territories. In the future, laparoscopic and robotic-assisted techniques might play a more important role in open repair management of splenic artery aneurysm.

Endovascular techniques are a revolutionary progress, especially beneficial for high-risk patients. In our study, endovascular repair of embolization with coils demonstrated excellent technical success and satisfactory middle outcome. The sacrifice of the splenic artery through embolization to exclude aneurysm was safe and feasible because of the good collateral circulation of short-gastric artery and gastroduodenal artery[22]. However, end-organ ischemia risk emerged after this intervention, especially in distal cases. The most common ischemia incidents were PSE. In our study, the PSE rate was 31.8%. Fortunately, all patients recovered with short-term conservative treatment. This result demonstrated that PSE was not equal to splenic infraction and can be a conservative management without sequelae. This finding was also confirmed in previous studies[23]. Only one patient suffered with severe end-organ ischemia of splenic abscess after endovascular repair. In the follow-up time, two patients presented with sac reperfusion, suggesting that patients with endovascular repair need strict surveillance postoperatively. To decrease this risk of sac reperfusion, some investigators apply embolization with coils accompanied with glues (such as n-butyl cyanoacrylate). This method achieved good clinical outcome without increasing ischemia risk[23]. However, further evidence is needed to testify this result. Recently, the importance of protecting normal splenic artery blood flow to maintain spleen function is gradually recognized. With the help of advanced endovascular techniques and flexible small-covered stent, endovascular repair with covered stent had already be an alternative choice. Previous studies showed that this method displays high-success rate, low mortality and morbidity, and good longtime patency in limited samples[24]. This method also restricted rigid anatomical aneurysm conditions in endovascular techniques and suitable endovascular devices. Moreover, a minimal splenic artery aneurysm was observed, especially invloved in its major branches repaired by multilayer layer stent with flow redirection, obtaining satisfied short-time outcome[25]. In general, embolization is a relatively simple and effective method in repairing splenic artery aneurysm, and planting covered stent to reserve normal blood flow is an alternative option. In our opinion, endovascluar repair also have anatomatic restrictions, which include deficiency of adequate neck or sealing zones, extremely tortuous access to target aneurysm, large aneurysm located at hilum of spleen, and splenic artery aneurysm involved in major branches for providing essential blood supply for end-organ.

No significant difference was observed in technical success and middle-time outcome between open repair and endovascular repair in this study. Meanwhile, endovascular repair is less invasive, obviously decreasing the surgery time, anesthesia risk, and short hospital time. This result consisted with other researches[7,11]. Both two methods were safe and effective in the management of intact splenic artery aneurysm.

Undeniably, these methods also have their own pros and cons. Endovascular repair becomes increasingly popular in the field of vascular surgery because it is safe, effective, and less invasive. Chin et al.'s population-based evaluation in the management of visceral aneurysm demonstrated that endovascular management compared with open repair is associated with decreased mortality and complications and shorter hospital days[10]. They further recommended this method as the first alternative option. In addition, systematic review and meta-analysis in the management of splenic artery aneurysm by Hogendoorn and his colleagues found that endovascular intervention improved short outcome by significantly decreasing perioperative mortality, and open repair was associated with few late complications and few reinterventions in follow-up time[26]. Many centers adopted the priority strategies of endovascular repair for splenic artery aneurysms. The authors of this study also hold the same attitude. However, we should also recognize the weakness of endovascular repair in increasing the risk of late complications and reinterventions in longtime follow-up. Meanwhile, perioperative risk of open repair for intact splenic artery aneurysm was very low and acceptable. In our study, perioperative mortality was nil, and all patients were successfully discharged. In selected patients, such as young patients with good general conditions, open repair may be a good option to obtain a good longtime outcome. Young patients might benefit in less late complication and reintervention and less radial exposure. In high-risk patients, endovascular repair will be an optimum choice. The comparison between the two methods still needs further high-quality studies. Patient-tailed management strategies might be mostly beneficial in optimal intervention in the future.

The limitations of this study were as follows. First, the nature of study was retrospective, and limited samples and follow-up time were applied in this study. Second, selection bias existed between the two interventions. Third, etiologies of splenic artery aneurysms were not included during the analysis. Lastly, the outcome of conservative treatment for small size splenic artery aneurysm was not included in this work.

Conclusion

Open repair and endovascular repair were equally feasible, safe, and effective for intact splenic artery aneurysm. Endovascular repair is less invasive accompanied with an obvious decrease in surgery time and rapid recovery with a short hospital time.

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References

1. Lakin RO, Kashyap VS. Splanchnic artery aneurysms. Rutherford's vascular surgery 2014; Chapter 141:2220-35.e4

2. Trastek V F, Pairolero P C, Joyce J W, et al. Splenic artery aneurysms. Surgery[J]. Surgery, 1982, 91(6):694-699.

3. Dave S P, Reis E D, Hossain A, et al. Splenic artery aneurysm in the 1990s[J]. Annals of Vascular Surgery, 2000, 14(3):223-229.

4. Pulli R, Dorigo W, Troisi N, et al. Surgical treatment of visceral artery aneurysms: A 25-year experience[J]. Journal of Vascular Surgery, 2008, 48(2):334-342

5. Fankhauser G T, Stone W M, Naidu S G, et al. The minimally invasive management of visceral artery aneurysms and pseudoaneurysms[J]. Journal of Vascular Surgery, 2011, 53(4):966-970.

6. Ikeda O, Tamura Y, Nakasone Y, et al. Nonoperative management of unruptured visceral artery aneurysms: treatment by transcatheter coil embolization.[J]. Journal of Vascular Surgery, 2008, 47(6):1212-1219.

7. Shukla A J, Eid R, Fish L, et al. Contemporary outcomes of intact and ruptured visceral artery aneurysms.[J]. Journal of Vascular Surgery, 2015, 61(6):1442-7.

8. Pitton M B, Dappa E, Jungmann F, et al. Visceral artery aneurysms: Incidence, management, and outcome analysis in a tertiary care center over one decade[J]. European Radiology, 2015, 25(7):2004-2014.

9. Marone E M, Mascia D, Kahlberg A, et al. Is open repair still the gold standard in visceral artery aneurysm management?[J]. Annals of Vascular Surgery, 2011, 25(7):936-946.

10. Chin J A, Heib A, Ochoa Chaar C I, et al. Trends and outcomes in endovascular and open surgical treatment of visceral aneurysms[J]. Journal of Vascular Surgery, 2017, 64(3):833-834.

11. Batagini N C, El-Arousy H, Clair D G, et al. Open versus endovascular treatment of visceral artery aneurysms and pseudoaneurysms[J]. Annals of Vascular Surgery, 2016, 35(3):1-8.

12. Abbas M A, Stone W M, Fowl R J, et al. Splenic artery aneurysms: two decades experience at Mayo clinic.[J]. Annals of Vascular Surgery, 2002, 16(4):442-449.

13. Wilmink A B, Quick C R. Epidemiology and potential for prevention of abdominal aortic aneurysm[J]. Br J Surg, 1998, 85(2):155-162.

14. Sadat U, Dar O, Walsh S, et al. Splenic artery aneurysms in pregnancy--a systematic review.[J]. International Journal of Surgery, 2008, 6(3):261-265.

15. Carr S C, Pearce W H, Vogelzang R L, et al. Current management of visceral artery aneurysms.[J]. Surgery, 1996, 120(4):633-4.

16. Chiesa R, Astore D, Guzzo G, et al. Visceral Artery Aneurysms[J]. Annals of Vascular Surgery, 2005, 19(1):42-48.

17. Regus S, Lang W. Management of true visceral artery aneurysms in

ACCEPTED MANUSCRIPT

31 cases[J]. Journal of Visceral Surgery, 2016, 153(5):347-352.

18. Panayiotopoulos Y P, Assadourian R, Taylor P R. Aneurysms of the visceral and renal arteries[J]. Ann R Coll Surg Engl, 1996, 78(5):412-419.

19. Heestand G, Sher L, Lightfoote J, et al. Characteristics and management of splenic artery aneurysm in liver transplant candidates and recipients[J]. American Surgeon, 2003, 69(11):933-40.

20. Tiberio G A, Bonardelli S, Gheza F, et al. Prospective randomized comparison of open versus laparoscopic management of splenic artery aneurysms: a 10-year study[J]. Surgical Endoscopy, 2012:1-7.

21. Pier C. Giulianotti, Nicolas C. Buchs, Andrea Coratti, et al. Robot-Assisted Treatment of Splenic Artery Aneurysms[J]. Annals of Vascular Surgery, 2011, 25(3):377-83.

22. Pasha SF, Gloviczki P, Stanson AW, Kamath PS. Splanchnic artery aneurysms. Mayo Clin Proc 2007;82(4):472–9

23. Lakin R O, Bena J F, Sarac T P, et al. The contemporary management of splenic artery aneurysms[J]. Journal of Vascular Surgery, 2011, 53(4):958.

24. Cappucci M, Zarco F, Orgera G, et al. Endovascular treatment of visceral artery aneurysms and pseudoaneurysms with stent-graft: Analysis of immediate and long-term results.[J]. Cir Esp, 2017.

25. Ruffino M A, Rabbia C. Endovascular Repair of Peripheral and Visceral Aneurysms With the Cardiatis Multilayer Flow Modulator:

ACCEPTED MANUSCRIPT

One-Year Results From the Italian Multicenter Registry[J]. Journal of Endovascular Therapy An Official Journal of the International Society of Endovascular Specialists, 2012, 19(5):599-610.

26. Hogendoorn W, Lavida A, Hunink M G, et al. Open repair, endovascular repair, and conservative management of true splenic artery aneurysms.[J]. Journal of Vascular Surgery, 2014, 60(6):1667-1676.

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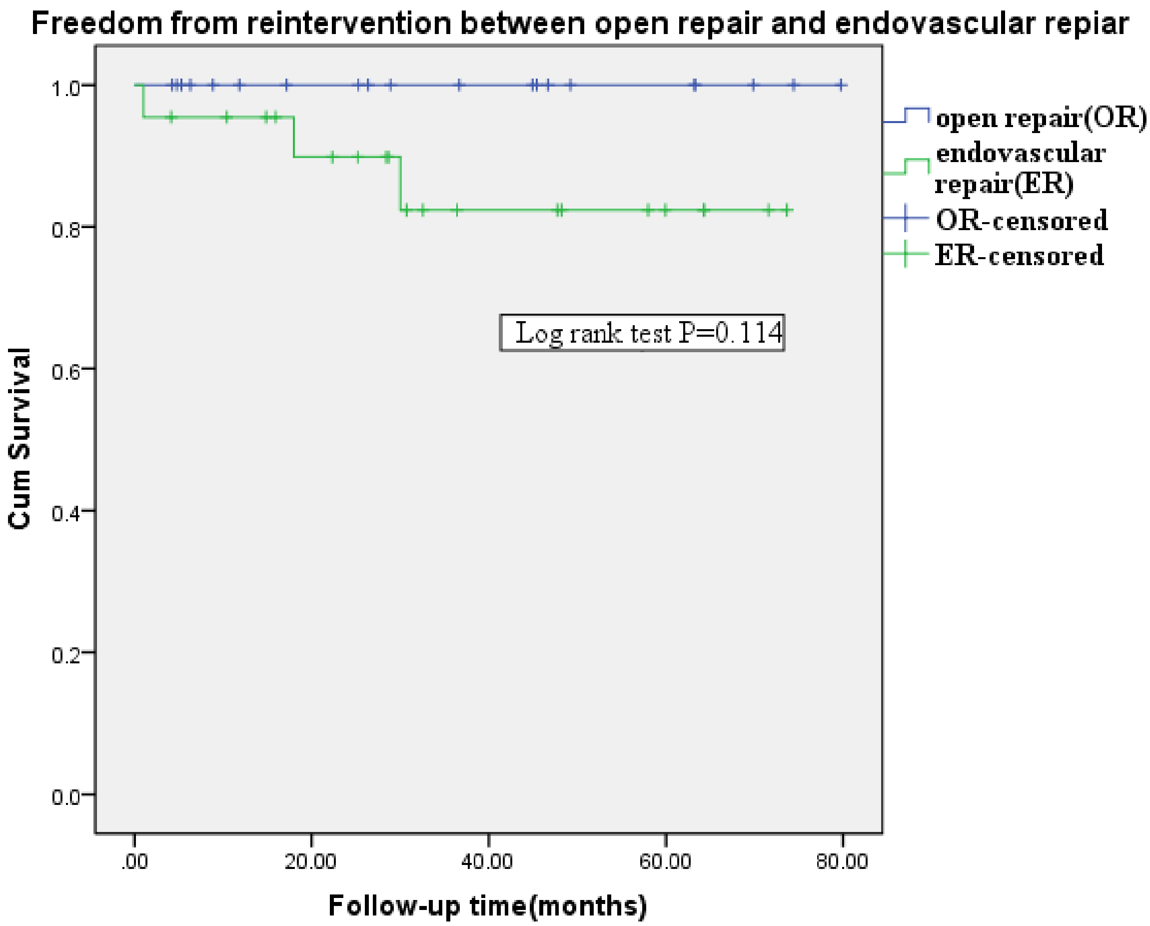
Fig 1 Kaplan-Meier analysis of freedom from reintervention



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