

## REVIEW ARTICLES

Richard P. Cambria, MD, Section Editor

# Open repair, endovascular repair, and conservative management of true splenic artery aneurysms

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**Objective:** True splenic artery aneurysms (SAAs) are a rare but potentially fatal pathology. For many years, open repair (OPEN) and conservative management (CONS) were the treatments of choice, but throughout the last decade endovascular repair (EV) has become increasingly used. The purpose of the present study was to perform a systematic review and meta-analysis evaluating the outcomes of the three major treatment modalities (OPEN, EV, and CONS) for the management of SAAs.

**Methods:** A systematic review of all studies describing the outcomes of SAAs treated with OPEN, EV, or CONS was performed using seven large medical databases. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to ensure a high-quality review. All articles were subject to critical appraisal for relevance, validity, and availability of data regarding characteristics and outcomes. All data were systematically pooled, and meta-analyses were performed on several outcomes, including early and late mortality, complications, and number of reinterventions.

**Results:** Original data of 1321 patients with true SAAs were identified in 47 articles. OPEN contained 511 patients (38.7%) in 31 articles, followed by 425 patients (32.2%) in CONS in 16 articles and 385 patients (29.1%) in EV in 33 articles. The CONS group had fewer symptomatic patients (9.5% vs 28.7% in OPEN and 28.8% in EV;  $P < .001$ ) and fewer ruptured aneurysms (0.2% vs 18.4% in OPEN and 8.8% in EV;  $P < .001$ ), but no significant differences were found in existing comorbidities. CONS patients were usually older and had smaller-sized aneurysms than patients in the OPEN and EV groups. The only identified difference in baseline characteristics between OPEN and EV was the number of ruptured aneurysms (18.4% vs 8.8%;  $P < .001$ ). OPEN had a higher 30-day mortality than EV (5.1% vs 0.6%;  $P < .001$ ), whereas minor complications occurred in a larger number of the EV patients. EV required more reinterventions per year (3.2%) compared with OPEN (0.5%) and CONS (1.2%;  $P < .001$ ). The late mortality rate was higher in patients treated with CONS (4.9% vs 2.1% in OPEN and 1.4% in EV;  $P = .04$ ).

**Conclusions:** EV of SAA has better short-term results compared with OPEN, including significantly lower perioperative mortality. OPEN is associated with fewer late complications and fewer reinterventions during follow-up. Patients treated with CONS showed a higher late mortality rate. Ruptured SAAs are predictors of a significantly higher perioperative mortality compared with nonruptured SAAs in the OPEN and EV groups. (*J Vasc Surg* 2014;60:1667-76.)

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Additional material for this article may be found online at [www.jvascsurg.org](http://www.jvascsurg.org). Reprint requests: Bauer E. Sumpio, MD, PhD, 333 Cedar St, BB 204, New Haven, CT 06510 (e-mail: [bauer.sumpio@yale.edu](mailto:bauer.sumpio@yale.edu)).

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True splenic artery aneurysms (SAAs) are a rare but potentially fatal pathology. The splenic artery is considered aneurysmal when the size of the artery is  $>1$  cm in diameter. True SAAs are defined as expansions of all wall layers, whereas pseudoaneurysms are defined as expansions of the artery with focal disruption of the arterial wall.<sup>1</sup> Although rare, SAAs are the third most common abdominal aneurysms after aortic and iliac artery aneurysms and account for almost all visceral artery aneurysms.<sup>2</sup> Previous studies have shown a high risk for SAA rupture when the aneurysm measures  $>2$  cm.<sup>3,4</sup> Although most SAAs are asymptomatic, they have the potential to rupture, which can result in life-threatening complications.<sup>2-5</sup> This emphasizes the importance of continued surveillance of SAAs and timely intervention if the SAA reaches the threshold limit.

SAA was first described in 1770 by Beaussier,<sup>6</sup> but surgical repair was not reported until 1940.<sup>7</sup> Open repair (OPEN) or conservative management (CONS) was the treatment of choice for many years. During the last decade, however, endovascular repair (EV) of SAAs has been increasingly used with good short-term results.<sup>8-11</sup> Because this disease is rare, most studies are retrospective, reporting only a small number of patients, and therefore, no Level I evidence is available.

With the more frequent use of diagnostic tests, there has been an increase in the detection of SAAs and, thus, an increasing need for clear directives. The current general consensus has been to intervene in all symptomatic patients and aneurysms >2 cm in diameter, but no clear guidelines for indications of treatment have been reported. All three management options have pros and cons. OPEN has shown excellent long-term results but high perioperative mortality.<sup>12-15</sup> EV has shown low short-term morbidity and mortality but a higher reintervention rate as result of long-term complications.<sup>8-11</sup> CONS has no immediate procedural risk but an increasing risk of aneurysm rupture potentially resulting in life-threatening hemorrhage.<sup>2-5</sup> However, most evidence is disseminated over several smaller studies over a broad period of time, and no clear overviews, guidelines, or management recommendations are available.

The purpose of the present study was to perform a systematic review and meta-analysis evaluating the outcomes of the three treatment modalities—OPEN, EV, and CONS—for the management of SAAs, taking into account the clinical presentation.

## METHODS

**Literature search.** The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to perform this systematic review and meta-analysis.<sup>16</sup> To identify all articles describing treatment of SAAs, MEDLINE, EMBASE, Web of Science, Scopus, PubMed as supplied by the publisher, Cochrane Library Central, and Google Scholar were systematically searched through December 12, 2013. No publication date restriction was applied.

The following search string was used for EMBASE: (“spleen artery aneurysm”/de or (“spleen artery”/de or spleen/de) and (“aneurysm surgery”/exp or aneurysm/exp)) or ((spleen or splenic) NEAR/3 aneurysm\*):ab,ti) and (therapy/exp or therapy:lnk or surgery/exp or surgery:lnk or procedures/de or (therap\* or treat\* or curing or cure or repair or technique\* or procedure\* or equipment\* or surg\* or operat\*):ab,ti). This resulted in 1121 articles. A similar search string was used for other search engines. Details of search strings and number of articles can be found in the [Appendix](#) (online only). We identified 2702 articles, and after removal of duplicate articles, 1490 unique articles remained.

**Selection of articles.** Review of titles and abstracts was performed independently by two investigators (W.H. and A.L.). For a report to be excluded, both reviewers had to

agree that the article was ineligible for inclusion. Disagreements between reviewers were discussed and resolved by consensus. Articles were included if (1) original data of characteristics and outcomes of true SAAs were reported, (2) they described OPEN, EV, or CONS management, and (3) reported at least 10 patients, because case reports and case series have the tendency toward publication bias, only reporting successful cases.<sup>17</sup> Exclusion criteria included (1) articles without original data, (2) articles specifically reporting pregnant patients with SAAs because of the different pathophysiology, (3) not describing OPEN, EV, or CONS management, (4) describing false/pseudoaneurysms, (5) if there was no clear distinction between splenic aneurysms and visceral aneurysm, and (6) if no useful information regarding the outcomes was presented. To prevent inclusions of duplicate cases, articles published by identical authors or institutions were studied in detail, and the most recent article was included.

Because administrative data (eg, Medicare files) are considered to be less reliable and less consistent and could have been published previously in other included articles, these articles were not included. To identify additional relevant articles, references of included articles were searched manually and retrieved three additional articles. A total of 47 relevant articles were identified and included in the final selection ([Fig 1](#)).

**Data extraction.** Two independent investigators (W.H., A.L.) analyzed the included articles and extracted the data. All extracted characteristics and outcomes were systematically included in a database. If a variable was described only for the whole group in an article that described multiple types of treatment, but not specific for OPEN, EV, or CONS, this variable was not included in the analysis. The variables extracted included year of publication, institution, number of patients, number of aneurysms, age, sex, size of the SAA, percentage of symptomatic patients, type of symptoms, percentage of ruptures, number of patients with hypertension, hyperlipidemia, diabetes mellitus, coronary artery disease, number of patients smoking, type of treatment, type of intervention, type of surgery, number of splenectomies, elective or emergency cases, technical success, conversion from EV to OPEN, 30-day minor complications, type of morbidity, major complications, 30-day mortality, cause of death <30 days, late complications, late (>30 days) mortality, number of reinterventions, hospital length of stay in days, length of follow-up in months, number lost to follow-up, and overall survival. Patient selection was based on the recommendations of the Quality of Reporting of Meta-analyses (QUOROM) statement.<sup>18</sup> Additional information on the exact techniques used for OPEN and EV is beyond the scope of this report, but the relevant information is addressed in the referenced article.<sup>19</sup> Original data of 1321 patients with true SAAs treated with OPEN, EV, or CONS were analyzed.

**Statistical analyses.** Statistical analyses were performed using IBM SPSS 22.0 software (IBM Corp, Armonk, NY), Review Manager (RevMan) 5.2 software

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