Cost-effectiveness of endovascular repair, open repair, and conservative management of splenic artery aneurysms

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Objective: **Open repair (OPEN) and conservative management (CONS) have been the treatments of choice for splenic artery aneurysms (SAAs) for many years. Endovascular repair (EV) has been increasingly used with good short-term results. In this study, we evaluated the cost-effectiveness of OPEN, EV, and CONS for the treatment of SAAs.**

Methods: **A decision analysis model was developed using TreeAge Pro 2013 software (TreeAge Inc, Williamstown, Mass) to evaluate the cost-effectiveness of the different treatments for SAAs. A hypothetical cohort of 10,000 55-year-old female patients with SAAs was assessed in the reference-case analysis. Perioperative mortality, disease-specific mortality rates, complications, rupture risks, and reinterventions were retrieved from a recent and extensive meta-analysis. Costs were analyzed with the 2014 Medicare database. The willingness to pay was set to $60,000/quality-adjusted life years (QALYs). Outcomes evaluated were QALYs, costs from the health care perspective, and the incremental cost-effectiveness ratio (ICER). Extensive sensitivity analyses were performed and different clinical scenarios evaluated. Probabilistic sensitivity analysis was performed to include the uncertainty around the variables. A flowchart for clinical decision-making was developed.**

Results: **For a 55-year-old female patient with a SAA, EV has the highest QALYs (11.32; 95% credibility interval [CI], 9.52-13.17), followed by OPEN (10.48; 95% CI, 8.75-12.25) and CONS (10.39; 95% CI, 8.96-11.87). The difference in effect for 55-year-old female patients between EV and OPEN is 0.84 QALY (95% CI, 0.42-1.34), comparable with 10 months in perfect health. EV is more effective and less costly than OPEN and more effective and more expensive compared with CONS, with an ICER of $17,154/QALY. Moreover, OPEN, with an ICER of $223,166/QALY, is not cost-effective compared with CONS. In elderly individuals (age >78 years), the ICER of EV vs CONS is $60,503/QALY and increases further with age, making EV no longer cost-effective. Very elderly patients (age >93 years) have higher QALYs and lower costs when treated with CONS. The EV group has the highest number of expected reinterventions, followed by CONS and OPEN, and the number of expected reinterventions decreases with age.**

Conclusions: **EV is the most cost-effective treatment for most patient groups with SAAs, independent of the sex and risk profile of the patient. EV is superior to OPEN, being both cost-saving and more effective in all age groups. Elderly patients should be considered for CONS, based on the high costs in relation to the very small gain in health when treated with EV. The very elderly should be treated with CONS. (J Vasc Surg 2015;61:1432-40.)**

Splenic artery aneurysms (SAAs) are a rare clinical entity that carry the risk of rupture and fatal hemorrhage. SAAs are the third most common intra-abdominal aneurysms[1] and are increasingly diagnosed due to the wider use of cross-sectional imaging.[2] Although most SAAs are asymptomatic, previous studies have shown that SAAs, and particularly those sized >2 cm, can rupture, resulting in potentially life-threatening complications.[3-5] To treat symptoms and prevent complications, SAA repair is often required.

Conservative management (CONS) and open repair (OPEN) were the preferred treatment options for many years. Endovascular repair (EV) of SAAs has been increasingly used since 2000, and a recent extensive meta-analysis reported superior short-term outcomes for EV compared with OPEN.[6] However, considering the better long-term results of OPEN compared with EV and CONS shown in the meta-analysis, the preferred treatment option for patients with a SAA is still matter of debate, and no clear treatment guidelines exist. In addition, EV is usually accompanied by higher intervention costs and more reinterventions.[6] Thus, the treatment of a patient with an SAA is not a straightforward decision. Importantly, a

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Author conflict of interest: none.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

http://dx.doi.org/10.1016/j.jvs.2014.12.064

contemplated decision should not only be based on the expected mortality and complications but should also account for quality of life (QOL), associated interventional and lifetime costs, and expected reinterventions.

The purpose of this study was to use a clinical decision model to assess the cost-effectiveness of the three major treatment modalities for treatment of SAAs. The secondary objective was to provide guidance for the treatment of a patient with a SAA with regards to patient age, sex, and risk profile as well as associated costs, QOL, and expected reinterventions.

METHODS

A Markov cohort model was constructed using TreeAge Pro 2013 software (TreeAge Inc, Williamstown, Mass) to assess the cost-effectiveness from the health care perspective of OPEN, EV, and CONS for 10,000 hypothetical patients treated for an SAA. In a Markov model, a patient is always in one of a finite number of discrete health states, and the prognosis of clinical problems with risks that change over time can be analyzed. No actual patients were involved, and therefore, no Investigational Review Board or patient consent was required. All possibilities are modeled as transitions from one health state to another. Each health state is assigned a QOL value, and the contribution of this QOL value to the overall outcome of the different strategies depends on the time spent in this health state.[7] Overall outcomes are given in quality-adjusted life years (QALYs).

Decision model. All patients entered the model with a SAA of 2.0 cm. Patients in the OPEN and EV groups started immediately with an intervention and could transition to the following health states:

- Well after intervention, if only the aneurysm was excluded;
- Well after splenectomy, if an additional splenectomy was performed;
- Major complications if a major complication occurred and the patient had to stay significantly longer in the hospital or the patient died as result of the intervention and was thus in the dead health state.

Patients in the EV group could also transition to the OR group if a conversion was required. Patients originally treated with CONS management remained in this health state but were still at risk for complications or rupture of the SAA. If complications or a rupture occurred in these patients, an intervention with OPEN or EV was required. After this intervention, the same health states as described previously were possible. For subsequent years, patients could remain in their health state, could develop complications requiring a reintervention, or could die as a result of normal background mortality.

A simplified overview of the decision model and health states is depicted in Fig 1. The cycle length was 1 year, and the model cycled until all patients had died. To prevent overestimation or underestimation, a half-cycle correction was applied, because most events generally do not specifically occur at the beginning or end of a year but occur throughout a cycle.[8]

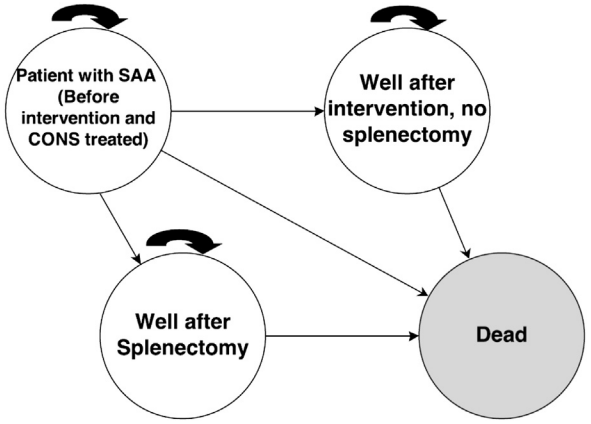

Fig 1. Simplified bubble diagram shows the Markov state transition model for treatment of splenic artery aneurysms (*SAA*). *CONS,* Conservative management.

Input variables. Most of the input variables were retrieved from a recent and extensive meta-analysis of the three major treatment options for patients with SAAs.[6] Input probabilities required for the model but not reported in the meta-analysis were retrieved from articles reporting the necessary probabilities. For example, the risk of infection, overwhelming postsplenectomy infection, percentage that required hospitalization, and mortality rate were extracted from studies reporting these outcomes.[9-14]

Because mortality rates in patients with SAAs are higher than those in the general population, disease-specific mortality rates were modeled. No specific mortality rates for patients with SAAs were reported; thus, mortality rates for patients with abdominal aortic aneurysms (AAAs) were used.[15] These mortality rates were assumed to be similar for patients with SAAs justified by the similar prevalence of diabetes, coronary artery disease, and hypertension. The prevalence of diabetes is 15% in patients with AAA vs 12% in patients with SAAs, and the prevalence is 13% vs 16% for coronary artery disease and 65% vs 48% for hypertension.[6,15] The mortality rates were tested over a wide range, including the mortality rate for AAA patients, to take the uncertainty around these mortality rates into account.

Relative risk was used to account for differences between the risk profiles of different patient groups. All the input variables used in the model are reported in Table I.

QOL values. QOL values were assigned to all health states. QOL values for patients with SAAs have not been reported; therefore, QOL values for patients with AAAs were used instead. These QOL values were assumed to be similar for patients with SAAs because both groups are usually asymptomatic and carry the risk of rupture and life-threatening hemorrhage. The same QOL values were used for patients after splenectomy because patients after splenectomy have not been proven to have a different