Splenic Artery Embolization: Have We Gone Too Far?

Hadley E. Smith, MD, Walter L. Biffl, MD, Sarah D. Majercik, MD, Jeff Jednacz, MD, Robert Lambiase, MD, and William G. Cioffi, MD

Background: Splenic artery angioembolization (EMBO) has been promoted to increase the success rate of nonoperative management of splenic injuries. Our institutional clinical pathway calls for EMBO in the setting of ongoing splenic bleeding or contrast blush on computed tomography scan. We perceived a higher rate of failure than that reported in the literature. The purpose of this study was to review our experience with splenic EMBO to identify predictors of failure of nonoperative/EMBO management.

Methods: The trauma registry and interventional radiology database of a Level I trauma center were reviewed for patients with splenic injuries from January 2000 through June 2004. Charts and films of patients undergoing EMBO were reviewed.

Results: There were 221 patients admitted with blunt splenic injuries. Of these, 165 (75%) were selected for nonoperative management; 41 (25%) of them underwent splenic EMBO. Of the 41, 11 patients (27%) failed nonoperative/EMBO management. Of nine patients with low-grade injury (I, II) and small or no hemoperitoneum, none failed EMBO, whereas 10 of 23 (43%) with high-grade injury (III, IV, V) and moderate or large hemoperitoneum failed. EMBO was more likely to fail if extravasation was seen on angiography (59% vs. 4%). Coils (vs. particles) and main (vs. selective) artery EMBO were more often successful. Of EMBO patients who experienced transient hypotension, 57% required splenectomy.

Conclusions: EMBO may have salvaged many spleens, but splenectomy was required in 27% of EMBO patients. Patient selection is critical to successful management. Any hypotension in the face of a contrast blush probably warrants laparotomy. The combination of high grade injury and significant hemoperitoneum, or extravasation on angiogram, predict a high risk of failure and thus warrant a low threshold for splenectomy if bleeding persists. Technical EMBO considerations may impact success, but this requires further investigation.

Key Words: Spleen, Embolization, Nonoperative management, Splenic injury, Trauma, Arteriography.


The management of splenic injuries has evolved over the past two decades. In an effort to minimize patient morbidity and preserve splenic function, nonoperative management of stable patients has become the standard of care. Early nonoperative failure rates were relatively high, and a number of investigators sought to identify risk factors for failure of nonoperative management. One particular finding that was associated with a high rate of failure was a contrast blush on initial computed tomography (CT) scan.

Splenic angioembolization (EMBO) was first described in 1981 by Sclafani as an effective means of achieving hemostasis of splenic injuries, and it became much more widely used in the late 1990s. Many individual institutional reviews have supported the use of EMBO to increase the success rate of nonoperative management, with failure rates as low as 5 to 7%. The Western Trauma Association (WTA) Multicenter Review reported an EMBO failure rate of 13%. Success rates decreased with increasing grade, but even the grade IV and V injuries had EMBO success rates >80%. Rhode Island Hospital (RIH) was one of the four contributing institutions, providing data through the year 2002. Our institutional clinical pathway has called for EMBO in the setting of contrast blush on CT scan or ongoing splenic bleeding. However, since our participation in the WTA review, we have perceived a higher rate of EMBO failure than that reported in the literature. Just as Velmahos and colleagues questioned the liberal use of nonoperative management of splenic injuries, we wondered if we had gone too far in employing EMBO as an alternative to operative intervention. The purpose of this study was to review our experience with splenic EMBO and to identify predictors of failure.

PATIENTS AND METHODS

RIH is a 719-bed American College of Surgeons-verified Level I trauma center. It is the only trauma center in Rhode Island and also serves as a referral center for southeastern Massachusetts and eastern Connecticut. A RIH institutional management algorithm for blunt splenic trauma was published in our Trauma Handbook in 1999 (Fig. 1). A stable patient with a splenic injury by CT scan is taken for EMBO if there is an arterial blush on CT. Additionally, patients without arterial blushes may be considered for EMBO if they show signs of ongoing bleeding attributed to the splenic injury. Embolization techniques (coil vs. particulate embolization and proximal vs. distal arterial embolization) are at the discretion of the attending interventional radiologist.

This study was approved by the Institutional Review Board of RIH. Trauma registry and interventional radiology databases

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were searched to identify all patients with blunt splenic injuries and those undergoing splenic artery EMBO between January 2000 through June 2004. A detailed chart review was performed for all patients undergoing EMBO. All of the admission CT scans were re-read and graded according to the AAST Spleen Injury Scale\(^4\) by a radiologist (R.L.) blinded to the clinical outcome. He also defined the degree of hemoperitoneum as none, small (perisplenic blood only), moderate (perisplenic plus paracolic blood) and large (blood in the pelvis).\(^4\) All EMBO studies were reviewed by the radiologist for techniques, findings, and results.

Statistical analysis was performed using the SAS System (SAS Institute, Cary, N.C.). Bivariate relationships between predictive factors were assessed using the Fisher’s Exact Test in the case of dichotomous variables and Pearson Correlation in the case of continuous variables. The predictive ability of factors was assessed using a multiple logistic regression with stepwise variable selection. Individual variables were sequentially added, or removed, based on significance level (Wald test) and the model re-assessed until only variables whose significance level was below 0.05 were remaining.

### RESULTS

During the study period, 221 patients were admitted with blunt splenic injuries. There were 151 (68%) male patients and 70 (32%) female patients with a mean age of 38 (range, 17–93). Fifty-six (25%) patients went directly to the operating room (OR) and underwent splenectomy (Table 1). Of the remaining 165, 124 (75%) were managed expectantly and 41 (25%) were taken for EMBO. The overall failure rate of nonoperative management was 14%. The failure rate increased with increasing injury grade for the overall group and for those managed without EMBO (Table 2). Of the patients who underwent EMBO, none of those with grade I or II injuries failed. However, 40% with grade III, 38% with grade IV, and 40% with grade V injuries ultimately required splenectomy. Overall, there was a 27% failure rate of EMBO.

Failure of EMBO as it related to degree of hemoperitoneum is shown in Table 3. Most patients undergoing EMBO and high hemoperitoneum (56%), but the failure rate was highest among those with moderate hemoperitoneum. If there was no or small hemoperitoneum, only 1 (8%) of 13 patients failed EMBO. This patient had a grade IV splenic injury. On the other hand, 10 (36%) of 28 with moderate or large hemoperitoneum failed. All had grade III, IV, or V injuries. Four of the 41 EMBO patients experienced transient hypotension in the emergency department (ED) and three of these patients ultimately required splenectomy.

Angiography appears to have good predictive value. Embolization was more likely to fail if active extravasation was seen on angiography before embolization (59%), versus 4% if no active extravasation was seen (odds ratio [OR] 32.9; 95% confidence interval [CI] 3.6–303.4). When active extravasa-

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### Table 1 Patients Treated for Blunt Splenic Injury

<table>
<thead>
<tr>
<th>AAST Grade</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>32</td>
<td>70</td>
<td>63</td>
<td>48</td>
<td>8</td>
<td>221</td>
</tr>
<tr>
<td>Direct to OR</td>
<td>1</td>
<td>4</td>
<td>20</td>
<td>28</td>
<td>3</td>
<td>56</td>
</tr>
<tr>
<td>Non-OP</td>
<td>31</td>
<td>66</td>
<td>43</td>
<td>20</td>
<td>5</td>
<td>165</td>
</tr>
</tbody>
</table>

OR, operating room; Non-OP, nonoperative management.

### Table 2 Failure Rates of Nonoperative Management, Without (No EMBO) and With (EMBO) Angioembolization

<table>
<thead>
<tr>
<th>Grade</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Failed</td>
<td>12</td>
<td>6</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>41</td>
</tr>
<tr>
<td>Non-OP</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>27</td>
</tr>
<tr>
<td>No EMBO</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>27</td>
</tr>
</tbody>
</table>

Non-OP, nonoperative management.
tion on angiography was combined with moderate or large hemoperitoneum, 10 out of 14 (71%) patients failed. One patient had an arteriovenous fistula, and he failed. Those who were embolized with occlusive particles such as gelfoam had a 50% failure rate, whereas those undergoing coil embolization failed 23% of the time. Selective distal embolization failed in 33% of the cases compared with main splenic artery failure rate of 22%. Fourteen patients had evidence of pseudoaneurysms on angiography, of whom four (29%) failed.

Nonoperative management and failure rates as they have changed over the study period are demonstrated in Table 4. The failure rate for nonoperative management was 18% in the final 18 months, compared with 10% in the prior 36 months. The increase in failures was predominantly in the EMBO group. Of note, the patients going directly to the OR increased from 17% in the first 18 months to 28% in the last 36 months of the study period.

**DISCUSSION**

Splenic salvage by nonoperative management has become the standard of care in treating splenic injuries in stable patients. Delayed rupture and ongoing bleeding remain the threats of nonoperative splenic trauma management. Therefore, predicting and possibly preventing this has become the most recent focus. A number of centers have reported their management protocols for splenic injuries. Sclafani and colleagues performed arteriography on all patients with splenic injuries and embolized injuries failed 23% of the time. Selective distal embolization failed in 33% of the cases compared with main splenic artery failure rate of 22%. Fourteen patients had evidence of pseudoaneurysms on angiography, of whom four (29%) failed.

Nonoperative management and failure rates as they have changed over the study period are demonstrated in Table 4. The failure rate for nonoperative management was 18% in the final 18 months, compared with 10% in the prior 36 months. The increase in failures was predominantly in the EMBO group. Of note, the patients going directly to the OR increased from 17% in the first 18 months to 28% in the last 36 months of the study period.

The overall failure rate of nonoperative management during the study period was 14%. The majority of these failures were among the group undergoing EMBO. This is not surprising, as these patients were selected for EMBO based on either radiographic or clinical evidence of active hemorrhage. However, the failure rate among our EMBO patients was 27%, which is much higher than that reported by individual institutional studies and the WTA multicenter trial. Our recognition of a recent increase in these failures prompted this review.

The largest single-center splenic injury series to date is the recent retrospective review of 648 patients by Haan and colleagues. Of their patients, 280 (43%) went directly to the OR. They reported 132 (20%) patients undergoing EMBO, with a failure rate of 10%. Although our EMBO failure rate is higher (27%), our initial operative rate is only 25%. Thus, when nonoperative failures are included, our total operative rate is 36%, compared with their total operative rate of 47%. Obviously, the primary concern is not the splenectomy rate, but patient safety. A secondary concern is resource utilization.

We could not find evidence that any patients were harmed by failed EMBO, although we recognize that it could be difficult to determine that with certainty. There were a number of complications related to EMBO, which in some cases led to the need for splenectomy. There were 3 procedural complications: a femoral artery dissection, a femoral artery arteriovenous fistula, and a splenic artery dissection. The third patient required splenectomy. One EMBO patient developed a splenic abscess requiring splenectomy, which was complicated by portal vein thrombosis. Another patient suffered a deep vein thrombosis requiring anticoagulation. One patient returned 1 month after injury with a symptomatic left pleural effusion requiring drainage. Seven patients experienced thrombocytosis, but none required treatment or had adverse effects.

We do not think we have simply shifted patients from the direct-to-OR group to the EMBO group. In fact, the direct-to-OR rate increased markedly from the first 18-month period.
(17%) to the later 36 months (28%). While the purpose of this study was not to evaluate the severity of injuries that present to our hospital, the trend of increasing numbers of patients requiring initial operative management suggests a more severely injured population in recent years. This is consistent with a recently published review of our experience over the past decade.15

Prior studies have suggested that extravasation on CT scan predicts a high risk of failure.8,12 Our clinical pathway dictates that if a patient has extravasation on CT scan, they undergo angiography and EMBO. If extravasation was still evident on angiography in this series, there was a 59% chance of failure, compared with only 4% if there was no extravasation seen. This, in fact, was the only variable significantly predictive of failure. Unfortunately, we have no way of predicting which patients with blush on CT scan will have a splenic arteriogram without extravasation. Thus, we cannot necessarily be more selective about sending patients for EMBO. Pseudoaneurysms have also been identified as a risk factor for failure.6 In the current study, 29% of those with evidence of pseudoaneurysms on angiography ultimately failed EMBO; roughly the same failure rate as those without pseudoaneurysms. A larger study might clarify whether pseudoaneurysms actually represent increased risk of failure. If so, it is possible that the newer-generation multidetector row CT scanners will be able to accurately distinguish pseudoaneurysms from extravasation.

Although the differences were not statistically significant, our data indicate a higher failure rate among older patients: 5 of 23 (22%) of patients age 55 or older failed, whereas 18 of 142 (13%) patients younger than 55 failed. In reviewing the hemodynamics of the EMBO patients, we found that four (10%) of the 41 who underwent EMBO had transient hypotension in the ED. There is little experience with embolizing patients who are transient responders. Hagiwara and colleagues16 have suggested that EMBO be used routinely in hypotensive patients who transiently respond to fluid administration. While the potential for splenic salvage is enticing, our 75% failure rate (3 of 4) in this group suggests that this course be undertaken with caution. We feel that any hypotension in the ED warrants close monitoring and a low threshold to fluid resuscitation.

In summary, our EMBO failure rate increased markedly in the most recent 18 months of our study period. While injury severity and embolization techniques may impact success, patient selection appears to be the critical factor. With the realization that angioembolization is not the panacea for splenic bleeding, we anticipate a correction in this trend. We recommend a low threshold to operate if there is any evidence of bleeding in an embolized patient who had extravasation on arteriography, if the patient is older than 55, or if there is a grade III to V injury combined with moderate or large hemoperitoneum. Further study is needed to determine the risks, benefits, and long-term ramifications of splenic EMBO.

REFERENCES

DISCUSSION

Dr. Kimberly A. Davis (Maywood, Illinois): Dr. Smith and her colleagues evaluated the Brown University, Rhode Island Hospital experience with failures of nonoperative management after embolization for blunt splenic injury. They identified transient hypotension, high splenic injury grade, volume of hemoperitoneum and frank contrast extravasation on angiography as predictive of high failure rates.

I have several questions. As you stratified your patient population, did you compare those patients with evidence of pseudoaneurysm, defined as a well-circumscribed intraparenchymal contrast collection, to those patients who had frank contrast extravasation on CT scan with respect to their failure rate of embolization?

The EAST multi-center trial by Dr. Peitzman and colleagues supports your findings that increased hemoperitoneum predicts failure with a reported failure rate in that study of 50% for moderate hemoperitoneum and 73% for large hemoperitoneum irrespective of grade. When one factors in the associated grade of injury, the failure rates were even higher with 12% of grade IV injuries and less than 5% of grade V injuries with large hemoperitoneum being managed successfully nonoperatively. Your management strategy of incorporating embolization has actually significantly improved upon those numbers with an overall failure rate of 36% or 10 of 28 patients. My questions are, therefore, how many of these patients of the 28 with moderate or large hemoperitoneum had active contrast extravasation on angiography, and how many had evidence of ongoing bleeding clinically? Is there a population in whom angiography is appropriate as a diagnostic modality, but who would benefit from early laparotomy rather than attempts at embolization?

Other authors have identified an age greater than 55 as a predictor of failure of nonoperative management. Recognizing your relatively small sample size and the possibility of a type II error, did you evaluate patient age relative to the failures that you identified?

The Western Trauma Association multi-center trial that you quoted by Dr. Haan and colleagues reported the role of repeat angiography to augment splenic salvage. Were any of your patients candidates for repeat angiography? Was this modality considered before proceeding with laparotomy?

Although it did not reach statistical significance in the WTA trial, the presence of arteriovenous (AV) fistula on angiography was associated with an increased failure rate. Did any of your patients have AV fistulae?

Finally, your conclusions state that patient selection is the key to the successful nonoperative management of blunt splenic injuries. Based on the data that you present here and your review of the literature, which patients should we, as clinicians, refer for angiography with attempted embolization?

Dr. Hadley E. Smith (Providence, Rhode Island): We had 14 patients who had pseudoaneurysms by angiography, and four of those ultimately ended up going to splenectomy. However, three of those four also had active extravasation, so it makes it difficult to tease out what contributions the pseudoaneurysm had.

However, because we had such a high amount of failure without active extravasation, I can imagine that it’s more than the pseudoaneurysms.

What we found interesting is in reviewing CT scans over 4 years later that it was actually difficult to identify the type of vascular injury that was present causing the bleeding.

In the later years, we have upgraded to 16-slice CT scans, and the radiologists are now more confident in their calling of the injuries. It seems, hopefully, that with the newer scanners we will have a better correlation with what we see on angiography. In our review, what we saw on CT scan didn’t necessarily correlate with what we saw on angiography.

Potentially, with these new scanners we can more confidently triage patients to embolization or to the operating room in more confidence.

In answer to your second question regarding hemoperitoneum and active extravasation, of our 28 patients with moderate or large hemoperitoneum, 14 of them had active extravasation, and then 10 of those ultimately failed.

Whether or not we should take those patients directly to the operating room and bypass embolization, our management is to embolize everybody who undergoes angiography. These patients potentially will fail, as we have seen. At the very least, this should give us pause of continuing transfusions after embolization. Instead, just take them straight to the operating room if they clinically appear to still be bleeding.

In answer to your third question regarding age, it did not reach statistical significance for us. However, we did have about 21% of patients older than 55 fail versus approximately 13 or 14% less than 55. However, you bring up a very good point that our number is too small. It’s very possible we’re making a type II error.

We had one patient who underwent repeat angiography but he was not a good candidate for repeat angiography. He failed.

So, with our number of one patient who underwent repeat angiography, we were not successful. However, appropriately chosen, I see how patients could benefit from repeat angiography if stable and the reason for repeat angiography is a decrease in hemoglobin.

In regards to AV fistulas, we only had one patient who had a documented AV fistula, and that patient failed as well.

Dr. Carl J. Hauser (Newark, New Jersey): I’d agree with the hypothesis that we probably have gone too far and we will swing back towards a central position, but I think there are several important issues here you haven’t brought up.

First of all, interventional radiology is highly operator-dependent as well as patient-selection dependent. I think we all have the experience that there are certain of our angiographers who have more interest and experience in trauma than others.

So, the question is, did you break down your failure rate by interventional angiographers specifically?
Do you have a big dog and some little dogs who are there at night who aren’t as good as the big dog who is there during the day?

Secondly, the differences in technique are very important. Central embolization may well tend to fail because of persistent hemorrhage, whereas peripheral embolization may fail late because of sepsis and infarction of the spleen.

So, did you track whether these failures were early or late? Whether they were all because of persistent hemorrhage or whether some of them were because of late complications of sepsis in the left upper quadrant?

Dr. Hadley E. Smith: As far as tracking the angiographers, we have not broached that; however, our data is in their hands as well, as they have helped us with the grading, and they are currently looking at their own protocols, because there isn’t a set protocol into who gets what.

Some patients received coil embolizations. Some received particles. Therefore, in some patients it seemed they received coils, then particles, then more coils, and then more particles. It’s hard to tell if this aggressive approach was necessary because of technical placement or because of severity of injury. This is currently under study in their department.

As far as our complications and failures, the majority of our failures happened fairly early, within the first 2 or 3 days. We did have one patient who had a failure of a splenic abscess, and that patient returned to the OR at about 6 days. Currently, I don’t know if that patient had a main or a distal embolization.

Dr. Donald D. Trunkey (Portland, Oregon): I am disappointed in your conclusions. Based on your data and Dr. Peitzman’s most recent paper, I think the answer is, unequivocally, that we have gone too far.

However, I am curious, regarding a fundamental question that isn’t being answered: If you embolize, either the splenic artery or peripherally, is there function afterwards? If we leave it up to the radiologists, we’ll never answer that question.

We should be studying spleen function after embolization to see if T-cell function is maintained, and does it really work in preventing the late thrombo-embolism and myocardial infarction?

I would encourage you to do this on those patients that “had successful embolization”, because I have real doubts.

Dr. Hadley E. Smith: I agree. In reviewing the charts, we were able to see complications, like we had thrombocytosis in seven patients.

We gave them aspirin and there were no complications as a result. However, do we follow our trauma patients up any significant distance? Can we find them after a certain amount of time?

It’s very difficult and a daunting task, but I agree. We can get them through the beginning and stop their hemorrhage, but it’s hard to know exactly what benefit we’re giving them long term.
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