

Management of blunt splenic injury: down the rabbit hole and into the bucket

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ABSTRACT

Management of splenic trauma has changed dramatically over the past 30 years. Many of these advances were driven by the Memphis team under the leadership of Dr. Timothy Fabian. This review article summarizes some of those changes in clinical care, especially related to nonoperative management and angioembolization.

Matching into a fellowship in Memphis, TN, had a lot of implications beyond learning to be a trauma surgeon at one of the busiest trauma centers in the country. Crossing the threshold of the Elvis Presley Trauma Center was joining a family or the Memphis Mafia depending on your preference. But as with all families, there were idiosyncrasies, rules and expectations. And one of the behaviors modeled time and again was that of scientific curiosity. Memphis did not have a lot of fancy labs and expensive toys but they did have a history of research productivity. Dr Fabian, the head of the family to perpetuate the analogy, was legendary for asking a question and then following it down the rabbit hole. All of us who have worked for Dr Fabian remember a time he would simply show up in our office, sit down across the desk from us and say “What the heck are you doing?” This was prime time to bounce a concept off him or get direction for your research trajectory.

This intellectual curiosity, along with the wealth of clinical material available at Memphis, represented a wonderful opportunity to pursue a rigorous and longitudinal approach to answer some of the most controversial issues of the day. An excellent example of this is the issue of the management of blunt splenic injury (BSI). Though we all know that the spleen loves the bucket, Dr Fabian and his team at Memphis set out to prove if and how much love there was. During the course of 13 papers which he coauthored and 21 subsequent papers from past fellows and faculty, the Memphis group evaluated and re-evaluated the management of BSI during a 30-year period ([figure 1](#)).

Returning to this body of literature today, it is fascinating to observe what was gospel gradually morph into the practice patterns we now use. The first BSI paper in Dr Fabian’s library was published in the *Journal of the Tennessee Medical Association* in 1993.¹ This historic document, preserved in an actual book (, saw an early foray into the nonoperative management of an injured spleen. The initial decision to observe was clearly radical and somewhat aggressive, as the authors noted at the time that only 12% to 15% of adults were candidates

for nonoperative management. The threshold for failure was also different, and lower, as the patient was taken for splenectomy on hospital day #4 after his heart rate rose 10 beats per minute (from 95 to 105 bpm) and his hematocrit dropped from 39% to 31%. The authors’ conclusions were prescient however. “The data presented here support the nonoperative management of BSI in selected adult and pediatric patients. Selection criteria must be strict and the threshold for subsequent operative intervention must be low.”¹

During the following 5 years, Fabian *et al* worked to define the strict selection criteria needed for the nonoperative approach to BSI. Increased utilization and sophistication of CT allowed identification of contrast blushes and abnormalities of the splenic vasculature, such as pseudoaneurysms. These findings served as clinical predictors of increased failure rates.²⁻⁴ Bee *et al* further defined clinical factors which were associated with increased nonoperative failure including low Glasgow Coma Score, hypotension, large hemoperitoneum and older age.⁵ Importantly, during this same period, the use of angioembolization to manage some of these concerning characteristics allowed trauma surgeons to attempt splenic salvage in even more patients.

True to Fabian’s leadership and approach, it was down the rabbit hole to try and understand every aspect of BSI and management options ([table 1](#)). Santaniello *et al*, Miller *et al* and Malhotra *et al* looked at how BSI was managed in the setting of other major injuries.⁶⁻⁸ Weinberg *et al* evaluated serial imaging to understand the incidence and management of pseudoaneurysm in BSI.⁹ Savage *et al* and Zarzaur *et al* followed BSI longitudinally to determine the time to healing and the incidence of late rupture.^{10 11} These inquiries led to multicenter studies sponsored¹² by the American Association for

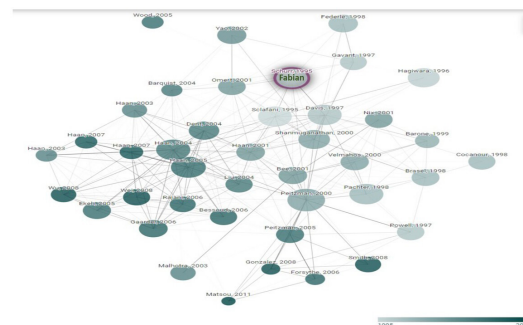


Figure 1 Network analysis of the impact of Dr Timothy Fabian's blunt splenic injury research.

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Table 1 Longitudinal study of blunt spleen injury by Fabian *et al*

Authors	Study	Findings
Charash <i>et al</i> ¹	Case report of early nonoperative management of BSI	Nonoperative management reasonable with strict patient criteria
Schurr <i>et al</i> ²	309 total patients ▶ 69% managed nonoperatively ▶ Initial CT to determine management	Contrast blush on CT highly predictive of failure of observation for BSI
Gavant <i>et al</i> ³	263 patients with BSI ▶ 40% treated nonop ▶ 85% of nonop treatment successful	Vascular abnormalities in BSI, aka pseudoaneurysms, highly associated with failure of nonop management
Davis <i>et al</i> ⁴	524 patients, 66% managed initially without operation ▶ CT imaging to evaluate for pseudoaneurysm or blush	Embolization is successful in salvaging blunt spleen injuries in the setting of contrast blush or pseudoaneurysm
Bee <i>et al</i> ⁵	558 patients with BSI ▶ 77% initially observed ▶ Age and higher grade of injury associated with higher failure	More severe splenic injuries may be managed nonoperatively with ever-improving success rates
Santaniello <i>et al</i> ⁶	84 patients with blunt aortic injuries, 33% with associated intra-abdominal organ injury	It is safe to anticoagulated low-grade spleen or liver injuries in the setting of aortic repair
Miller <i>et al</i> ⁷	803 patients with blunt spleen, liver or both spleen and liver injuries ▶ Assessed for missed injury in the setting of nonoperative management	Incidence of missed injury is very low (though greater with blunt liver over blunt spleen injury)
Malhotra <i>et al</i> ⁸	1288 patients with blunt spleen, blunt liver or both injured	Patients with injury to both liver and spleen have higher ISS, greater mortality and higher rates of nonoperative failure
Weinberg <i>et al</i> ⁹	426 patients with nonoperative management of BSI were managed with serial imaging	Improved late detection and embolization of pseudoaneurysm, further improving success of nonoperative management
Savage <i>et al</i> ¹⁰	637 patients with BSI managed nonoperatively with serial imaging to determine healing rates	Most injuries heal by 2 months but 10% worsen. Recommend ongoing follow-up to 3 months
Zarzaur <i>et al</i> ¹¹	4103 patients with BSI assessed for readmission or late mortality	Most late splenectomies occur within 8 days but 1.4% of patients readmitted with spleen-related complications
Zarzaur <i>et al</i> ²⁸	Survey of practice patterns for management of BSI among AAST members	Considerable variation exists in regard to management of BSI, especially with higher grade injuries
Zarzaur <i>et al</i> ²⁹	11 793 patients from the NTDB identified to determine factors related to urgent splenectomy	Specific patient factors related to need for urgent splenectomy. Important hospital factors include region, hospital type and trauma center status

AAST, American Association for the Surgery of Trauma; BSI, blunt splenic injury; ISS, Injury Severity Score; NTDB, National Trauma Data Bank.

the Surgery of Trauma, Western Trauma Association and others to further refine our management strategies.^{13–34}

The management of BSI remains surprisingly controversial to this day. Though most would agree that nonoperative management is the gold standard in hemodynamically stable patients, that is about all that we agree on. Centers vary significantly in timing and frequency of angioembolization and the threshold for splenectomy versus continued observation in the face of physiologic changes. Despite such variations, Fabian's contribution has been fundamental. To return to the conclusion from his 1993 paper, "Selection criteria must be strict and the threshold for subsequent intervention must be low."¹

At the core, Dr Fabian's contribution to splenic science has been to define the natural history of the bluntly injured spleen when left in situ. The fundamental aspect of this was identification of the incidence of pseudoaneurysm and the description of how this vascular abnormality contributes to delayed failure. Much of his subsequent oeuvre then expanded on this core concept including patient, global injury characteristics and the evolution of the spleen in the wild, that is, time to healing or rupture after discharge. With his quintessential 'he he he,' bow tie and soft-spoken presence, Dr Fabian has influenced a generation of us to truly learn about the spleen and remains a much-loved mentor.

It is a relative triumph that nonoperative management has such a high success rate. In part, this is due to a refinement of our management strategies during the last three decades but is also in large part due to improved patient selection (a selection

bias perhaps). Fabian's "strict criteria" are the heart of successful management of BSI because, fundamentally, the spleen does love the bucket. Our job as trauma surgeons is to ensure the right ones get there.

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REFERENCES

- 1 Charash WE, Croce MA, Fabian TC. Nonoperative management of blunt splenic injury in adults. *J Tenn Med Assoc* 1993;86:197–9.
- 2 Schurr MJ, Fabian TC, Gavant M, Croce MA, Kudsk KA, Minard G, Woodman G, Pritchard FE. Management of blunt splenic trauma: computed tomographic contrast blush predicts failure of nonoperative management. *J Trauma* 1995;39:507–12;
- 3 Gavant ML, Schurr M, Flick PA, Croce MA, Fabian TC, Gold RE. Predicting clinical outcome of nonsurgical management of blunt splenic injury: using CT to reveal abnormalities of splenic vasculature. *AJR AM J Roentgenol* 1997;168:207–12.
- 4 Davis KA, Fabian TC, Croce MA, Gavant ML, Flick PA, Minard G, Kudsk KA, Pritchard FE. Improved success in nonoperative management of blunt splenic injuries: embolization of splenic artery pseudoaneurysms. *J Trauma* 1998;44:1008–13;
- 5 Bee TK, Croce MA, Miller PR, Pritchard FE, Fabian TC. Failures of splenic nonoperative management: is the glass half empty or half full? *J Trauma* 2001;50:230–6.
- 6 Santaniello JM, Miller PR, Croce MA, Bruce L, Bee TK, Malhotra AK, Fabian TC, Mattox KL. Blunt aortic injury with concomitant intra-abdominal solid organ injury: treatment priorities revisited. *J Trauma* 2002;53:442–5;
- 7 Miller PR, Croce MA, Bee TK, Malhotra AK, Fabian TC. Associated injuries in blunt solid organ trauma: implications for missed injury in nonoperative management. *J Trauma* 2002;53:238–42;
- 8 Malhotra AK, Latifi R, Fabian TC, Ivatury RR, Dhage S, Bee TK, Miller PR, Croce MA, Yelon JA. Multiplicity of solid organ injury: influence on management and outcomes after blunt abdominal trauma. *J Trauma* 2003;54:925–9.
- 9 Weinberg JA, Magnotti LJ, Croce MA, Edwards NM, Fabian TC. The utility of serial computed tomography imaging of blunt splenic injury: still worth a second look? *J Trauma* 2007;62:1143–7;
- 10 Savage SA, Zarzaur BL, Magnotti LJ, Weinberg JA, Maish GO, Bee TK, Minard G, Schroepel T, Croce MA, Fabian TC. The evolution of blunt splenic injury: resolution and progression. *J Trauma* 2008;64:1085–91;
- 11 Zarzaur BL, Vashi S, Magnotti LJ, Croce MA, Fabian TC. The real risk of splenectomy after discharge home following nonoperative management of blunt splenic injury. *J Trauma* 2009;66:1531–6;
- 12 Zarzaur BL, Rozycki GS. An update on nonoperative management of the spleen in adults. *Trauma Surg Acute Care Open* 2017;2:e000075.
- 13 Lopez JM, McGonagill PW, Gross JL, Hoth JJ, Chang MC, Parker K, Requarth JA, Miller PR. Subcapsular hematoma in blunt splenic injury: a significant predictor of failure of nonoperative management. *J Trauma Acute Care Surg* 2015;79:957–9.
- 14 Requarth JA, D'Agostino RB, Miller PR. Nonoperative management of adult blunt splenic injury with and without splenic artery embolotherapy: a meta-analysis. *J Trauma* 2011;71:898–903.
- 15 Miller PR, Chang MC, Hoth JJ, Mowery NT, Hildreth AN, Martin RS, Holmes JH, Meredith JW, Requarth JA. Prospective trial of angiography and embolization for all grade III to V blunt splenic injuries: nonoperative management success rate is significantly improved. *J Am Coll Surg* 2014;218:644–8.
- 16 Requarth JA, Miller PR. The splenic artery stump pressure is affected by arterial anatomy after proximal embolotherapy in blunt splenic injury. *J Trauma Acute Care Surg* 2012;73:1221–4.
- 17 Danelson KA, Hoth JJ, Miller PR, Stitzel JD. A semi-automated approach for measuring splenic injury using computed tomography. *Biomed Sci Instrum* 2007;43:13–7.
- 18 Zarzaur BL, Dunn JA, Leininger B, Lauerman M, Shanmuganathan K, Kaups K, Zarny K, Hartwell JL, Bhakta A, Myers J, et al. Natural history of splenic vascular abnormalities after blunt injury: a Western trauma association multicenter trial. *J Trauma Acute Care Surg* 2017;83:999–1005.
- 19 Bhattacharya B, Becher RD, Schuster KM, Davis KA, Maung AA. Anticoagulation is associated with increased mortality in splenic injuries. *J Surg Res* 2021;266:1–5.
- 20 Haan JM, Biffl W, Knudson MM, Davis KA, Oka T, Majercik S, Dicker R, Marder S, Scalea TM, Western Trauma Association Multi-Institutional Trials Committee. Splenic embolization revisited: a multicenter review. *J Trauma* 2004;56:542–7.
- 21 Hurtuk M, Reed RL 2nd, Esposito TJ, Davis KA, Luchette FA. Trauma surgeons practice what they preach: the NTDB story on solid organ injury management. *J Trauma* 2006;61:243–54;
- 22 O'Connor SC, Doud AN, Sieren LM, Miller PR, Zeller KA. The spleen not taken: differences in management and outcomes of blunt splenic injuries in teenagers cared for by adult and pediatric trauma teams in a single institution. *J Trauma Acute Care Surg* 2017;83:368–72.
- 23 Weinberg JA, Lockhart ME, Parmar AD, Griffin RL, Melton SM, Vandromme MJ, McGwin G Jr, Rue LW 3rd. Computed tomography identification of latent pseudoaneurysm after blunt splenic injury: pathology or technology? *J Trauma* 2010;68:1112–6.
- 24 Byerly SE, Jones MD, Lenart EK, Seger CP, Filiberto DM, Lewis RH, Kerwin AJ, Magnotti LJ. Serial CT for nonoperatively managed splenic injuries. *Am Surg* 2022;88:1504–9.
- 25 Velmahos GC, Zacharias N, Emhoff TA, Feeney JM, Hurst JM, Crookes BA, Harrington DT, Gregg SC, Brotman S, Burke PA, et al. Management of the most severely injured spleen: a multicenter study of the research Consortium of new England centers for trauma (reconnect). *Arch Surg* 2010;145:456–60.
- 26 Bhattacharya B, Askari R, Davis KA, Dorfman J, Eid AI, Elsharkawy AE, Kasotakis G, Mackey S, Odom S, Okafor BU, et al. The effect of anticoagulation on outcomes after liver and spleen injuries: a research consortium of new england centers for trauma (reconnect) study. *Injury* 2020;51:1994–8.
- 27 Dolejs SC, Savage SA, Hartwell JL, Zarzaur BL. Overall splenectomy rates stable despite increasing usage of angiography in the management of high-grade blunt splenic injury. *Ann Surg* 2018;268:179–85.
- 28 Zarzaur BL, Kozar RA, Fabian TC, Coimbra R. A survey of American association for the surgery of trauma member practices in the management of blunt splenic injury. *J Trauma* 2011;70:1026–31.
- 29 Zarzaur BL, Croce MA, Fabian TC. Variation in the use of urgent splenectomy after blunt splenic injury in adults. *J Trauma* 2011;71:1333–9.
- 30 Kozar RA, Crandall M, Shanmuganathan K, Zarzaur BL, Coburn M, Cribari C, Kaups K, Schuster K, Tominaga GT, AAST Patient Assessment Committee. Organ injury scaling 2018 update: spleen, liver, and kidney. *J Trauma Acute Care Surg* 2018;85:1119–22.
- 31 Zarzaur BL, Kozar R, Myers JG, Claridge JA, Scalea TM, Neideen TA, Maung AA, Alarcon L, Corcos A, Kerwin A, et al. The splenic injury outcomes trial: an American Association for the surgery of trauma multi-institutional study. *J Trauma Acute Care Surg* 2015;79:335–42.
- 32 Coccolini F, Montori G, Catena F, Kluger Y, Biffl W, Moore EE, Reva V, Bing C, Bala M, Fugazzola P, et al. Splenic trauma: WSES classification and guidelines for adult and pediatric patients. *World J Emerg Surg* 2017;12:40.
- 33 Malhotra AK, Carter RF, Lebman DA, Carter DS, Riaz OJ, Aboutanos MB, Duane TM, Ivatury RR. Preservation of splenic immunocompetence after splenic artery angioembolization for blunt splenic injury. *J Trauma* 2010;69:1126–30;
- 34 Robinson WP 3rd, Ahn J, Stiffler A, Rutherford EJ, Hurd H, Zarzaur BL, Baker CC, Meyer AA, Rich PB. Blood transfusion is an independent predictor of increased mortality in nonoperatively managed blunt hepatic and splenic injuries. *J Trauma* 2005;58:437–44;