Treatment of the Injured Spleen:
To Embolize or Remove?

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Trauma Surgeon, Intermountain Medical Center,
Intermountain Healthcare; Salt Lake City, Utah

Objectives:

• Recognize the signs and symptoms of splenic injuries
• Describe the important principles for successful resuscitation and treatment of an actively bleeding spleen injury
• Examine the usefulness of splenic artery embolization and compare it with surgery for patients with actively bleeding spleen injuries
• Recognize the complications following embolization of the spleen and compare them with complications of splenectomy
Splenic Trauma
Unlocking the Mysteries
My Spleen’s Ruptured: What should I do?

http://www.codeproject.com/Articles/66341/A-Simple-Yet-Quite-Powerful-Palette-Quantizer-in-C
Goals

• Diagnosis
  – Review splenic trauma grading system / imaging
• Understand management options and algorithms after splenic trauma
  – Laparotomy for splenic trauma
    • Define unstable
  – Angiographic embolization in splenic trauma
    • Relevance of a contrast blush during CT
    • Proximal versus Distal embolization
    • Temporary versus Permanent product deployment
  – Selective non-operative management (NOMST)
    • Factors associated with failure of NOMST
• Who / when should
  – Chemoprophylaxis
  – Follow-up imaging
  – Immunizations
  – Return to activity
Splenic Trauma Grading System

- **Grade 1**
  - < 1 cm laceration depth
  - Or <10% subcapsular hematoma
- **Grade 2**
  - 1-3 cm laceration depth
  - Or 10-50% subcapsular hematoma
- **Grade 3**
  - >3 cm laceration depth
  - Or >50% subcapsular hematoma
- **Grade 4**
  - Hilar injury with >25% devascularization
- **Grade 5**
  - Shattered spleen
  - Or near complete devascularization
Predictions from Grading System

American Association for the Surgery of Trauma Organ Injury Scale I: Spleen, Liver, and Kidney, Validation Based on the National Trauma Data Bank

Glen Tinkoff, MD, FACS, Thomas J Esposito, MD, MPH, FACS, James Reed, PhD, Patrick Kilgo, PhD, John Fildes, MD, FACS, Michael Pasquale, MD, FACS, J Wayne Meredith, MD, FACS

BACKGROUND: This study attempts to validate the American Association for the Surgery of Trauma (AAST) Organ Injury Scale (OIS) for spleen, liver, and kidney injuries using the National Trauma Data Bank (NTDB).

STUDY DESIGN: All NTDB entries with Abbreviated Injury Scale codes for spleen, liver, and kidney were classified by OIS grade. Injuries were stratified either as an isolated intraabdominal organ injury or in combination with other abdominal injuries. Isolated abdominal solid organ injuries were additionally stratified by presence of severe head injury and survival past 24 hours. The patients in each grading category were analyzed for mortality, operative rate, hospital length of stay, ICU length of stay, and charges incurred.
### Table 4. Outcomes of Intraabdominal Solid Organ Injuries in Combination with All Other Intra- and Extraabdominal Injuries

<table>
<thead>
<tr>
<th>OIS grade</th>
<th>n</th>
<th>Mortality (%)</th>
<th>OR (%)</th>
<th>LOS (d)</th>
<th>ICU (d)</th>
<th>Charges ($)</th>
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</thead>
<tbody>
<tr>
<td>Spleen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I and II</td>
<td>12,636</td>
<td>9.9</td>
<td>11.3</td>
<td>9.9</td>
<td>4.9</td>
<td>66,069</td>
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<tr>
<td>III</td>
<td>4,357</td>
<td>10.4</td>
<td>30.0*</td>
<td>10.2*</td>
<td>5.1*</td>
<td>74,264*</td>
</tr>
<tr>
<td>IV</td>
<td>3,122</td>
<td>14.1*</td>
<td>57.0*</td>
<td>11.6*</td>
<td>6.1*</td>
<td>77,398*</td>
</tr>
<tr>
<td>V</td>
<td>1,657</td>
<td>29.8*</td>
<td>77.5*</td>
<td>12.5*</td>
<td>7.1*</td>
<td>101,717*</td>
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<td>Total</td>
<td>21,722</td>
<td>12.1</td>
<td>26.6</td>
<td>10.4</td>
<td>5.3</td>
<td>72,263</td>
</tr>
</tbody>
</table>

### Table 6. Outcomes of Isolated Intraabdominal Solid Organ Injury Excluding Severe Traumatic Brain Injury (AIS Head ≥ 4)

<table>
<thead>
<tr>
<th>OIS grade</th>
<th>n</th>
<th>Mortality (%)</th>
<th>OR (%)</th>
<th>LOS (d)</th>
<th>ICU (d)</th>
<th>Charges ($)</th>
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<tbody>
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<td>Spleen</td>
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<td></td>
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</tr>
<tr>
<td>I and II</td>
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<td>27.3*</td>
<td>8.8*</td>
<td>4.0*</td>
<td>61,977</td>
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<tr>
<td>IV</td>
<td>1,978</td>
<td>6.0</td>
<td>53.1*</td>
<td>9.7*</td>
<td>4.6*</td>
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<td>77.3*</td>
<td>11.7*</td>
<td>6.1*</td>
<td>79,796*</td>
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<tr>
<td>Total</td>
<td>13,746</td>
<td>5.3</td>
<td>24.0</td>
<td>8.7</td>
<td>3.9</td>
<td>56,503</td>
</tr>
</tbody>
</table>

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Tinkoff et al. AAST Organ Injury Scale I
Case Report

• 44 yo female driver on her way to work at 7:00 am when she suffered a drivers side T-bone MVC
  – positive LOC
  – Significant left chest, abdomen and pelvic pain
  – Initial vitals 120/70, HR 110s, GCS 15
    • Chest and abdomen were moderately tender on exam
    • Scalp laceration with some associated EBL noted
    • No obvious long bone injuries, moving all 4 extremities
  – i-stat HCT 38
Grade IV Splenic Laceration
Grade IV Splenic Laceration and Right Adrenal Laceration
Case Report

• Problem List
  – Left sided rib fractures 2-7
  – Left hemo / pneumothorax
  – Grade 4 splenic laceration with a through and through injury including active extravasation
  – Right adrenal hemorrhage with question of potential IVC involvement
  – Left Shoulder Coracoid fracture
  – Blunt cardiac injury with peak troponin of 4.1
    • EKG with PVCs
    • Normal echo obtained upon initial admission to ICU
      – EF 70% no valvular or wall motion abnormalities
  – Left sacral, acetabular and pubic rami fractures
Case Report

• After CT workup patient becomes hypotensive in the trauma bay with recorded BPs of 85/50s and HR 130s

• Now what, source?
  – Adrenal/IVC, Spleen, Pelvis
Case Report

• Options – where is she bleeding, will it stop without surgery, what can we do about it?

1. Initially what should we do?
   a) ABCs - reassess
      • Resuscitate – with what?
         o Bleeding = give blood

2. If someone is bleeding we want to?
   a) Stop the bleeding ..... How?
      • Surgery
      • Embolization
      • Coagulopathy correction
Case Report

- Urgent uncrossmatched trauma blood given
- Good response to PRBC and a period of observation in the ED – decision to transport to ICU normotensive
- No additional blood products required
- HCT drift to 27 and stabilized over 2 days in the ICU
- No additional hemodynamic instability
- Non-operative management
  - orthopedic injuries
- Air leak for nearly a week
  - eventually resolved
- Repeat CT planned
  - prior to discharge
  - looking for pseudoaneurysm
Planned repeat CT abdomen at PTD #7
Looking for splenic pseudoaneurysm performed
Case Report

- Successful angiographic embolization of her splenic pseudoanuerysm
- Discharged PTD 11
- Coumadin / Lovenox for DVT
- Follow-up in Trauma clinic and Ortho clinic without complications
Case Report

• Questions include:
  – Who should go to the OR
  – Who should go to Angioembolization
  – Who can be managed or should be attempted to be managed non operatively
  – When can you give Lovenox / Coumadin
  – Who should have repeat imaging
  – Discharge timing, return to activity ....
  – Is there an organized way to figure this all out
Selective nonoperative management of blunt splenic injury: An Eastern Association for the Surgery of Trauma practice management guideline

Nicole A. Stassen, MD, Indermeet Bhullar, MD, Julius D. Cheng, MD, Marie L. Crandall, MD, Randall S. Friese, MD, Oscar D. Guillamondegui, MD, Randeep S. Jawa, MD, Adrian A. Maung, MD, Thomas J. Rohs, Jr, MD, Ayodele Sangosanya, MD, Kevin M. Schuster, MD, Mark J. Seamon, MD, Kathryn M. Tchorz, MD, Ben L. Zarzaur, MD, and Andrew J. Kerwin, MD

BACKGROUND: During the last century, the management of blunt force trauma to the spleen has changed from observation and expectant management in the early part of the 1900s to mainly operative intervention, to the current practice of selective operative and nonoperative management. These issues were first addressed by the Eastern Association for the Surgery of Trauma (EAST) in the Practice Management Guidelines for Non-operative Management of Blunt Injury to the Liver and Spleen published online in 2003. Since that time, a large volume of literature on these topics has been published requiring a reevaluation of the current EAST guideline.
Splenic Trauma - Management

“Just a darn minute! Yesterday you said X equals two!”
Splenic Trauma – Management

Growing List of Questions

- Who should undergo laparotomy?
- What is unstable?
- Is nonoperative management appropriate for all hemodynamically stable adults regardless of severity of solid-organ injury or presence of associated injuries?
- What is the optimal imaging method for splenic injury (CT, FAST, US)?
- Is the risk of missing a hollow viscous injury a deterrent to nonoperative management?
- What is significance / reaction to contrast blush?
- Who should undergo angiogram?
- Necessity and timing of repeated imaging?
- Timing of initiating chemical deep venous thrombosis?
- Is the need for transfusion greater for patients managed nonoperatively?
- What type of angioembolization (distal, proximal, permanent?)
- Should patients be placed on a “bed rest” activity status, and if so, for what duration?
- Is there a transfusion trigger after which operative or angiographic intervention should be considered?
- Time to reinitiating oral intake?
- Optimum length of stay for both the intensive care unit (ICU) and hospital?
- The duration and intensity of restricted activity after discharge?
- Is there an immunologic deficiency after splenic embolization?
- Should patients with severe injuries/or embolized injuries receive postsplenectomy vaccines?
Splenic Trauma - Management

Level 1
• The recommendation is convincingly justifiable based on the available scientific information alone. This recommendation is usually based on Class I data; however, strong Class II evidence may form the basis for a Level 1 recommendation, especially if the issue does not lend itself to testing in a randomized format. Conversely, low-quality or contradictory Class I data may not be able to support a Level 1 recommendation.

Level 2
• The recommendation is reasonably justifiable by available scientific evidence and strongly supported by expert opinion. This recommendation is usually supported by Class II data or a preponderance of Class III evidence.

Level 3
• The recommendation is supported by available data, but adequate scientific evidence is lacking. This recommendation is generally supported by Class III data. This type of recommendation is useful for educational purposes and in guiding future clinical research.
Splenic Trauma - Management

• **Level 1**
  – Patients who have diffuse peritonitis or who are hemodynamically unstable after blunt abdominal trauma should be taken urgently for laparotomy.
When to go to Laparotomy

Level 1 evidence
• Identifying peritonitis
  – blood and abdominal trauma also “hurt”
• “Unstable vitals”
  – AAST – TraumaSource Guideline on Splenic Trauma
  • “If the patient has a low blood pressure and/or a high heart rate (unstable), the trauma surgeon must identify the cause, which is often due to bleeding. Next the trauma surgeon determines the location of the bleeding ........ If it appears that the abdomen is the source, the patient may need to be taken to the operating room emergently for exploratory abdominal surgery.”
Management = Laparotomy

• “Unstable” vitals
  – Typically SBP < 90 mm Hg and/or HR > 120 bpm
• Should every patient who has vitals appear in the “Unstable” category = Laparotomy?

I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail.

(Abraham Maslow)
Failure of Observation of Blunt Splenic Injury in Adults: Variability in Practice and Adverse Consequences

Andrew B Peitzman, MD, FACS, Brian G Harbrecht, MD, FACS, Luis Rivera, MD, Brian Heil, MD, and the Eastern Association for the Surgery of Trauma Multiinstitutional Trials Workgroup

J Am Coll Surg 2005

• Failure of non-operative management (NOMST) was associated with:
  – High grade injury
  – Hemoperitoneum
  – Higher ISS
  – Lower systolic blood pressure at admission
  – 61% of failures of NOMST were within 24 hours
Failure of Observation of Blunt Splenic Injury in Adults: Variability in Practice and Adverse Consequences

Andrew B Peitzman, MD, FACS, Brian G Harbrecht, MD, FACS, Luis Rivera, MD, Brian Heil, MD, and the Eastern Association for the Surgery of Trauma Multiinstitutional Trials Workgroup

BACKGROUND: The Eastern Association for the Surgery of Trauma Multiinstitutional Workgroup reported a failure rate for nonoperative management of blunt splenic injury in adults of 10.8%. Sixty percent of the failures occurred within 24 hours of admission. The purpose of this multiinstitutional study by the Eastern Association for the Surgery of Trauma was to determine common variables in failure of nonoperative management of blunt splenic injury in adults.

– Used patients from a previous 2001 EAST study of 913/1488 patients who were placed in NOMST category at 27 Trauma centers (26 level I, 1 level II)

– Looked at vitals first and placed them in 3 categories
  • Stable (44%) – always had normal vitals
  • Responders (31%) – had 1 or 2 periods of hypotension/tachycardia responsive to resuscitation
  • Unstable (25%) – 3 or more periods of hypotension/tachycardia
    – These were patient’s whom they initially attempted to managed without surgery
Results

- Mortality was significantly higher in Unstable patients vs Stable and vs Responders
  - 10 deaths, majority in the unstable group
    - 6/10 deaths felt to be potentially preventable (5 in unstable group and 1 in responder group)
- 2/3rds of Unstable group had laparotomy by 12 hours
- 80% of failures in stable and responder group had laparotomy by 72 hours
- No difference in age, quantity of hemoperitoneum, grade of injury
- ISS was higher comparing unstable to stable groups
- 80% (62/78 pts) “failed” NOMST had splenectomy at laparotomy
  - 14 “failures of NOMST” did not have splenectomy
  - 5% had non-therapeutic laparotomies
  - 10% splenorrhapsy
  - 10% spleen left untouched (no indication for intervention)
Failure of Observation of Blunt Splenic Injury in Adults: Variability in Practice and Adverse Consequences

Andrew B Peitzman, MD, FACS, Brian G Harbrecht, MD, FACS, Luis Rivera, MD, Brian Heil, MD, and the Eastern Association for the Surgery of Trauma Multiinstitutional Trials Workgroup

Authors Conclusions

– Inappropriate selection of patients for nonoperative management leads to higher, potentially preventable, mortality rates

– These observations seem to emphasize the importance of the trend and continuum of blood pressure measurements rather than a single value

– Also felt that abdominal examination was de-emphasized contributing to improper attempts at non-operative management in several patients
Management = Laparotomy

- Three Categories
  - Stable
  - Responder
  - Unstable
- Key appears to be identifying the unstable patient early to avoid preventable mortality
- Unstable / peritonitis = laparotomy
- Stable and Responder = non operative attempt at management
Splenic Trauma – Management
2012 EAST Trauma Guideline

Level 2 Evidence =

- A routine laparotomy is not indicated in the hemodynamically stable patient without peritonitis presenting with an isolated splenic injury.
- The severity of splenic injury (as suggested by CT grade or degree of hemoperitoneum), neurologic status, age > 55 and/or the presence of associated injuries are not contraindications to a trial of nonoperative management in a hemodynamically stable patient.
- In the hemodynamically normal blunt abdominal trauma patient without peritonitis, an abdominal CT scan with intravenous contrast should be performed to identify and assess the severity of injury to the spleen.
- Angiography should be considered for patients with American Association for the Surgery of Trauma (AAST) grade of greater than III injuries, presence of a contrast blush, moderate hemoperitoneum, or evidence of ongoing splenic bleeding.
- Nonoperative management of splenic injuries should only be considered in an environment that provides capabilities for monitoring, serial clinical evaluations, and an operating room available for urgent laparotomy.
List of Questions

• Who should undergo laparotomy?
• What is unstable?
• Is nonoperative management appropriate for all hemodynamically stable adults regardless of severity of solid-organ injury or presence of associated injuries?
• What is the optimal imaging method for splenic injury (CT, FAST, US)?
• What is significance of a contrast blush?
• Who should undergo angiogram?
• Necessity and timing of repeated imaging?
• Timing of initiating chemical deep venous thrombosis?
• Is the need for transfusion greater for patients managed nonoperatively?
• What type of angioembolization (distal, proximal, permanent?)
• Should patients be placed on a “bed rest” activity status, and if so, for what duration?
• Is there a transfusion trigger after which operative or angiographic intervention should be considered?
• Time to reinitiating oral intake?
• Optimum length of stay for both the intensive care unit (ICU) and hospital?
• The duration and intensity of restricted activity after discharge?
• Is there an immunologic deficiency after splenic embolization?
• Should patients with severe injuries/or embolized injuries receive postsplenectomy vaccines?
Level 3 Evidence =

- Contrast blush on CT scan alone is not an absolute indication for an operation or angiographic intervention. Factors such as patient age, grade of injury, and presence of hypotension need to be considered in the clinical management of these patients.

- Angiography may be used either as an adjunct to nonoperative management for patients who are thought to be at high risk for delayed bleeding or as an investigative tool to identify vascular abnormalities such as pseudoaneurysms that pose a risk for delayed hemorrhage.

- After blunt splenic injury, clinical factors such as a persistent systemic inflammatory response, increasing/persistent abdominal pain, or an otherwise unexplained drop in hemoglobin should dictate the frequency of and need for follow-up imaging for a patient with blunt splenic injury.

- Pharmacologic prophylaxis to prevent venous thromboembolism can be used for patients with isolated blunt splenic injuries without increasing the failure rate of nonoperative management, although the optimal timing of safe initiation has not been determined.
At first blush: Absence of computed tomography contrast extravasation in Grade IV or V adult blunt splenic trauma should not preclude angioembolization

Indermeet Singh Bhullar, MD, Eric R. Frykberg, MD, Joseph J. Tepas III, MD, Daniel Siragusa, MD, Todd Loper, MD, and Andrew J. Kerwin, MD, Jacksonville, Florida

BACKGROUND:
To clarify the role, indications, and outcomes for angioembolization (AE) of nonoperatively managed (NOM) splenic trauma, the implications of absent contrast blush (CB) on computed tomography of high-grade (IV–V) blunt splenic trauma (BST) in adults were analyzed.

- University of Florida, Jacksonville, looked at their 11 year experience with Blunt Splenic Trauma (BST)
- 1,056 BST patients
  - 556 they categorized as hemodynamically stable and were managed non-operatively (NOMST)
  - 95 of these had a contrast blush (CB) on initial CT
- Method
  - Angioembolization (AE) was performed employing Cook “Tornado coils” of various sizes in 2 general categories of therapy per attending Interventionalist:
    1) Proximal main splenic artery embolization (PMSAE)
    2) Or both PMSAE and selective distal splenic artery embolization (SDSAE)
At first blush: Absence of computed tomography contrast extravasation in Grade IV or V adult blunt splenic trauma should not preclude angioembolization

Results

- 88 of the 95 who had CB underwent angiography
  - 86/88 had extravasation at angio (97.7%)
  - 3 of the 88 who underwent AE failed post-angio NOMST and underwent subsequent splenectomy (3.4%)
  - 7 with CB did not undergo angiography
    - 5 failed NOMST (71.4%) and underwent splenectomy
- 51/556 NOM patients had high grade injuries without CB
  - 20 underwent AE (40%)
    - 17 of these had extravasation at angiography (85%)
    - 0/20 failure of NOMST (0%)
  - 31 of this high grade group did not undergo AE (60%)
    - 8/31 failed NOMST (26%)
      » P=0.03 compared to AE group without CB who underwent AE
At first blush: Absence of computed tomography contrast extravasation in Grade IV or V adult blunt splenic trauma should not preclude angioembolization

Results (cont)

– 397/555 in NOM group had Grade I-III injuries without CB – labeled as not indicated for AE
  • Failure of NOM in 7/397 (1.8%)
– 12 Grade I-III were moved in to AE group because of decreasing Hgb during NOM and taken to AE
  • 2 had extrav and underwent AE
  • 10 had No extrav and underwent AE
  • 0/12 had failure of NOMST after AE for low grade injury with decreasing Hgb
At first blush: Absence of computed tomography contrast extravasation in Grade IV or V adult blunt splenic trauma should not preclude angioembolization

Conclusions

– Very strong correlation of CB with actively bleeding
  • 97.7% = active extravasation by angio

– Absence of CB does not reliably exclude active bleeding
  • 17/20 who underwent angio for high grade injuries without CB had active extravasation by angio

– Data Suggests high grade injury failure rate of NOM is from ongoing hemorrhage that can be successfully treated by AE

– Recommended that all hemodynamically stable high-grade (IV-V) BST adult patients should undergo AE regardless of CB to optimize success and safety of NOM
At first blush: Absence of computed tomography contrast extravasation in Grade IV or V adult blunt splenic trauma should not preclude angioembolization.
Consider Angiography for:

- Grade IV or V splenic lacerations
- Contrast blush
- Moderate hemoperitoneum
- Evidence of ongoing splenic hemorrhage

  • Drifting HCT, hemodynamics, etc
List of Questions

• Who should undergo laparotomy?
• What is unstable?
• Is nonoperative management appropriate for all hemodynamically stable adults regardless of severity of solid-organ injury or presence of associated injuries?
• What is the optimal imaging method for splenic injury (CT, FAST, US)?
• Is the risk of missing a hollow viscous injury a deterrent to nonoperative management?
• What is significance / reaction to contrast blush?
• Who should undergo angiogram?
• Necessity and timing of repeated imaging?
  - Would our first case have had repeat or maybe original rx would have sufficed ..... 
• Timing of initiating chemical deep venous thrombosis?
• Is the need for transfusion greater for patients managed nonoperatively?
  • What type of angioembolization (distal, proximal, permanent?)
  • Should patients be placed on a “bed rest” activity status, and if so, for what duration?
  • Is there a transfusion trigger after which operative or angiographic intervention should be considered?
  • Time to reinitiating oral intake?
  • Optimum length of stay for both the intensive care unit (ICU) and hospital?
  • The duration and intensity of restricted activity after discharge?
  • Is there an immunologic deficiency after splenic embolization?
  • Should patients with severe injuries/or embolized injuries receive postsplenectomy vaccines?
Case Report

- On December 21st a 15 yo male snowboarding with a fall, negative LOC but with quite significant left sided pain prompting EMS transport from ski resort.
- ED evaluation - patient pale, diaphoretic, BP 110s/50s, HR 80s and with abdominal and left chest wall tenderness.
- Described by ED attending as “presyncopal in appearance”.
- FAST performed and impression in note states negative FAST .....
- Initial HCT 40.
- Is the patient stable, unstable or responder?
- Concerning exam?
Grade IV Splenic Laceration
With Contrast Blush
Hemoperitoneum
Moderate Hemoperitoneum
Decision Time

Unstable

Splenectomy

What is unstable?

Who could benefit from AE?

High risk for decompensation and/or blush by CT

What is “high risk” for decompensation?
- Predictors?

Angioembolization

Immunizations, Splenic function?

ICU Observation

Then what, how long in ICU, floor, RTW?
Trauma Consulted

- Trauma exam similar
  - Normotensive, pale, diaphoretic, HR 80s
- Angiography pursued
- Proximal splenic artery angioembolization with Gel Foam pledgets
- ICU 48 hours, HCT leveled out at 28
- Repeat CT PTD #4 for mild abdominal pain and patient desire for discharge on Christmas
Repeat CT – PTD#4
Findings?
Discharged

- Discharge December 25\textsuperscript{th}, PTD #4
- No transfusions required
- No chest tube required
- No readmission required
- No delayed splenic hemorrhage occurred
PTD - 9 Months

- Jumping all day at a trampoline park had some minor abdominal pain prompting ED visit with CT
Clinical questions from this case?

- Unstable
  - Splenectomy
    - What type of AE
      - Permanent vs Temporary
      - Proximal vs Distal / selective
  - High risk for decompensation and/or blush by CT
- Angioembolization
- ICU Observation
  - How long in ICU, floor, return to activity?
  - Immunizations, Splenic function?
• Review out of University of Texas, San Antonio in 2010 on principles, techniques and recommendations for angiographic embolization (AE) for abdominal pathology and trauma

• Splenic Trauma AE principles
  – Proximal versus Distal – remains controversial (lacks comparative data)
    • Distal coiling/treatment if extensive will result in loss of more parenchyma and be more time consuming
    • The incidence of segmental splenic infarction and intrasplenic air is increased with distal embolization
  – Proximal embolization allows collateral circulation to preserve organ parenchyma while lowering blood pressure within the organ by 50-75%
Embolicization in Trauma: Principles and Techniques

Jorge E. Lopera, M.D., F.S.I.R.¹

Embolicization agents

• Temporary agents including may allow for recannulization between 3 weeks and 4 months
  – Gelfoam commonly used in trauma
    • Encourage platelet aggregation
    • Distal / selective embolization followed by proximal coil embolization
    • Or in combination with coils proximally to reinforce thrombosis
    • Disadvantages relate to non-uniform size with possible early rebleeding
  – Liquid and small particle agents have no role in treatment of traumatic injuries because of distal tissue necrosis without proximal blood pressure control

• Permanent
  – Metallic Coils
    • Frame for clot and have the addition of some fibers (wool, nylon, silk, etc) to increase thrombogenicity
    • Multiple configurations / materials available
  – Amplatzer plugs
Complications of Splenic Trauma and/or Splenic angiographic embolization

- Splenic infarction
- Splenic atrophy
- Post-procedure bleeding
- Fever
- Pleural Effusion
- Splenic Abscess
- Pancreatitis
List of Questions

- Who should undergo laparotomy?
- What is unstable?
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  - Is there a transfusion trigger after which operative or angiographic intervention should be considered?
  - Time to reinitiating oral intake?
  - Optimum length of stay for both the intensive care unit (ICU) and hospital?
  - The duration and intensity of restricted activity after discharge?
  - Is there an immunologic deficiency after splenic embolization?
  - Should patients with severe injuries/or embolized injuries receive postsplenectomy vaccines?
There was not enough literature available to make recommendations regarding the following:

- Frequency of hemoglobin measurements
- Frequency of abdominal examinations
- Intensity and duration of monitoring
- Is there a transfusion trigger after which operative or angiographic intervention should be considered?
- Time to reinitiating oral intake
- The duration and intensity of restricted activity (both in-hospital and after discharge)
- Optimum length of stay for both the intensive care unit (ICU) and hospital
- Timing of initiating chemical deep venous thrombosis (DVT) prophylaxis after a splenic injury
- Should patients with severe injuries/or embolized injuries receive postsplenectomy vaccines?
- Is there an immunologic deficiency after splenic embolization?
List of Questions

- Who should undergo laparotomy?
- What is unstable?
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- What is the optimal imaging method for splenic injury (CT, FAST, US)?
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3 Groups
- 14 Splenectomized (SPL) patients
- 13 Splenic artery embolization patients (SPL)
- 29 health controls

Splenectomized patients had been immunized after their splenectomy

Long list of variables analyzed
- General blood work / counts
- Peripheral blood smears
- Flowcytometric analysis of lymphocytes
- Immunoglobulin quantifications
- Ultrasound/Doppler evaluation of the spleen in SAE patients
Preserved splenic function after angioembolisation of high grade injury

Jorunn Skattum\textsuperscript{a,*}, Thomas Larsen Titze\textsuperscript{b}, Johann Baptist Dormagen\textsuperscript{c}, Ingeborg S. Aaberge\textsuperscript{d}, Anne Grete Bechensteen\textsuperscript{e}, Per Ivar Gaarder\textsuperscript{f}, Christine Gaarder\textsuperscript{g}, Hans Erik Heier\textsuperscript{h}, Pål Aksel Næss\textsuperscript{i}

\textsuperscript{a}Trauma Unit, Oslo University Hospital Ullevaal, Kirkeveien 166, N-0407 Oslo, Norway


## Results

<table>
<thead>
<tr>
<th></th>
<th>SAE</th>
<th>SAE-control</th>
<th>(p)</th>
<th>SPL</th>
<th>SPL-control</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hgb, g/dL</td>
<td>15.5 ± 1.6</td>
<td>15.0 ± 0.7</td>
<td>0.29</td>
<td>14.6 ± 0.7</td>
<td>14.9 ± 1.0</td>
<td>0.33</td>
</tr>
<tr>
<td>WBC, (10^{9}$/L</td>
<td>6.9 ± 2.3</td>
<td>5.3 ± 1.6</td>
<td>&lt;0.01</td>
<td>8.4 ± 2.5</td>
<td>4.7 ± 0.7</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lymphocytes, (10^{9}$/L</td>
<td>2.1 ± 0.6</td>
<td>1.9 ± 0.6</td>
<td>0.33</td>
<td>2.7 ± 0.9</td>
<td>1.5 ± 0.3</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Neutrophils, (10^{9}$/L</td>
<td>4.0 ± 1.9</td>
<td>2.7 ± 0.9</td>
<td>0.02</td>
<td>4.4 ± 1.8</td>
<td>2.5 ± 0.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Monocytes, (10^{9}$/L</td>
<td>0.63 ± 0.1</td>
<td>0.46 ± 0.1</td>
<td>&lt;0.01</td>
<td>0.89 ± 0.3</td>
<td>0.46 ± 0.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Platelets, (10^{9}$/L</td>
<td>267 ± 40</td>
<td>211 ± 35</td>
<td>&lt;0.01</td>
<td>389 ± 153</td>
<td>223 ± 43</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>H–J bodies, %</td>
<td>0.2 ± 0.4</td>
<td>0.1 ± 0.3</td>
<td>0.53</td>
<td>7.3 ± 11.8</td>
<td>0.1 ± 0.5</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Values are given in mean ± SD. GBC, general blood counts; Hgb, hemoglobin; H–J bodies, Howell–Jolly bodies; SAE, splenic artery embolisation; SPL, splenectomy.

<table>
<thead>
<tr>
<th></th>
<th>SAE</th>
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<th>(p)</th>
<th>SPL</th>
<th>SPL-control</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgA, g/l</td>
<td>2.3 ± 0.9</td>
<td>1.9 ± 1.0</td>
<td>0.2</td>
<td>2.6 ± 1.1</td>
<td>1.8 ± 0.6</td>
<td>0.04</td>
</tr>
<tr>
<td>IgM, g/l</td>
<td>0.8 ± 0.4</td>
<td>0.8 ± 0.3</td>
<td>0.5</td>
<td>0.7 ± 0.3</td>
<td>0.8 ± 0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>IgG, g/l</td>
<td>10.8 ± 2.3</td>
<td>11.1 ± 2.2</td>
<td>0.7</td>
<td>12.2 ± 2.4</td>
<td>11.2 ± 2.5</td>
<td>0.5</td>
</tr>
<tr>
<td>IgG/14, (\mu$g/ml</td>
<td>6.4 ± 7.3</td>
<td>3.3 ± 4.9</td>
<td>0.2</td>
<td>9.8 ± 7.8</td>
<td>2.3 ± 3.1</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>IgG/18c, (\mu$g/ml</td>
<td>1.4 ± 1.5</td>
<td>1.8 ± 1.9</td>
<td>0.6</td>
<td>3.5 ± 2.4</td>
<td>1.2 ± 0.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>IgG/23F, (\mu$g/ml</td>
<td>2.8 ± 3.1</td>
<td>2.5 ± 2.6</td>
<td>0.9</td>
<td>3.2 ± 3.0</td>
<td>1.3 ± 0.9</td>
<td>0.04</td>
</tr>
<tr>
<td>IgG/35B, (\mu$g/ml</td>
<td>6.8 ± 9.4</td>
<td>4.4 ± 4.7</td>
<td>0.6</td>
<td>6.9 ± 6.4</td>
<td>2.8 ± 2.3</td>
<td>0.05</td>
</tr>
<tr>
<td>IgM/19F, (\mu$g/ml</td>
<td>1.5 ± 1.2</td>
<td>1.9 ± 1.8</td>
<td>0.4</td>
<td>1.6 ± 0.9</td>
<td>1.1 ± 1.5</td>
<td>0.05</td>
</tr>
<tr>
<td>IgG pneumovax, U/l</td>
<td>20.7 ± 13.9</td>
<td>13.6 ± 9.5</td>
<td>0.2</td>
<td>23.9 ± 11.9</td>
<td>12.3 ± 6.5</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Results (cont)

• SPL and SAE are associated with increased leukocytes and platelet counts
  – Previously study showed this in patients who underwent splenic salvage (splenorrhaphy) as well
  – Clinical relevance not known

• H-J bodies only seen in SPL patients
  – Absence in SAE group indicates preserved splenic reticuloendothelial function

• Doppler/US eval of SAE
  – Return to near normalization of flow parameters
    • Size, mean parenchymal flow, acceleration, systolic/diastolic flow ratio almost identical to previously studied controls from this institution
Conclusions

• SPL and SAE are associated with mild leukocytosis and thrombocytosis of unclear clinical significance

• SAE patients
  – Appear to have preservation of splenic size and splenic function
  – May not benefit from vaccinations
List of Questions

• Who should undergo laparotomy?
• What is unstable?
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Conclusions

• Traumatic splenic injuries can be life threatening
• The unstable patient should undergo laparotomy while the patient responding to resuscitation can be considered for angiographic embolization
• Non-operative management of splenic trauma is the standard of care in the hemodynamically stable patient
• Contrast blush and high grade splenic injuries likely benefit from angiographic embolization
• Proximal embolization is associated with potentially less splenic necrosis allowing for collateral flow and preservation of immune function
• Repeat imaging recommendations vary but should be protocol driven to standardize treatments - centered around persistent clinical concerns / symptoms and severity of injuries.
• Splenic vaccinations are recommended after splenectomy but may not be necessary after proximal angioembolization
• Best timing for length of ICU and hospital stays and timing for return to normal activities remain unanswered
• **Protocol driven treatment plans** are recommended to standardize approach
Now you’ve become
Segway riding .... Oozie carrying .... Ninjas in Management of Splenic Trauma Questions?