CHANGES IN MANAGEMENT OF INJURIES TO THE LIVER AND SPLEEN

J. David Richardson, MD
Department of Surgery
University of Louisville
Louisville, Kentucky
GOAL

- Treatments often change based on change in mindset without any real change in knowledge

- Flexible about our views about treatment
METHOD OF REVIEW

- Full length papers (not abstracts) reviewed on injuries to liver and spleen
- Sources were Current List of Medical Literature, Index Medicus, and bibliographies from other publications
- Reviewed most literature in English before 1950 and several sentinel paper in German and French
- Most major papers from last 50 years but not all
- Over 500 papers reviewed
Comparative literature of 1930s to 2010

- Citations on spontaneous splenic rupture secondary to typhoid, malaria, or mono-nucleosis greatly outnumber reports on traumatic splenic injuries.

- Less than 30 citations on splenic trauma.

- 1990-2010 over 1500 references, etc.
MANAGEMENT OF LIVER INJURIES

• Advent of operative treatment to WW II

• Post-war to mid-1980s → period of aggressive operative treatment

• Late 1980s to present
Most of the concepts on the treatment of liver injuries in use today were developed prior to WW I and were generally discarded only to be rediscovered 70 or 80 years later.
HIGHLIGHTS FROM THE PAST

1890  Clementi – inflow occluded by portal triad clamp

1896  Kousnetzoff & Penski – abdominal packing and special blunt liver needle

1906  Schroeder – perihepatic packing and balloon occlusion of intra-hepatic hemorrhage

1908  Pringle – compression of artery & vein for inflow occlusion

1910  Boljarski – omental pedicle sutured to liver wounds
PREDOMINANT TREATMENT PRIOR TO WW II

• Liver suture with variety of inventive techniques

• Liver packing

• Mortality from WW I -- 66.2%
IMPACT OF WORLD WAR II

- Following WW II, Madding reported on 829 operations for liver injury by Second Auxiliary Surgical Group
- 1941 – 34% packed → 1945 – 9.6%
- Hepatorrhaphy 5% in any year of war
- Drainage 90% of cases
WORLD WAR II
IMPACT OF TREATMENT ON
MORTALITY

- Mortality of 27% in 827 pts
- Dramatic improvement over the 66.2 of WW I
- Only 9.7% death rate from isolated liver injury
- Authors’ assessment
  - uniform drainage
  - avoidance of packing
  - no mention of better perioperative care
OPERATIVE TREATMENT: 1945-85

- Beginning in 1950s, multiple large series of liver wounds reported
- More GSWs and higher speed motor crashes
- Better resuscitation
- Increasing problems with bleeding and deaths from hemorrhage
TYPES OF BLEEDING NOTED

- Arterial hemorrhage
- Major venous injuries including retrohepatic vena cava
- Diffuse (non-surgical tissue) from injured or devitalized tissue
- Combination of above
SURGICAL TRENDS: 1945 TO 1985

- No gauze packing
- Uniform drainage
- Increased use of liver debridement
- Tractomy
- Popularization of omental patch
- Brief rise of anatomic resection
- Selective hepatic artery ligation
- Atriocaval shunt for retrohepatic vena caval injury
- Rediscovery of temporary inflow occlusion
RETROSPECTIVE OBSERVATIONS ON SURGICAL TREATMENT: 1945-85

• Aggressive treatment
• Every injury was treated by some method (at least drainage)
• Aggressive surgical procedures described – tractomy, anatomic hepatic lobectomy, atriocaval shunt, hepatic artery ligation to prevent rebleeding
• Most of these treatments have not stood the test of time
LIVER INJURIES: 1985-PRESENT

- Overall mortality had improved by early 1980s
- Steep decline in deaths from perihepatic sepsis
- Death from hemorrhage remained a problem
- Literature focused on strategies to combat fatal bleeding
TREATMENT TRENDS: 1985-PRESENT

- Direct repair of perihepatic venous injuries
- Perihepatic packing and damage control strategies
- Arteriographic embolization of hepatic arterial hemorrhage
- Non-operative treatment
JUXTAHEPATIC VENOUS INJURIES

- Major venous injuries remain an unsolved problem
- Atriocaval shunt had dismal results
- San Francisco General – 1968-1987 best reported results in 27 pts. – 55% mortality
- Collected 412 cases of AC shunt from literature 88% mortality
DIRECT REPAIR OF VENOUS INJURIES

- Beathea – 3 cases of direct repair with inflow occlusion → all survived
- Other reports of direct repair equal to ACS
- Coln – 4 children successfully with direct repair
- Pachter – 5 pts w/o shunt and all survived
- Carrillo & Richardson – 4 survived using in-situ vascular clamp & packing
PERIHEPATIC PACKING

• Although denigrated after WW II, packing was reported sporadically in large series of liver injuries

• Lucas and Ledgerwood packed 3 survivors in series of 625 cases (1976)

• Calne –1979 -- 4 cases -- pack and transport to a center
REAPPRAISAL OF PACKING

- Coagulopathy well recognized—focus on component replacement
- Feliciano & Mattox (1981) – 9/10 seriously injured survived
- Carmona (1982) and Svoboda (1984) report on packing with improved survival
- “Damage control” strategy became a recognized concept
REFINEMENTS OF PACKING

• Correct coagulopathy
• Planned re-exploration in 1-3 days
• Abdominal compartment syndrome
• Treatment of open abdomen
• Multiple reports with 40-60% survival of pts who would have previously died
ANGIOGRAPHY AND EMBOLIZATION

- Numerous reports on embolization
- Contrast blush on CT, combined with other strategies
- Over 80% success rate
- Low mortality but high morbidity
- Gall bladder necrosis and liver infarction are problems
NONOPERATIVE MANAGEMENT (NOM)

- Hinton (1926) advocated non-op Rx but success of WW II led to uniform operation

- Pediatric surgeons initially concerned with nonoperative treatment of spleen injuries in children, began to practice similar treatment in liver injuries
ADJUNCTIVE TECHNIQUES TO LIVER NOM

- Must be prepared to offer adjunctive treatment
- ERCP for large bile leaks
- Angiography
- Percutaneous drainage
- Laparoscopy to drain bile – 60 cases with excellent results
# Major Juxtahepatic Venous Injuries

<table>
<thead>
<tr>
<th>Period</th>
<th>Injuries</th>
<th>Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-1994</td>
<td>54</td>
<td>2.7</td>
</tr>
<tr>
<td>1995-2004</td>
<td>14</td>
<td>1.5</td>
</tr>
<tr>
<td>2005-2010</td>
<td>10</td>
<td>1.7</td>
</tr>
</tbody>
</table>
AGGRESSIVE OPERATIVE TREATMENT

• Several recent reports have focused use of operation with resection for major hepatic injuries
• Often use staplers and techniques borrowed from surgeons performing hepatic resections electively
• Clearly some injuries require major operative treatment
TRAINING NEEDS IN HEPATIC TRAUMA

- One of the major concerns for the future is provision of expertise required to perform operations for complex liver injuries when required.
- Operative management is difficult and skill acquisition is hard in NOM-era.
- Use other opportunities to learn: surgical oncology, transplant, cadaver lab, etc.
Treatment of Liver Injuries

Blunt Trauma

- Stable
  - Non-operative treatment in monitored setting
    - Discharge
    - Follow-up
    - Scans? Activity?

- Unstable
  - Interventional procedures for complications
    - Drainage, ERCP, Angiographic embolization
  - Celiotomy
    - Continued bleeding
    - Associated injury
    - Other complications

Penetrating Injury

- Unstable
  - Celiotomy
    - CT scans and no other injury, possible observations
  - Angiography
    - Blush on CT scan

- Stable
INJURY TO THE SPLEEN

- Historical references date to the Renaissance
- Bessel-Hagen reported 37 splenectomies collected from 19th century, although cause not specified
- Pre-1930, less than 500 reported cases of splenectomy for trauma with 38% mortality
IMPACT OF THE WORLD WARS

- Splenectomy in AEF experience nearly 100% mortality

- WW II – mortality decline to 10-20%—less than 5% when isolated
ERAS IN MANAGEMENT OF SPLENIC TRAUMA

• Splenectomy for all splenic wounds

• Splenic conservation
POST-WW II EXPERIENCES

- Large series of splenic injuries reported treated by splenectomy
- Relatively high overall mortality but virtually no deaths related to spleen itself or isolated spleen injury
- Low specific complication rate
- Concern over delayed splenic rupture as a cause of death
DELAYED SPLENIC BLEEDING

• 1943 – Zabinski & Harkins – delayed ruptured – risk of sudden death
• 1956 – Bollinger – 258 cases – 21.5% delayed bleeding
• 12 collected series – 6% mortality pre-NOM
• 1990 – Farhat – 1 death + 30 other cases
• 1994 – Kluger – 27 cases from 1985-1992
• 1930s-present – 1-2% incidence of major bleeding
PHILOSOPHY OF SURGEONS OF PREVIOUS ERA

- Hemorrhage from ruptured spleen killed people
- In addition to bleeding on presentation, delayed bleeding could kill
- This could be prevented by another operation that was technically straightforward; produced virtually no deaths and low morbidity
HEMORRHAGE VS. INFECTION
POST-SPLENECTOMY INFECTION

- 1919 -- Morris and Bullock – splenectomy increased deaths in rats injected with rat plague
- Several other studies suggested increased infection rate after splenectomy
  - King and Shumacker (1952) – Indiana
  - Singer (1973) – Texas Children’s
CLASSIC PEDIATRIC STUDIES

King and Shumacker – 5 children undergoing splenectomy for congenital hemolytic anemia at ages 2, 3, 4 weeks and 6 and 25 mos. of age; two pairs of siblings died

Singer – 6 cases from Texas Children’s at 4, 5, 10, 17 mos. and 2 and 3 yrs. of age. The 2-yr. old was a trauma pt who died of H. flu 3 yrs. later

Singer collected 688 trauma pts including 388 children with splenectomy and found 4 deaths due to sepsis.

Death rate in children 0.58% & .01% overall
POST-SPLENECTOMY INFECTION IN ADULTS

- Whitaker – 1969 – noted infection (not trauma pt)
- O’Neal and McDonald – 7 cases of fatal sepsis in 256 asplenic pts
CONFUSING LITERATURE

- Many reports cite the same cases
- 45 articles on about 70 pts with post-trauma splenectomy and infection
- West Australia – 628 trauma splenectomy pts with 3922 persons--yrs of follow-up → 8 infections and 1 death
- British questionnaire of microbiologist cites 24 trauma cases –no details on methodology – 46% mortality
- Zarrabi & Rossner – 34 adult trauma pts in world’s literature with 50 mortality
WHAT WE KNOW ABOUT POST-SPLENECTOMY SEPSIS

- Much more common in children
- Occurs in adults but rarely
- Encapsulated organisms
- At-risk period long
- OPSI much less common than P.S. infection which has high survival
## POSTOPERATIVE INFECTION RATES AFTER SPLENECTOMY FOR TRAUMA (INCIDENCE PER 100 YRS OF PTS EXPOSURE)

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>SEPSIS</th>
<th>MORTALITY</th>
<th>OPSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schwartz</td>
<td>3.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Malangoni</td>
<td>0.25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sekikawa</td>
<td>0.57</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>1.91</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Cullingford</td>
<td>0.21</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.59</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>
LOUISVILLE EXPERIENCE

- 1972-1988 → 414 splenectomies with 2167 pt years follow-up
- One likely case (of Gram + pneumonia) who survived
- One aspiration with polymicrobial lung abscess in alcoholic
- Major health problems were sequelae of original injury, alcohol and drug dependence, and trauma recidivism
OPERATIVE SPLENIC SALVAGE

- Autotransplantation/splenic implants
- Splenorrhaphy
- Partial splenectomy
- Wrapping techniques
- Rarely used in current environment: NOM or splenectomy
SPLENIC ARTERY EMBOLIZATION

- Originally introduced in transplant & hypersplenic pts as an alternative to splenectomy
- 1995 – Scalfani and Scalea performed diagnostic angiograms on 150 pts with suspected splenic injuries and embolized 60 with “positive” angiograms for 98.5% success rate
- “Contrast blush” on CT predicts failure of non-op management → treated by embolization
SPLENIC EMBOLIZATION

- Early study espousing its use
- Han – 2004 – multicenter experience
  - Significant hemoperitoneum
  - Contrast extravasation
  - Splenic artery pseudoaneurysm
  - AV fistula
- Failure rate 13.5%
- 14 pts required repeat embolization
- 20% complication rate
  - hemorrhage 13%
  - missed injuries 3%
  - infection 4%
  - 6 splenic abscesses
- Authors felt these were good results
## VALUE OF SPLENIC EMBOLIZATIONS

<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Aids NOM</td>
<td>- Failure rate is real</td>
</tr>
<tr>
<td>- Preserves splenic function</td>
<td>- Complications understated</td>
</tr>
<tr>
<td>- Usually successful</td>
<td>- Secondary operation difficult</td>
</tr>
<tr>
<td></td>
<td>- Is splenic function preserved?</td>
</tr>
</tbody>
</table>
NON-OPERATIVE MANAGEMENT OF SPLENIC INJURY

- NOM is clearly the strategy of choice in children; its benefits are much better defined than in adults, and its failure rate is low.

- Some controversies in adults (should it be used in over 55 year group) but has emerged as the predominant treatment strategy in trauma centers.
FAILURE OF NOM

• Most fail early but not all -- 7 pts failed after Day 9
• Cogbill – failures at Day 5,6,9,10,13,19 and 36
• Cleveland – 31 failed at average of 71 hours – one at 29 days
• Pittsburgh – Day 8 – outside smoking at Day 8
NOM IN ADULTS

- EAST multi-institutional experience on 1488 pts from 27 centers
- 39% required immediate operation
- 11% failure rate of NOM
- Advanced grade of injury, degree of hemoperitoneum, associated injuries predicted failures
- Failures in > 55 y.o. had increased mortality
LOUISVILLE EXPERIENCE

- 6 deaths due to splenic bleeding in NOM
- Days 6 and 10 in ICU; Day 9 on ortho service; Day 16 at local Walmart
- One hypoxic brain injury after arrest due to bleeding
- Not all failures are drifting hemoglobin levels
- Recent delayed rupture
REAL RISK OF SPLENECTOMY AFTER DISCHARGE

- Used Tennessee statewide hospital discharge data system

- Non-op treatment of blunt splenic injury had a 1.4% incidence of splenectomy on readmission over 180 days (27 of 1932 pts in 5 yrs)
MORTALITY OF SPLENIC INJURIES
SELECTED SERIES

* Spleen related mortality < 1%
IMPACT OF NOM ON RESIDENT TRAINING

• The continued attempt to “push the envelope” on NOM sends mixed messages and unclear signals to trainees (is it wrong to do a splenectomy?)

• We run the risk of training surgeons who cannot do a life-saving splenectomy

• Not every hospital where splenectomy might need to be performed has an angiographer to embolize the splenic artery
SUMMARY

• The characteristics of “solid organ injuries” which implies uniform treatment of both organs is probably an oversimplification.

• Liver injury risk is front-loaded with few long-term problems while spleen injuries have more long-term problems, despite more straightforward operative treatment.

• Attempts to “finesse” NOM with complex spleen injuries is fraught with peril.
COMMENTS