Complex hepatic trauma

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Liver Injury Scale

I  - subcapsular (<10%) hematoma, <1cm laceration
II - subcapsular (10-50%), intraparenchymal (<10 cm) hematoma
    - 1-3 cm deep laceration (<10 cm long)
III - subcapsular (>50% or exp.), intraparenchymal
      (>10 cm or exp.) or ruptured hematoma
      - >3cm deep laceration
IV - parenchymal disruption (25-75% of lobe or 1-3
    segments in one lobe)
V  - parenchymal disruption (>75% of lobe, >3 segments)
    - juxtahepatic venous injury, hepatic avulsion

Moore et al. 1995
Management strategy of liver injuries

- same principles apply to blunt and penetrating injuries
- unstable hemodynamics
  - urgent laparotomy → intraoperative assessment of all injuries → definitive repair or damage control
- stable hemodynamics
  - assessment of severity and other injuries (CT)
  → nonoperative management
    - adjuncts: angiography, endoscopy
  → operative management
    - “surgical” injuries, failed NOM
Severe hepatic trauma: Nonoperative management, definitive repair, or damage control surgery?

- n = 144 Grade III-V liver injuries (94% blunt)
- mean ISS 31, shock on admission 56 (39%)
- early laparotomy 50 (35%)
  - damage control 21 (42% of all operated injuries)
  - definitive repair 22 (44% of all operated injuries)
  - non-therapeutic 7
- nonoperative management 94 (65%)
  - failed 8 (9% of NOM patients)

Leppäniemi et al. WJS 2011;35:2643
## Complex liver injuries (Helsinki)

Factors predicting early laparotomy for blunt trauma patients (univariate analysis)

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shock on admission</strong></td>
<td>30.72</td>
<td>11.00-85.8</td>
</tr>
<tr>
<td><strong>Spleenic injury grade 4-5</strong></td>
<td>3.86</td>
<td>1.03-14.5</td>
</tr>
<tr>
<td><strong>Head injury grade 4-5</strong></td>
<td>3.54</td>
<td>1.46-8.59</td>
</tr>
<tr>
<td><strong>Liver injury grade 5</strong></td>
<td>3.5</td>
<td>0.83-10.82</td>
</tr>
<tr>
<td><strong>Multiple injury</strong></td>
<td>3</td>
<td>0.83-10.82</td>
</tr>
<tr>
<td><strong>Liver injury grade 4-5</strong></td>
<td>0.92</td>
<td>0.43-1.93</td>
</tr>
<tr>
<td><strong>Renal injury grade 4-5</strong></td>
<td>0.82</td>
<td>0.24-2.73</td>
</tr>
</tbody>
</table>

Leppäniemi et al. WJS 2011;35:2643
CT risk factors for operative treatment in initially stable patients with blunt liver trauma (n=214)

- more frequent findings in operated patients:
  - intraperitoneal contrast extravasation
  - hemoperitoneum in 6 compartments
  - maceration > 2 segments, high liver injury grade
  - deep laceration (>5 cm), porta hepatis involvement
- logistic regression:
  - extravasation = **continuous bleeding** (RR 12.5)
  - hemoperitoneum = **massive bleeding** (RR 22)

Fang et al. 2006
# Complex liver injuries (Helsinki)

Factors predicting failure (9%) of NOM (univariate analysis)

<table>
<thead>
<tr>
<th>Factor</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated Grade 4-5 splenic injury</td>
<td>14.00</td>
<td>1.67-117.55</td>
</tr>
<tr>
<td>Shock on admission</td>
<td>6.82</td>
<td>1.49-31.29</td>
</tr>
<tr>
<td>Renal injury grade 4-5</td>
<td>2.85</td>
<td>0.5-16.3</td>
</tr>
<tr>
<td>Multiple injury</td>
<td>1.72</td>
<td>0.2-14.98</td>
</tr>
<tr>
<td>Head injury grade 4-5</td>
<td>0.97</td>
<td>0.11-8.69</td>
</tr>
<tr>
<td>Liver injury grade 4-5</td>
<td>0.62</td>
<td>0.15-2.66</td>
</tr>
</tbody>
</table>

Leppäniemi et al. WJS 2011;35:2643
Key surgical techniques
Incision
Massive bleeding
hemorrhage!
Techniques for temporary control

Scoop out blood
  - 4 quadrant packing
  - determine source of bleeding
Manual compression
Pringle maneuver
Perihepatic packing
REBOA?
Pringle Maneuver

- finger dissection
- compression
- vascular clamp
- easier from patient’s left
- 15 (60) minutes
- intermittent
Temporary packing
Critical factors favoring damage control approach

• Critical factors (the deadly triad)
  – Hypothermia: $T^\circ < 34^\circ$
  – Severe metabolic acidosis
    • pH $< 7.2$
    • Lactate $> 5$ mmol/l
  – Coagulopathy
    • Massive transfusion

• Secondary factors
  – Severe injury
  – Operating time $> 90$ minutes
Definitive perihepatic packing
Through - and - thorough injury
Internal tamponade

- balloon (Poggetti 1992)
- plastic bag pulled though the injury and filled with sponges (Ong 2007)
- appropriate size “cigar” constructed from absorbable material and pulled into the tract
- does not require removal
Leave the abdomen open abdomen, temporary abdominal cover
Angiographic embolization of liver injuries

- 538 liver injuries, Gr III-VI (early angio as adjunct to oper.)
- 116 patients (22%) for angiography, 71 (13%) embolized
- liver-injury related death in 8/71 (11%)
- 43 (61%) patients liver-related complications
  - hepatic necrosis (30), bile leak (14), abscess (12), gallbladder infarct (5), rebleeding (2), pseudoaneurysm, cholecystitis, biliary stricture (1 each)
  - management of hepatic necrosis: lobectomy 16, operative debridement + percutaneous drainage 14

- Conclusion: AE useful adjunct to damage control surgery

Dabbs et al. 2009
When to remove the packs?

- too early → rebleeding, too late → infection
- 71 patients with damage control laparotomy
  - liver, pelvis, retroperitoneum, splenic bed

<table>
<thead>
<tr>
<th>Packing (hr)</th>
<th>Infection</th>
<th>Re-bleeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>4.8%</td>
<td>42.9%</td>
</tr>
<tr>
<td>48</td>
<td>22.2%</td>
<td>14.8%</td>
</tr>
<tr>
<td>72</td>
<td>31.6%</td>
<td>10.5%</td>
</tr>
<tr>
<td>96</td>
<td>67%</td>
<td>0</td>
</tr>
<tr>
<td>120-144</td>
<td>100%</td>
<td>0</td>
</tr>
</tbody>
</table>

Ordonez et al. 2009
Definitive repair: surgical goals

- hemostasis
  - liver parenchyma
  - juxtahepatic veins
- preserving liver function
  - blood supply
  - amount of parenchyma
- infection control
  - removing devitalized tissue
  - controlling bile leaks
Liver injury → graded response

- start with the simplest hemostatic option
- if ineffective, be ready with an alternative hemostatic option
No bleeding, no bile leak → no action
Superficial bleeding with capsular avulsion → local hemostatics
Capsular bleeding → suture
Peripheral injury $\rightarrow$ suture
If bile leak → drain
Major laceration $\rightarrow$ deep liver suture (pledgets or omentum if needed)
Finger fracture hepatotomy and vessel ligation
Nonanatomical resection

- resection along injury lines
- no hilar preparation
- ligation of vessels and bile ducts
- defect left open
Juxtahepatic venous injury

- suspect when Pringle does not help
- before mobilizing a retrohepatic hematoma: think!
  - perihepatic packing often safest
- suture repair after mobilization and initial vascular control
- shunts complicated, seldom used
Perihepatic drainage after major liver procedures
Complex liver injuries (Helsinki)

- overall mortality rate 21/144 (15%), 8 liver-related
- factors predicting death (univariate)

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<th>95% CI</th>
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<tbody>
<tr>
<td>Head injury (AIS 4-5)</td>
<td>13.75</td>
<td>4.8-39.36 *</td>
</tr>
<tr>
<td>Shock on admission</td>
<td>13.42</td>
<td>3.73-48.30 *</td>
</tr>
<tr>
<td>Compression injury</td>
<td>12.9</td>
<td>3.59-46.47</td>
</tr>
<tr>
<td>Laparotomy</td>
<td>8.50</td>
<td>2.69-26.90</td>
</tr>
<tr>
<td>Damage control laparotomy</td>
<td>6.35</td>
<td>2.25-17.92</td>
</tr>
<tr>
<td>Laparotomy &lt;12 hours</td>
<td>6.29</td>
<td>2.26-17.51</td>
</tr>
<tr>
<td>Liver injury Grade IV-V</td>
<td>3.11</td>
<td>1.04-9.34</td>
</tr>
</tbody>
</table>

* significant in multivariate analysis

Leppäniemi et al. WJS 2011;35:2643
Summary

1. Which injuries should be managed operatively?
   - hemodynamically unstable patients
   - continuous or massive bleeding on CT
   - associated high grade splenic injury
   - failed nonoperative management

2. When to apply damage control surgery?
   - physiological exhaustion of the patient and major liver trauma or multiple injuries

3. When to consider interventional radiology?
   - angio: extravasation on CT (NOM), after damage control?
   - percutaneous drainage of bile collections (± ERCP)