Penetrating Trauma to the Precordium-Cardiac Injuries

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Case

- 46 yo man s/p stab wounds to xiphoid region and left upper quadrant, slash to left wrist.

- Physical exam
  - VS 98.4, 125/67, 89, 20, 97%
  - Breath sounds b/l
  - Abd soft, nontender
  - 1.5 cm stab wounds to xiphoid, LUQ without active bleeding
  - Left wrist + distal pulses
• PM/SH: 1986 ex lap for gsw to back, chronic back pain
• ED course: CXR, FAST limited subxiphoid window, otherwise negative
• Labs:
  – CBC 15/13.8/42/298
  – Others WNL
TTE

- Suboptimal subxiphoid window
- No gross pericardial fluid or air
OR Course

- Subxiphoid window—negative
- Local wound exploration, LUQ—negative
- Exploration of left wrist laceration, wash out
Post Operative Course

• Regular diet POD 1, uncomplicated course
Contents

• History
• Work up
• Treatment algorithm
• Repair of cardiac injuries
• Drainage of hemopericardium
History

• “Any surgeon who should attempt to suture a wound of the heart should lose the respect of his colleagues.”
  
  — Theodore Bilroth 1883

• 1820- Dominique-Jean Larrey → cardiac wounds treated by pericardial drainage
History

• 1896- Ludwig Rehn, first successful primary repair of a cardiac wound

“Patient appears moribund…I decided to operate entering the chest through the left 4th intercostal space…There is a 1.5 cm gaping right ventricular wound…I decided to suture the heart wound…I used a small intestinal needle and silk suture…all bleeding was controlled…The patient is cured.”
History

• 1943 Alfred Blalock- step-wise approach. pericardial drainage → cardiorrhaphy if recur
• 1953- John Gibbon cardiac bypass
• 1962- AC Beall, first use of bypass in cardiac trauma
• 1966- technique of ED thoracotomy
Anatomy

- The “Box”: Clavicle, mid-clavicular lines, costal margins
- Injury to right ventricle > left
Presentation

- Asymptomatic $\rightarrow$ cardiopulmonary arrest
- Ventricles (L>R) can seal off injuries $\rightarrow$ signs of life
- Decreased breath sounds
  - Pneumothorax
  - Hemothorax
Presentation

• Pericardial tamponade
  – *Beck’s triad* (muffled heart sounds, JVD, hypotension) in 10%
  – *Kussmaul’s sign* (JVD on inspiration)
  – Effect *protective* → *deleterious*
Diagnostics

• CXR
  – **Essential** in all except when immediate surgery is indicated
  – Pneumo/hemothorax
  – Pulmonary contusion
  – Pneumomediastinum
  – Mediastinal hemorrhage
Diagnostics

- FAST
- 2D echo
  - TTE “Gold standard”
    - All patients, echo sensitivity 56%, specificity 93%
    - Without right sided pneumothorax or hemothorax, echo sensitivity 100%, specificity 89%
    - Echo is reliable if no right pneumo or hemothorax
  - No role for TEE during initial work up
2D echo

• Limitations
  – Operator dependent
  – False negative: clotted hemopericardium, effusion decompressed into pleural space
  – Obesity, subcutaneous emphysema
Diagnostics

- **Subxiphoid pericardial window**
  - Was “gold standard” until 2D echo
  - Less frequently done after echo introduced
  - Important in indeterminate or difficult cases

- **Transabdominal pericardial window**
  - During laparotomy

- **Pericardiocentesis**
  - High false positive and false negative rates
  - Therapeutic role limited
Diagnostics

• CT chest
  – Only in stable patients
  – CTA to evaluate for occult major vascular injuries
PENETRATING CARDIAC INJURY

Rapid primary survey (Exclude tension pneumothorax)

- Lifeless
  - Immediate intubation
  - No improvement
    - ERT
    - Improvement
      - OR for sternotomy

- Critically unstable
  - Immediate intubation & fluid resuscitation

- Cardiac Tamponade
  - OR for sternotomy

- Thoracoabdominal injury
  - Chest tube/s Fast
    - OR for laparotomy or sternotomy
      (Sequence decided by clinical judgement)

- Benign presentation
  - Formal echocardiogram
Hemodynamically Stable

Benign presentation

Formal 2D Echo (and CTA)

- +
- +/-
- -

OR for exploration

Pericardial Window

Observation

- +
- -

Sternotomy

No further Intervention
Atrial Repair

- Thin walls
- Simple interrupted or continuous
- 4-0 Prolene
- Autologous pericardium for large defects
Repair of Ventrices

- Mattress sutures
- Full thickness bites
- 2-0 Ethibond
- Teflon or native pericardium pledgets
Injuries over Coronary Arteries

- Sutures under artery bed
- Injuries to proximal segment $\rightarrow$ revascularization
- Distal segment $\rightarrow$ ligation
Complex Combined Injuries

- Intraoperative TEE
- R/o valvular, septal injuries, intracardiac fistulas
Indications for Cardiopulmonary Bypass

<table>
<thead>
<tr>
<th>Type of injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exsanguinating injury unable to be controlled by other means</td>
</tr>
<tr>
<td>Coronary artery injuries</td>
</tr>
<tr>
<td>Valvular injuries</td>
</tr>
<tr>
<td>Large intracardiac septal defects</td>
</tr>
<tr>
<td>Retained intracardiac projectiles</td>
</tr>
<tr>
<td>Coronary-cameral fistula</td>
</tr>
</tbody>
</table>

Cardiac apex
Left lung
Fibrous pericardium
Left anterior descending coronary artery
Arterial cannula
Venous cannula
Sternotomy or Drainage for a Hemopericardium After Penetrating Trauma

A Randomized Controlled Trial

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- Single center Cape Town, South Africa
- Cohort: penetrating injury with hemopericardium on subxiphoid pericardial window, hemodynamically stable, no active bleeding
- Randomization: sternotomy, pericardial drainage
- Primary outcome measure: survival to discharge
Background

• **Accepted management (Board Answer!)** of stable penetrating cardiac injuries with hemopericardium is immediate sternotomy and exploration

• **Pilot study 2001**: 71% (10/14) with hemodynamically stable penetrating cardiac injury had nontherapeutic sternotomies

• **Sealed vs. not sealed injuries**: active bleeding from subxiphoid window
Study Algorithm I

Penetrating Injury to Chest

Stable

2D echo

Positive ICU Observation

Negative Exclude

Stable after 24 hr

Unstable Exclude

OR for Window
Study Algorithm II

Window
- Blood
- Irrigate
- Blood
- Exclude

- active bleeding
- active bleeding
Exclude

Drainage
Sternotomy

Randomization
## Results

**TABLE 4. The Clavien-Dindo Classification of the Complications**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description of Grade</th>
<th>Complication</th>
<th>Sternotomy</th>
<th>Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions</td>
<td>Atelectasis</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Requiring pharmacological treatment with drugs other than such allowed for grade 1 complications</td>
<td>Pneumonia</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Requiring surgical, endoscopic, or radiological intervention</td>
<td>Pulmonary edema</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wound sepsis</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reaccumulation of hemothorax</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Life-threatening complication requiring ICU management</td>
<td>Cardiac arrest</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Death of a patient</td>
<td>Sternal sepsis</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Considerations

• Board answer is sternotomy!
• Patient selection
• Risks and benefits
• Resources
References

1. Trauma 6e, Feliciano et al.
2. Pearson’s Thoracic and Esophageal Surgery
3. Sabiston and Spencer’s Surgery of the Chest 8e
<table>
<thead>
<tr>
<th>Variable</th>
<th>Sternotomy, Mean (SD) (n = 55)</th>
<th>Drainage only, Mean (SD) (n = 56)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>29.4 (9.04)</td>
<td>26.7 (7.80)</td>
<td>0.09</td>
</tr>
<tr>
<td>Revised Trauma Score</td>
<td>7.813 (0.16)</td>
<td>7.791 (0.22)</td>
<td>0.56</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>11.4 (1.57)</td>
<td>11.2 (2.04)</td>
<td>0.54</td>
</tr>
<tr>
<td>CVP (cm H$_2$O)</td>
<td>13.5 (6.22)</td>
<td>13.7 (4.94)</td>
<td>0.88</td>
</tr>
<tr>
<td>Size of pericardial effusion on US in mm</td>
<td>8.3 (5.88)</td>
<td>8.9 (5.91)</td>
<td>0.57</td>
</tr>
<tr>
<td>Mechanism of trauma</td>
<td>SW 54</td>
<td>SW 55</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>GSW 1</td>
<td>GSW 1</td>
<td></td>
</tr>
</tbody>
</table>

SD indicates standard deviation; SW, stab wound.
<table>
<thead>
<tr>
<th>AAST Grade</th>
<th>No. Patients (%)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13 (24)</td>
<td>Penetrating pericardial wound without cardiac injury</td>
</tr>
<tr>
<td>2</td>
<td>38 (69)</td>
<td>Penetrating tangential myocardial wound not extending to the endocardium</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>Penetrating tangential myocardial wound with tamponade</td>
</tr>
<tr>
<td>4</td>
<td>3 (5)</td>
<td>Penetrating cardiac injury of RV/RA/LV/LA</td>
</tr>
<tr>
<td>5</td>
<td>1 (2)</td>
<td>Left ventricular perforation</td>
</tr>
</tbody>
</table>

LA indicates left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle.