Case Report

- 39yM stabbed in the left upper chest by wife with kitchen knife. Intubated in the field. Loss of vitals on arrival to hospital while in ambulance.
- In ED, (-) palpable pulse and (+) organized electrical cardiac activity
- On exam, stab wound to the left chest, third intercostal space, midclavicular line
ED Thoracotomy

- Left chest opened and extended across sternum with 1000mL blood drained
- Pericardium opened with 100mL blood drained
- 1cm laceration in the pulmonary artery controlled with digital pressure then Satinsky clamp
- Thoracic aorta clamped after NGT placement
- Return of palpable carotid pulse after direct cardiac massage
OR #1

• Injury to pulmonary artery over-sewed with two 2-0 prolene figure-of-eight stitches
• Through-and-through injury to left upper lobe lung resected with EndoGIA stapler
• Internal mammary arteries ligated
• Oozing from area of aortic dissection over-sewed with 2-0 prolene
• Unable to remove aortic clamp without immediate hypotension and desaturation
• No additional sources of bleeding identified
• After approximately 1h with multiple rounds of blood products, decision made to remove aortic clamp
• Gradual bradycardia resulted which responded to cardiac massage and epinephrine drip
• Hypothermia, acidosis and coagulopathy demanded transfer to SICU
• Oozing from area of aortic dissection packed with surgicel and two lap pads
• Three chest tubes placed and skin closed
SICU

- EBL 5L, 13U RBC, 5U FFP, 2U platelets
- ABG pH 6.7, pCO2 55, pO2 65, BE -23
- CBC 3.6/5.2/16.8/49
- Unstable on full dose epinephrine and norepinephrine
- Continuously receiving RBC, FFP, cryoprecipitate and platelets as well as factor VII
- Persistent chest tube output (≈2L/h)
OR #2

- Chest reopened and 2L blood evacuated
- Bleeding from PA repair controlled with pledgeded 4-0 prolene figure-of-eight
- Posterior mediastinum unpacked
- Bleeding from below the heart
- Laceration of right atrium at atriocaval junction identified extending from inferior surface of right atrium along anterior surface of supradiaphragmatic IVC
OR #2

- Injury site clamped
- Asystole requiring open massage and defibrillation
- Abdomen tense and diaphragm elevated prompting midline decompressive laparotomy
- Repair of laceration attempted with running 3-0 prolene
- Unable to control bleeding
- Asystole again unresponsive to cardiac massage
Autopsy

- Laceration to pulmonary artery
- Laceration to atriocaval junction
- No intracardiac injury to suggest that both injuries caused by stab wound
ED Thoracotomy

Christopher Turner

October 24, 2013
History: Animal models

- 1874

“He lays open the thoracic cavity, and, compressing the passive heart with his fingers, imitates in it the periodic movement of the organ.”

Moritz Schiff
History: First Successful Cardiac Repair

• 1897
• “In the desperate case of a stab wound of the right ventricle, I was forced to operate ... The sight of the heart beating in the opened pericardial sac was extraordinary ... I passed the needle quickly during the diastolic phase.”

Ludwig Rehn
History: Medical Men

• Closed chest compression, Kouwenhoven, JAMA 1960

• External defibrillation, Zoll, NEJM 1956

• Pericardiocentesis, Blalock and Ravitch, Surgery 1943

Virtually eliminated the open chest resuscitation for medical cardiac arrest and cardiac tamponade
History: Return of the Surgeons

Surgical Management of Penetrating Cardiac Injuries

American Journal of Surgery. 1966
Beall, Diethrich, Crawford, Cooley, DeBakey
Houston, Texas

Fig. 2. The plan of treatment. Regardless of method of therapy in progress, any patient experiencing cardiac arrest immediately undergoes thoracotomy.
Definitions

• ED thoracotomy = thoracotomy performed in the ED for patients arriving *in extremis*

• Vital signs = palpable pulse, measurable blood pressure, spontaneous respiratory activity

• Signs of life = respiratory or motor effort, cardiac electrical activity, pupillary activity
Physiologic Rationale

A. Release pericardial tamponade and control cardiac hemorrhage
B. Control intra-thoracic hemorrhage
C. Perform open cardiac massage
D. Achieve thoracic aortic cross-clamping
E. Evacuate bronchovenous air embolism
Clinical Results
Critical Analysis of Two Decades of Experience with Postinjury Emergency Department Thoracotomy in a Regional Trauma Center

Scott W. Branney, MD, Ernest E. Moore, MD, Kim M. Feldhaus, MD, and Richard E. Wolfe, MD

Journal of Trauma 1998
Denver Health Medical Center

- Retrospective review of 950 EDTs at a single center over 23 years
- Blunt 45%, GSW 38%, SW 17%
- 78% dead in ED, 15% dead in OR, 3% dead in SICU
- Overall survival 4.4%, Intact survival 3.9%
- 72% without vital signs in field
- 82% without vital signs in ED
<table>
<thead>
<tr>
<th>Mechanism and Site</th>
<th>Total No.</th>
<th>Survivors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n</td>
<td>%</td>
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<tr>
<td><strong>Stab wounds</strong></td>
<td></td>
<td></td>
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<tr>
<td>Chest</td>
<td>109</td>
<td>20</td>
<td>18</td>
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<tr>
<td>Abdomen</td>
<td>17</td>
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<td>Head injury</td>
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<tr>
<td>Other</td>
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</tr>
<tr>
<td><strong>Gunshot wounds</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Chest</td>
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<td>5</td>
<td>2</td>
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<tr>
<td>Chest</td>
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<td>Head injury</td>
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<tr>
<td>Other</td>
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### TABLE 2. Neurologically intact survival based on the presence or absence of vital signs in the field or emergency department

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>With Vital Signs</th>
<th>Without Vital Signs</th>
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<tbody>
<tr>
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<tr>
<td>Field</td>
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<tr>
<td>Overall</td>
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<tr>
<td>Blunt</td>
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<tr>
<td>Penetrating</td>
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<td>GSW</td>
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<td>9</td>
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<tr>
<td>SW</td>
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<td>10</td>
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<tr>
<td>Overall</td>
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<td>21</td>
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<tr>
<td>Blunt</td>
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<td>3</td>
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<td>Penetrating</td>
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<td>Mechanism and Anatomic Injury</td>
<td>Total No.</td>
<td>Survivors</td>
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<td>-----------------------------------</td>
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<td>-----------</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
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<tr>
<td>Stab wounds</td>
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<td>Cardiac tamponade</td>
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<td>Penetrating cardiac</td>
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<td>Great vessel</td>
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<tr>
<td>Chest wall</td>
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<tr>
<td>Abdomen</td>
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<tr>
<td>Head injury</td>
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<td>0</td>
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<tr>
<td>Gunshot wounds</td>
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<tr>
<td>Cardiac tamponade</td>
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<td>0</td>
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<tr>
<td>Penetrating cardiac</td>
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<tr>
<td>Great vessel</td>
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<tr>
<td>Hilar</td>
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<tr>
<td>Lung/chest</td>
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<tr>
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<td>0</td>
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<tr>
<td>Other</td>
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<td>0</td>
</tr>
</tbody>
</table>
Conclusions

• Chance of survival
  – SW > GSW > Blunt
  – ED vitals > Field vitals > No vitals
  – Chest > Abdomen
  – Cardiac > Non-cardiac

• Clinical algorithm involving mechanism, presence of vitals, and location of wound
Prospective review of 18 institutions over 6 years
56 patients survived to hospital discharge
Mean age 31.3 years
93% male
SW 54%, GSW 38%, Blunt 9%
Total number of thoracotomies not requested
#1 injury SW to ventricle (30%)
#2 injury GSW to lung (16%)
34% had prehospital CPR
18% had moderate to severe anoxic cerebral injury
7 survived with asystole at ED arrival, but only 3 of these had functional neurologic recovery
• Prehospital CPR for SW
  – 2-10min
  – Survivor at 10min had ventricular wound

• Prehospital CPR for GSW
  – 1-15min
  – Survivor at 15min had ventricular wound

• Prehospital CPR for blunt
  – 3-9min
  – Survivor at 9min had atrial rupture
Conclusions

• Limits of ED thoracotomy
  – Prehospital CPR >10min after blunt trauma
  – Prehospital CPR >15min after penetrating trauma
  – Asystole is presenting rhythm and no pericardial tamponade
Practice Management Guidelines
JACS 2001
Indication

• Penetrating thoracic injuries with short scene/transport times and signs of life (respiratory or motor effort, cardiac electrical activity, pupillary activity)
Possible Indication

• Penetrating abdominal injuries as an adjunct to definitive repair

• Blunt trauma patients who arrive with vital signs at the trauma center and experience a witnessed cardiopulmonary arrest
Algorithm Directing the Use of EDT

Patient Undergoing CPR — No Signs of Life**

Blunt Trauma

Penetrating Trauma

Torso

Non-torso

CPR < 10 min

CPR < 15 min

CPR < 5 min

Dead

EDT

Cardiac Rhythm?

Yes

No

Tamponade?

Yes

Repair Heart

Thoracic Hemorrhage

Control

Air Emboli

Hilar X-clamp

Extrathoracic Hemorrhage

Aortic X-clamp

SBP > 70 mmHg?

Yes

OR

**no respiratory or motor effort, electrical activity, or pupillary activity
Anatomy
Anterior Exposure

Pericardium (cut edge) at site of reflection from great vessels
Brachiocephalic trunk
Right internal jugular vein
Phrenic nerve
Subclavian artery and vein
Right brachiocephalic vein
Internal thoracic artery and vein
Superior vena cava
Right pulmonary artery
Right superior pulmonary vein
Transverse sinus of pericardium
Mediastinal pleura (cut edge)
Pericardium (cut edge)
Right atrium
Right auricle
Coronary sulcus and right coronary artery
Anterior interventricular sulcus and anterior interventricular artery
Left brachiocephalic vein
Left common carotid artery
Left internal jugular vein
Left vagus nerve [X]
Arch of aorta
Recurrent laryngeal nerve
Ligamentum arteriosum
Left pulmonary artery
Transverse sinus of pericardium
Left superior pulmonary vein
Root of left lung
Auricle of left atrium
Pulmonary trunk
Conus arteriosus
Obtuse margin of heart
Left ventricle
Apex of heart
Acute margin of heart
Instruments
Cardiac Tray
#20 Blade
Finochiettio Retractor
Lebsche Sternum Knife and Mallet
Technical Details
Bleeding from the Lung
Bleeding from the Lung
Bleeding from the Heart
Bleeding from the Heart
Bleeding from the Heart
Video #1
Video #2
Procedural Complications

• Technical complications involve virtually every intrathoracic structure

• Risk to health care providers
  – 26% of acutely injured patients had evidence of exposure to HIV (4%), HepB (20%), HepC (14%)
Consequences of Aortic Cross-Clamping

• Placement of clamp
  – Causes tissue acidoses and increased oxygen debt
  – Hypoxia of distal organs, WBC and endothelium induces inflammatory mediators
  – Intestinal tolerance to normothermic ischemia is 30-45min

• Removal of clamp
  – Return of large volume of blood with low pH, high lactase and other mediators may be cardiodepressant
  – Impaired LV function, systemic oxygen utilization, coronary perfusion
Future Considerations

• Defining nonsalvageability

• Temporary physiologic hibernation

• Temporary mechanical cardiac support
Summary

• Best indicated to repair a simple injury in the thoracic cavity that is causing a serious physiologic insult
  – Penetrating trauma with CPR <15min
  – Blunt trauma with CPR <10min

• Key moves: release of pericardial tamponade, control of intrathoracic vascular or cardiac hemorrhage, open cardiac massage, temporary occlusion of the descending thoracic aorta
Questions

“Trauma code to CCT ...”
Indications

• Salvageable postinjury cardiac arrest
  – Penetrating thoracic trauma with <15m of prehospital CPR
  – Penetrating nonthoracic trauma with <5m of prehospital CPR
  – Blunt trauma with <10m of prehospital CPR

• Persistent severe post-injury hypotension (SBP<60mmHg) due to:
  – Cardiac tamponade
  – Hemorrhage
  – Air embolism
Contra-Indications

• CPR >15m following penetrating injury and no signs of life
• CPR >10m following blunt injury and no signs of life
• Signs of life = pupillary response, respiratory effort, or motor activity