Damage Control Surgery in Thoracic Trauma

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전양빈

Contents

- Overview of Thoracic Trauma
- Pathophysiology of Trauma(Lethal Triads)
- Survey of Trauma patients
- Damage control operation

흉부외상의 개요

- 외상사망환자의 ¼
- 미국의 연간 사망환자의 ¼
- 흉부손상의 10-15%: 수술요함
- 즉사~ 심장 및 대혈관의 둔상성 파열, 대혈관의 관통상
- 초기사망~ 기도폐쇄, 긴장성기흉, 출혈, 심장압전
- 장기사망~ 폐합병증, 폐혈증, 미확인 손상

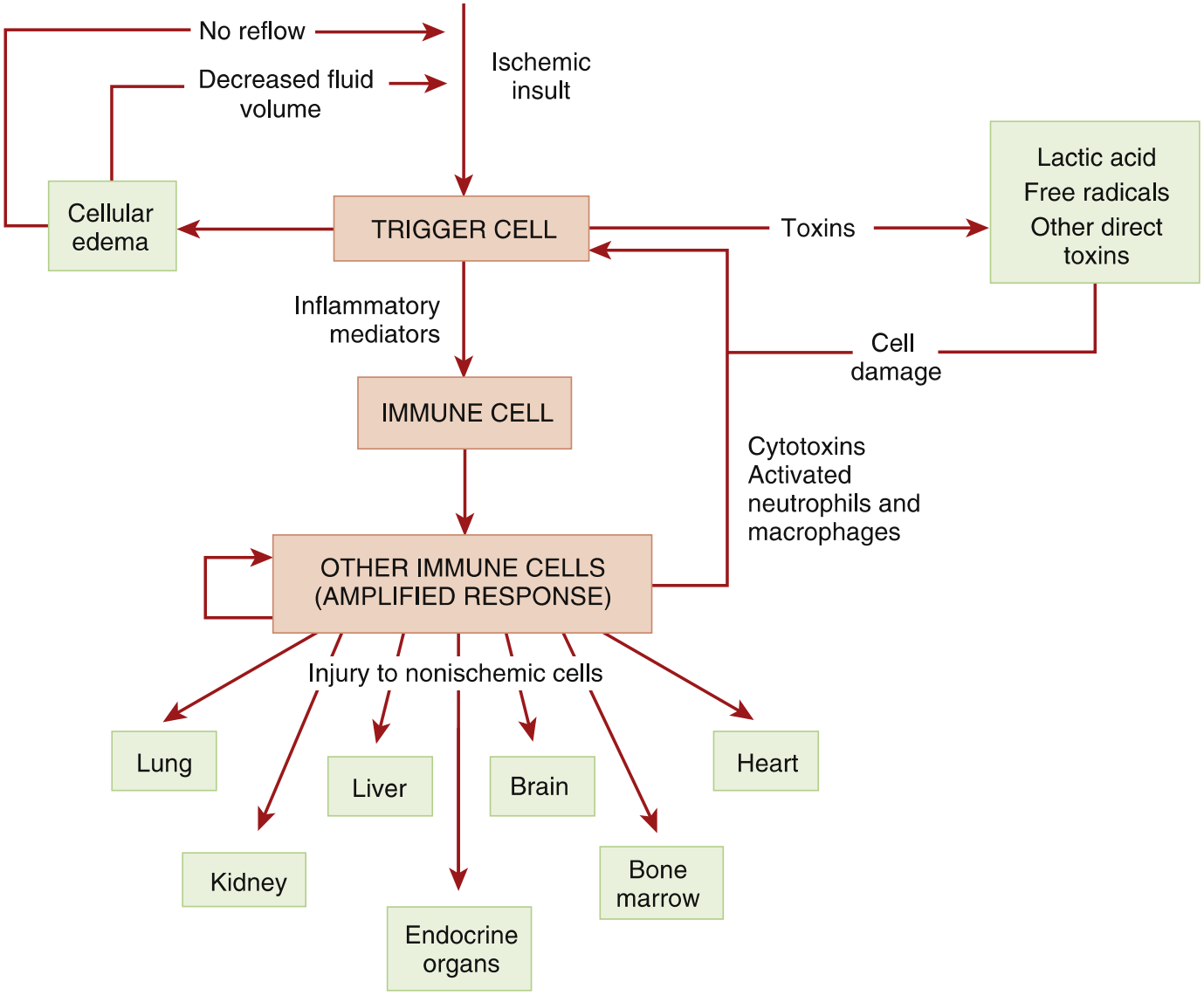
The Boston Globe

TUESDAY, APRIL 16, 2013

Marathon terror

Hemorrhagic Shock

- Imbalance between systemic O_2 delivery and O_2 consumption
- Macrocirculatory response: ↓BP, vasoconstriction, catecholamines
- Microcirculatory response: cellular edema, no-reflow phenomenon; lactate, free radicals, direct damage; inflammatory factors, immune system activation



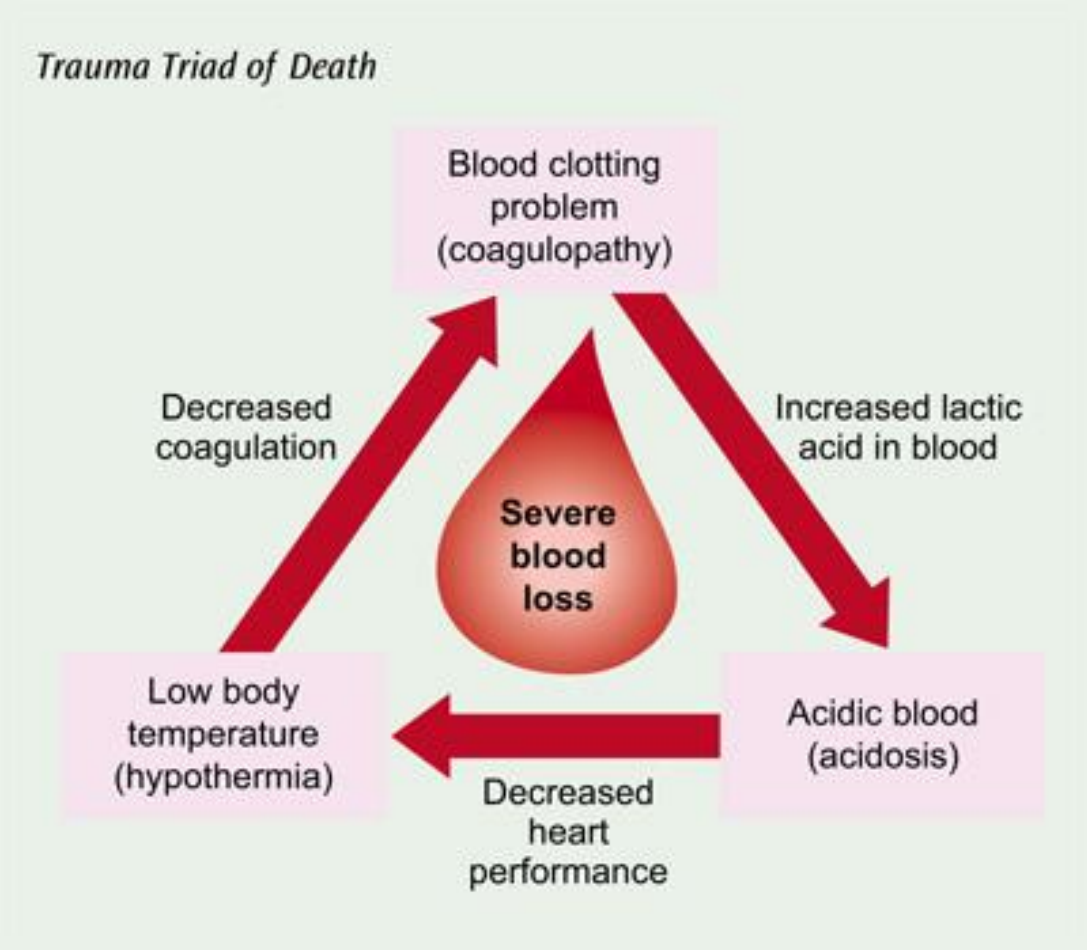
Miller's anesthesia 8th Ed. 2015

Influence on Specific organ systems

- CNS: prime trigger of neuroendocrine response, regional glc. uptake change, depressed reflex and cortical electrical activity
- Kidney, Adrenal glands:
  - prime responders to the neuroendocrine changes(renin, angiotensin, aldosterone, cortisol, erythropoietin, and catecholamines)
  - decreased cellular energy and an inability to con-centrate urine (renal cell hibernation)
  - patchy cell death, tubular epithelial necrosis, and renal failure

- Heart : cardiac dysfunction(terminal event), fixed stroke vol(cardiac ds, cardiac trauma)
- Lung : increased capillary permeability, destruction of lung architecture, and acute respiratory distress syndrome; sentinel organ for development of MOSF
- Gut : earliest organs affected by hypoperfusion and may be the prime trigger of MOSF; increased translocation of bacteria
- Liver : reperfusion injury during recovery, Failure of synthetic function of the liver after shock is almost always lethal.

치사 삼증후(Lethal Triads)



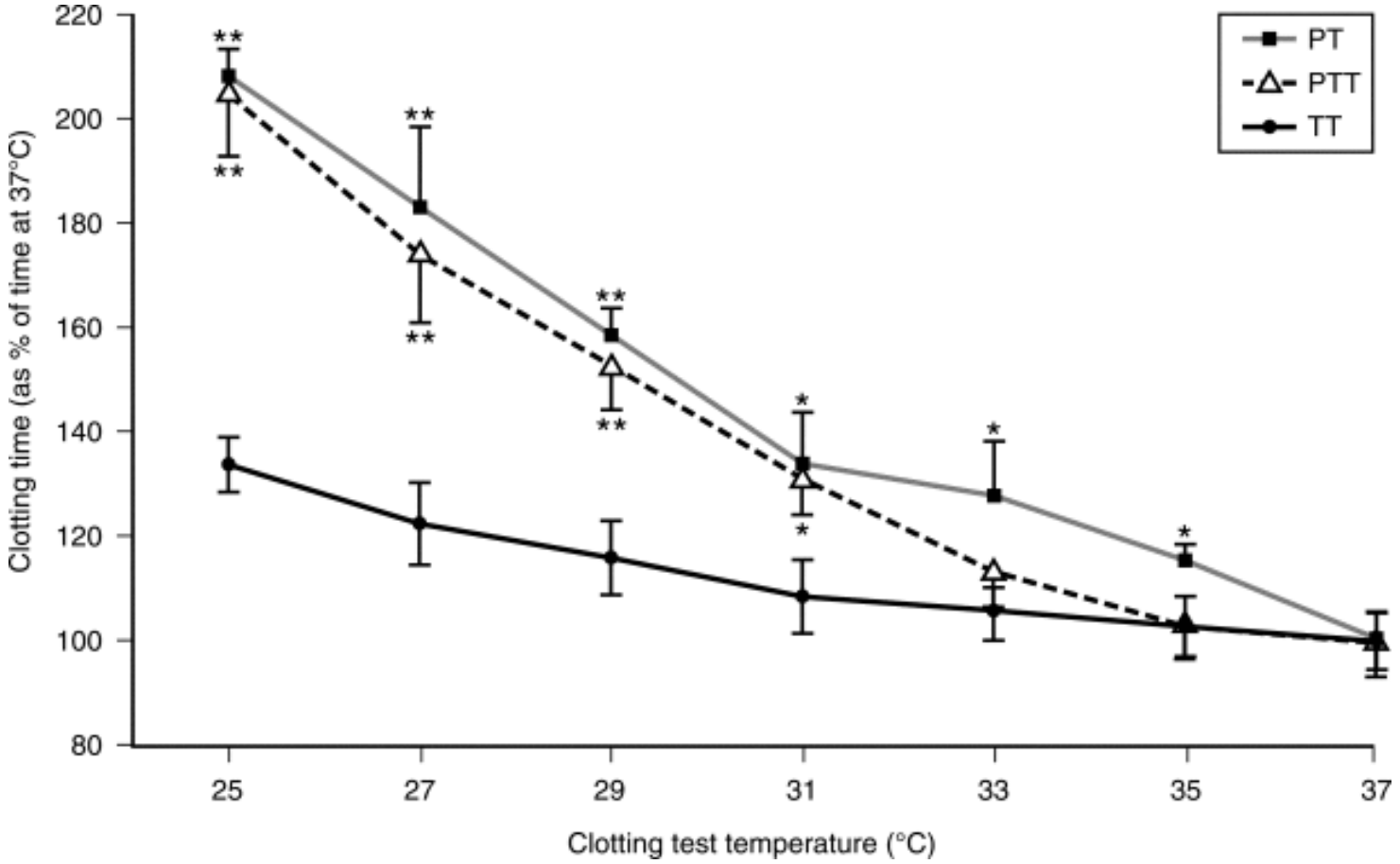
Acidosis

- Hemorrhagic shock> inadequate cellular perfusion> anaerobic metabolism> lactic acid

- Interfere with blood clotting mechanism> coagulopathy, blood loss

Hypothermia

1. coagulation



Hypothermia

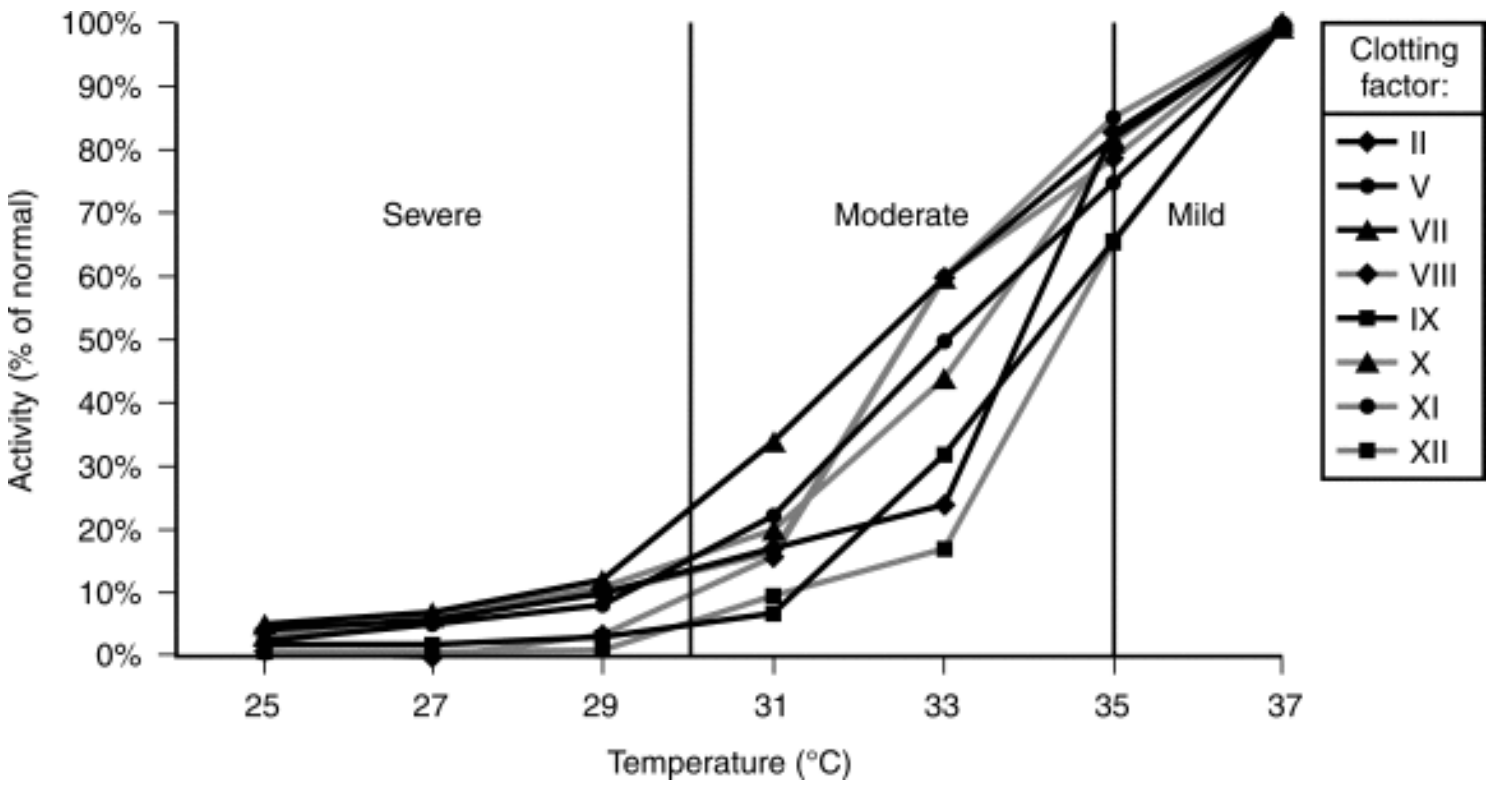
2. Platelet count and function

- reversible inhibition of function, mediated at least in part through the temperature dependence of thromboxane B_2 (a potent vasoconstrictor that stimulates platelet aggregation)
- transfusions in hypothermic patients may not be effective at reducing blood loss without concomitant, effective core rewarming

Hypothermia

3. clotting factor levels and function

- severe clotting factor deficiency와 유사한 coagulopathy, even at intermediate levels of hypothermia, and even though no actual deficiency of clotting factors
- at mild temperature reductions between 33° and 37° C, platelet activity and aggregation are more profoundly affected than are clotting factors, and are more responsible for hypothermia-related coagulopathy


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Activity (% of normal)
Severe
Moderate
Mild
25
27
29
31
33
35
37
Temperature (°C)
Clotting factor:
II
V
VII
VIII
IX
X
XI
XII

Hypothermia

4. other organs

- Cardiac function: bradydysrhythmia, ventricular fibrillation(28-30 ^{o}C), shivering> oxygen consumption 증가> oxygen delivery 감소
- Immunologic : surgical site infection
- Neurological : mental change below 33^{o}C
- Respiratory depression
- Decreased GFR : cold diuresis

Acute Coagulopathy

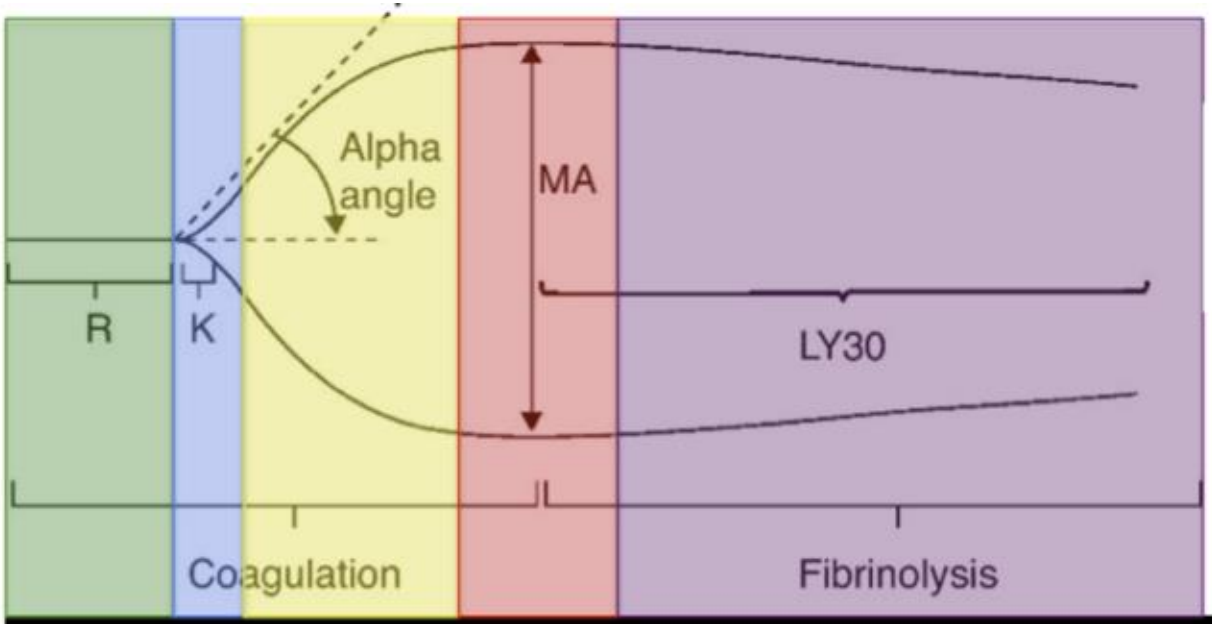
- 25% of trauma patients
- 3x or 4x increase in mortality and an 8x increase in intraoperative death within the first 24 hours
- shock-induced activation of the protein C pathway
- increased hyperfibrinolysis due to direct endothelial damage

Diagnosis of Acute Coagulopathy of Trauma

- prothrombin time (PT) and partial thromboplastin time (PTT): PTT, predicting outcomes and correlating to low protein C level; PT, need for substantial resuscitation and mortality
- Thromboelastography (TEG): multiple arms of the clotting cascade, in vivo clot dysfunction(plt fx);
  - Kaolin-activated (traditional) TEG: 1hr
  - rapid TEG: 4min, not sensitive to ASA, clopidogrel

TEG

Thromboelastography (TEG)



Thromboelastogram (TEG)

Components	Definition	Normal Values	Problem with...	Treatment
R Time	Time to start forming clot	5 – 10 minutes	Coagulation Factors	FFP
K Time	Time until clot reaches a fixed strength	1 – 3 minutes	Fibrinogen	Cryoprecipitate
Alpha angle	Speed of fibrin accumulation	53 – 72 degrees	Fibrinogen	Cryoprecipitate
Maximum Amplitude (MA)	Highest vertical amplitude of the TEG	50 – 70 mm	Platelets	Platelets and/or DDAVP
Lysis at 30 Minutes (LY30)	Percentage of amplitude reduction 30 minutes after maximum amplitude	0 – 8%	Excess Fibrinolysis	Tranexemic Acid and/or Aminocaproic Acid

NORMAL

R/K/MA/ANGLE = Normal

HEPARIN

R/K = Prolonged, MA/Angle = Decreased

THROMBOCYTOPENIA

R=Normal, K = Prolonged, MA= Decreased

FIBRINOLYSIS

R = Normal, MA = Continuous decrease

HYPERCOAGULATION

R/K = Decreased, MA/Angle = Increased

NO PLATELET FUNCTION

R = Prolonged, MA/Angle = Decreased

SURVEY OF TRAUMA PATIENTS

Phase I: ED assessment

- 5% of civilian casualties and 8% of combat casualties—arriving in an ED will benefit from a damage control approach

- Physical examination
- Begin resuscitation: Oxygen, Volume replacement, eFAST, intubation, 2x large-bore IV lines, prewarmed crystalloids, bood transfusion, cell saver, tetanus prophylaxis and A/B
- Monitor pulse oxymeter and EKG
- CXR
- ABGA
- Identify indications for immediate operation
- ABC score; predict massive transfusion

  Penetrating trauma

  Hypotension

  Tachycardia

  Positive FAST

Penetrating thoracic wounds

- Do not probe the wound
- Obtain chest X ray
- Prophylatic tetanus
- antibiotics

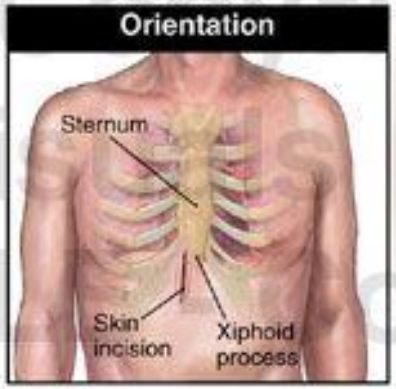
Transmediastinal penetrating wounds

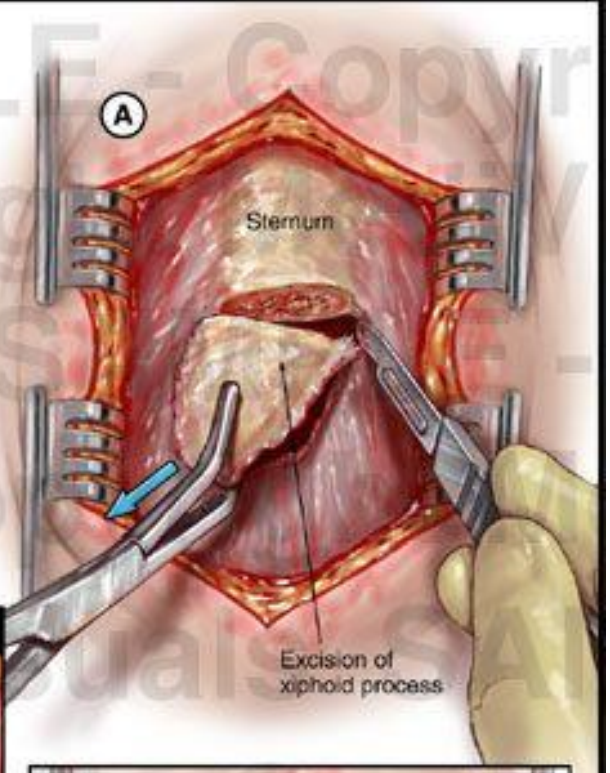
- Clinical suspiction, trajectory, CXR
- Classify patients: extremis, unstable, stable
  - Extremis: agonal respiration without BP; immediate ALT
  - Unstable: hypotensive; intubation, oxygenation, volume, CXR, thoracostomy, FAST, thoracotomy, flexible esopahgoscopy or bronchoscopy, angiogaphy
  - Stable: chest CT, same above

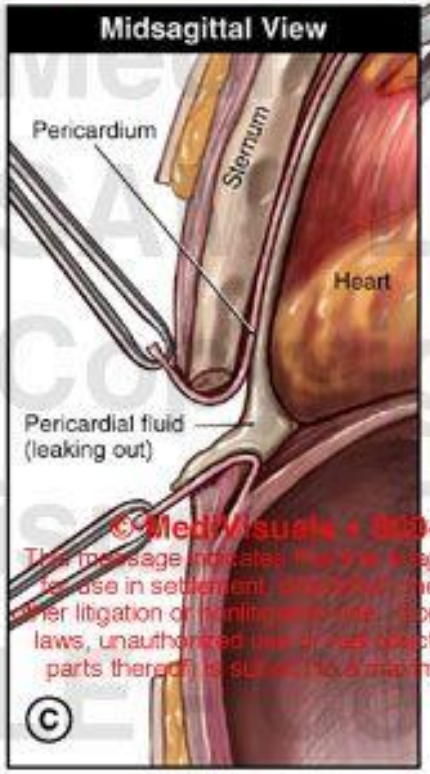
Emergency Thoracic Procedures

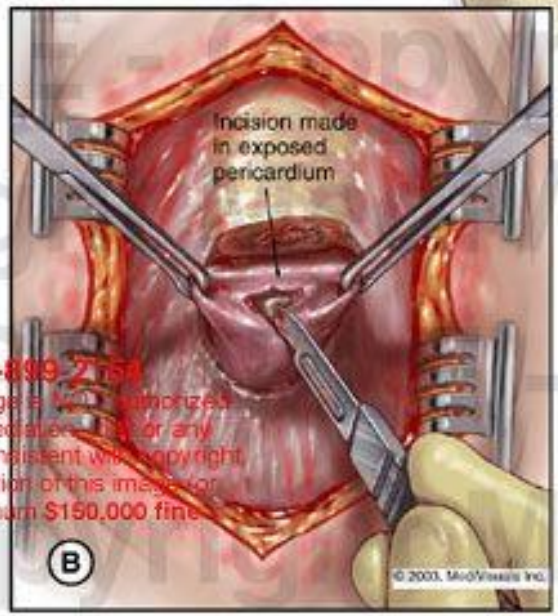
- Tube thoracostomy
- Pericardiocentesis : rarely in level I trauma center
- Pericardial window
- Resuscitative thoracotomy(RT) : release pericardial tamponade, control intrathoracic bleeding, control massive air embolism or bronchopleural fistula, permit open cardiac massage, allow for cross-clamping of the descending thoracic aorta

Pericardial Window Surgery









Exhibit# 303213_03XG

RT

No measurable blood pressure or pulse					
Blunt mechanism			Penetrating mechanism		
No SOL	SOL field only	SOL arrival	No SOL	SOL field only	SOL arrival
DOA	DOA	EDT	DOA	EDT	EDT

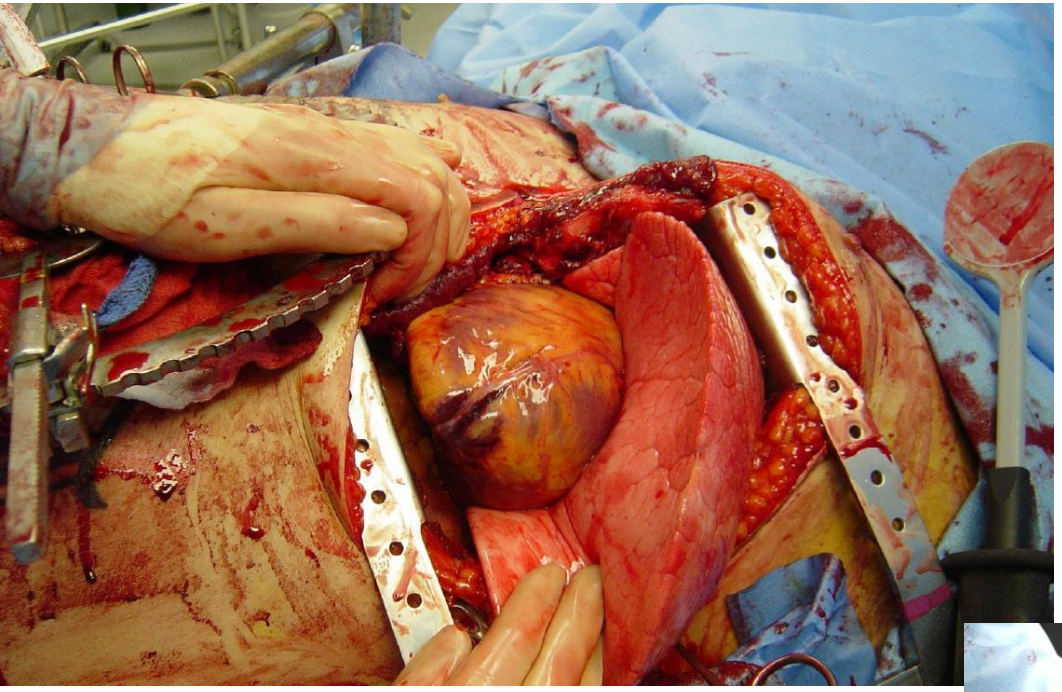
SOL(signs of life): eye movement, pupillary response, spontaneous respiration, electrical activity >40 complexes/min on EKG

Median sternotomy

Left anterolateral thoracotomy

Lt or Rt PL thoracotomy

Bilateral thoracotomy



Phase II: DCS

- *Preoperative* identification that DCO will be used
- Strategic determination of the order of intervention
- Communication with the OR team
- Prevent Hypothermia

What is Damage Control?

Damage Control Surgery

DR ASHIRWAD KARIGOUDAR

PG III[RD] YEAR

DR C K DURGA UNIT

Originally coined by the US Navy in reference to techniques for salvaging a ship.

Damage Control Operation(DCO)

- Reverse or Prevent the development of the “lethal triad”
- “Normal physiology is more important than normal anatomy”
- “A live patient above all else.”

hemorrhage cessation, contamination control, perfusion of vital organs, ICU resuscitation, delayed definitive surgery

Most common indications

- Complex upper abdominal or pelvic injuries
- Complex multisystem injuries
- A “stable” trauma patient with two or more of the “lethal triad”
- A hypotensive trauma patient with one or more of the “lethal triad”
- Mass casualties
- Projected need for massive transfusion
- Projected shortage in blood product supply

Parameters as a guideline for DCO

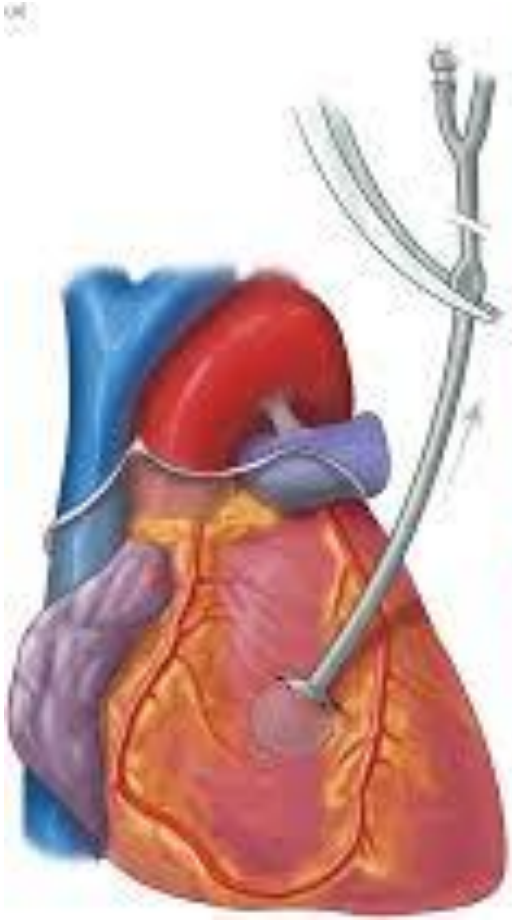
- pH ≤ 7.2
- Serum bicarbonate ≤ 15mEq/L
- Core Temp ≤ 34
- Transfusion of pRBC ≥ 4000ml
- Total blood replacement ≥ 5000ml
- Total fluid replacement ≥ 12000ml

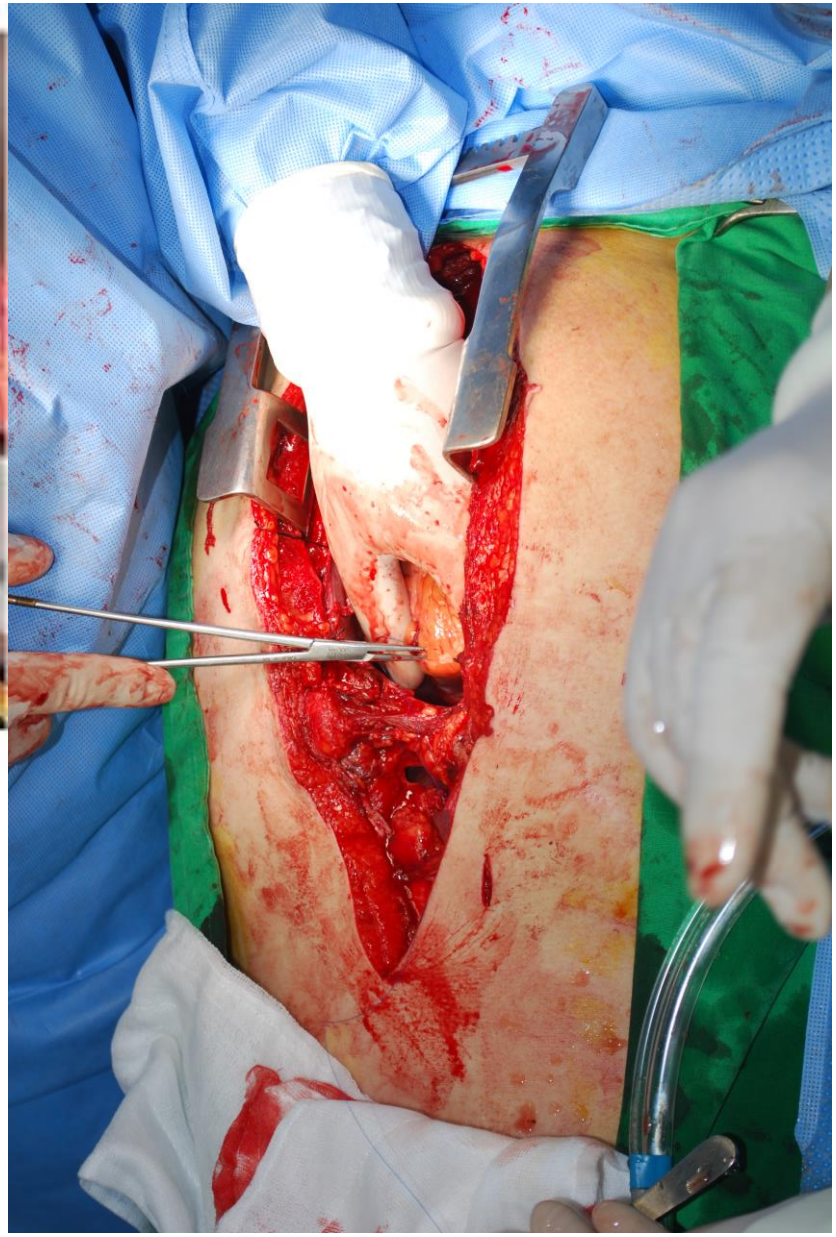
Damage control thoracic surgery

- Perform the least definitive repair using the fastest and easiest techniques to shorten the operative time as much as possible
- Witnessed cardiac arrest due to penetrating injury to chest; abdomen, pelvis or due to blunt trauma
- Massive hemorrhage from chest tube

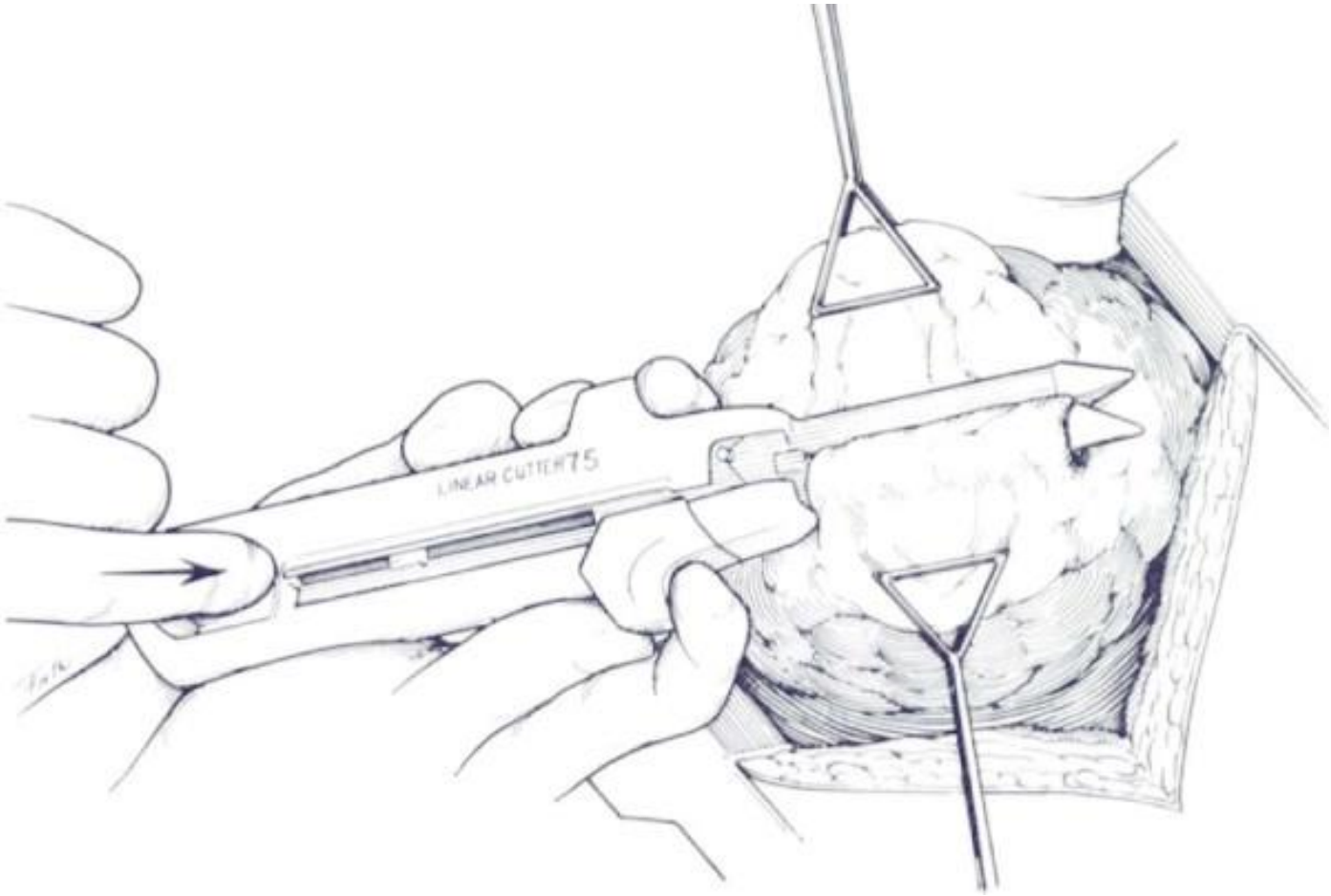
Procedures

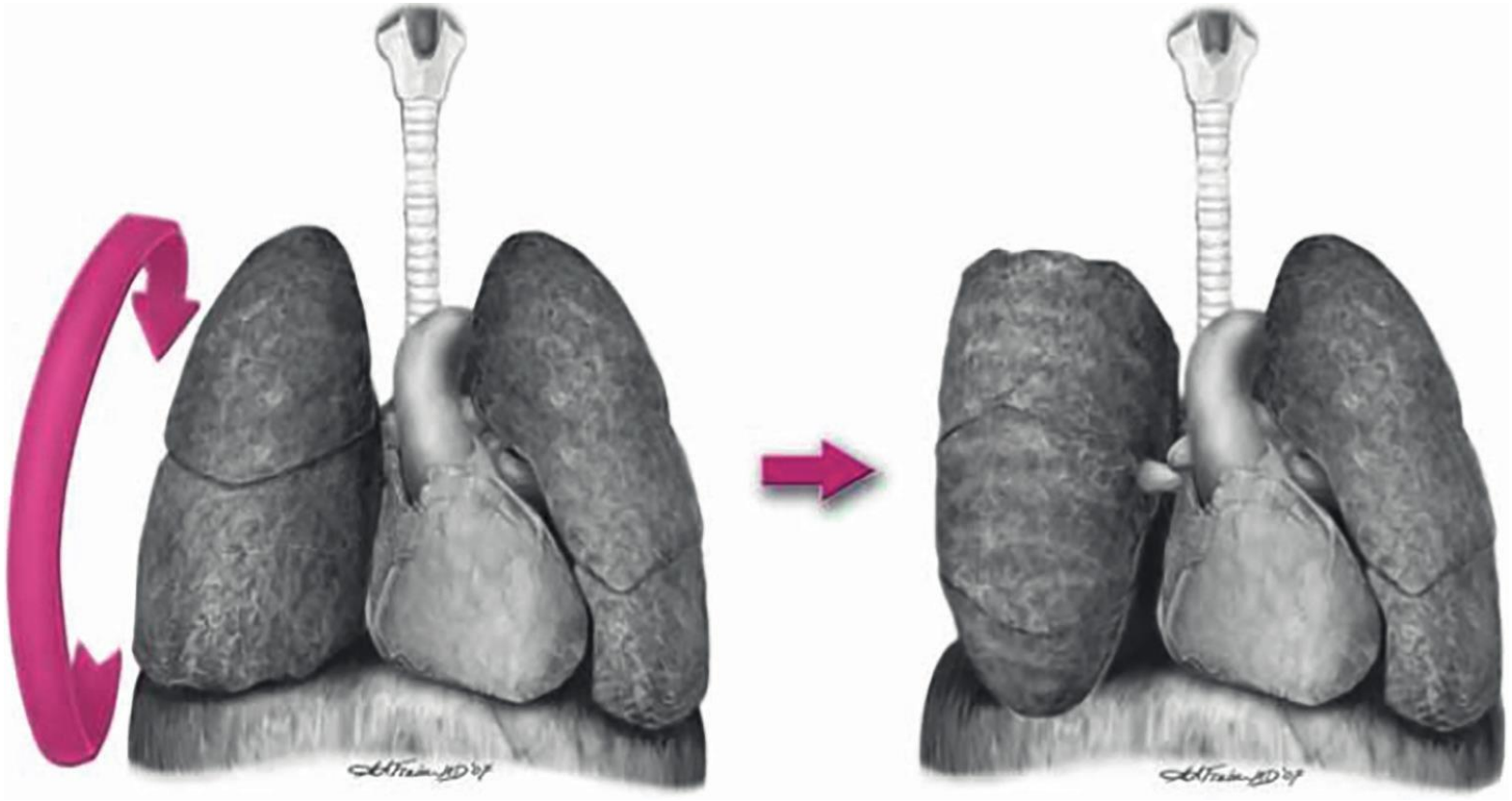
- Supine position with a single lumen endotracheal tube
- Left anterolateral thoracotomy, clamshell-style, if necessary.
- Descending aorta clamp in arrest or near arrest
- Pericardium opened
- DCS
- One layer thoracotomy closure, incorporating pleura, ribs, and muscle, using large interrupted sutures
- Skin left open for possible delayed closure !





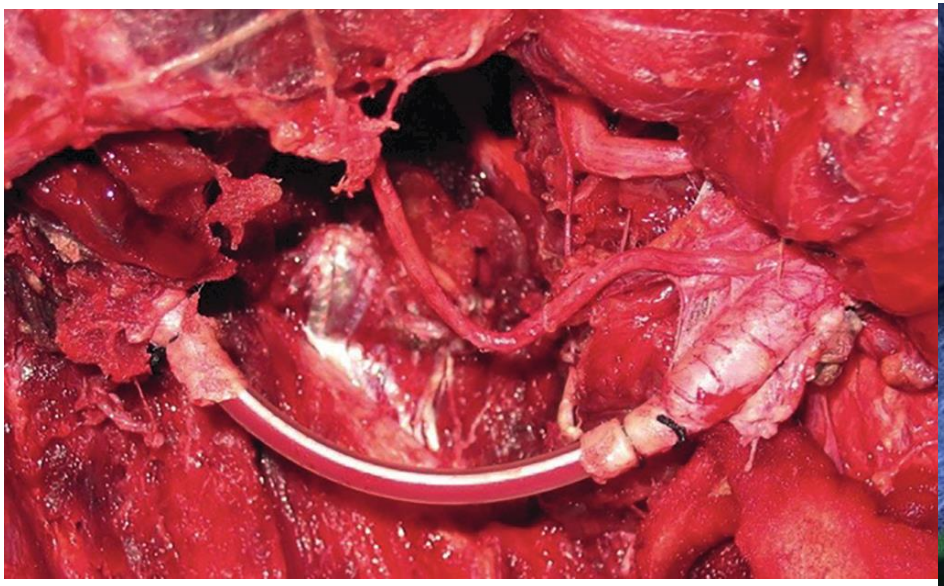
- Cardiac injuries : pledgeted 2-0 or 3-0 polypropylene, finger compression, Foley catheter
- Pulmonary hemorrhage : pneumonorraphy, wedge resection, pulmonary tractotomy, lobectomy and pneumonectomy


LINEAR CUTTER 75



A B

- Thoracic vascular structures injury: suture ligation or repair, temporary shunt(Argyle carotid shunt, chest tube), Fogarty balloon catheter occlusion
- Tracheobronchial injuries : suture, but if the injuries are large or proximal, stapled lobectomy, pneumonectomy rarely survived
- Esophageal injuries : suture primarily, widely drained, time permitting



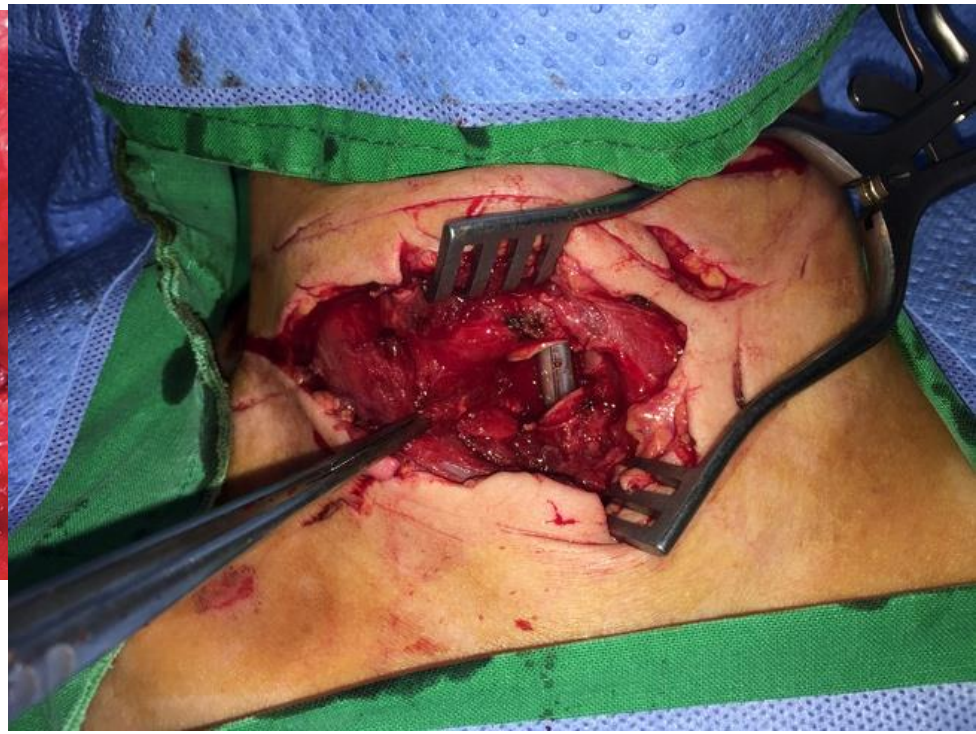
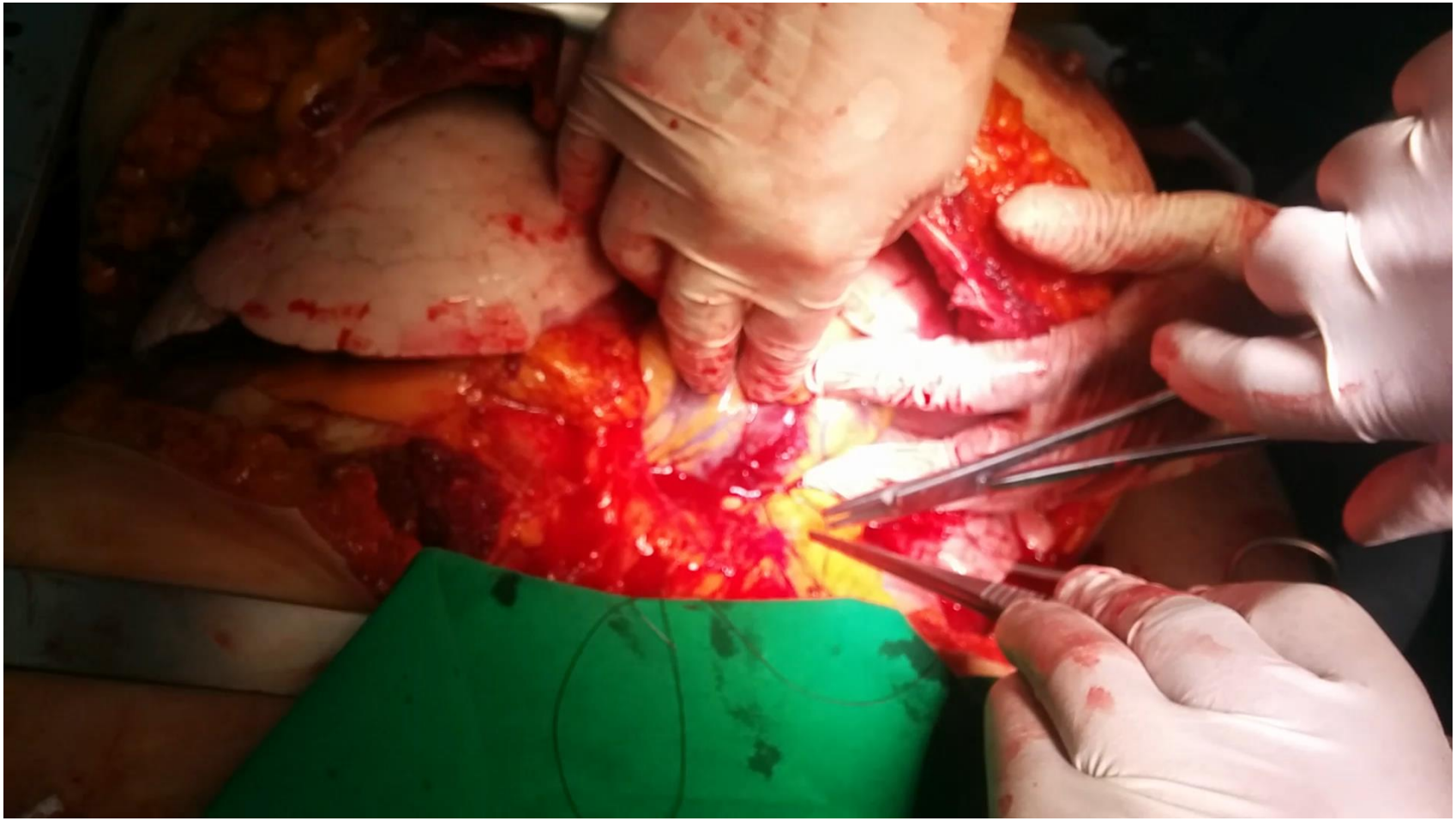


FIGURE 5 Temporary shunt placed in the superficial femoral artery. *(Courtesy Nessen SC, Lounsbury DE, Hetz SP, eds.* War Surgery in Afghanistan and Iraq: A Series of Cases, 2003–2007. *Washington, DC: Borden Institute, U.S. Army Office of the Surgeon General, Walter Reed Army Medical Center; 2008:21.)*

Phase 3: ICU Resuscitation

- Reverse the components of the “lethal triad”
- If lactic acidosis, hypotension, or coagulopathy worsens despite vigorous resuscitation, early return to the OR

Phase 4: Definitive Surgery



Effectiveness

- Cochrane Collaboration reviews : “evidence that supports the efficacy of damage control surgery with respect to traditional laparotomy in patients with major abdominal trauma is limited”
- Whereas initial DCO studies proclaimed a 50% survival rate as a significant step forward, the last 5 years have seen published data with comparably injured patients achieving 73% to 86% survival using this combined strategy (Cotton et al, 2011; Duchesne et al, 2010).

Take Home Message

- Hemodynamic instability from a chest wound indicates a major vascular or cardiac injury that mandates immediate control of hemorrhage.
- The choice of thoracic incision is determined by the expected anatomic injury, urgency with which surgical access is required, and the patient's hemodynamic stability.
- Diagnosis of transmediastinal penetration is based on clinical suspicion, trajectory of the missile, or CXR findings.
- Suspect the presence of tamponade in the patient with persistent hypotension, acidosis, or base deficit, despite adequate blood and fluid resuscitation.

The Trauma Manual: Trauma and Acute Care Surgery (Lippincott Manual Series Lippincot (Wolters Kluwer Health)