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Surgical Management of Chest Wall Injuries

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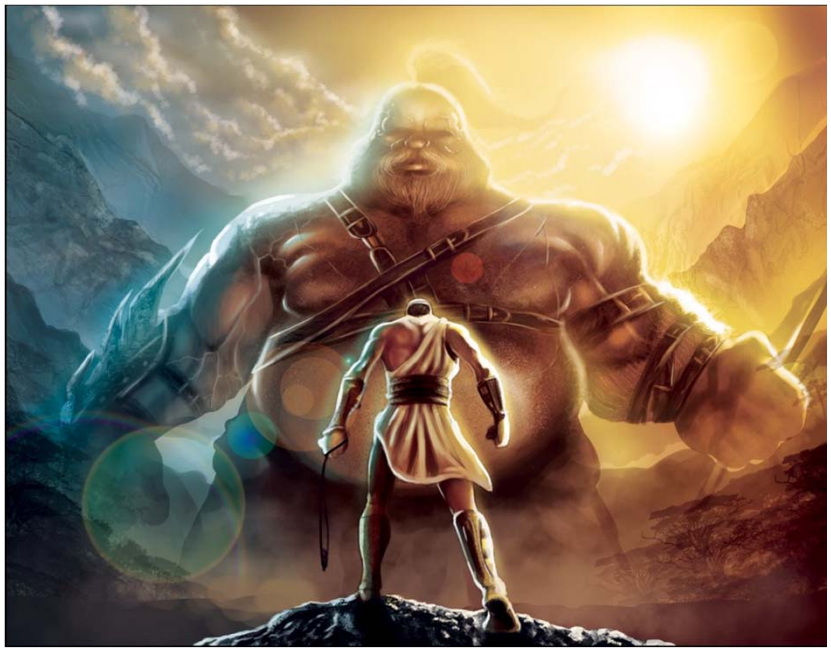
Thoracic Trauma

OBJECTIVES:

1- Outcomes of rib fracture fixation in trauma patients

2- Optimal treatment strategies for sternal and rib fractures

3- Management of hemothorax



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Thoracic Trauma

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Thoracic Trauma

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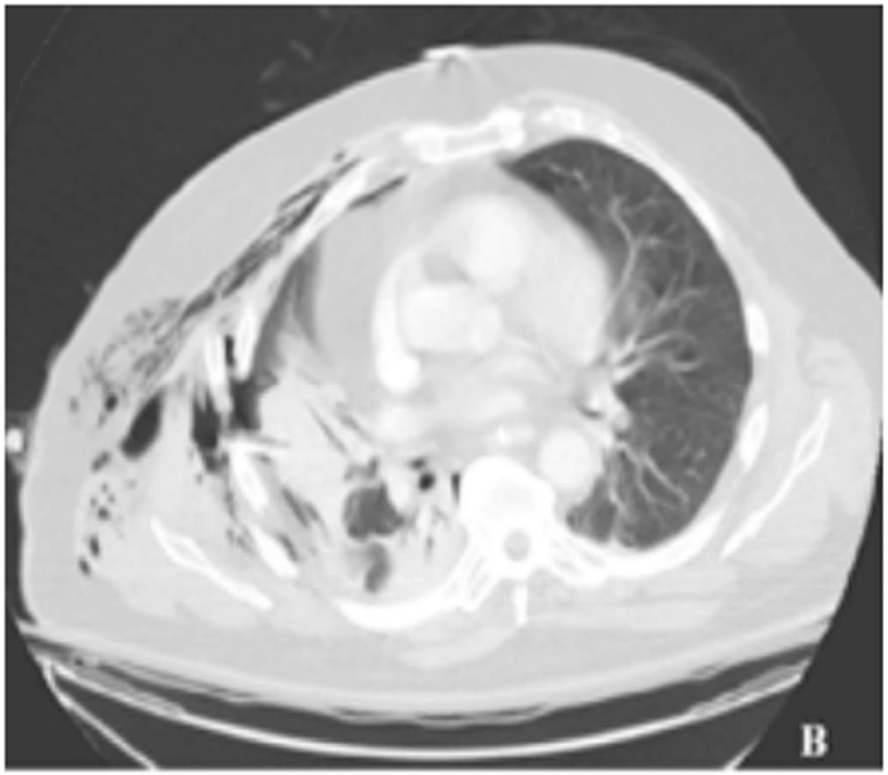
Thoracic Trauma



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Thoracic Trauma

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Thoracic Trauma

Incidence:

Blunt chest trauma 8% of all trauma admissions in the US

Penetrating chest trauma 7% of all trauma admissions in the US

Mortality:

28% mortality with blunt chest trauma

7% mortality with penetrating chest trauma

Thoracotomy is indicated only for:

5% of blunt chest trauma

15% of stab wounds of the chest

20% of gunshot wounds of the chest

Rib Fractures

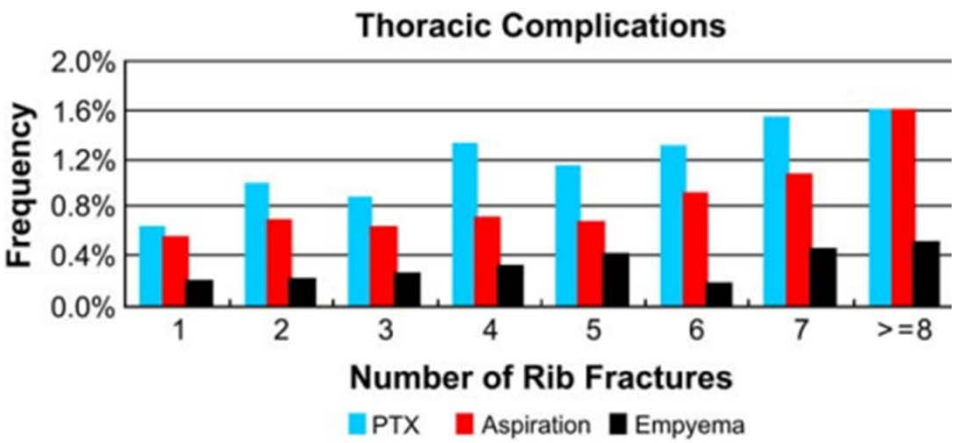
Surgery. 2005

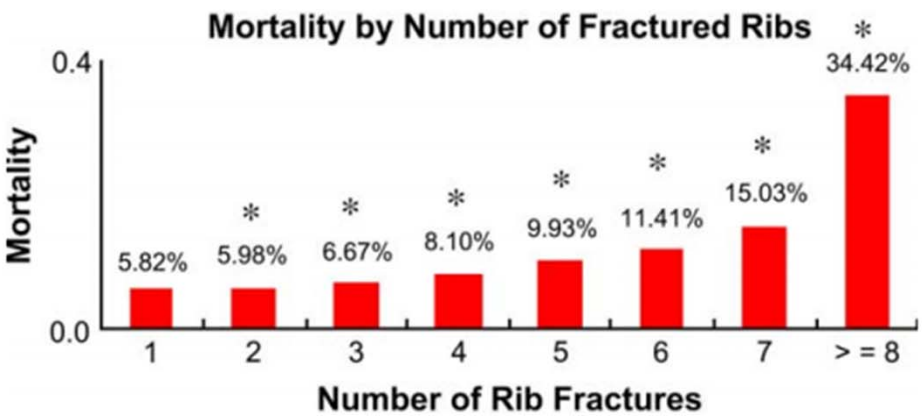
Half-a-dozen ribs: the breakpoint for mortality.

Flagel BT , Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, Gamelli RL.

- NTDB study
- 64,750 patients

- Mortality rate for patients with rib fractures was 10%





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Rib Fractures

- 2-year, NTDB
- 27,209 patients
- Elderly patients (≥ 65 years old) with isolated rib fractures

- Comp
- Morta

Elderly patients sustaining >3 rib fracture are at risk of higher mortality

Table. Multivariate Logistic Regression Analysis for Mortality

Number of Ribs Fractured*	Odds Ratio	95% Confidence Interval	*p*-value
2	1.16	0.89 – 1.52	0.26
3	1.21	0.92 – 1.59	0.15
4	1.72	1.34 – 2.22	< 0.001
5	1.80	1.34 – 2.42	< 0.001
6	2.26	1.64 – 3.11	< 0.001
7	2.31	1.61 – 3.31	< 0.001
8	3.62	2.78 – 4.71	< 0.001

Adjusted for age, gender, emergency department systolic blood pressure, heart rate, and GCS.
* One rib fracture is the reference.

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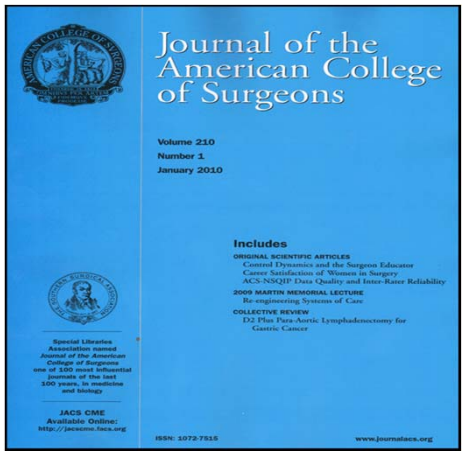
Rib Fractures

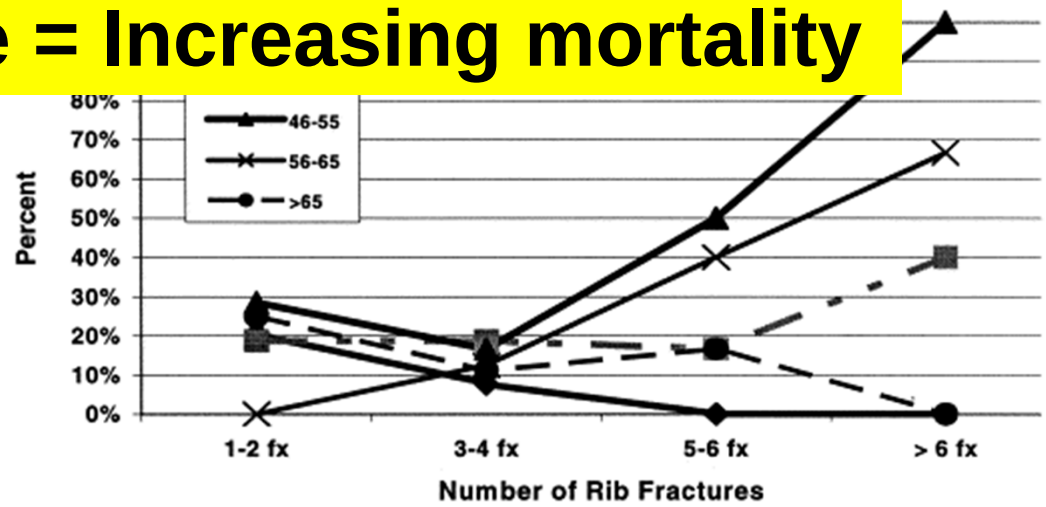
Morbidity from Rib Fractures Increases after Age 45

John B Holcomb, MD, FACS, Neil R McMullin, BS, Rosemary A Kozar, MD, PhD, FACS, Marjorie H Lygas, MS, FNP, Frederick A Moore, MD, FACS



- Retrospective study
- 171 patients (> 45 years old)

Increasing age = Increasing mortality



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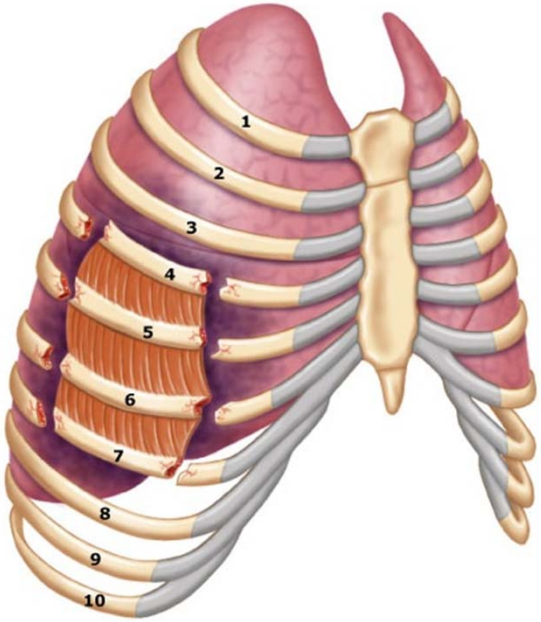
FLAIL CHEST

3 or more consecutive rib fractures, in two or more locations



Number of rib fractures	**Incidence of flail chest**
6 rib fractures	4 %
7 rib fractures	4.8%
8 rib fractures	6.4%

Mortality rates of up to 33%

Flagel BT et al. Surgery. 2005

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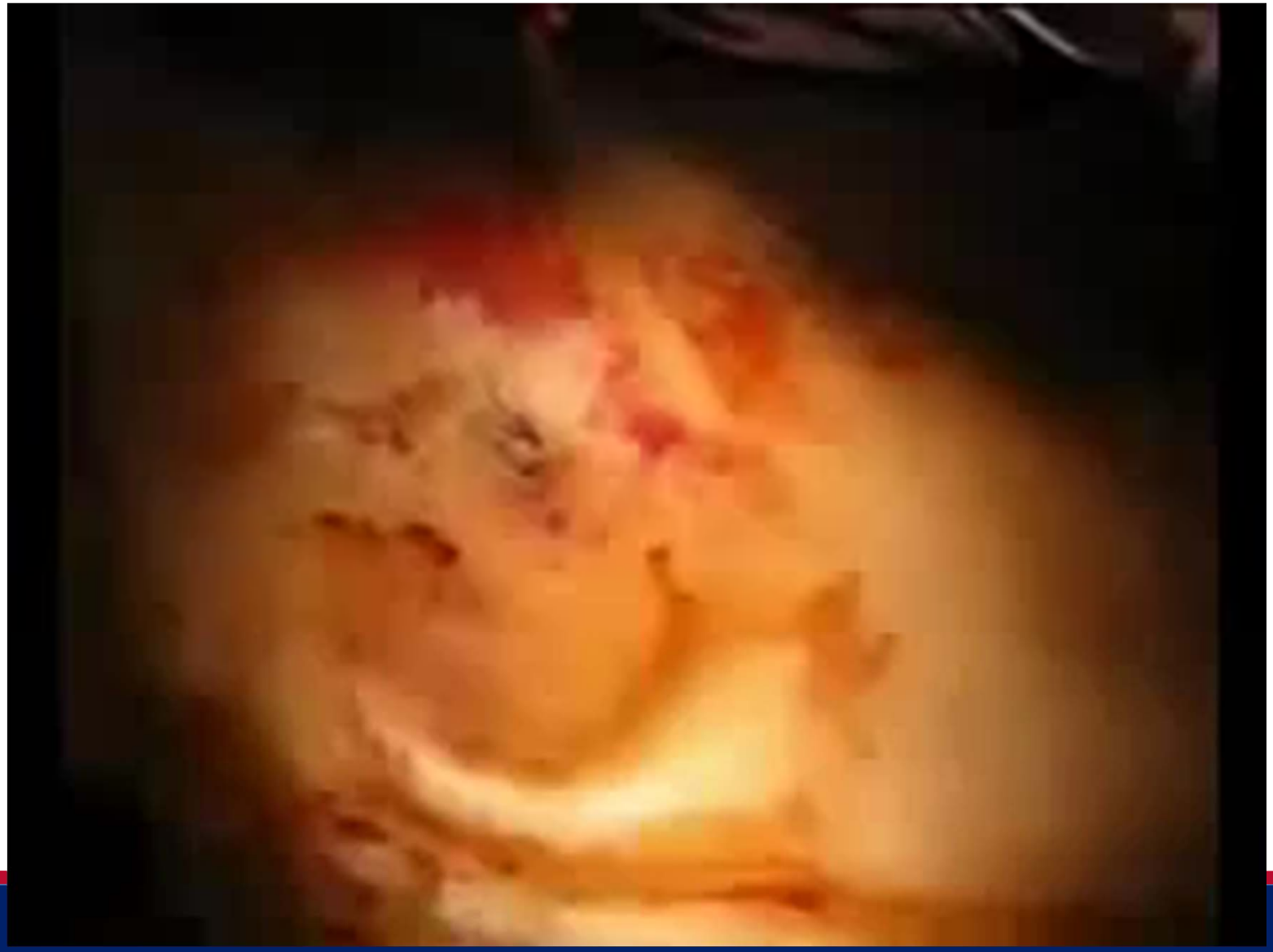
FLAIL CHEST



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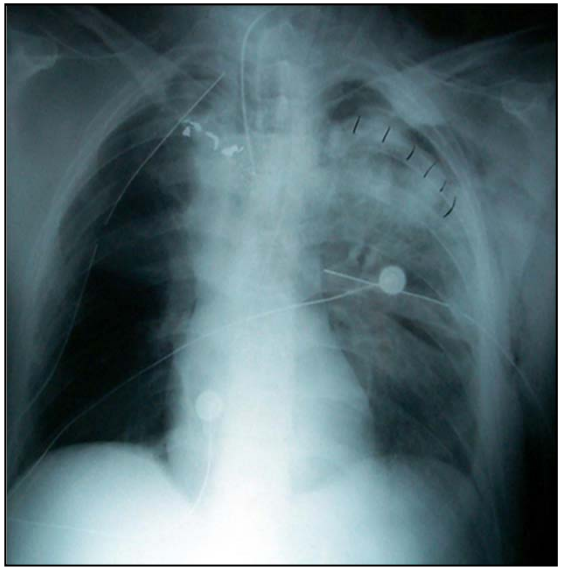
Summary

Always consider !

- Age
- Number of fracture ribs
- Presence of flail chest
- Presence of pulmonary contusion
- Associated injuries



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Management

"So what?"

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Management

Non-operative

Surgical Fixation

Controversy

95% of General surgeons
90% of Orthopaedic surgeons
82% of Thoracic surgeons

A randomized trial confirming efficacy is necessary to change their negative opinion about surgery

Non-operative Management

- Pulmonary toilet
- Respiratory support
- Pain control

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Non-operative Management

Pain control

Medication

- NSAIDs
- Oral narcotics
- IV narcotics
- Lidocaine patch

Regional Anasthesia

- Intercostal nerve blocks
- Intrapleural infusion catheters
- Epidural analgesia
- Thoracic paravertebral block

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Narcotics

Advantages:

Less painful
Rapid onset

Disadvantages

Cough suppression
Respiratory depression
RN certification

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Thoracic Epidural Analgesia (TEA)

Advantages:

No sedation
Best Studied
Better pulmonary function parameters

Disadvantages

Complex technique
Risk of spinal cord injury
Urine retention
Hypotension
Difficult monitoring
Coagulopahty

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Thoracic Paravertebral Block (TPVB)

Advantages:

No hypotension
No risk of spinal cord injury
Technically easier

Disadvantages

Risk of pneumothorax
No enough evidence in literature

Regional Anasthesia

Prospective, Randomized Comparison of Continuous Thoracic Epidural and Thoracic Paravertebral Infusion in Patients With Unilateral Multiple Fractured Ribs—A Pilot Study

30 adult patients

≥ 3 Unilateral fracture ribs

Ran

Or T

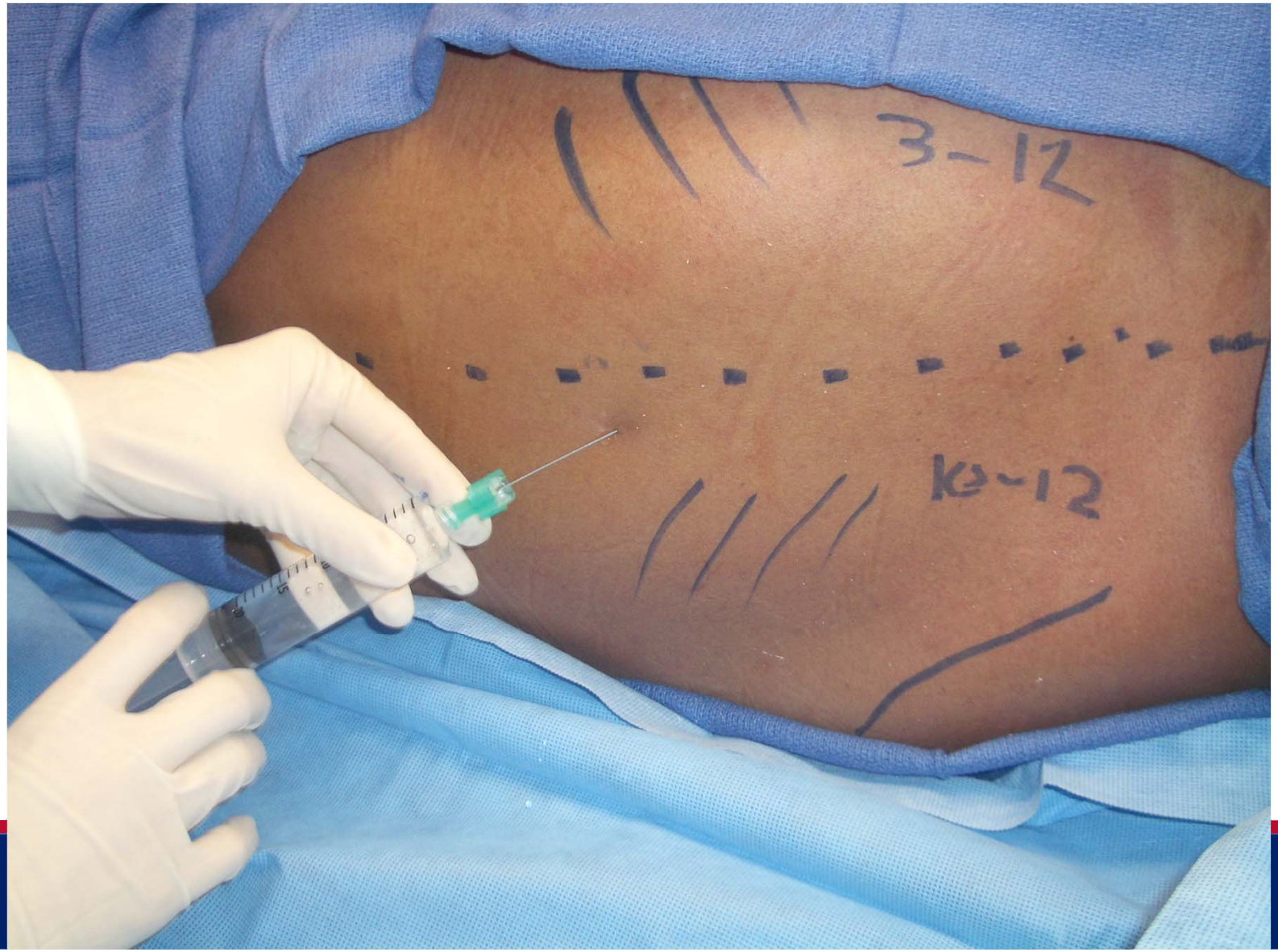
TPVB is as effective as TEA

No significant difference in:

- Pain scores at rest and on coughing
- Respiratory rate
- Peak expiratory flow rate

Morphine Requirement and Length of Stay Data (Mean ± SD)

Parameters	Group TEA (n = 15)	Group TPVB (n = 15)	*p*
Morphine requirement (mg)	9.2 ± 5.1	11.2 ± 9.5	0.477
Length of ICU stay (d)	6.3 ± 1.6	6.8 ± 4.2	0.650
Length of hospital stay (d)	10.1 ± 3.5	11.7 ± 5.5	0.350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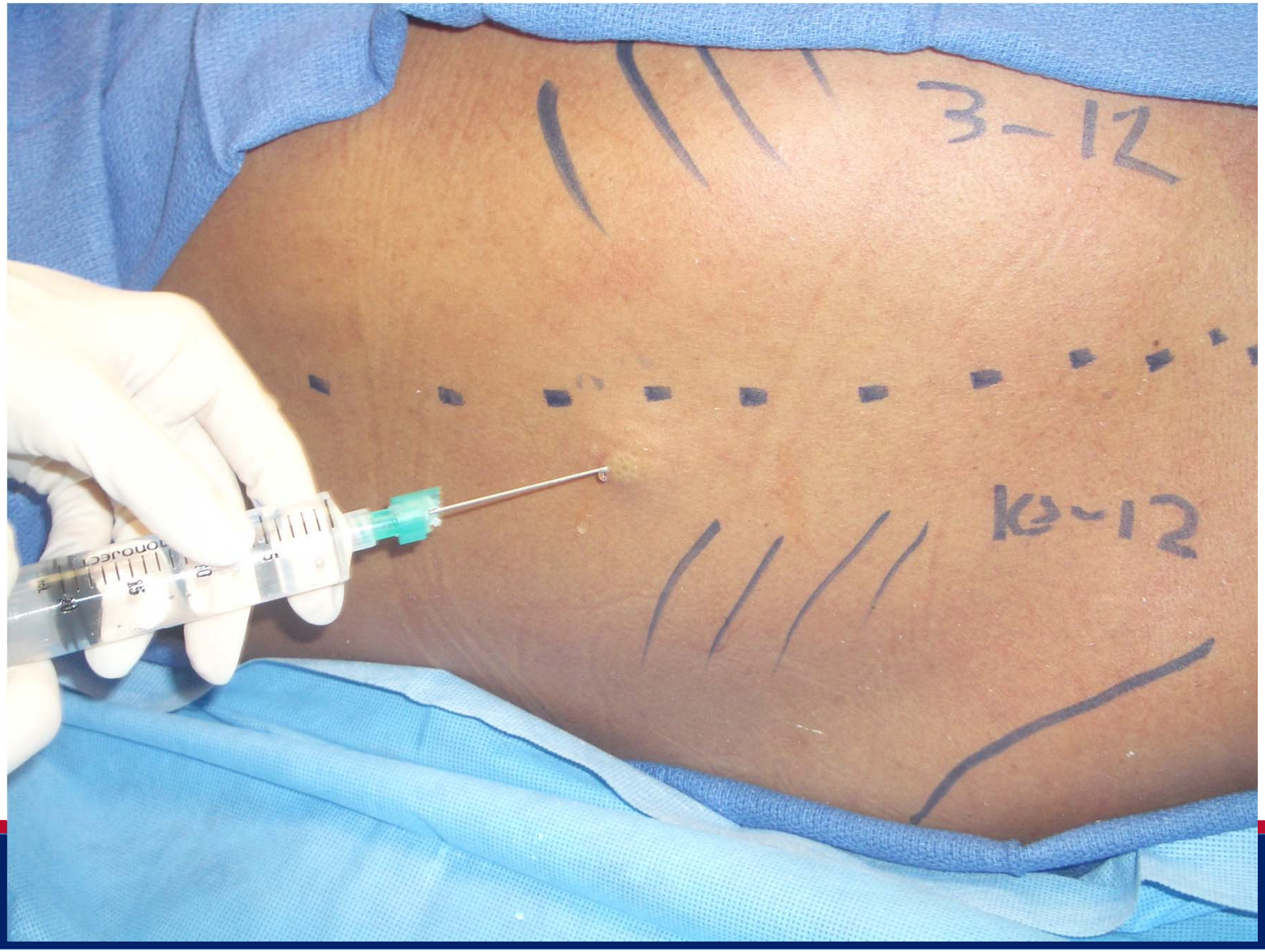
K3-12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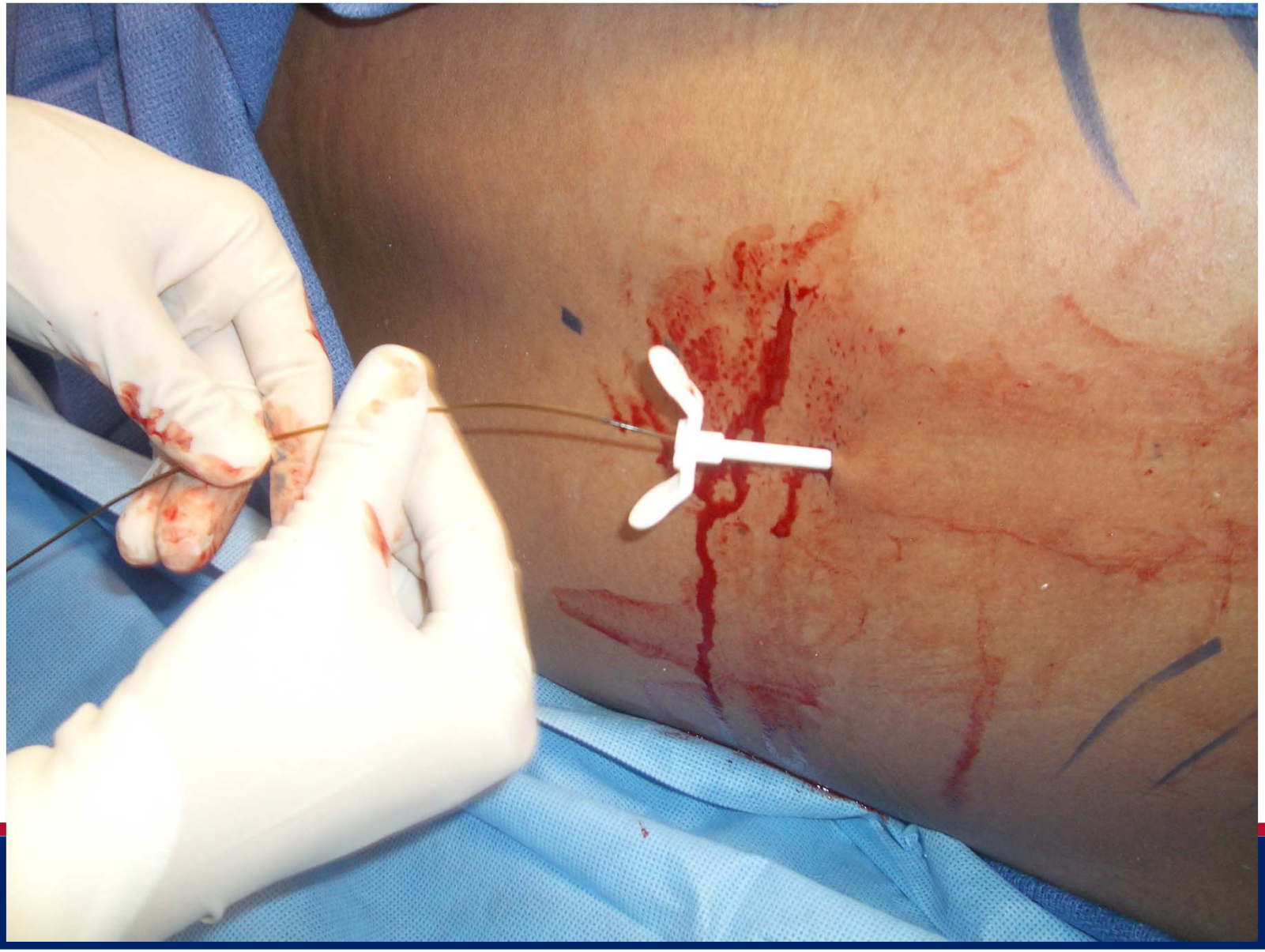

3-12
10-12

Summary

Top choices for patients with multiple rib fractures:

COMBINATION THERAPY

- Thoracic epidural analgesia (TEA)
- Thoracic paravertebral block (TPVB)
- Intercostal nerve blocks

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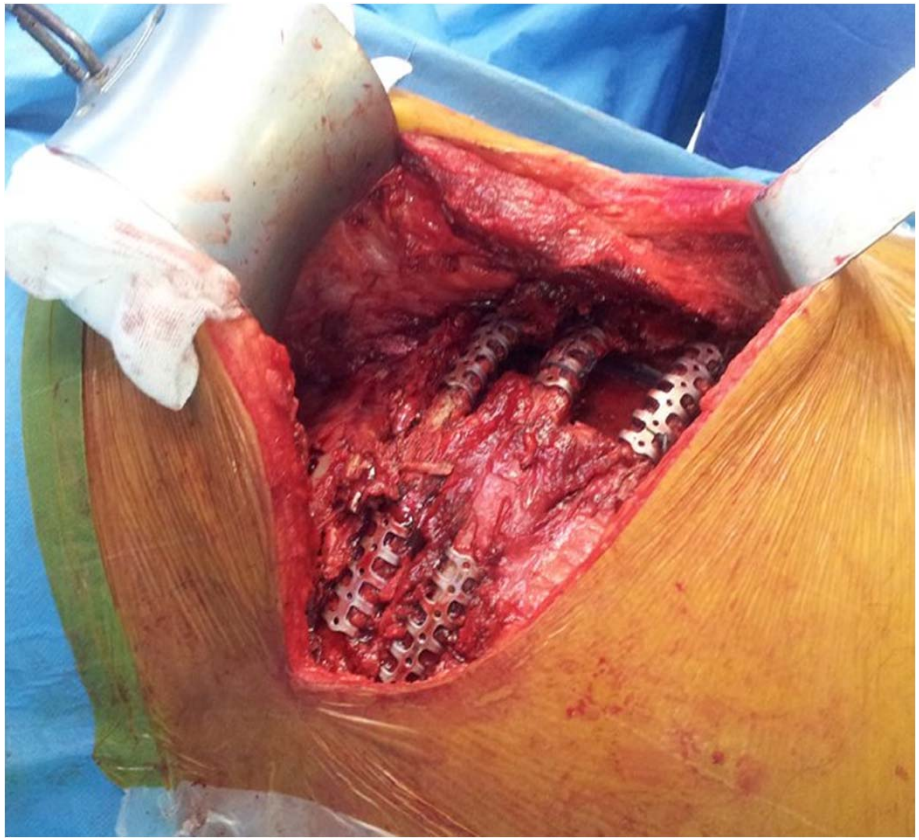
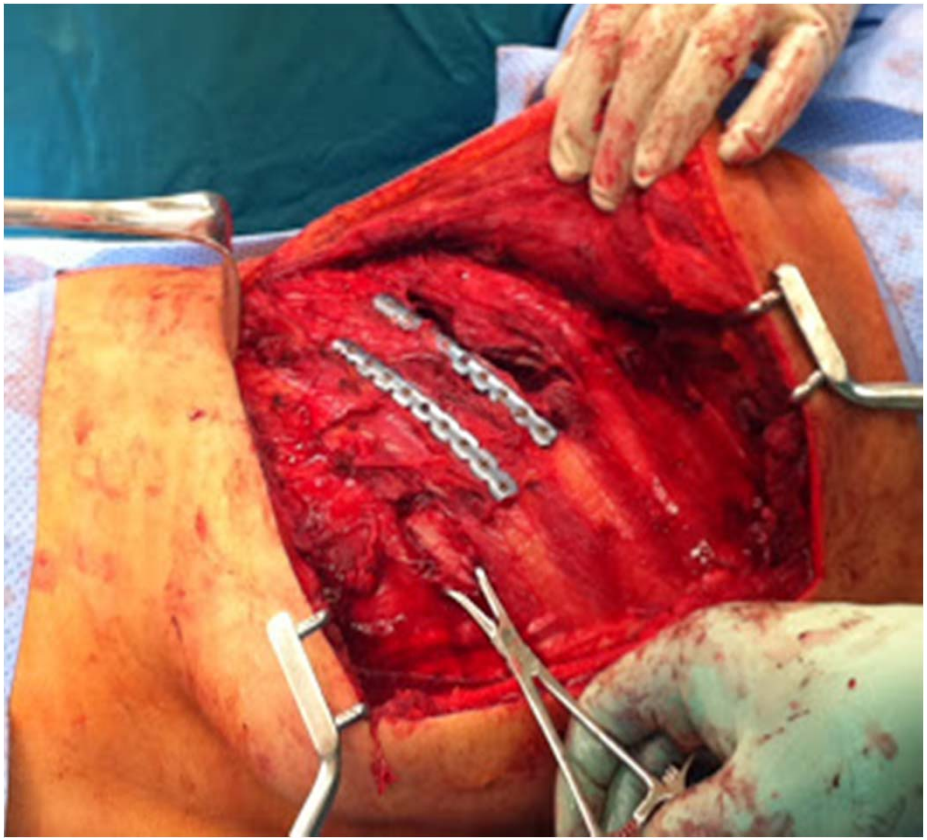
Surgical fixation





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Surgical fixation

- Improved understanding of rib biomechanics
- Advancements in fixation systems
- Development of muscle sparring techniques
- Reports showing better outcomes compared to conservative management

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Surgical Vs Non-operative

Surgical Stabilization of Internal Pneumatic Stabilization? A Prospective Randomized Study of Management of Severe Flail Chest Patients

- 37 patients with Severe flail chest injuries
- Randomized to surgery (n=18) versus internal pne

Surgical fixation is preferable

- **Surgery group had**:
- Shorter ventilatory period
- Shorter intensive care unit stay
- Lower incidence of pneumonia
- Higher forced vital capacity at 1 month
- Earlier return to work after 6 months

Tanaka et al. Journal of Trauma. 2002

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Surgical Vs Non-operative

J Am Coll Surg. 2013

Prospective randomized controlled trial of operative rib fixation in traumatic flail chest.

Marasco SF , Davies AR, Cooper J, Varma D, Bennett V, Nevill R, Lee G, Bailey M, Fitzgerald M.

- 46 patients with traumatic flail chest injury

Surgical fixation reduces ventilation requirement and intensive care stay

- **Surgery group had:**
- Shorter ICU stay
- Lesser need for noninvasive ventilation
- Less tracheostomy rate
- Less pulmonary complications

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Surgical Fixation

World J Surg. 2009

Rib fracture repair: indications, technical issues, and future directions.

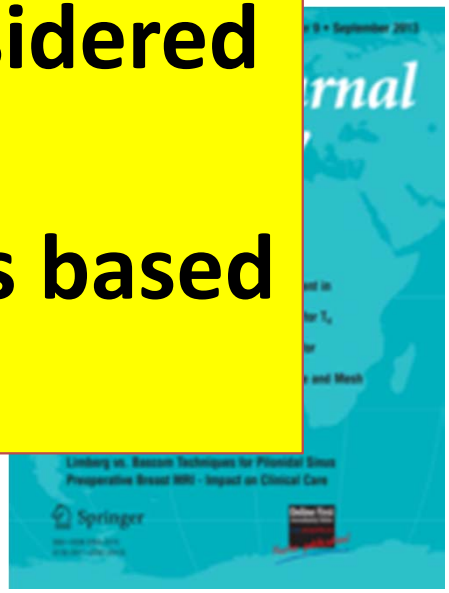
Nirula R , Diaz JJ Jr, Trunkey DD, Mayberry JC.

All indications are currently considered relative.

There are no absolute indications based on available studies.

Pot

-
-
-
-
- During thoracotomy for other traumatic indication.



Surgical Fixation

Contraindications:

- Active infection
- High operative risk
- Unlikely benefit from the procedure

Pieracci et al. J Trauma Acute Care Surg. 2015

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Surgical Fixation

Short-term Benefits:

- Accelerated restoration of pulmonary function
- Reduced morbidity from prolonged mechanical ventilation
- Shorter hospital and ICU stays
- Cost effective

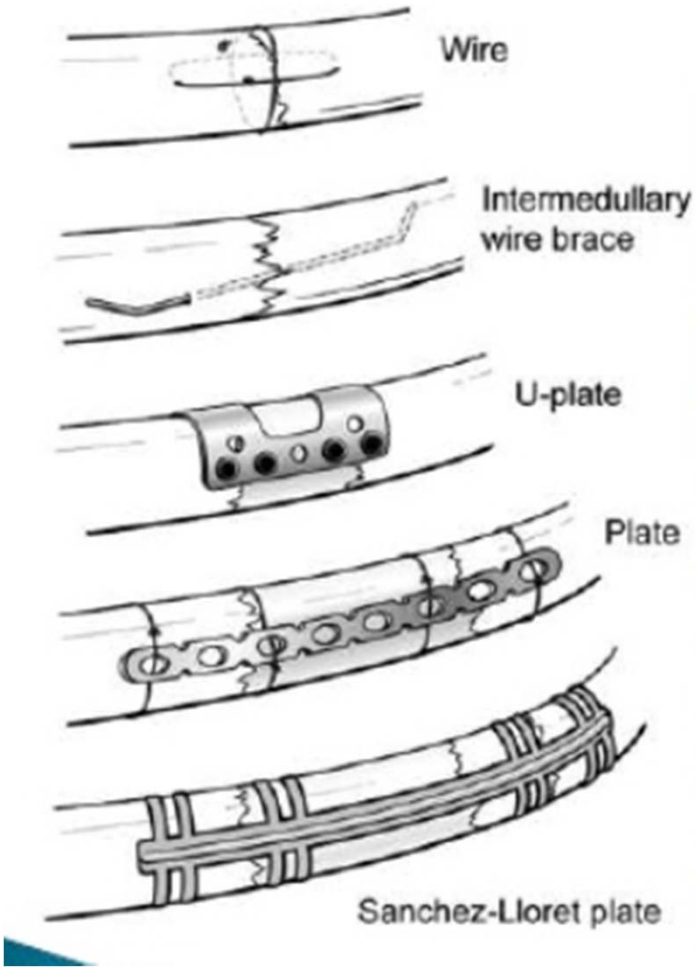
Long-term Benefits:

- Avoidance of chronic pain syndrome
- Avoidance of chest wall deformity

Surgical Fixation

Different fixation systems :

- Wires
- Metal plates
- Absorbable plates
- U-plate
- Judet strut



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Surgical Fixation

Surgical stabilization of severe rib fractures

Fredric M. Pieracci, MD, MPH, Maria Rodil, Robert T. Stovall, MD, Jeffrey L. Johnson, MD, Walter L. Biffl, MD, Cyril Mauffrey, MD, Ernest E. Moore, MD, *and* **Gregory J. Jurkovich, MD,** *Denver, Colorado*

Lack of consensus regarding both indications and technique

Current prospective randomized controlled study is in process

J Trauma Acute Care Surg. 2015

Surgical Fixation

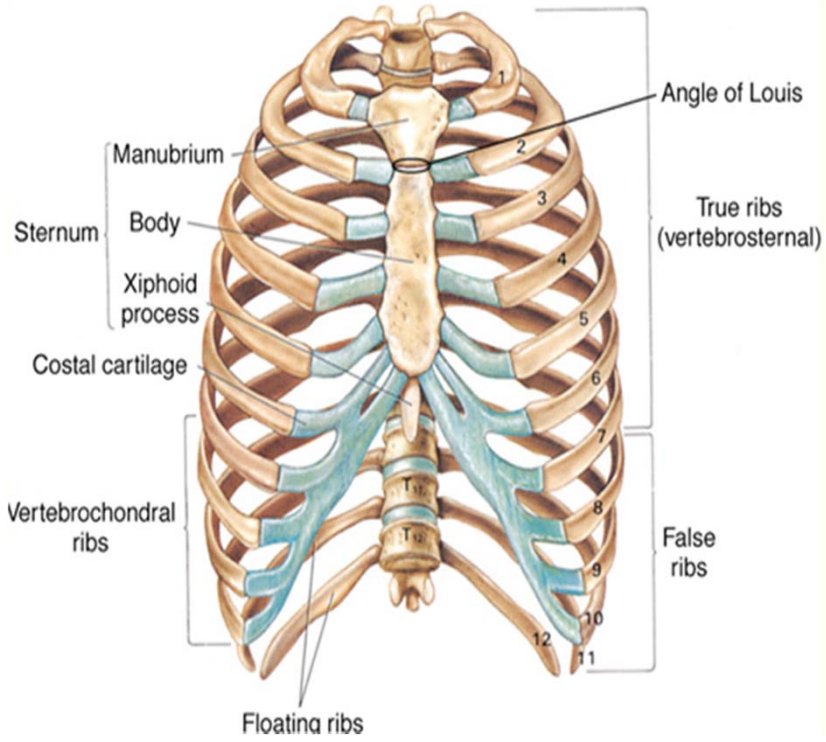
Surgical anatomy:

12 pairs of ribs

First 7 ribs articulate anteriorly to sternum and posteriorly to spine

Ribs 8-10 connect to the sternum indirectly via the costal cartilages of the ribs above them

Ribs 11-12 "Floating ribs"



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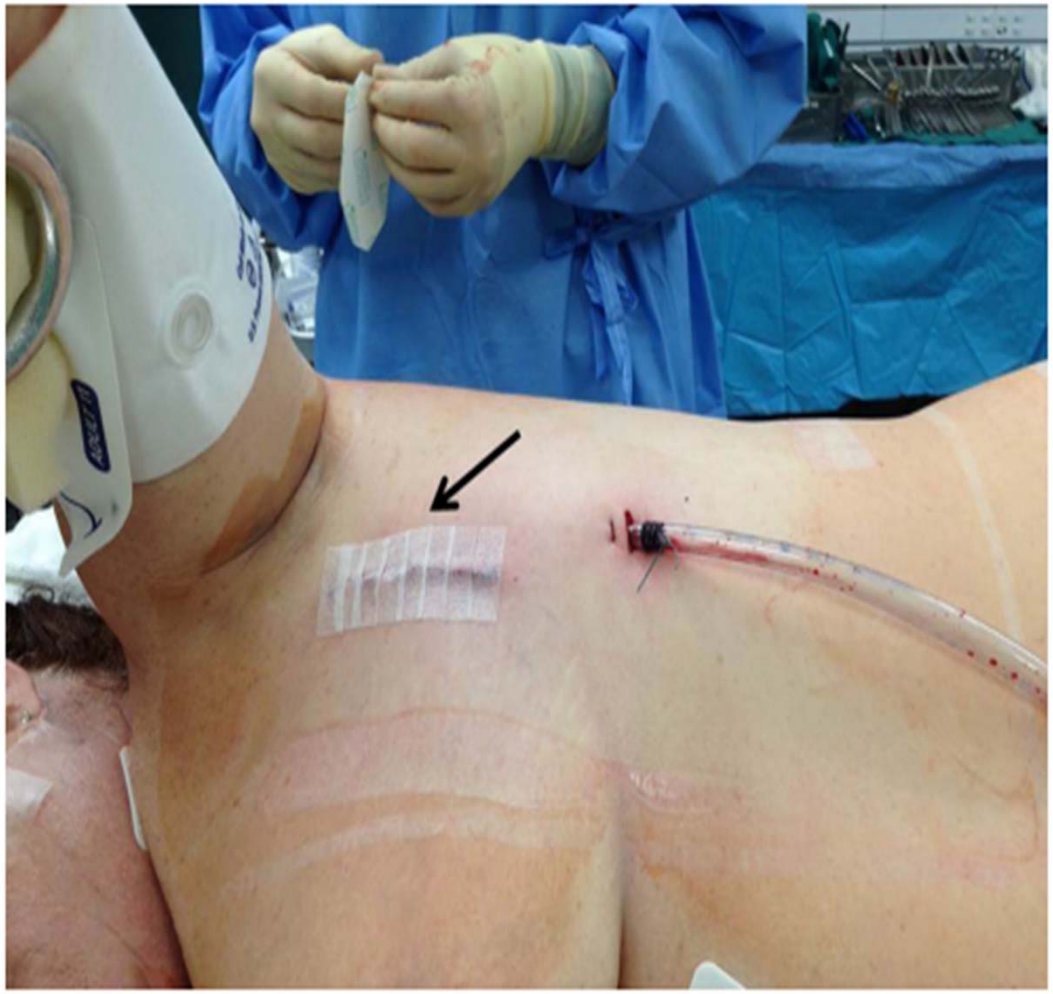
Incisions and Exposure

- **Anterolateral thoracotomy**
- **Lateral incision**
- **Posterolateral thoracotomy**
- **Parascapular incision**



Pieracci et al. 2015. J Trauma Acute Care Surg.

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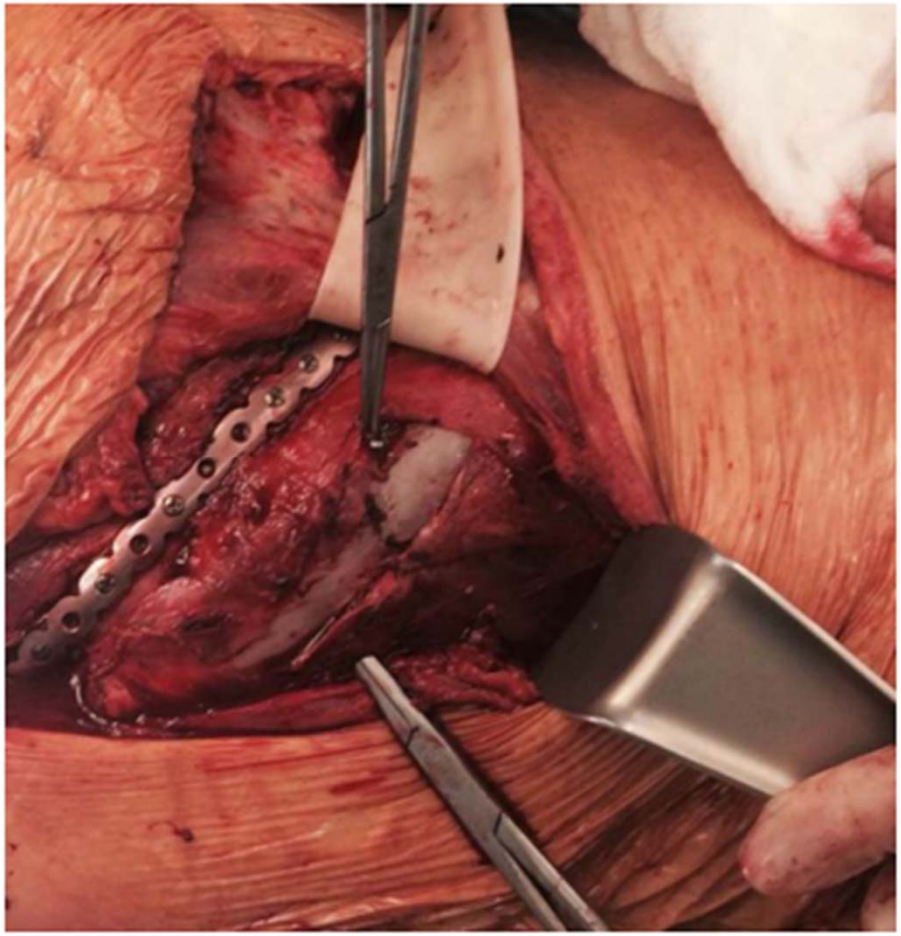
Fracture Reduction



“Double right angle” technique

Pieracci et al. 2015. J Trauma Acute Care Surg.

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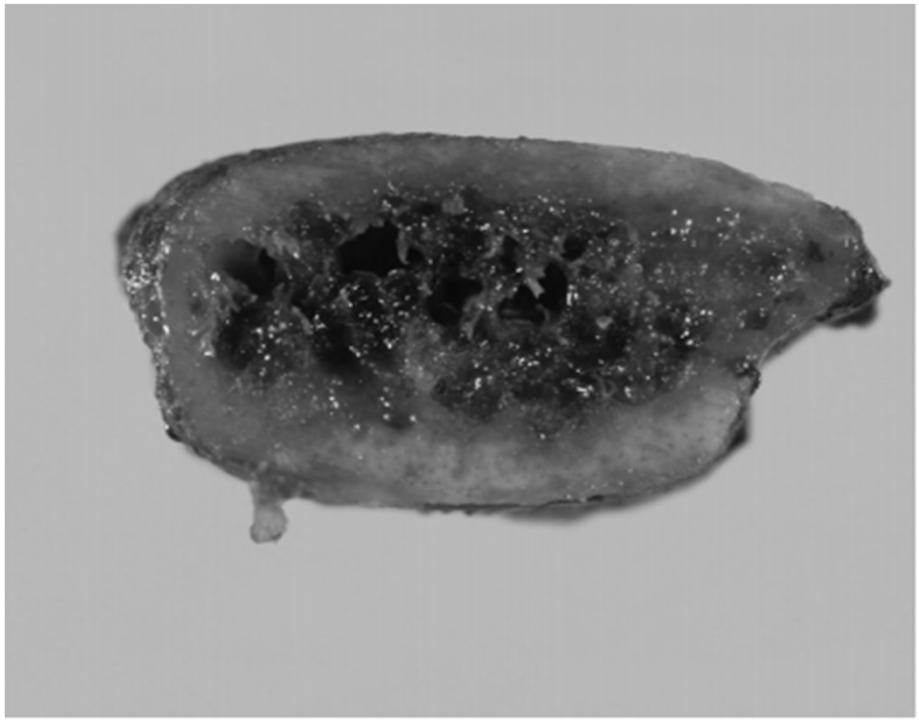
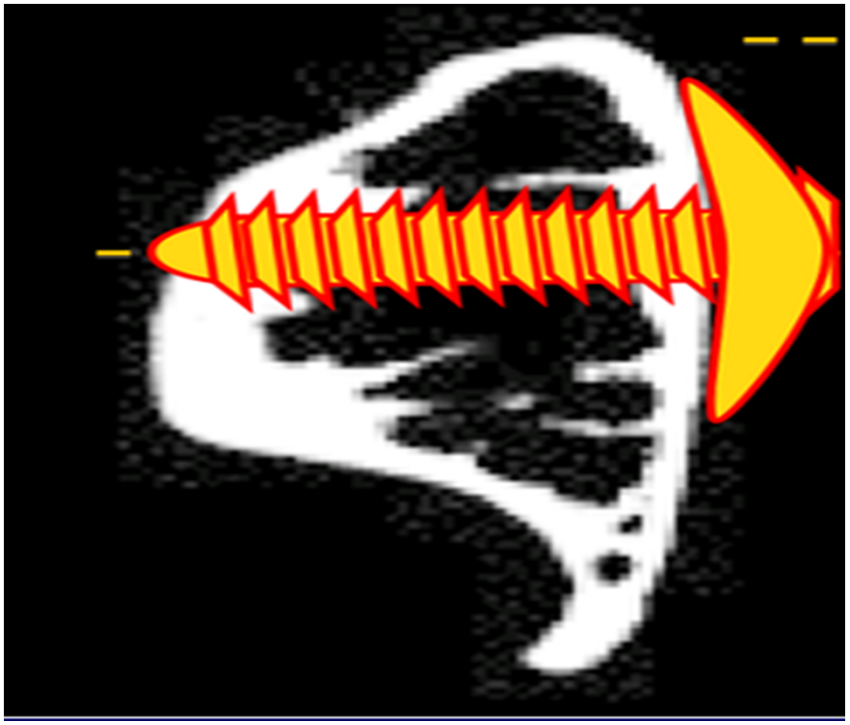
Fracture Fixation





- **Fixation must be bicortical .**
- **Drill holes at a right angle to the bone.**
- **Plates must sit flush with the ribs.**
- **Plates should sit over the superior portion of the rib.**

Sales et al, 2008. J Trauma.
Pieracci et al. 2015. J Trauma Acute Care Surg.

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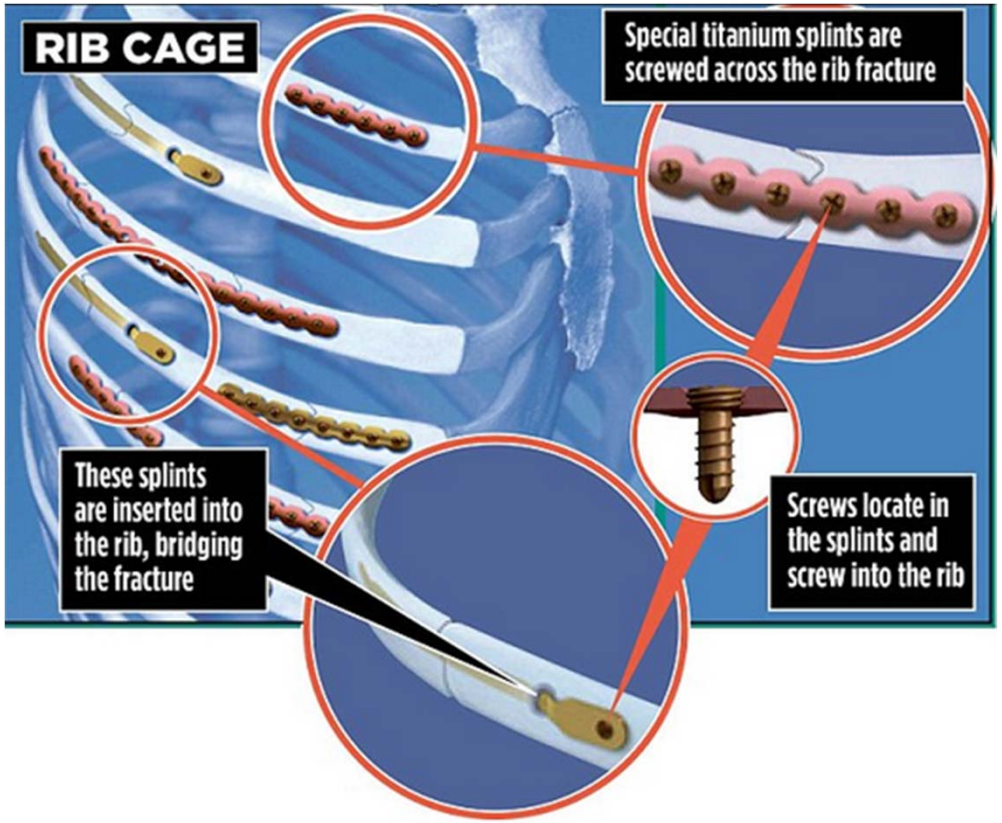
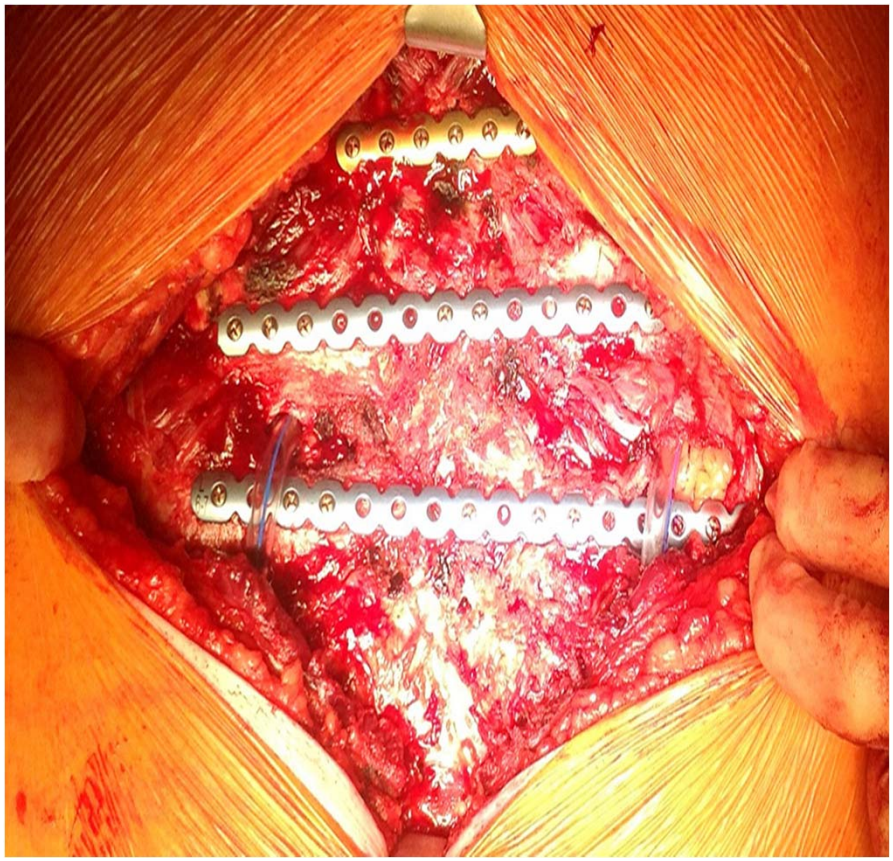
Metal Plates





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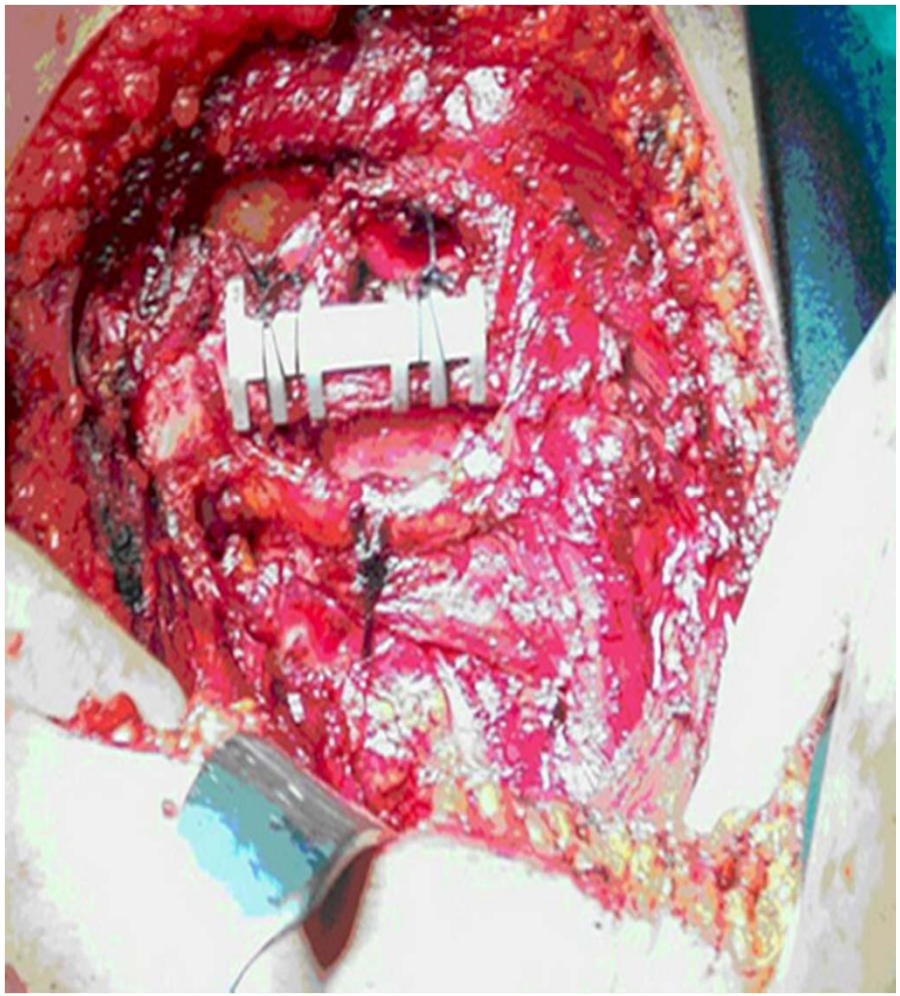
Judet Strut



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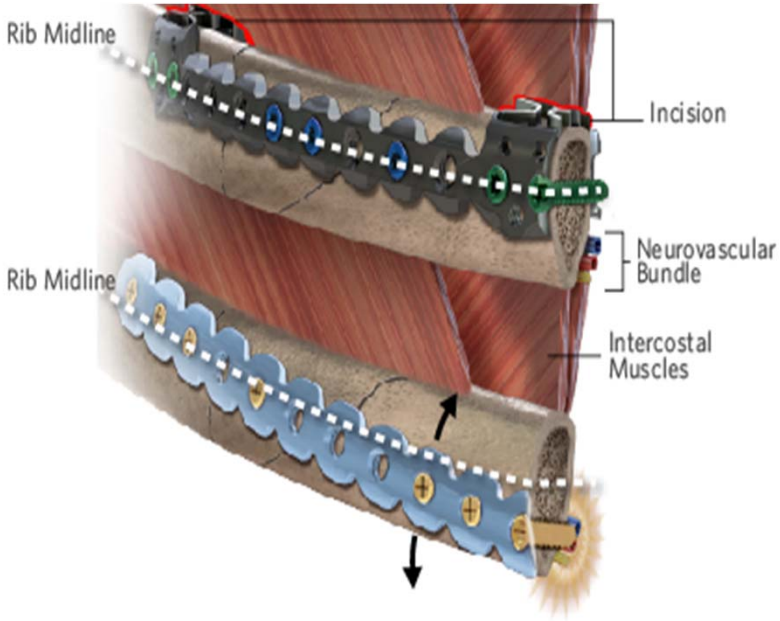
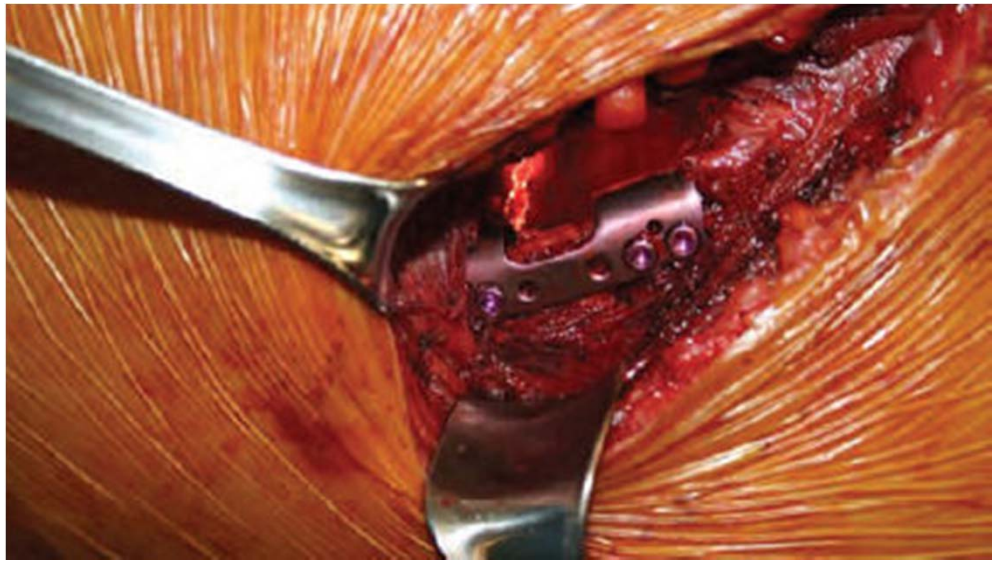
U-Plate System





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Fix One or Both ?

J Trauma Acute Care Surg. 2014

Analysis of bone healing in flail chest injury: do we need to fix both fractures per rib?

Marasco S , Liew S, Edwards E, Varma D, Summerhayes R.

All fractures in the flail segment should be fixed

- **Australia**
- **Retrospective review**
- **60 consecutive patients underwent surgical stabilization for flail chest**

54% of patients had callus formation and bony bridging between adjacent ribs where unfixed.a

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Take Home Message

- **Fracture ribs and Flail chest are serious problems**
- **Pain management is the cornerstone of management**
- **Knowledge about indications and techniques is needed**
- **Prospective randomized controlled studies are ongoing**

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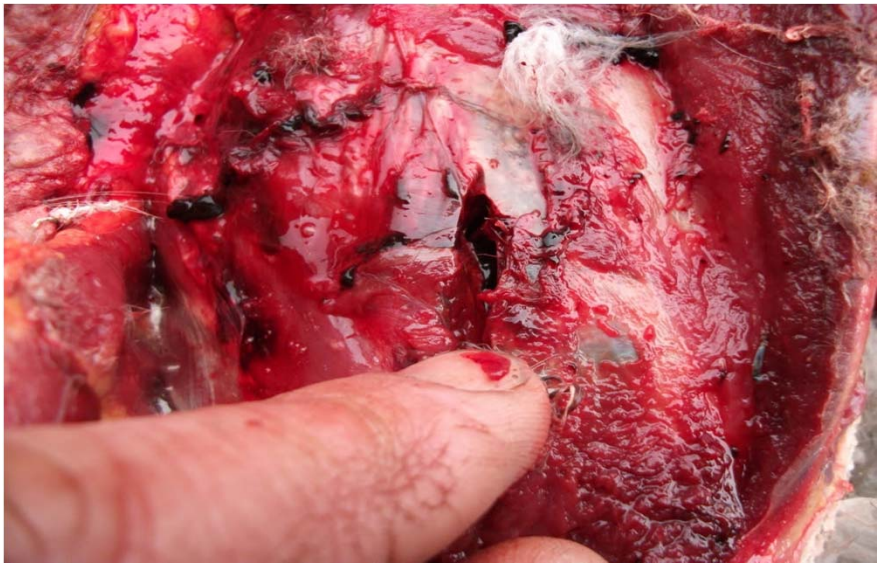
Sternal Fractures

3-8% of all trauma patients

A plaster jacket in 1941

Surgical fixation in 1943



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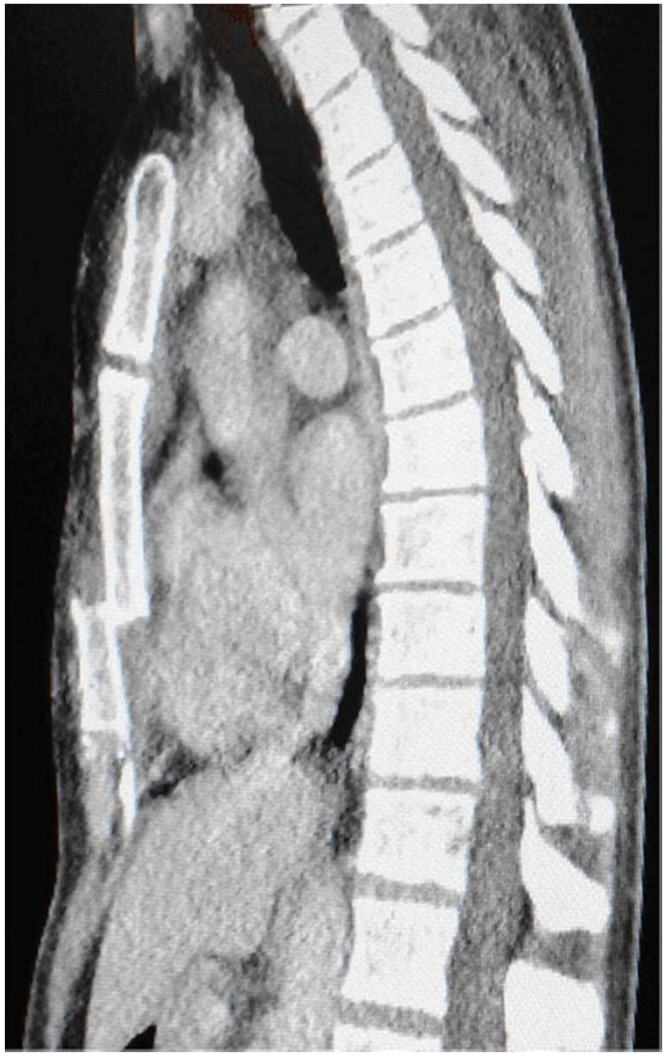
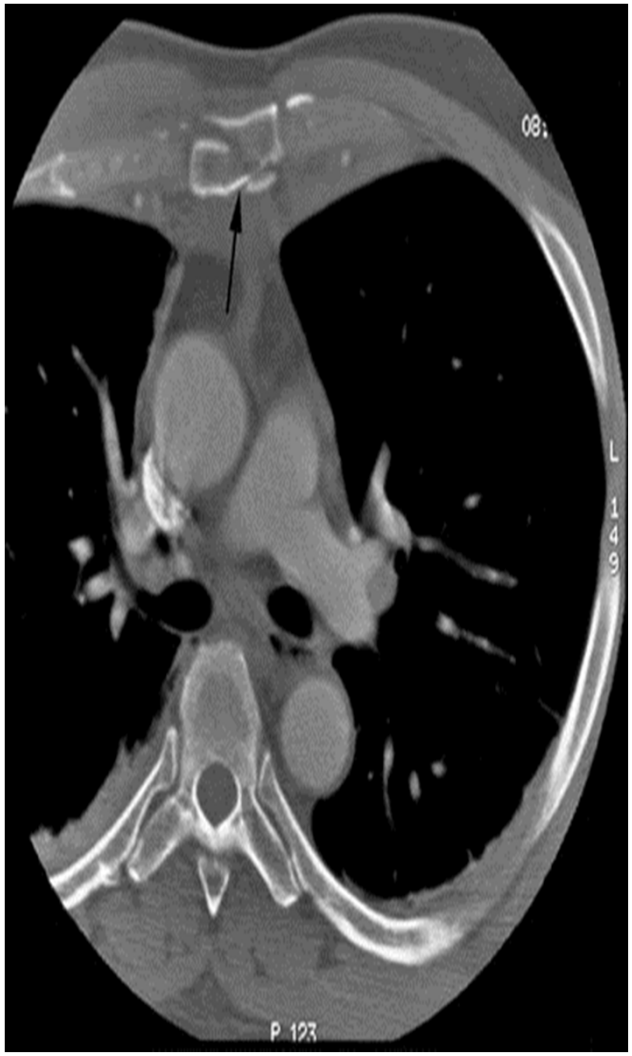
Sternal Fractures





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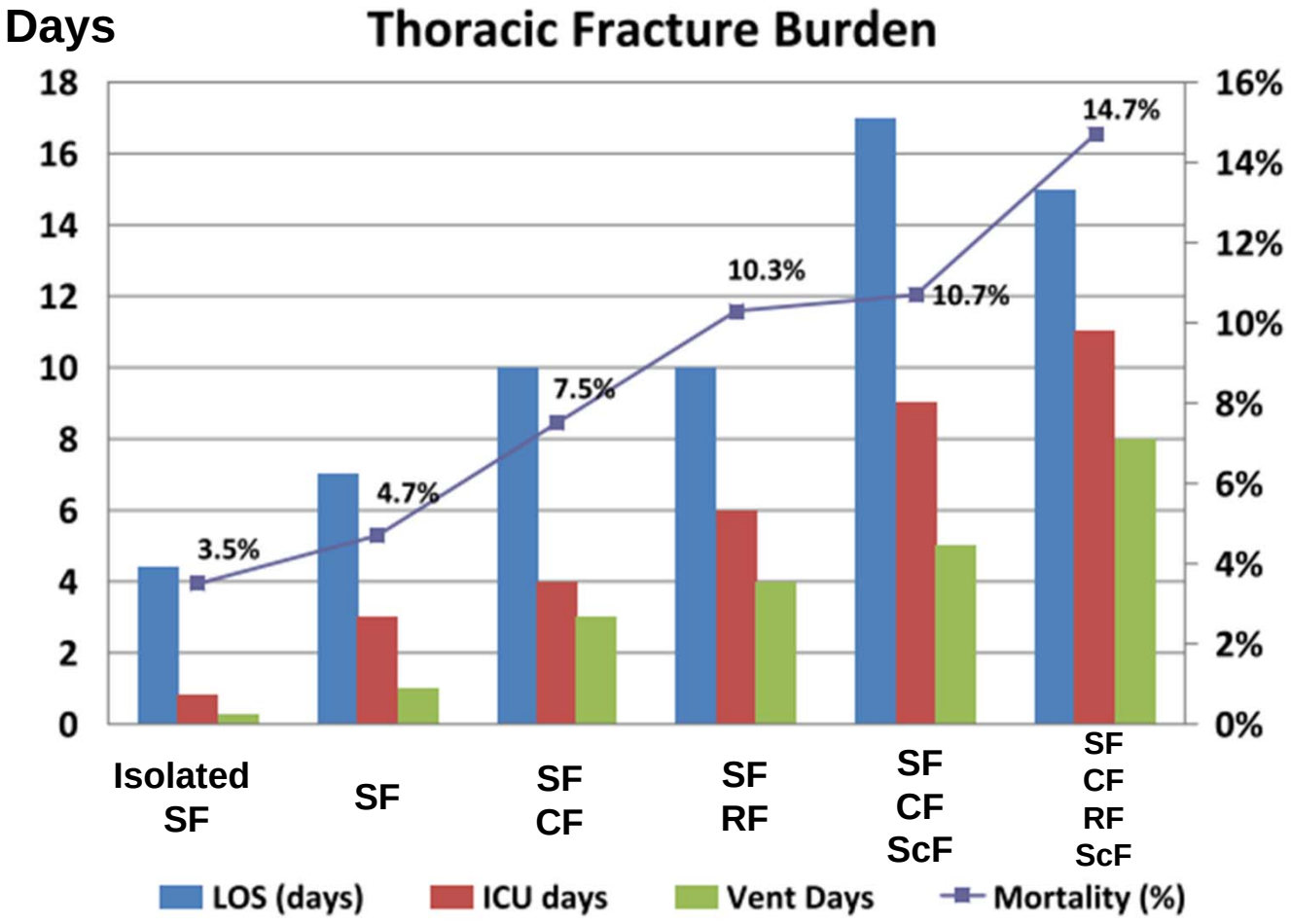
Sternal Fractures



Yeh et al. Journal of Surgical Research. 2014

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Sternal Fracture Fixation

J Trauma. 2011

Fixation of sternal fractures: a systematic review.

Harston A, Roberts C.

1990-2010 literature review

12 articles with 76 cases of surgically repaired sternal fractures

Plates were used in 52 patients and **wiring** was selected in 24 patients for fixation

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Sternal Fracture Fixation

Indications for Sternal Fracture Repair and Percentage of Surgeons Accepting as Indication in Selected Patients

Indication for Repair	% Accepting
Sternal fracture non-union (>6 wk)	68
Acute sternal deformity	48
Chronic sternal deformity	32
Sternal fracture pain 4–8 wk	29
Sternal fracture pain 2–4 wk	11
Sternal fracture pain <2 wk	5

Mayberry et al. Journal of Trauma. 2009

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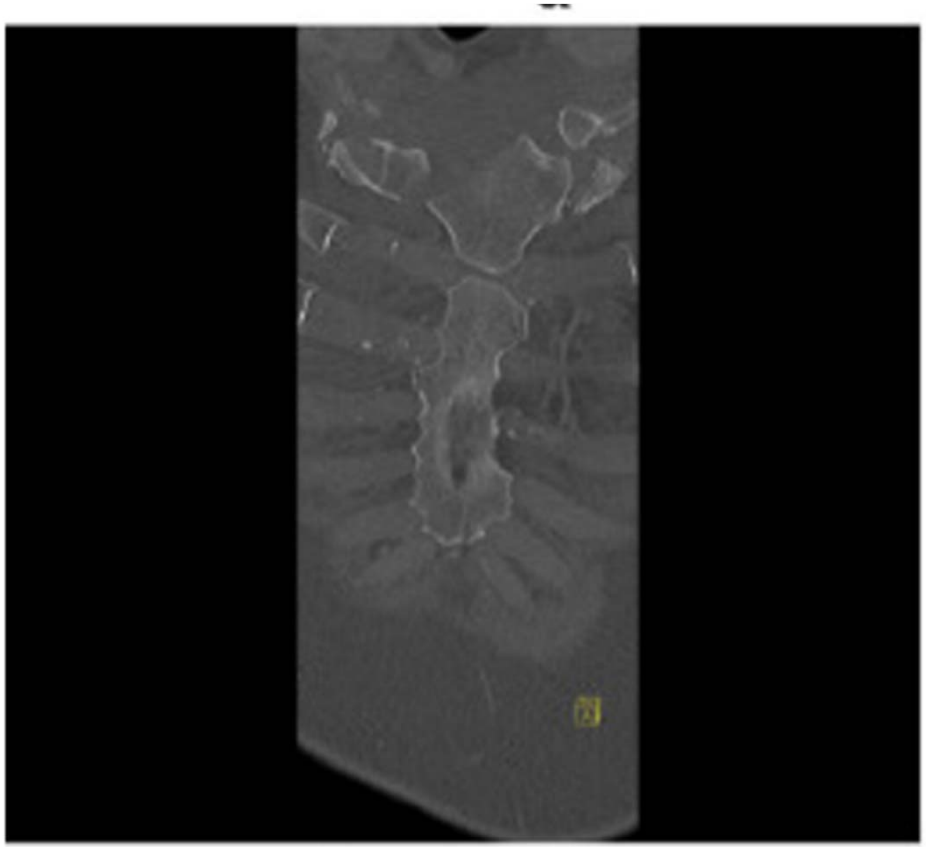
Sternal Fracture Fixation

Preoperative



Schulz-Drost et al. Journal of Visualized Experiments. 2015

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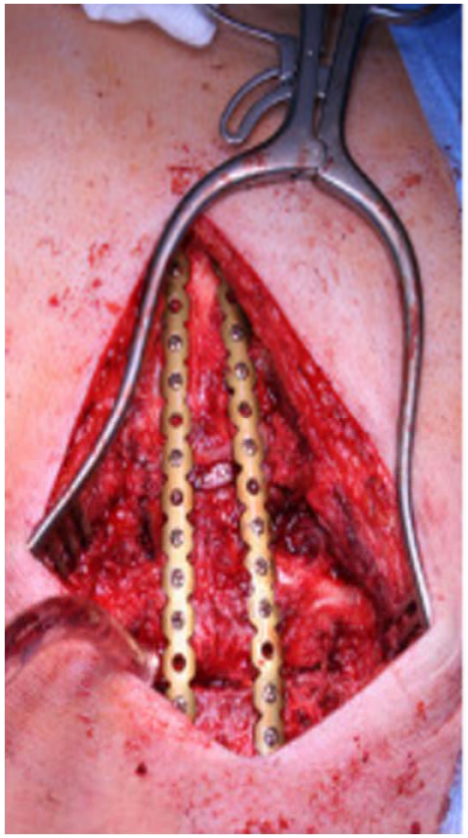
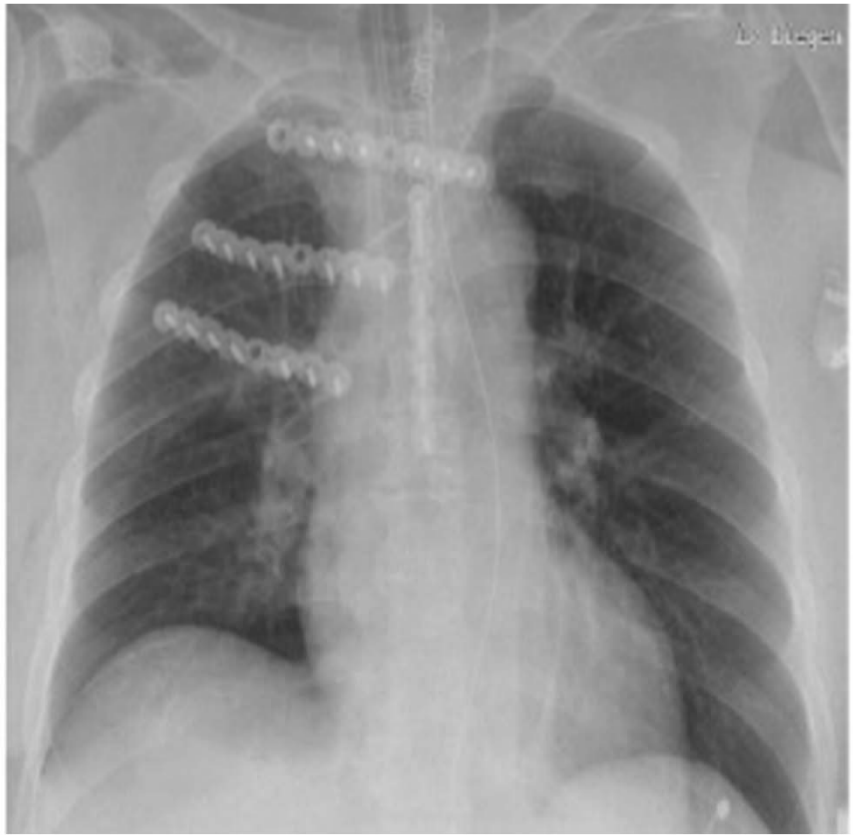
Sternal Fracture Fixation

Post-operative





Schulz-Drost et al. Journal of Visualized Experiments. 2015

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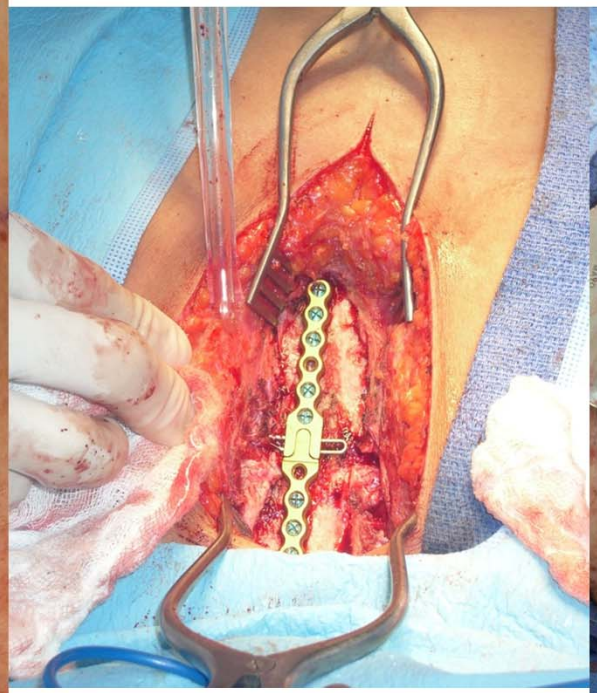
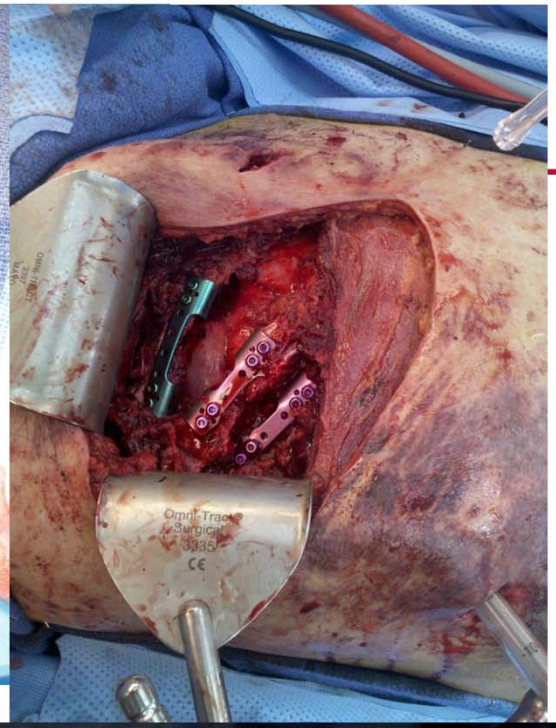
Sternal Fracture – Pre op




Omni-Tract
Surgical
3935
CE

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Sternal Fracture – Post op

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Take Home Message

- Surgical fixation is currently indicated only for displaced sternal fractures
- Currently no indication for sternal fixation exists for pain control in non-displaced fractures
- Randomized control studies are required to compare surgical fixation and conservative management for non-displaced sternal fractures

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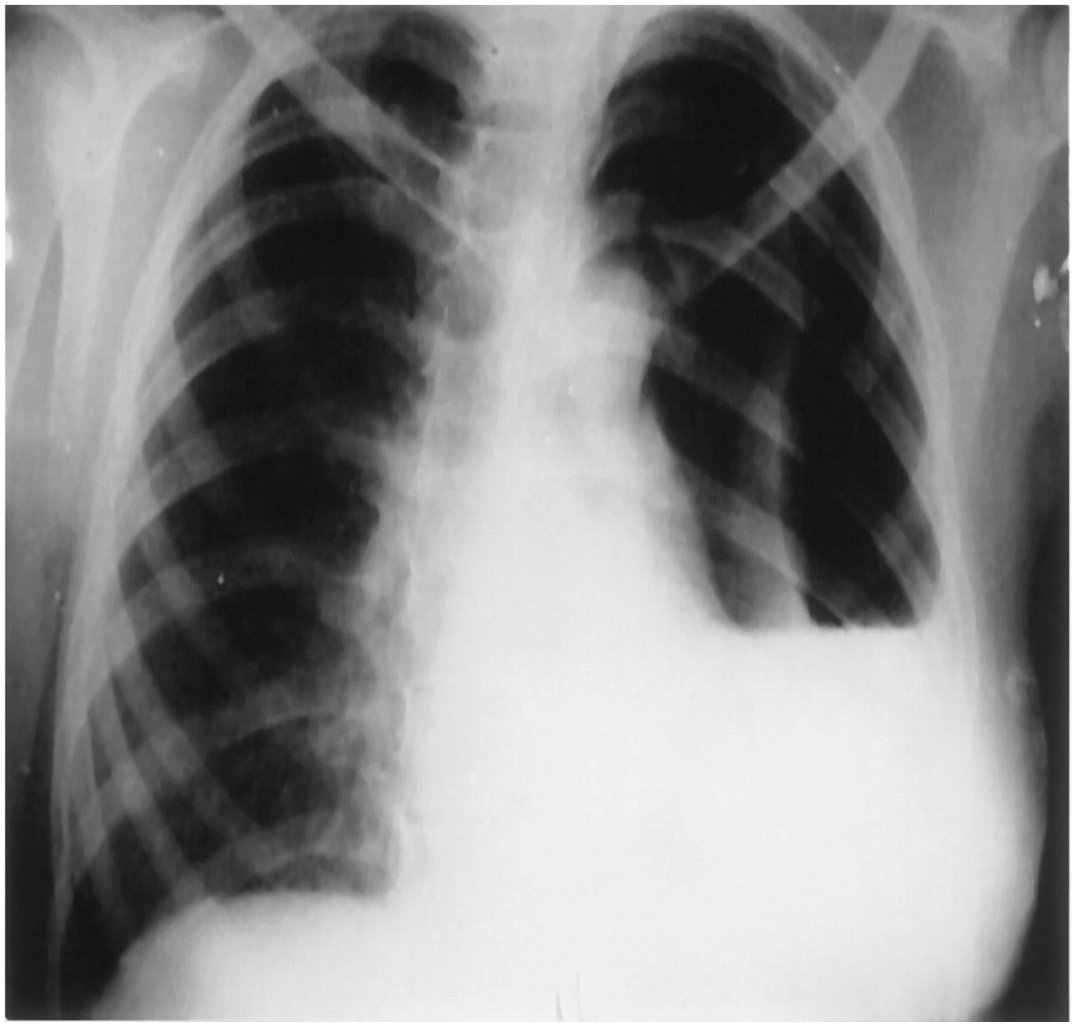
HEMOTHORAX



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HEMOTHORAX

- Should all hemothoraces be drained?
- Does size matter? Chest tube vs. Pig tail catheter
- Retained pneumothorax?
- Is autotransfusion safe?

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HEMOTHORAX

Should all hemothoraces be drained?

Practice Management Guidelines for Management of Hemothorax and Occult Pneumothorax

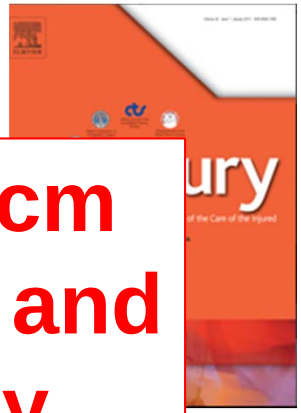
Mowery, Nathan T. MD; Gunter, Oliver L. MD; Collier, Bryan R. DO; Diaz, Jose' J. Jr. MD; Haut, Elliott MD; Hildreth, Amy MD; Holevar, Michelle MD; Mayberry, John MD; Streib, Erik MD

All hemothoraces, regardless of size, should be considered for drainage

HEMOTHORAX

Should all hemothoraces be drained?

To drain or not to drain? Predictors of tube thoracostomy insertion and outcomes associated with drainage of traumatic hemothoraces



Bry
An

HTX <300cc corresponds to 1.5-2.0 cm posterior lamellar strip on a CT scan and can be safely managed expectantly

- 655 patients
- No difference in mortality between tube thoracostomy vs. expectant management
- Shorter hospital LOS in patients without tube thoracostomy

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HEMOTHORAX

Does size matter?

Trust me...
size matters, bro.

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HEMOTHORAX

Does size matter?

Does size matter? A prospective analysis of 28–32 versus 36–40 French chest tube size in trauma

Inaba

Brow

No difference in efficacy, rate of retained hemothorax, need for additional drainage, or invasive procedures

emj EMERGENCY MEDICINE JOURNAL

BET 4: Does size matter? Chest drains in haemothorax following trauma

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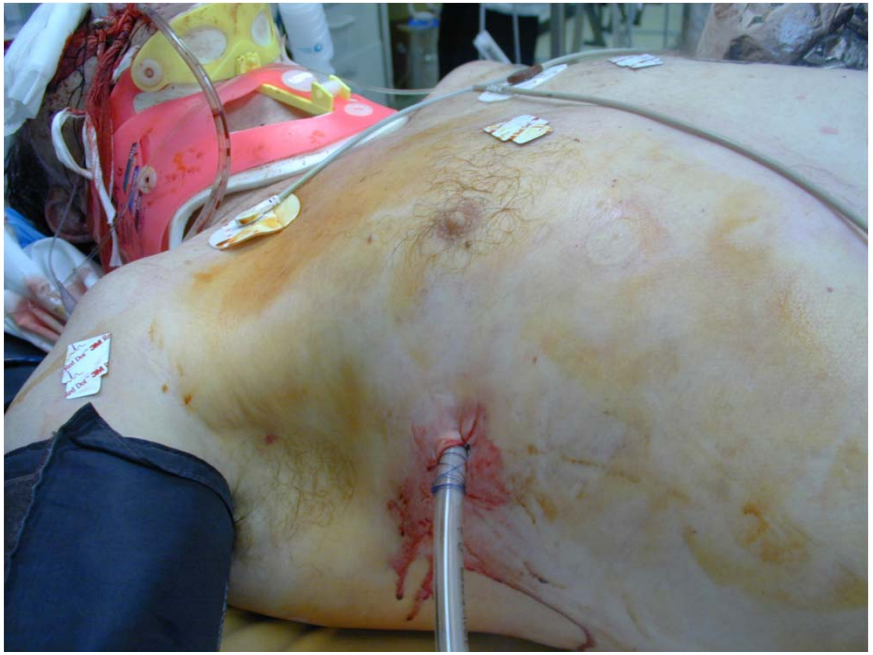
HEMOTHORAX

Pigtail vs. Chest tube



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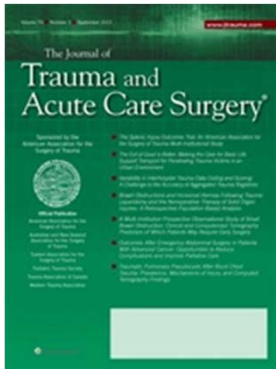
HEMOTHORAX

Pigtail vs. Chest tube

14 French pigtail catheters placed by surgeons to drain blood on trauma patients: Is 14-Fr too small?

Narong Kulvatunyou, MD, Bellal Joseph, MD, Randall S. Friese, MD, Donald Green, MD, Lynn Gries, MD, Terence O'Keeffe, MD, Andy L. Tang, MD, Julie L. Wynne, MD, *and* **Peter Rhee, MD,** *Tucson, Arizona*



- Prospective study
- 36 Pigtail catheter vs. 191 chest tubes
- Similar rate of drainage
- Similar tube duration, complications, and failure rates

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HEMOTHORAX

	Kulvatunyou et al.		Inaba et al. (3)	
	14F PC (n = 36)	32-40F CT (n = 191)	28-32F CT (n = 144)	36-40F CT (n = 131)
Initial output, ml, mean ± SD	560 ± 81	426 ± 37	312± 314	393 ± 364
Tube days, mean ± SD	5 ± 0.8	6 ± 0.3	6.3 ± 3.9	6.2 ± 3.6
Failure (retained HTX), %	8%	24%	12%	11%

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HEMOTHORAX

Size does not matter

- Unclotted blood **will** drain……14F PCs
- Clotted blood **will not**…… 32-40F CTs

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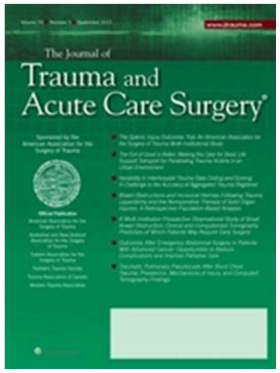
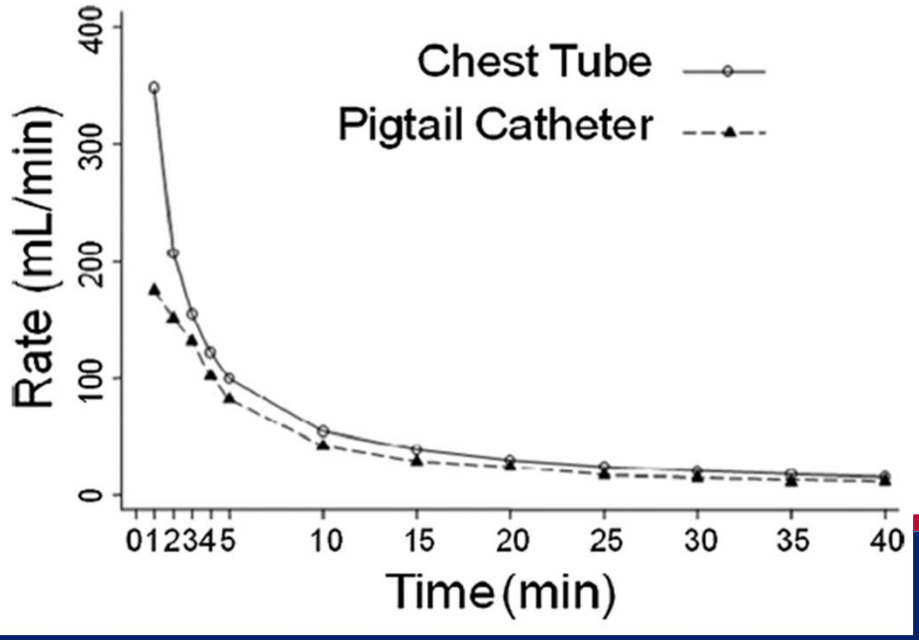
HEMOTHORAX

Pigtail vs. Chest tube

A pilot study of chest tube versus pigtail catheter drainage of acute hemothorax in swine

Rachel M. Russo, MD, Scott A. Zakaluzny, MD, Lucas P. Neff, MD, J. Kevin Grayson, DVM, PhD, Rachel A. Hight, MD, Joseph M. Galante, MD, *and* David V. Shatz, MD, *Sacramento, California*





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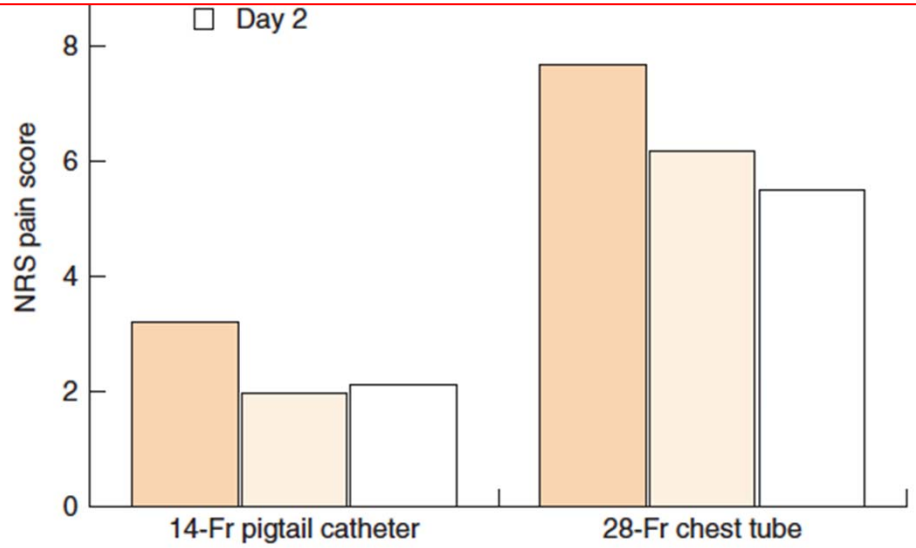
HEMOTHORAX

Why choose pigtail?

Randomized clinical trial of pigtail catheter *versus* chest tube in injured patients with uncomplicated traumatic pneumothorax

N. Ku
A. L.

Significantly lower pain with pigtail catheter



HEMOTHORAX

Retained hemothorax

Retained hemothorax is defined as failure to adequately drain a haemothorax

Consequences of retained hemothorax

- Empyema formation
- Organization and fibrosis of clot

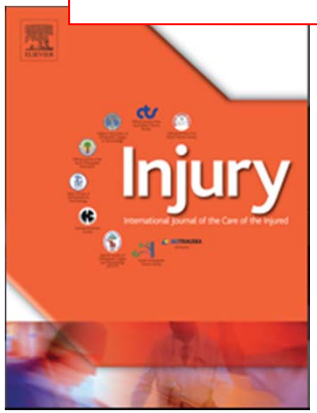
HEMOTHORAX

Retained hemothorax

Management of post-traumatic retained hemothorax: A prospective, observational, multicenter AAST study

Joseph
Jame
Ant

VATS performed within 3 days has better outcomes



How early should VATS be performed for retained haemothorax in blunt chest trauma?

Hsing-Lin Lin [b,e,g], Wen-Yen Huang [c], Chyan Yang [c], Shih-Min Chou [f], Hsin-I. Chiang [d], Liang-Chi Kuo [b,e,g], Tsung-Ying Lin [b,e,g], Yi-Pin Chou [a,h,*]

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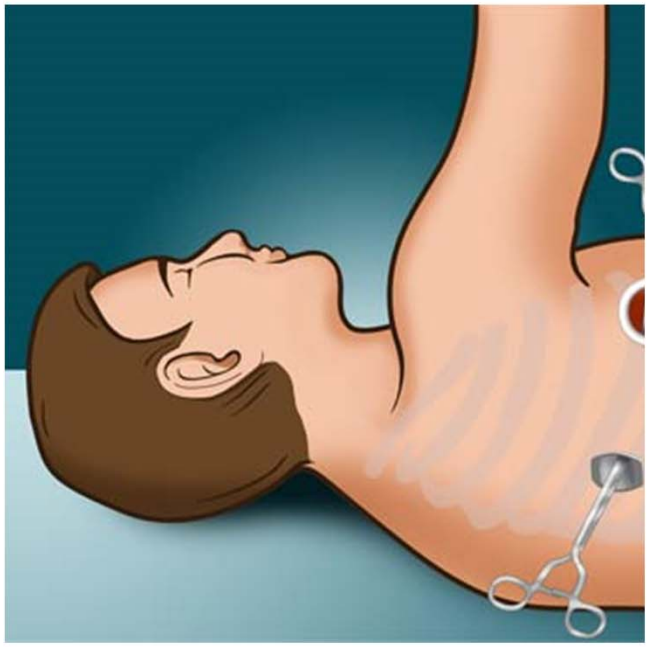
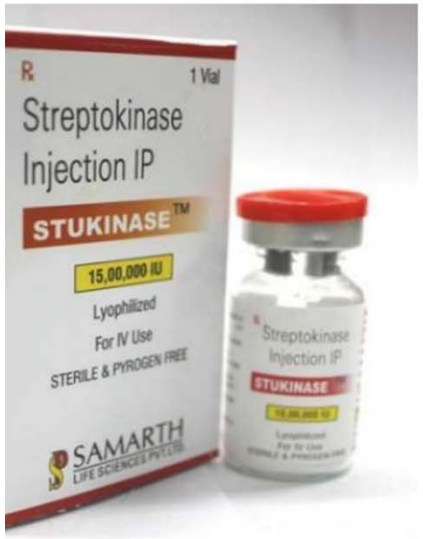
HEMOTHORAX

Retained pneumothorax



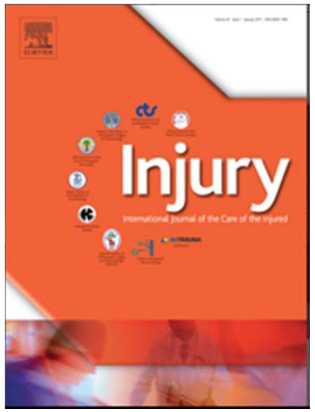


HEMOTHORAX

VATS vs. Streptokinase for retained hemothorax

VATS versus intrapleural streptokinase: A prospective, randomized, controlled clinical trial for optimum treatment of post-traumatic Residual Hemothorax

S. Kumar [a], V. Rathi [b], A. Rattan [c,*], S. Chaudhary [d], N. Agarwal [a]



- Prospective randomized control trial
- 35 patients randomized to VATS (n=18) and intrapleural streptokinse (n=17)
- No difference in resolution of retained hemothorax or complications

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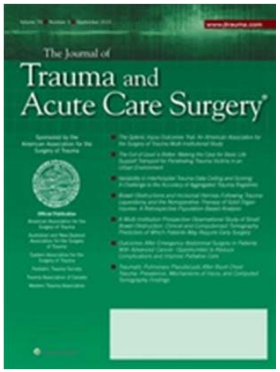
HEMOTHORAX

Autotransfusion

Early autologous fresh whole blood transfusion leads to less allogeneic transfusions and is safe

Peter Rhee, MD, Kenji Inaba, MD, Viraj Pandit, MD, Mazhar Khalil, MD, Stefano Siboni, MD, Gary Vercruysse, MD, Narong Kulvatunyou, MD, Andrew Tang, MD, Anum Asif, MD, Terence O'Keeffe, MD, *and* **Bellal Joseph, MD,** *Tucson, Arizona*



Variables	AT (n = 136)			No-AT (n = 136)	*p*
24-h blood product requirement					
PRBC, median (IQR), U	7 (3–10)			9 (5–11)	0.01
Platelets, median (IQR), U	5 (3–5)			7 (3–9)	0.01
FFP, median (IQR), U	4 (3–6)			4 (3–7)	0.1
24-h Hgb, mean (SD), mg/dL	9.4 (6.3)			9.8 (6.5)	0.61
Sepsis,% (n)	2.9 (4)	2.2 (3)	0.71		
Renal insufficiency,% (n)	2.2 (3)	2.2 (3)	0.89		
TRALI,% (n)	2.2 (3)	1.5 (2)	0.67		
Mortality,% (n)	18.3 (25)	15.4 (21)	0.51		
24-h INR, mean (SD)	1.3 (1.1)	1.1 (1)	0.12		

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HEMOTHORAX-Autotransfusion

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HEMOTHORAX

- Should all hemothoraces be drained?
- Small hemothoraces <300cc may be managed expectantly

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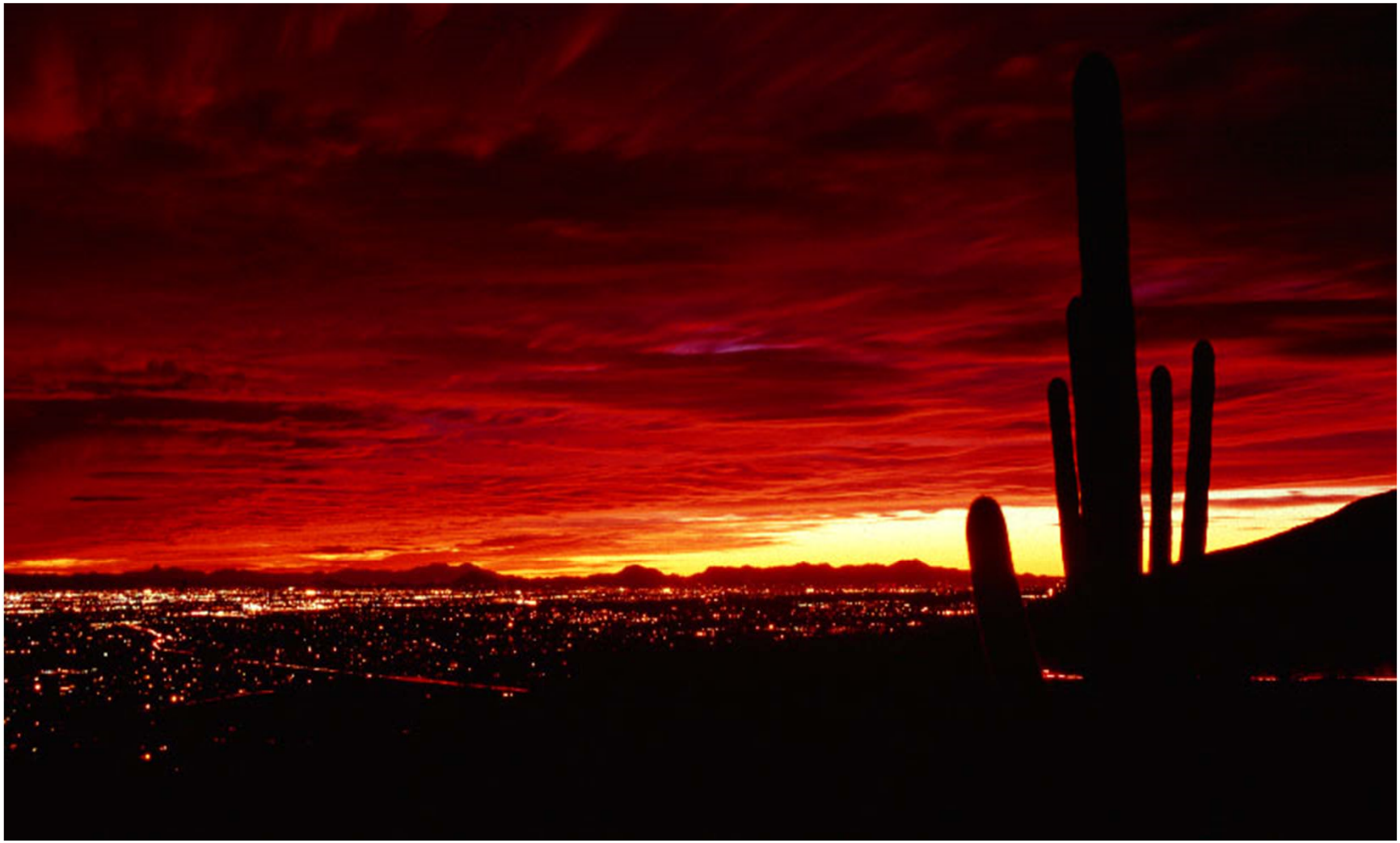
THANK YOU