Damage Control and Definitive Surgery for Thoracic and Chest Wall Surgery

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national medical center

Damage Control

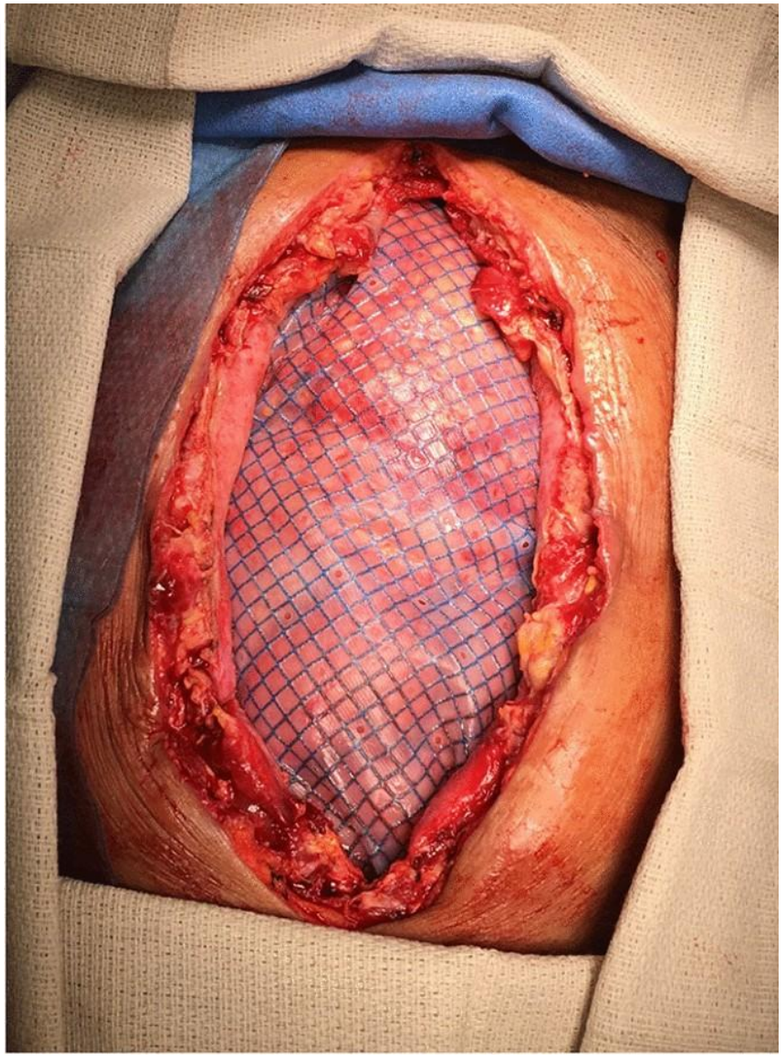
Thoracic

Chest wall

국립중앙의료원
national medical center

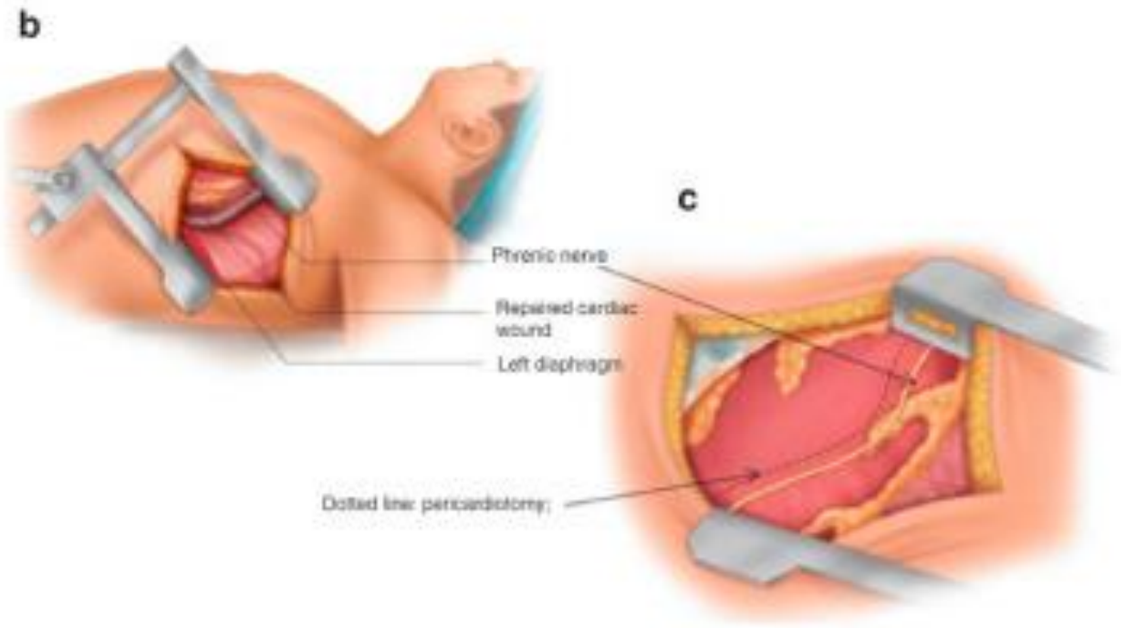
Damage Control

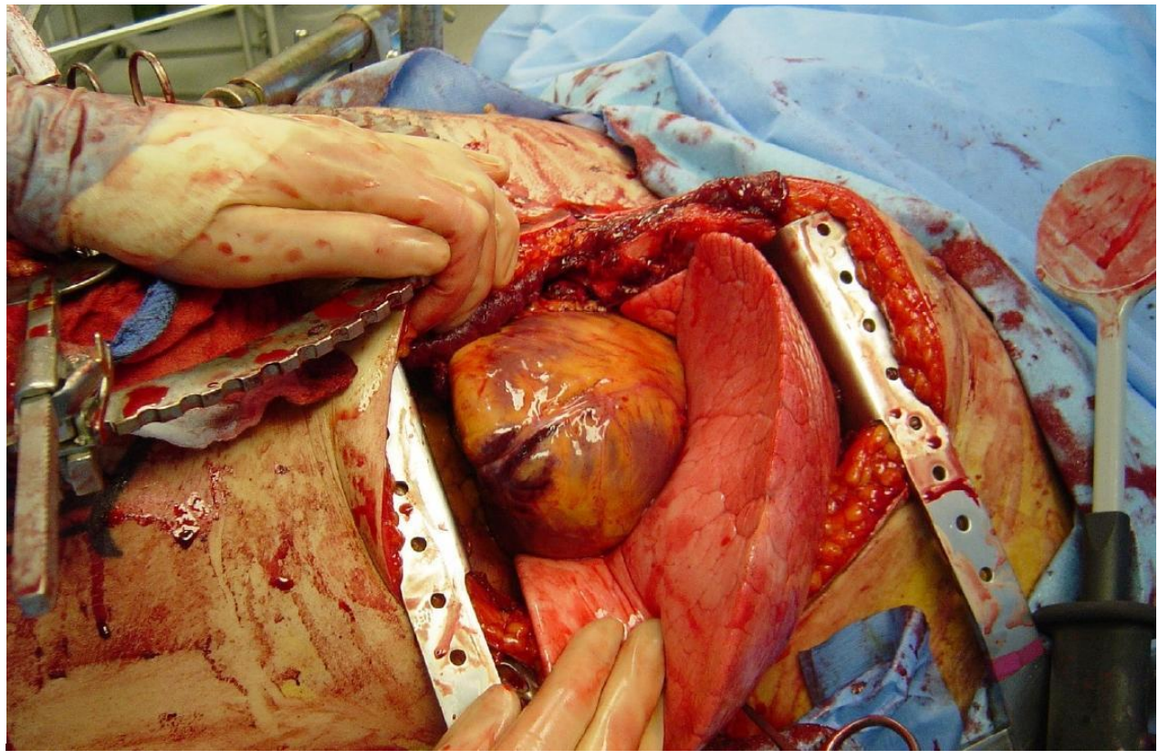
* Naval History and Heritage Command National Archives #80-G-270357



* https://link.springer.com/article/10.1007/s40719-023-00262-8
* https://thoracickey.com/thoracic-damage-control/

Emergency **D**epartment **T**horacotomy (**R**esuscitative **T**horacotomy)





* Cothren, C.C., Moore, E.E. Emergency department thoracotomy for the critically injured patient: Objectives, indications, and outcomes. World J Emerg Surg 1, 4 (2006).

Open cardiac massage

- **In animal studies**

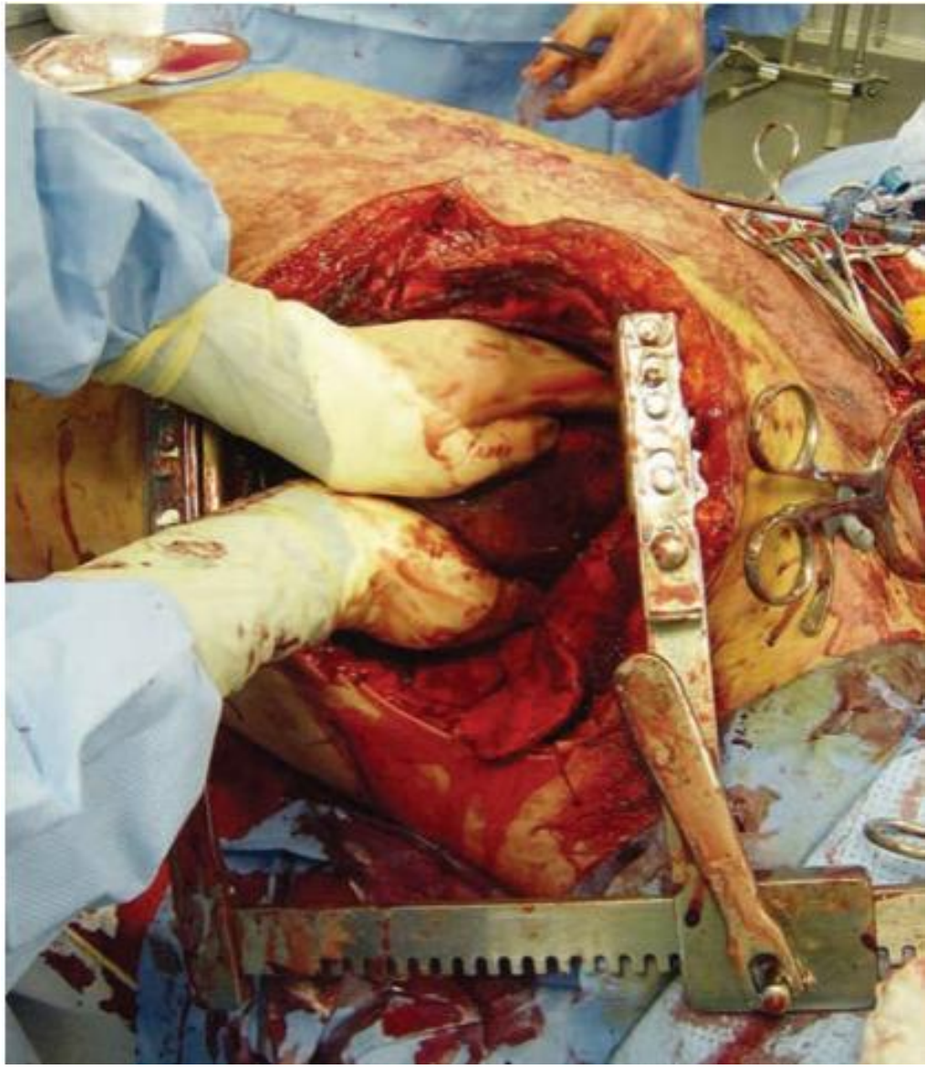
  External : 25% of CO

  Open cardiac : 60 to 70% of CO

- **In a small study of 10 patients**

  Coronary perfusion pr.

  : 400% greater with open cardiac

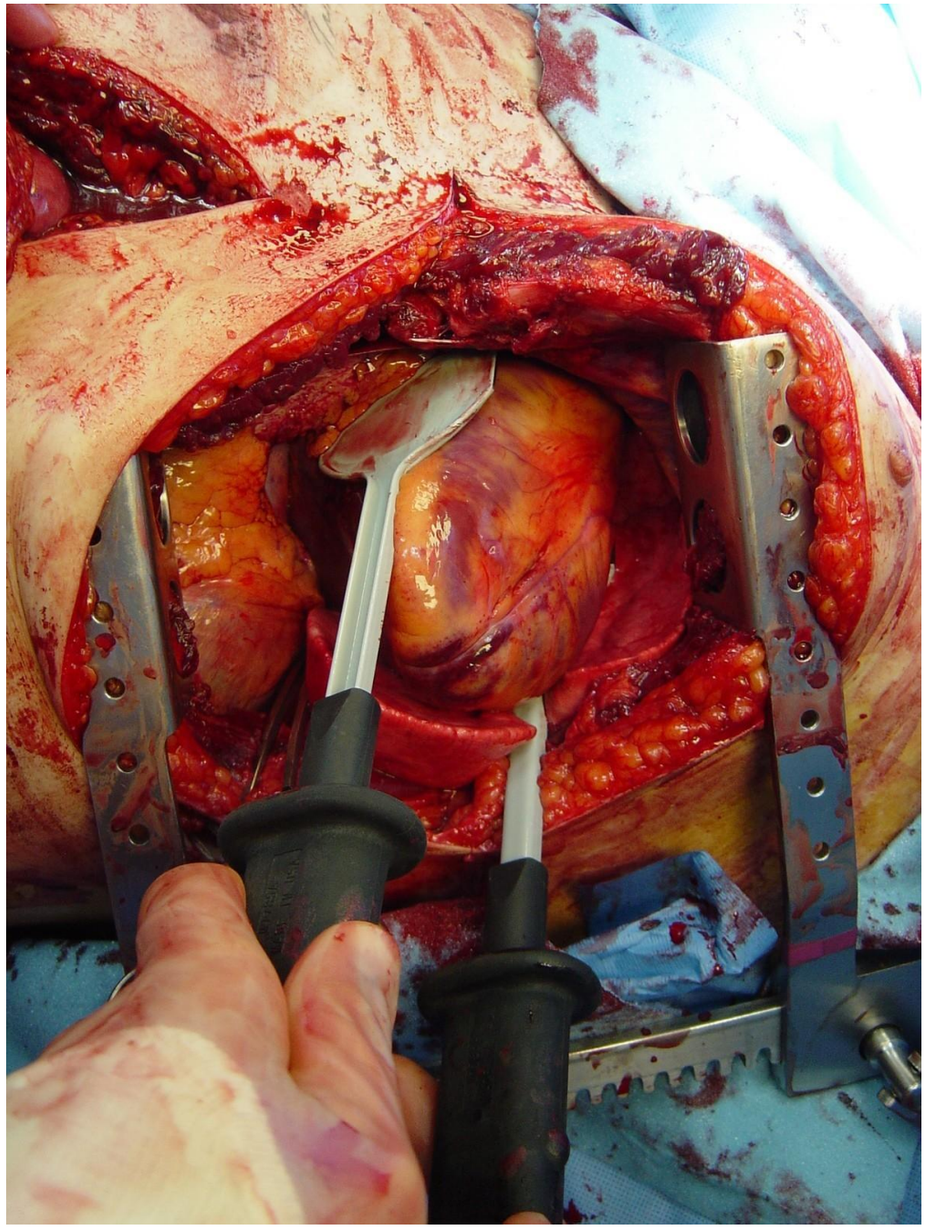


* Hemodynamic effects of closed and open chest cardiac resuscitation in normal dogs and those with acute myocardial infarction.” The American journal of cardiology vol. 10 (1962): 555-61.

Open cardiac massage

- **Two-hand ("clapping") technique**
  - The wrists placed together
  - The thumb adjacent to finger
  - Apex to base

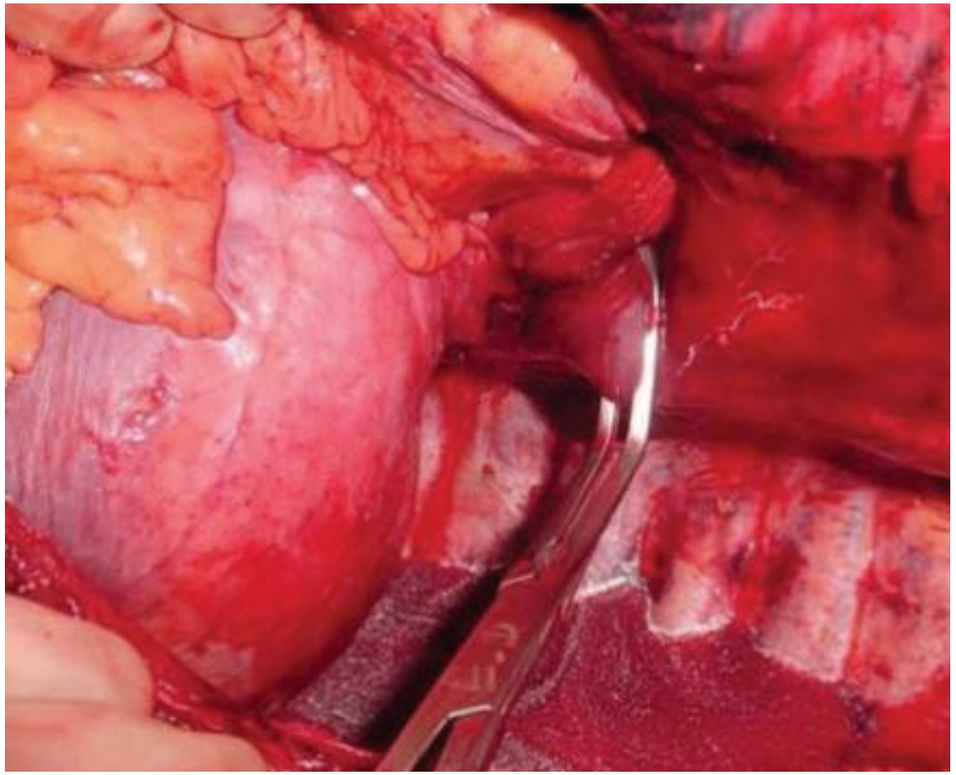
- **Internal defibrillation (10-50 J)**

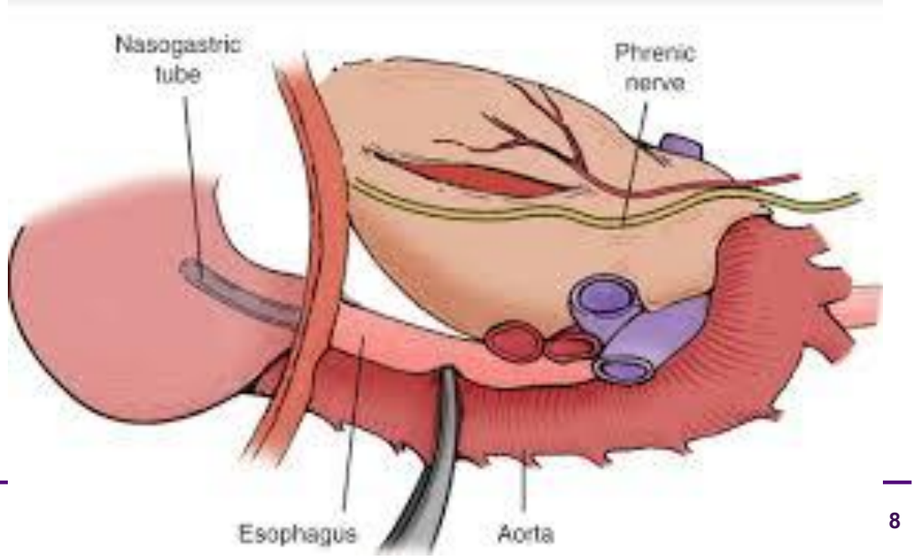


* Cothren, C.C., Moore, E.E. Emergency department thoracotomy for the critically injured patient: Objectives, indications, and outcomes. World J Emerg Surg 1, 4 (2006).

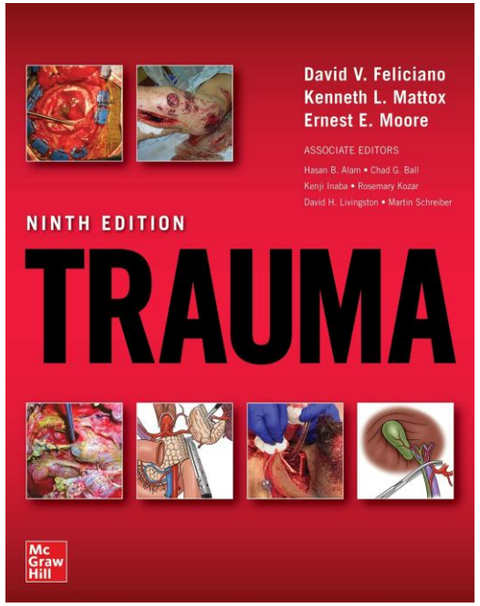
Aortic Cross Clamping

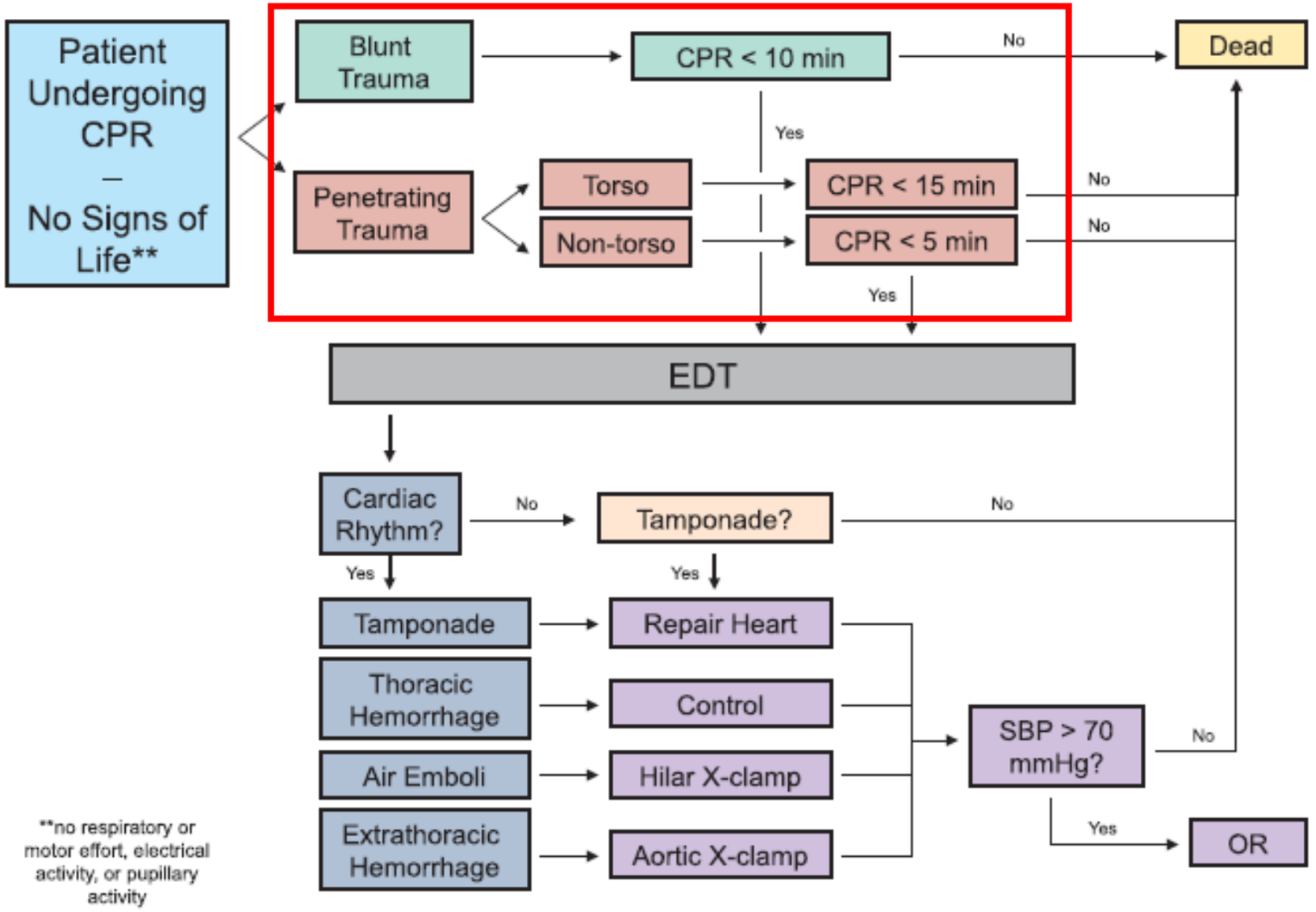
- **Redistribution** (heart & brain)
- Subdiaphragmatic loss **X**
- Just above the **diaphragm**
- No more than **30mins**



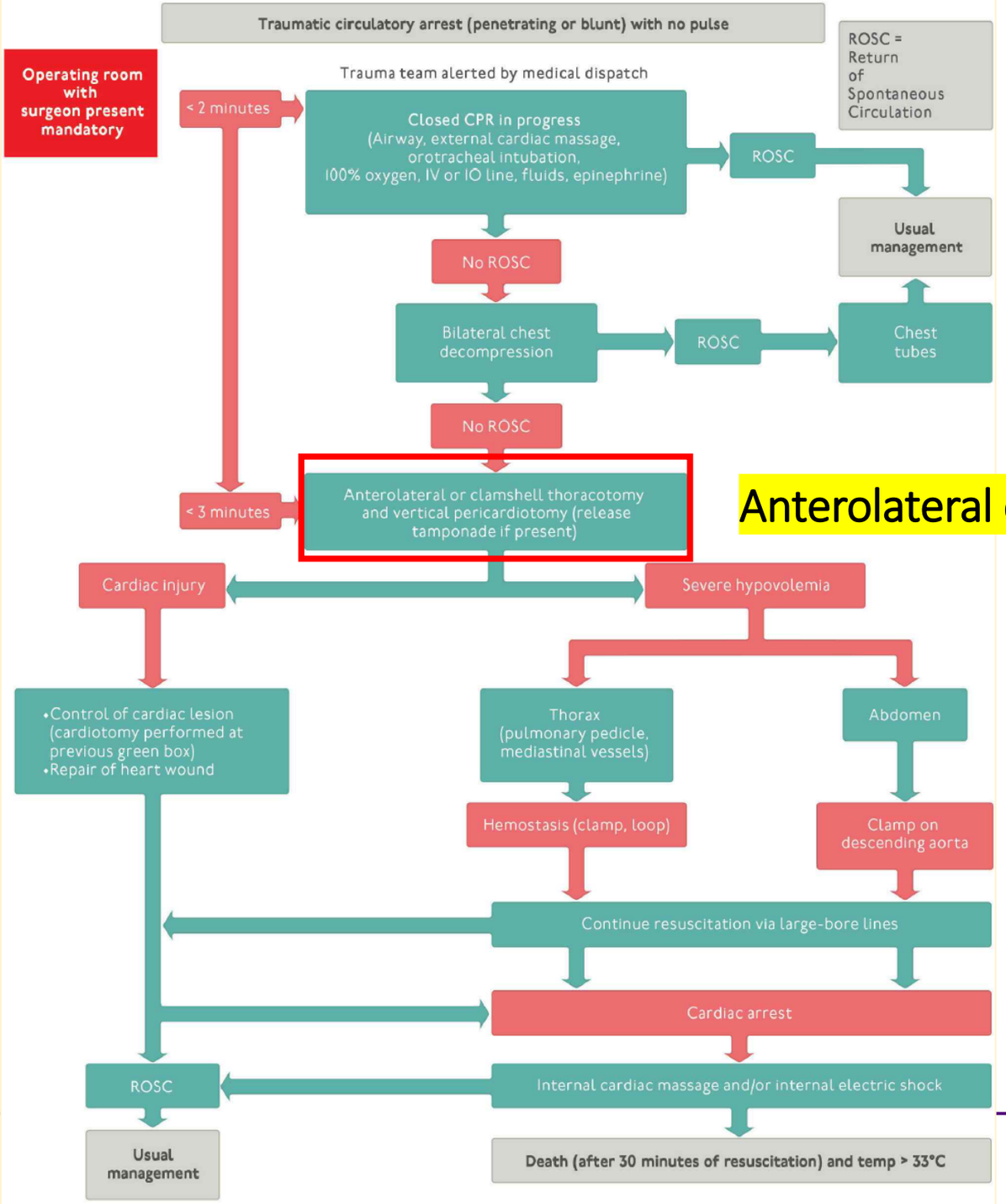


Indication of EDT



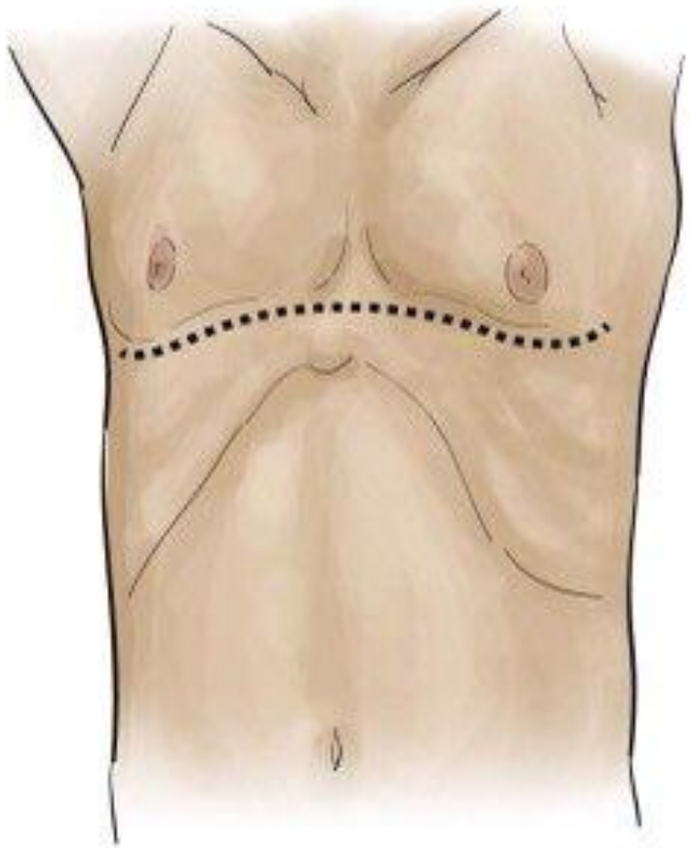


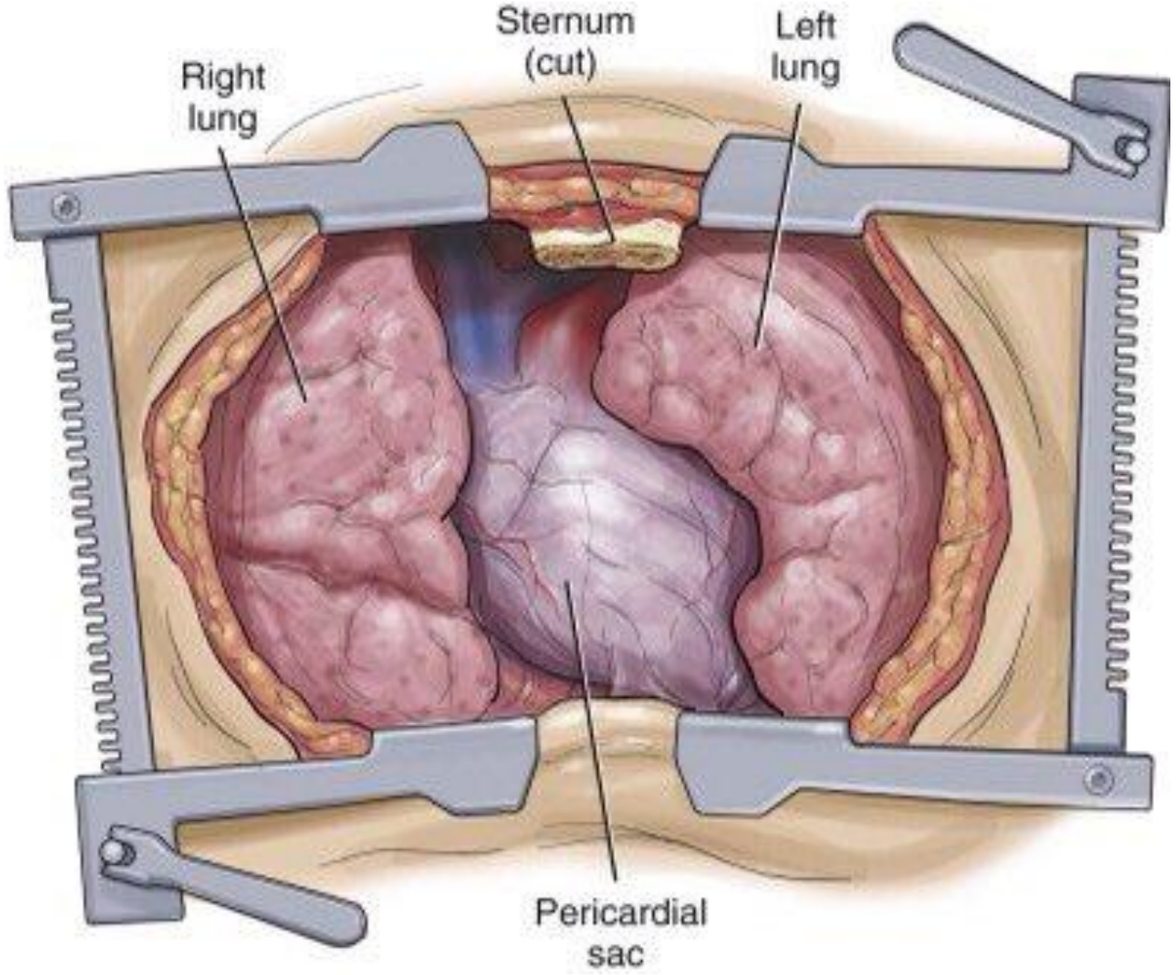
ATLS protocol



Anterolateral or clamshell thoracotomy

Bilateral anterior thoracotomy (Clamshell thoracotomy)





* https://thoracickey.com/cardiac-great-vessel-and-pulmonary-injuries/

› World J Surg. 2013 Jun;37(6):1277-85. doi: 10.1007/s00268-013-1961-5.

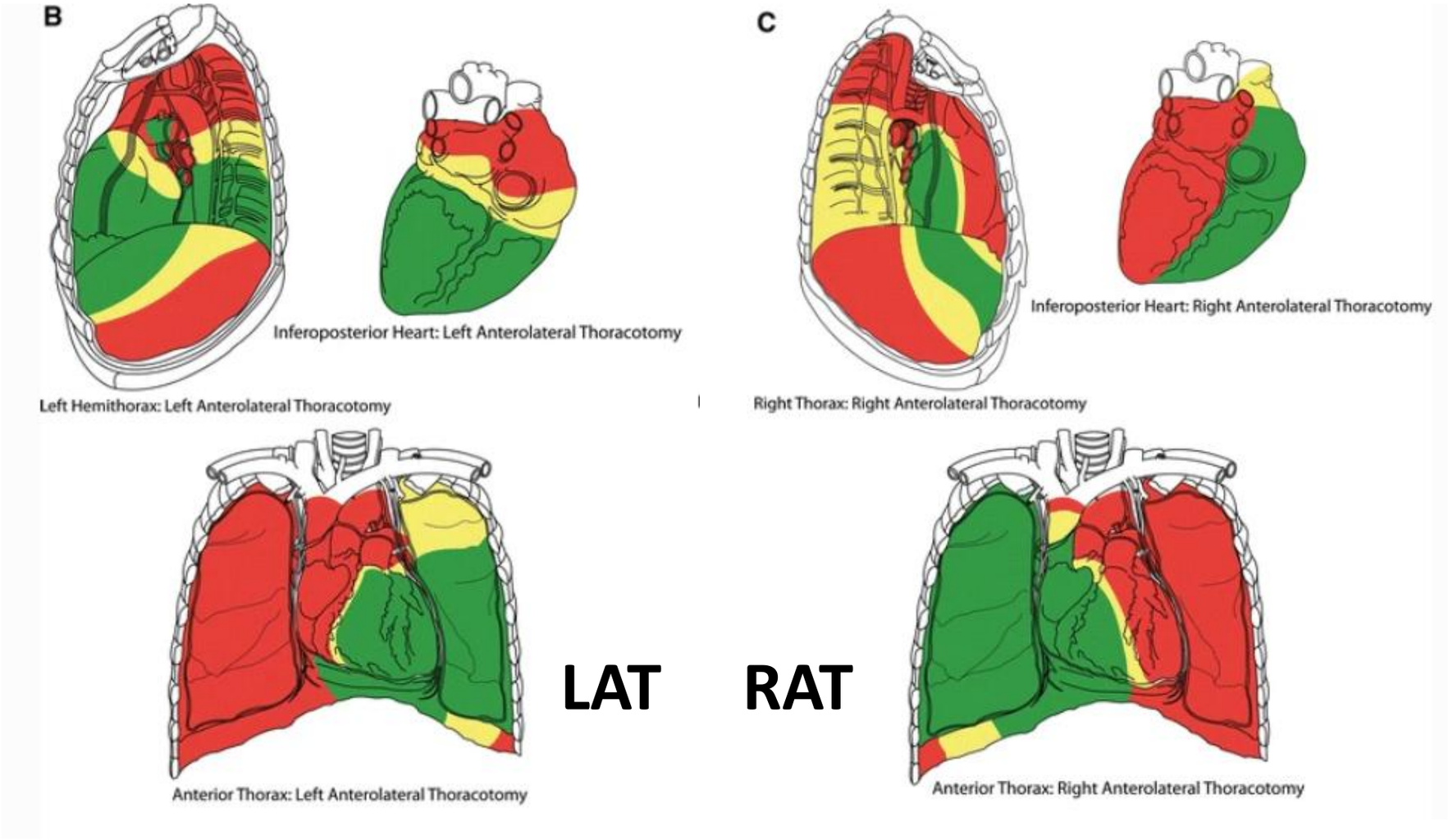
Bilateral anterior thoracotomy (clamshell incision) is the ideal emergency thoracotomy incision: an anatomic study

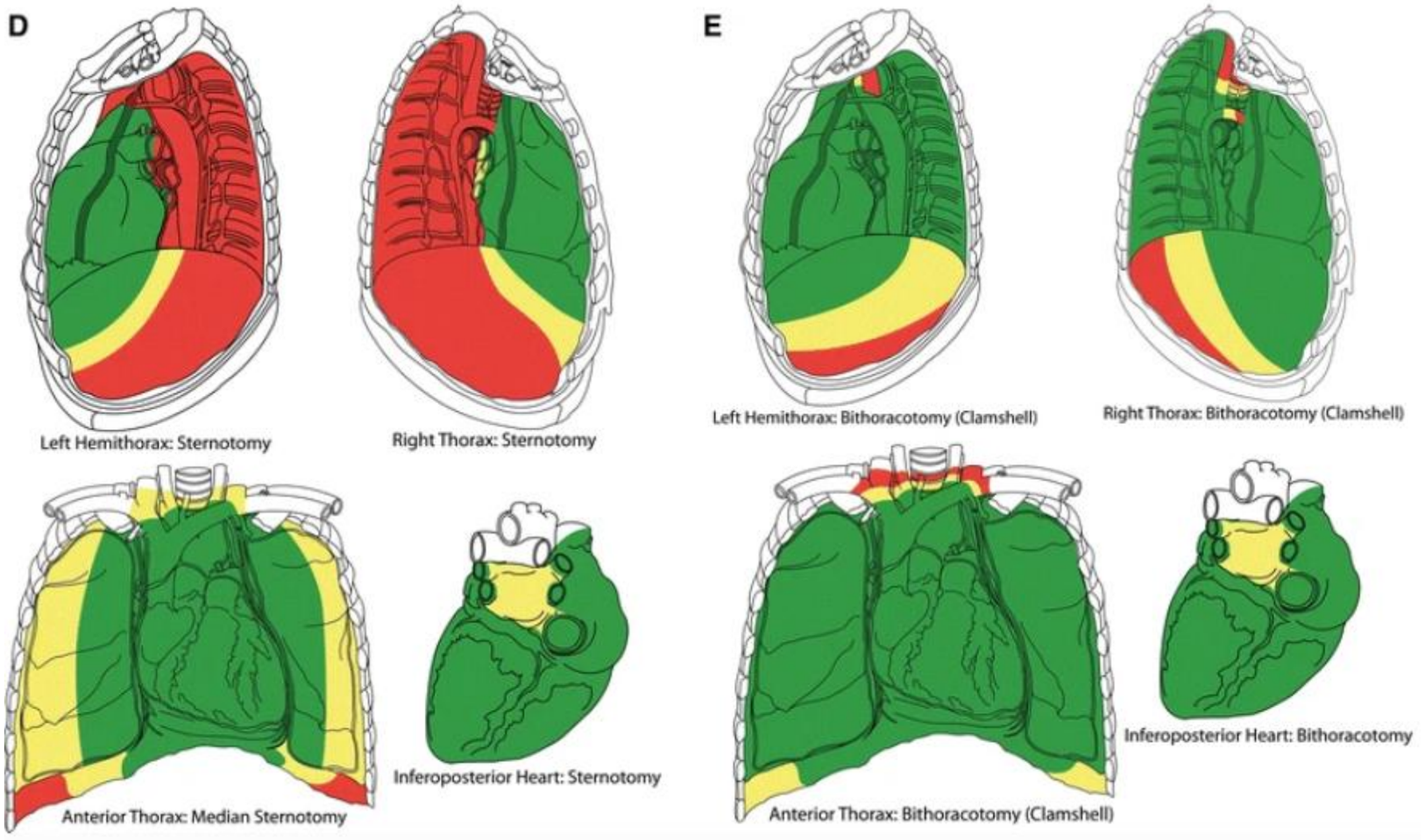
Eric R Simms [1], Alexandros N Flaris, Xavier Franchino, Michael S Thomas, Jean-Louis Caillot, Eric J Voiglio

Randomized Controlled Trial › Ann Emerg Med. 2021 Mar;77(3):317-326.
doi: 10.1016/j.annemergmed.2020.05.042. Epub 2020 Aug 15.

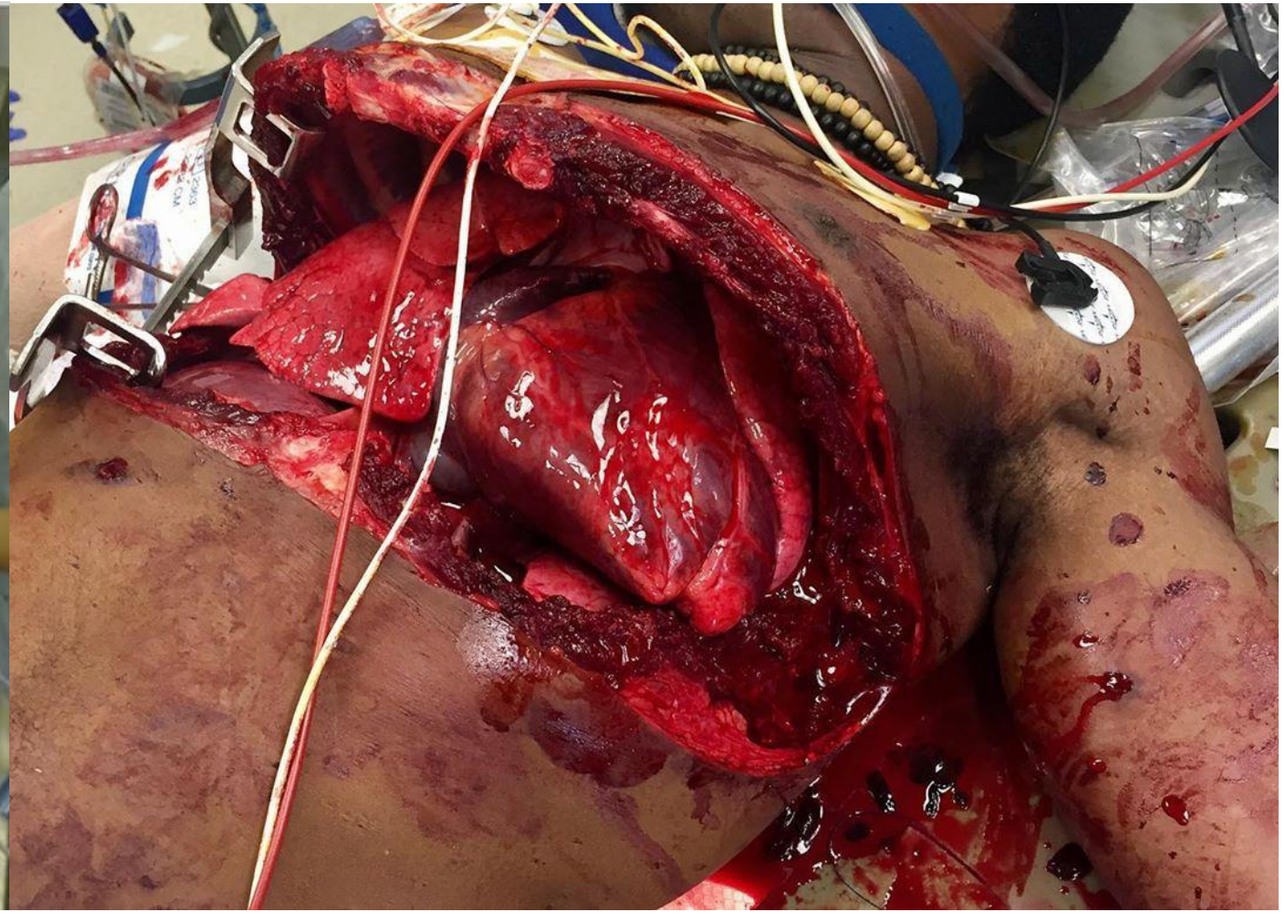
Prospective Randomized Trial of Standard Left Anterolateral Thoracotomy Versus Modified Bilateral Clamshell Thoracotomy Performed by Emergency Physicians

Ryan Newberry [1], Derek Brown [2], Thomas Mitchell [3], Joseph K Maddry [4], Allyson A Arana [4], Jennifer Achay [5], Stephen Rahm [5], Brit Long [6], Tyson Becker [7], Gareth Grier [8], Gareth Davies [8]


B
Inferoposterior Heart: Left Anterolateral Thoracotomy
Left Hemithorax: Left Anterolateral Thoracotomy
C
Inferoposterior Heart: Right Anterolateral Thoracotomy
Right Thorax: Right Anterolateral Thoracotomy
Anterior Thorax: Left Anterolateral Thoracotomy
LAT
RAT
Anterior Thorax: Right Anterolateral Thoracotomy



Sternotomy **Clamshell**



* Life-saving emergency clamshell thoracotomy with damage-control laparotomy BMJ Case Reports CP 2019;12:e227879.

Damage Control

Thoracic

Chest wall

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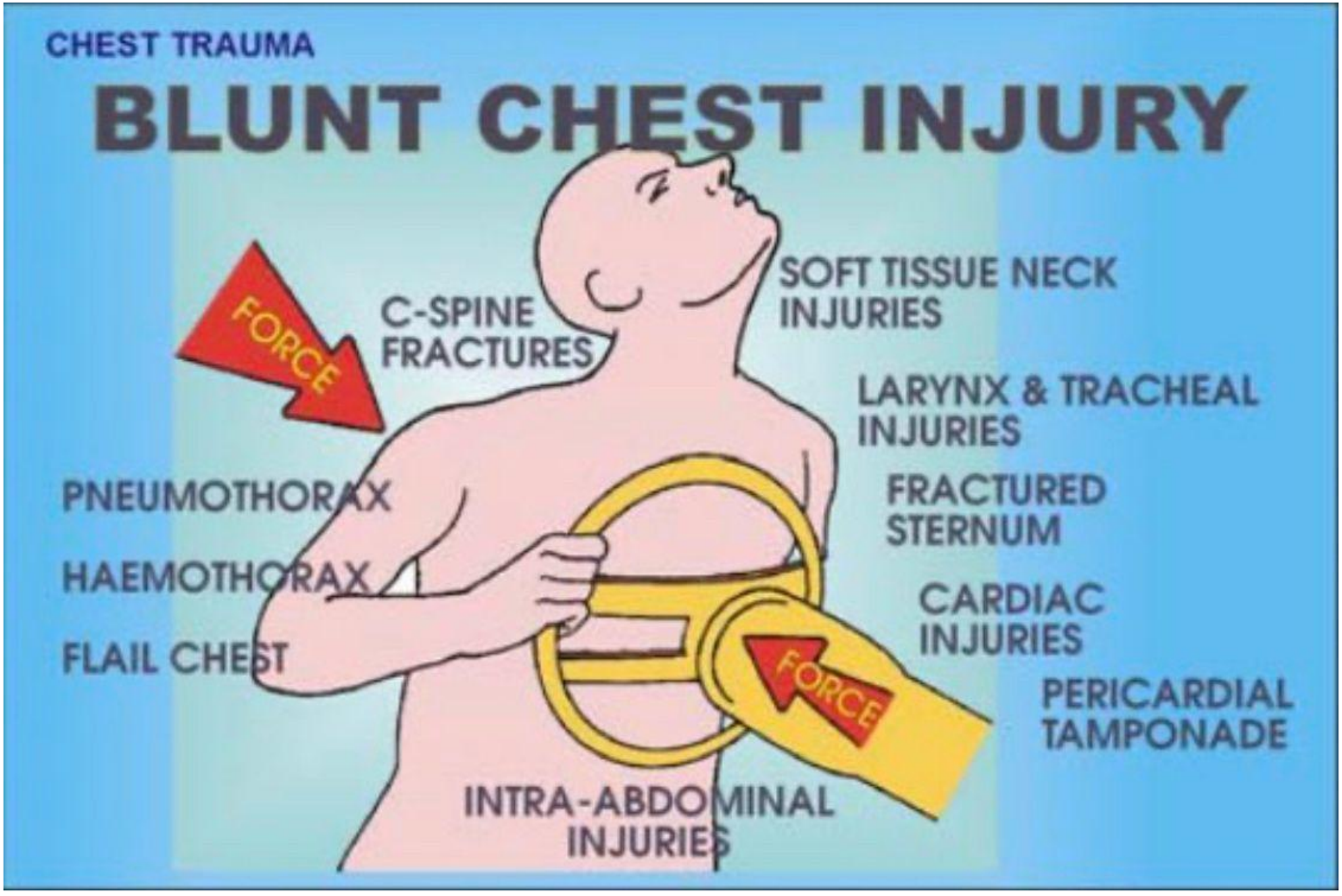

CHEST TRAUMA
BLUNT CHEST INJURY
FORCE
C-SPINE FRACTURES
SOFT TISSUE NECK INJURIES
LARYNX & TRACHEAL INJURIES
FRACTURED STERNUM
CARDIAC INJURIES
PERICARDIAL TAMPONADE
PNEUMOTHORAX
HAEMOTHORAX
FLAIL CHEST
FORCE
INTRA-ABDOMINAL INJURIES

BLUNT CHEST INJURY

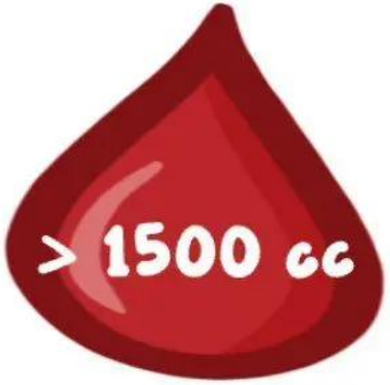
PRIMARY SURVEY

STABLE

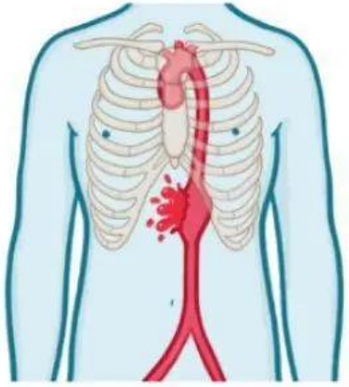
UNSTABLE

TENSION PNEUMOTHORAX

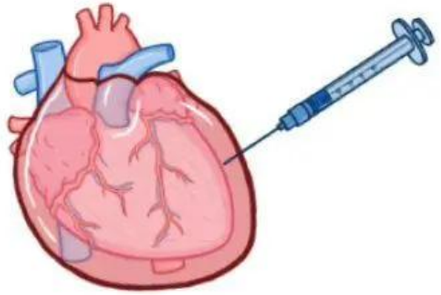
MASSIVE HEMOTHORAX



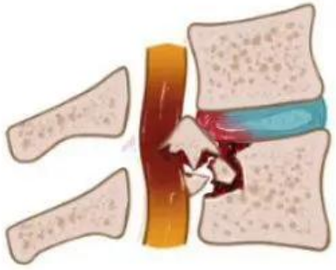
AORTIC RUPTURE



CARDIAC TAMPONADE

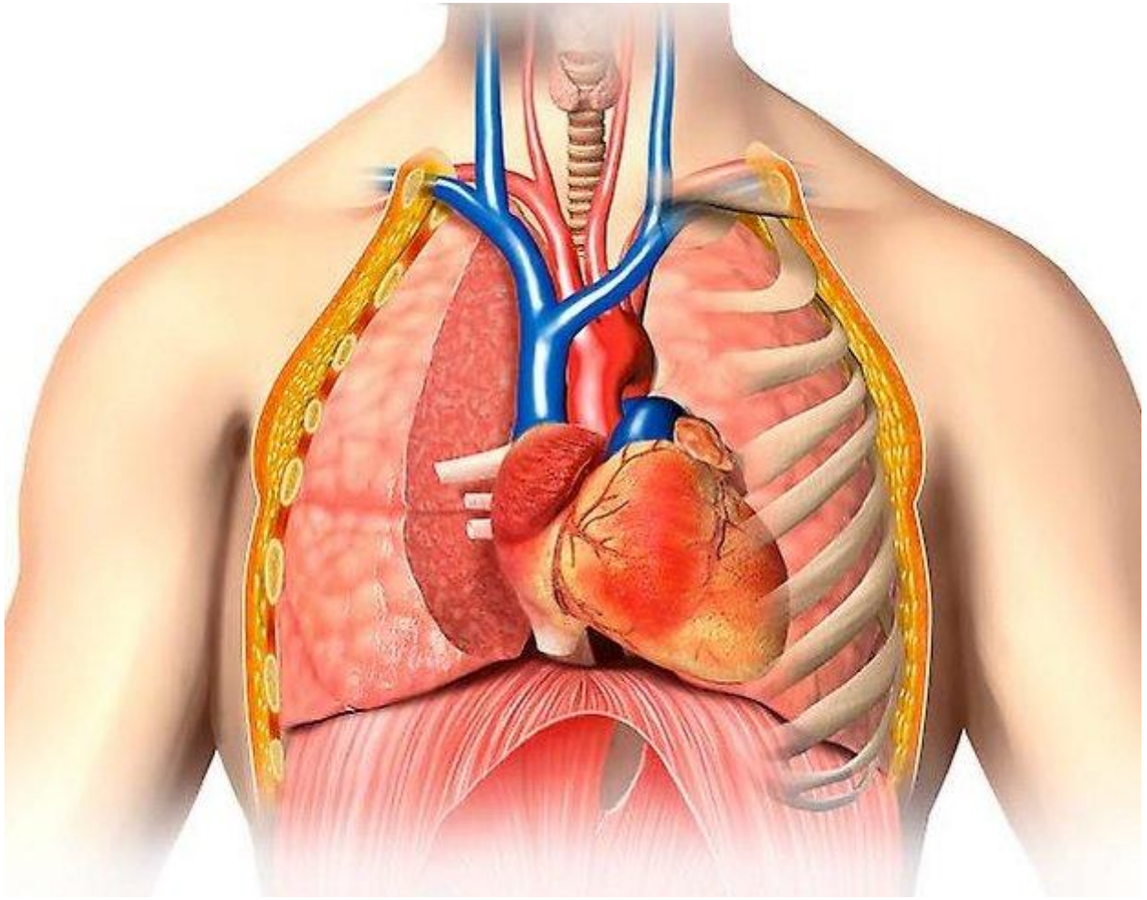


THORACIC VERTEBRAL FRACTURE

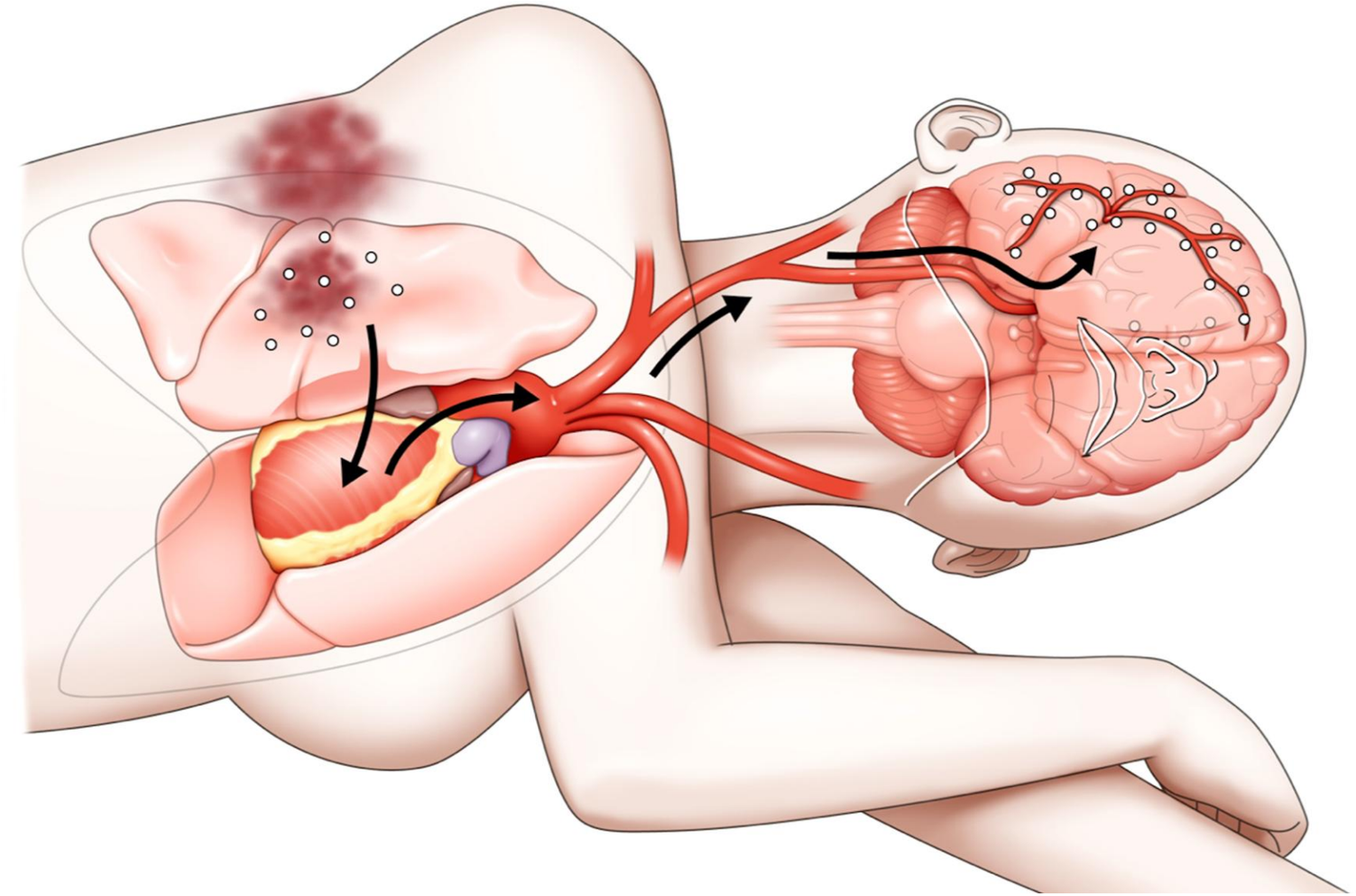


* https://www.osmosis.org/learn/Approach_to_blunt_chest_injury:_Clinical_sciences

Penetrating Thoracic Injury

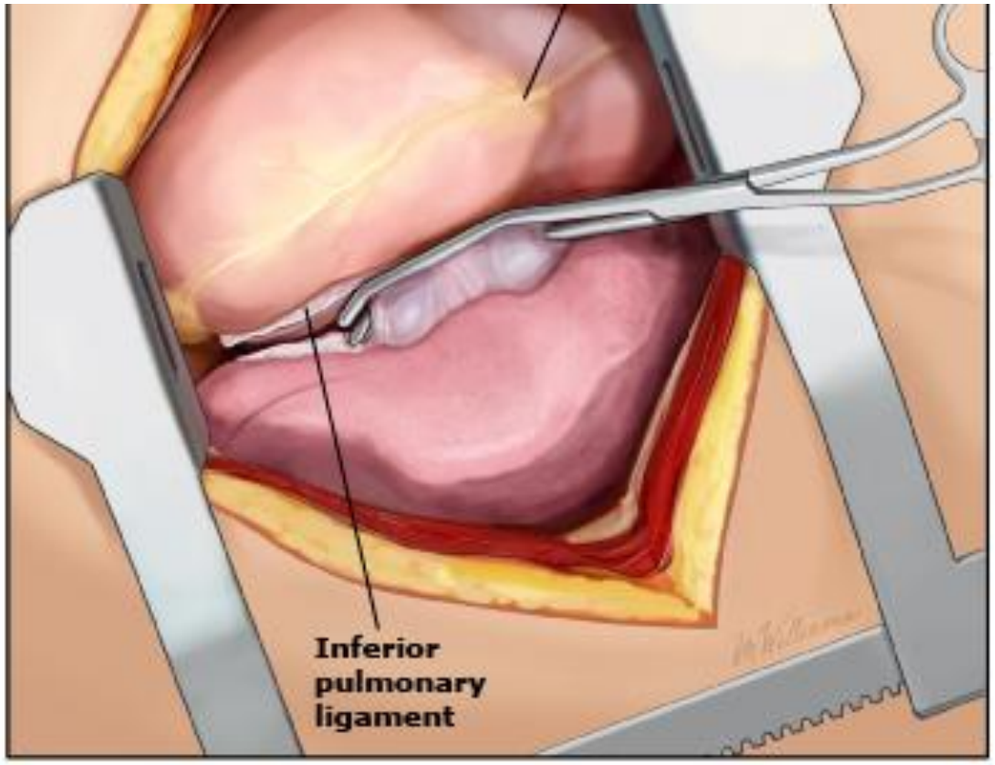


Air Embolism after Thoracic Trauma

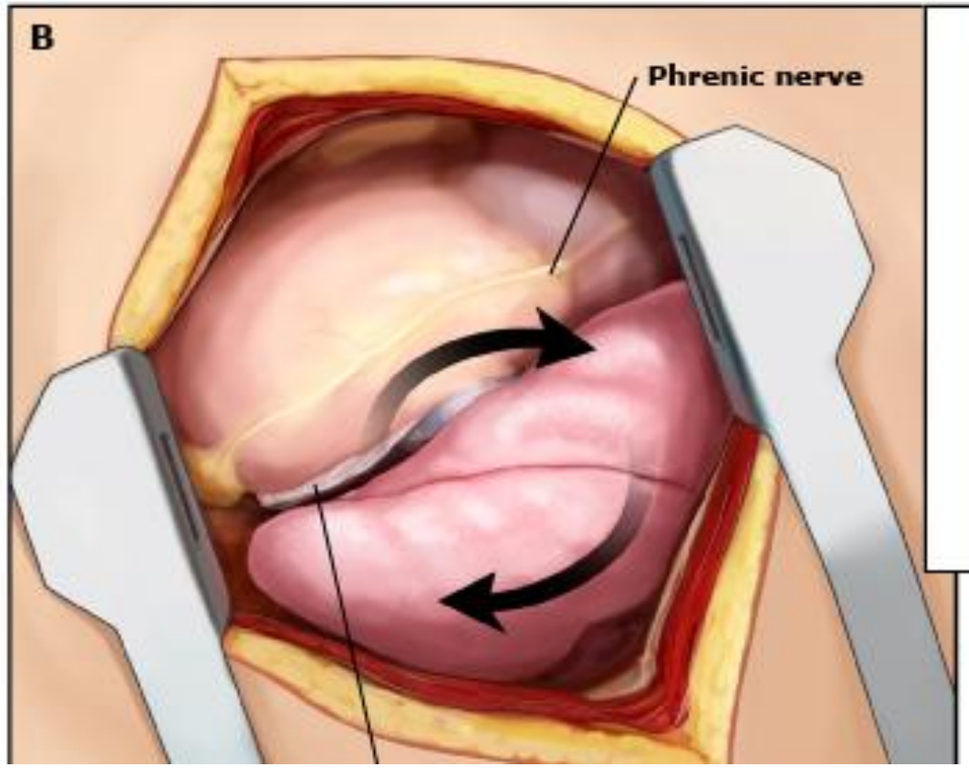


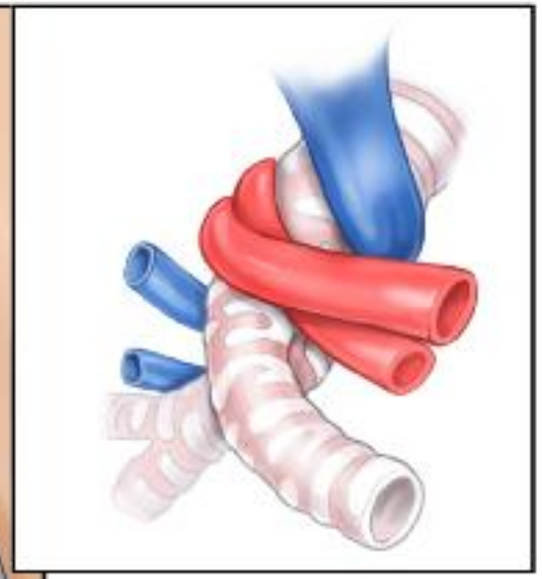
* Persistent Air Embolism after Blunt Chest Trauma with Recovery to Pre-Existing Consciousness Level: A Case Report and Literature Review, Neurotrauma Reports 2022 3:1, 38a-43

Pulmonary Hilar Control

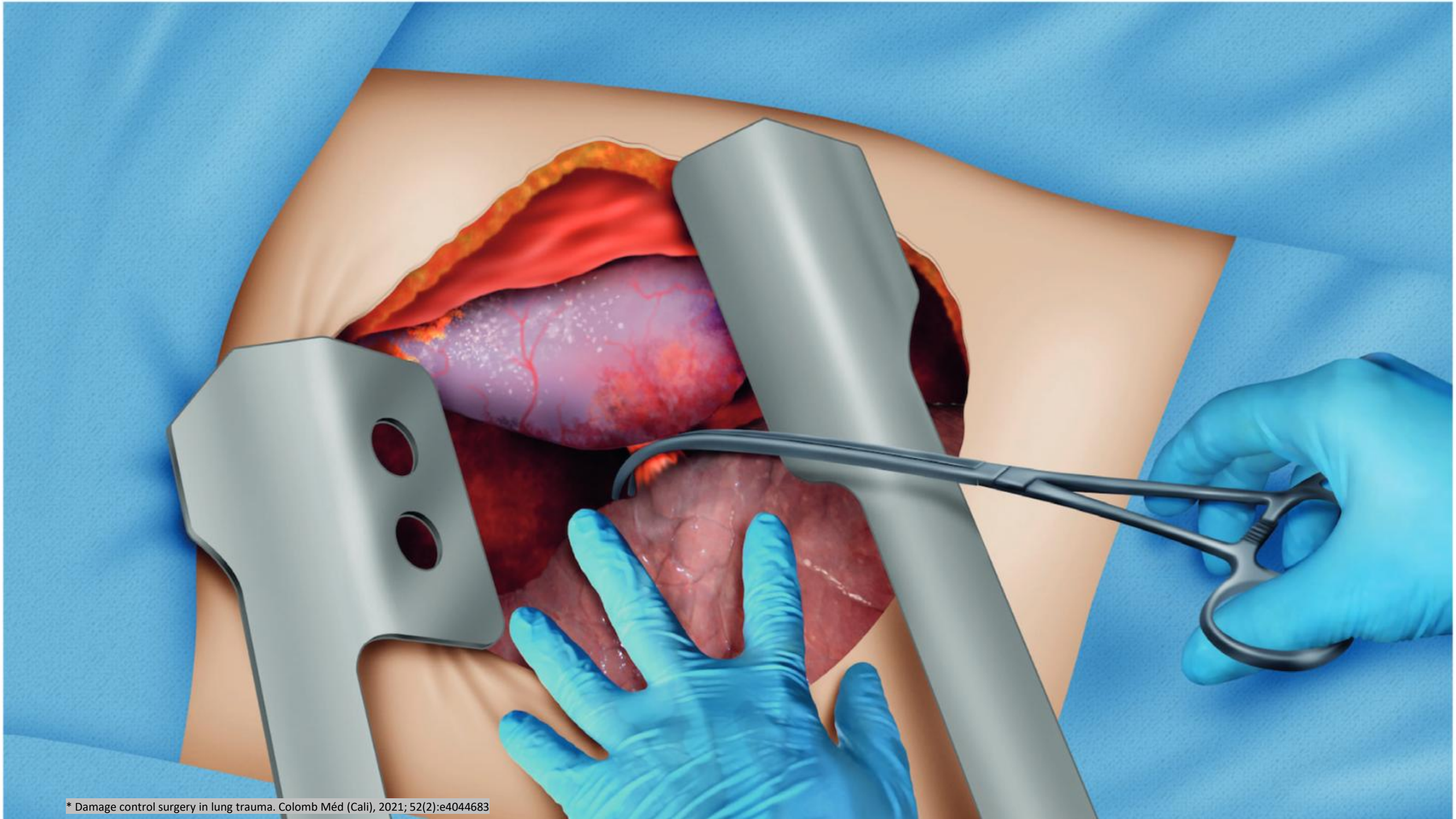


Clamp

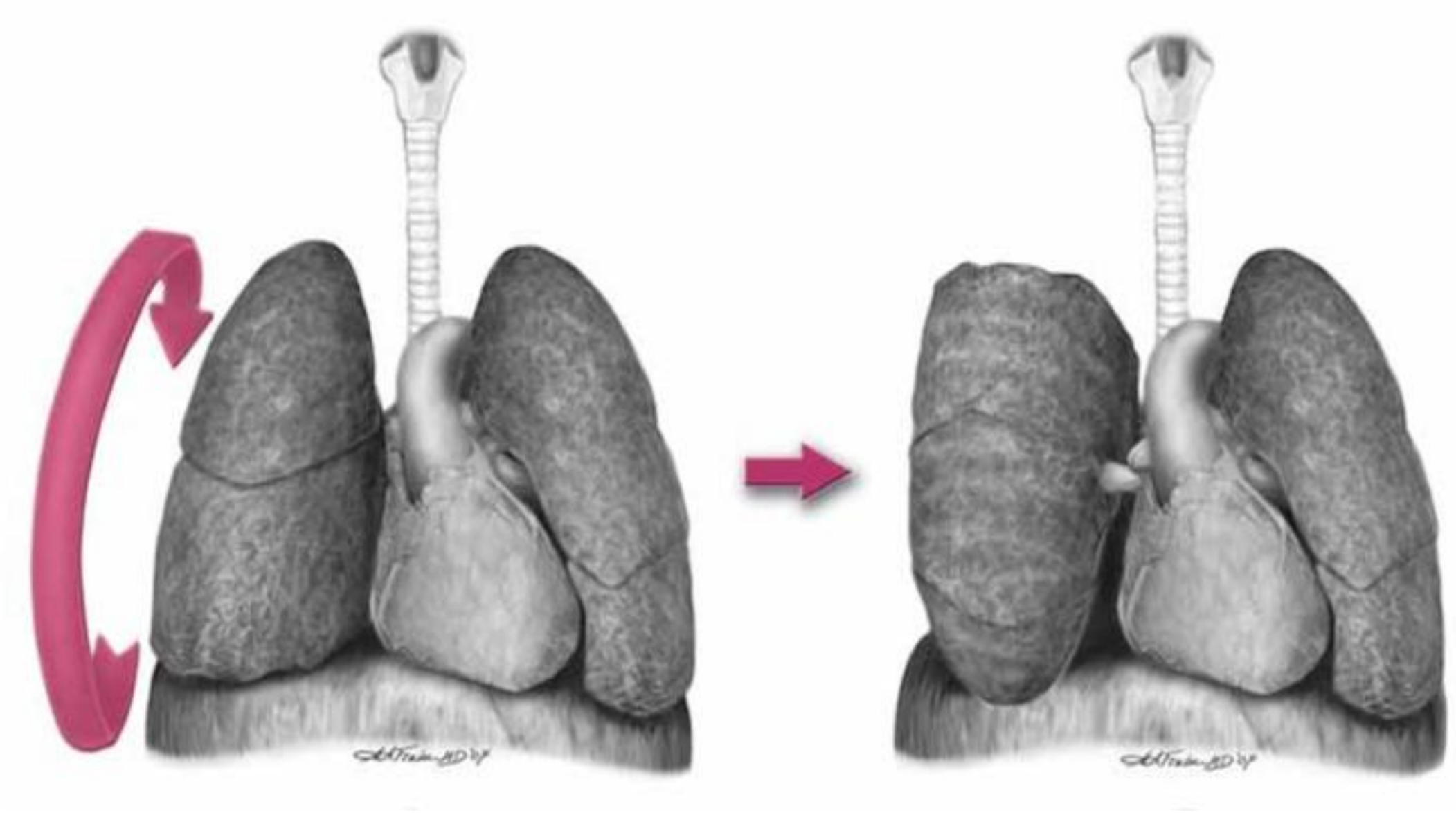




Twist

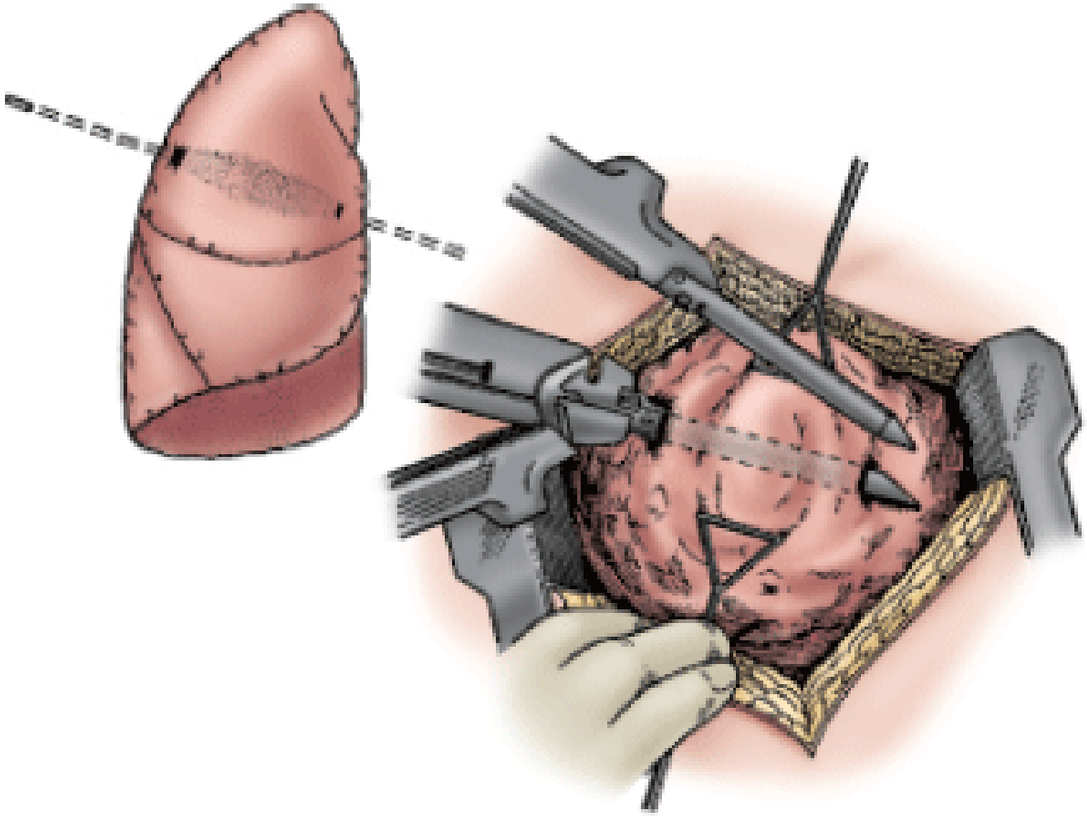


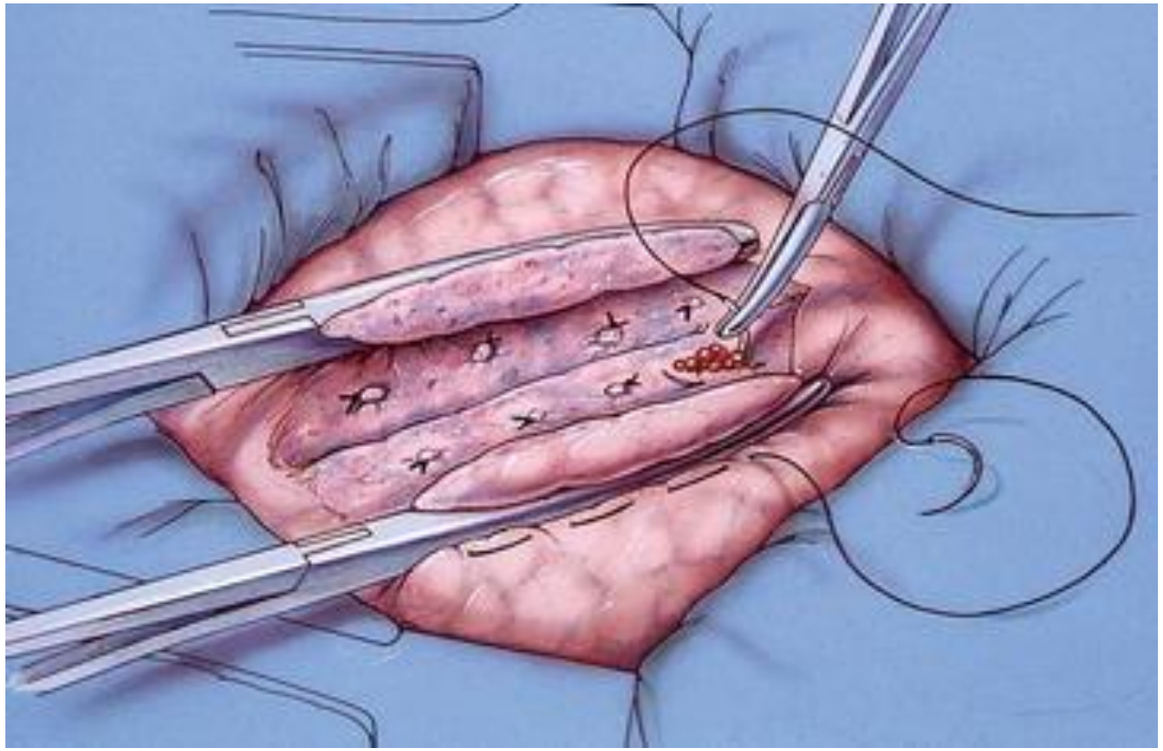
* Damage control surgery in lung trauma. Colomb Méd (Cali), 2021; 52(2):e4044683

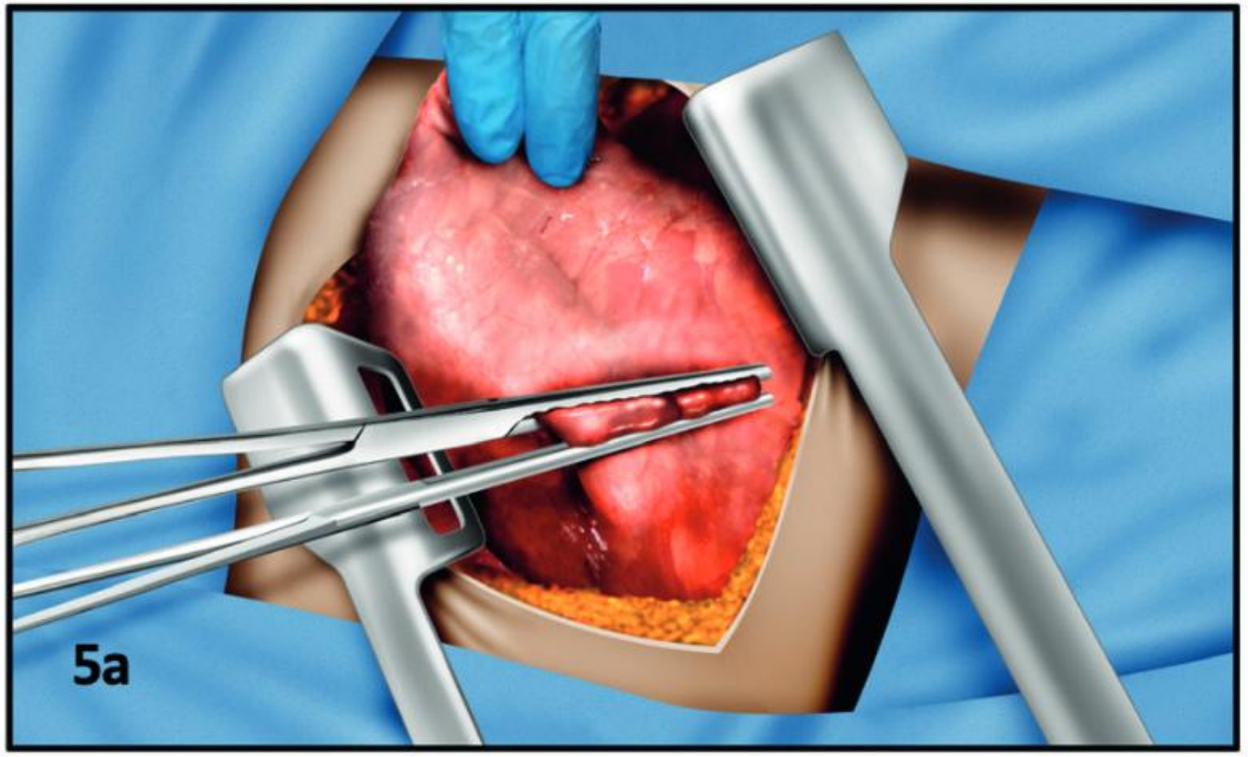


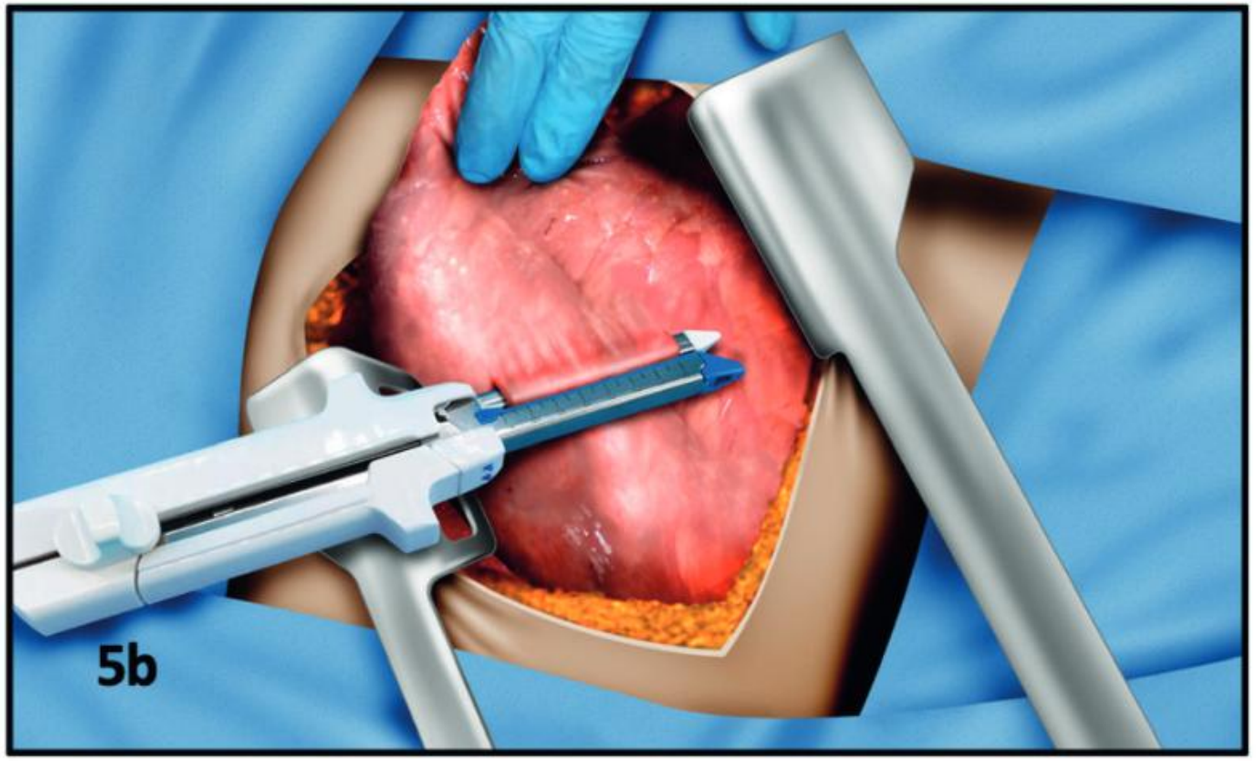
* https://resus.me/tag/thoracotomy/

Pulmonary tractotomy






5a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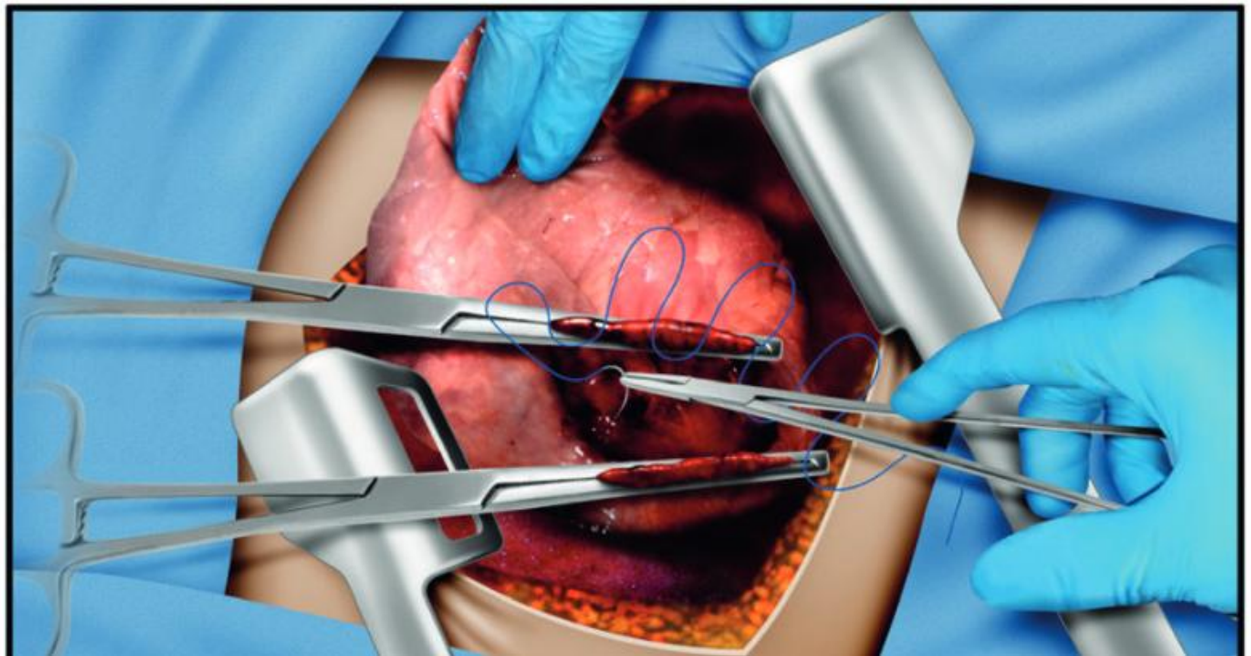
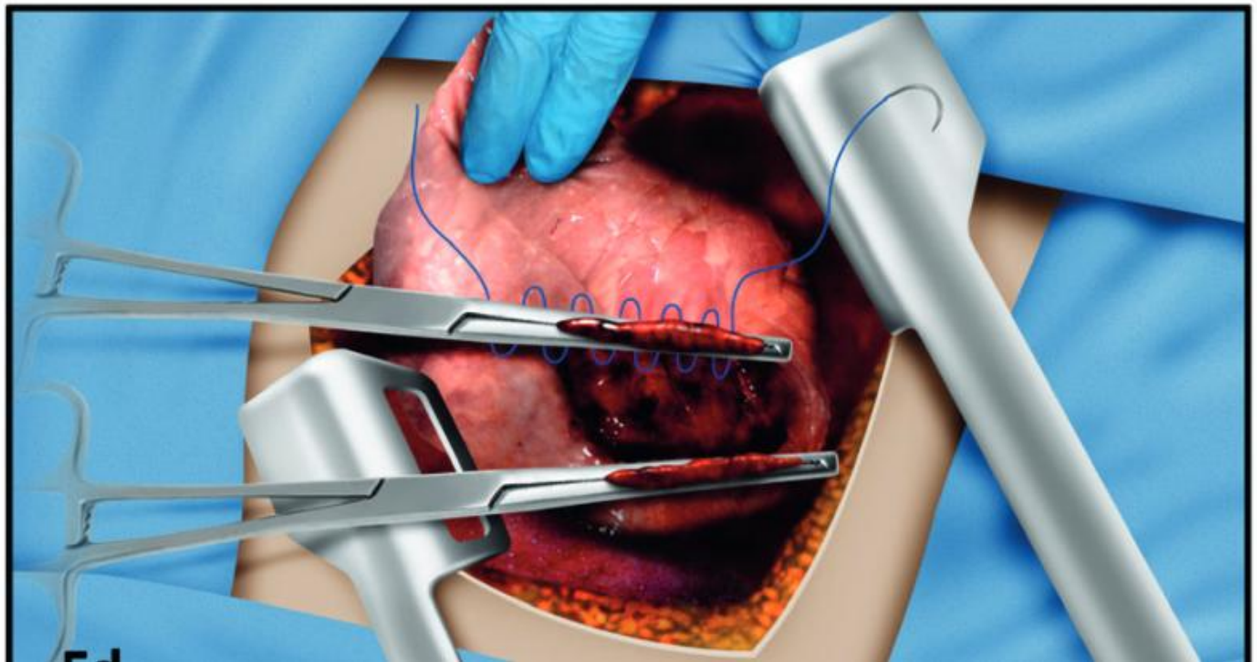
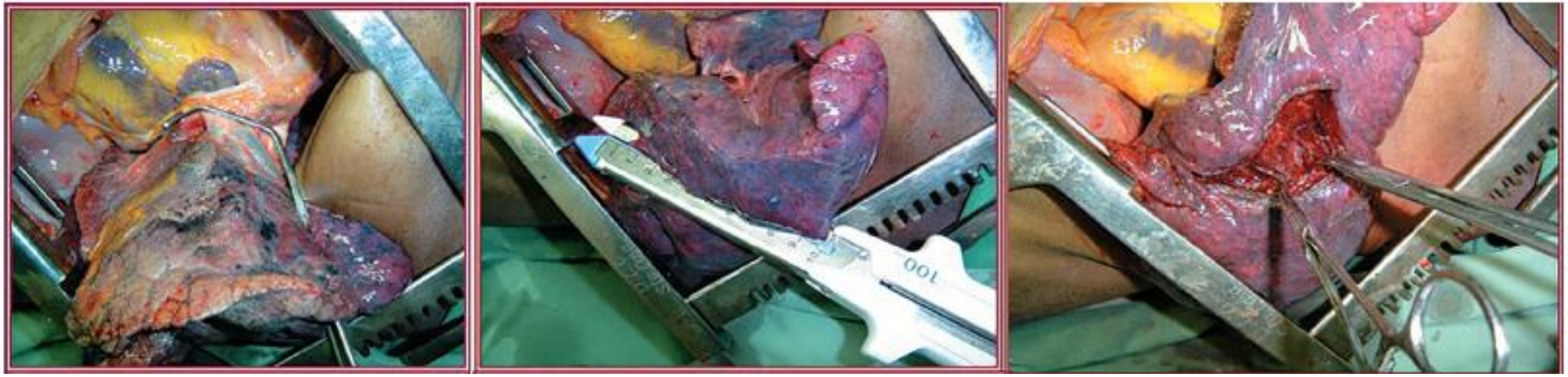
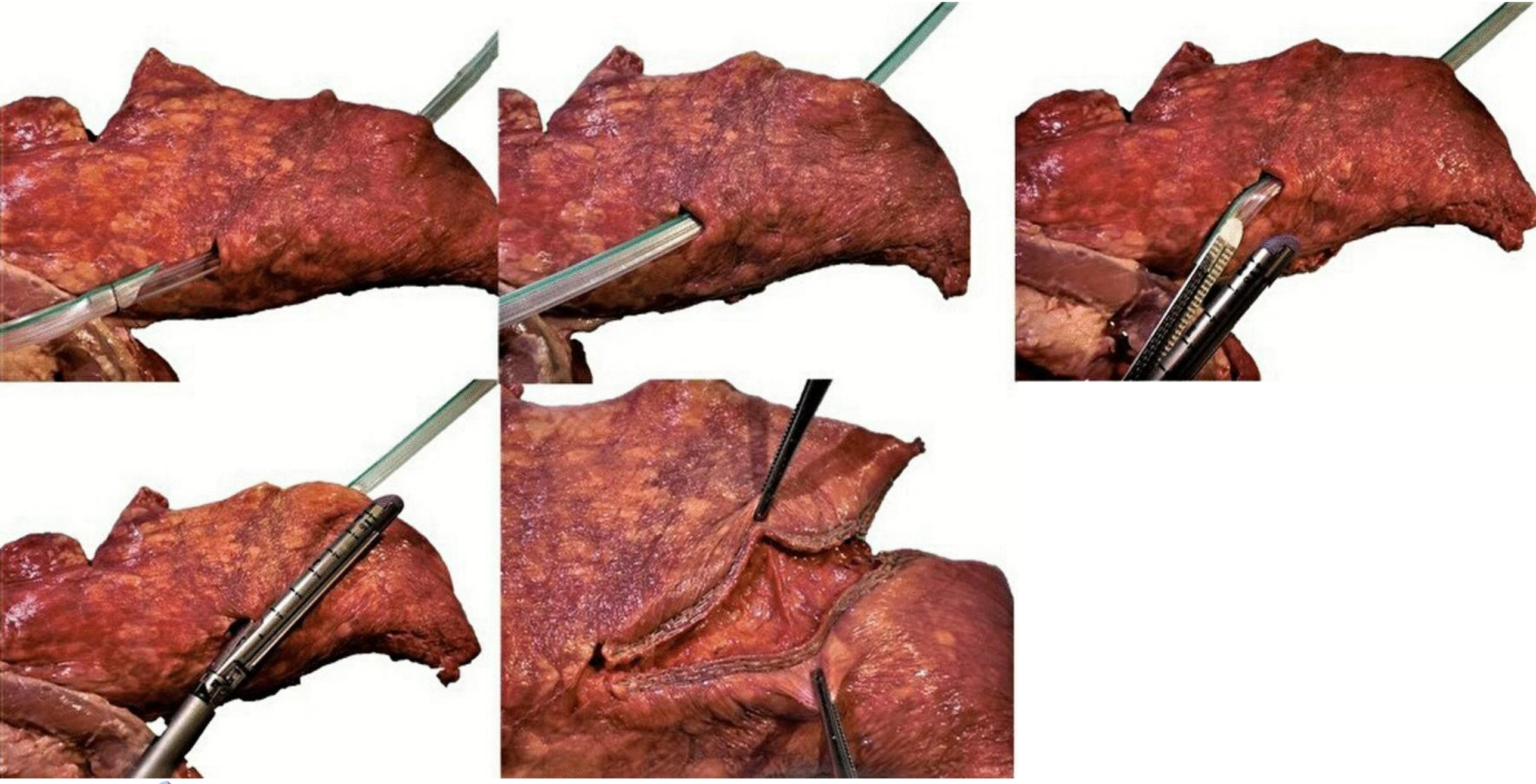






* Rev. Col. Bras. Cir. 43 (05) • Sep-Oct 2016 /



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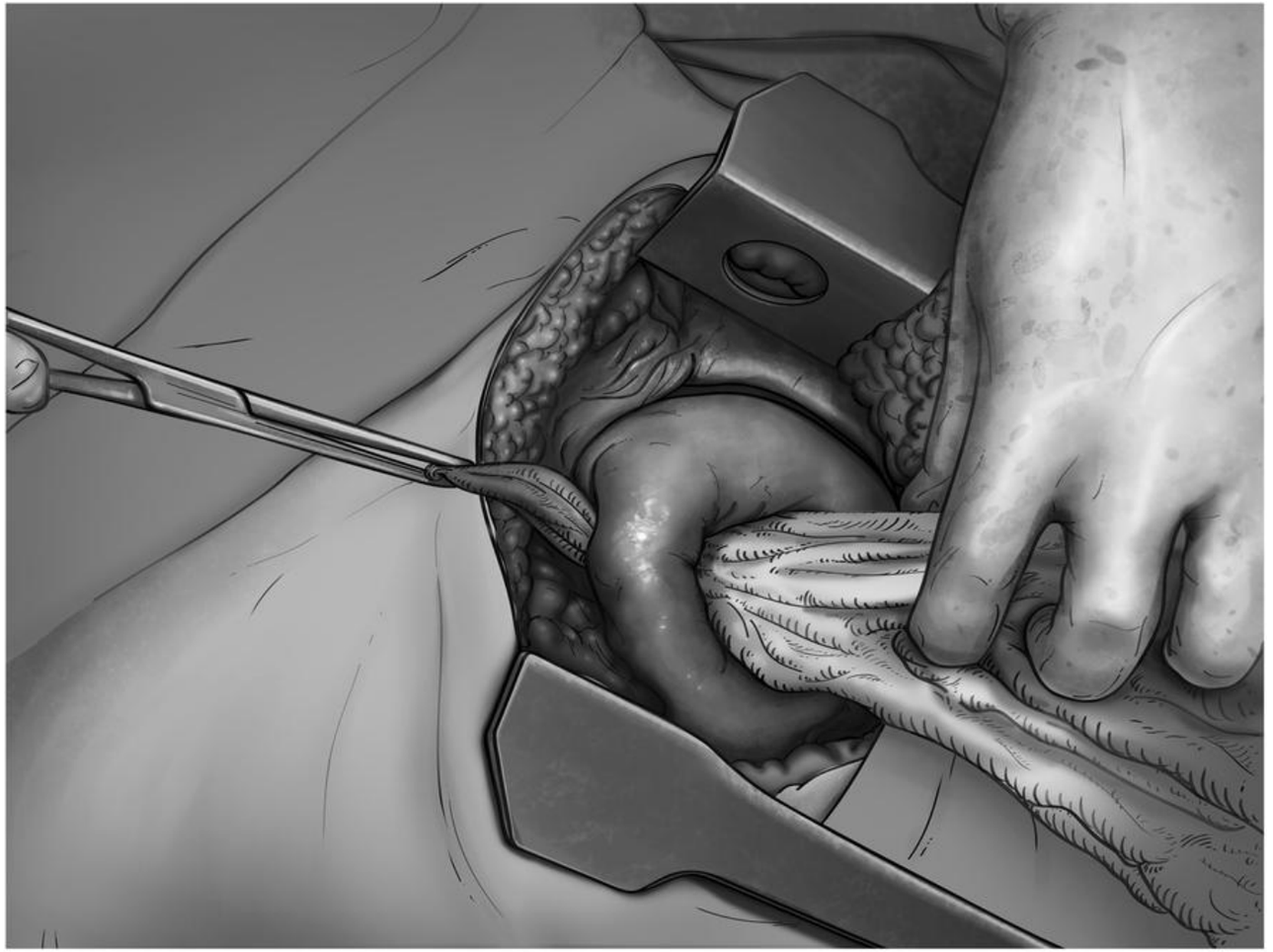
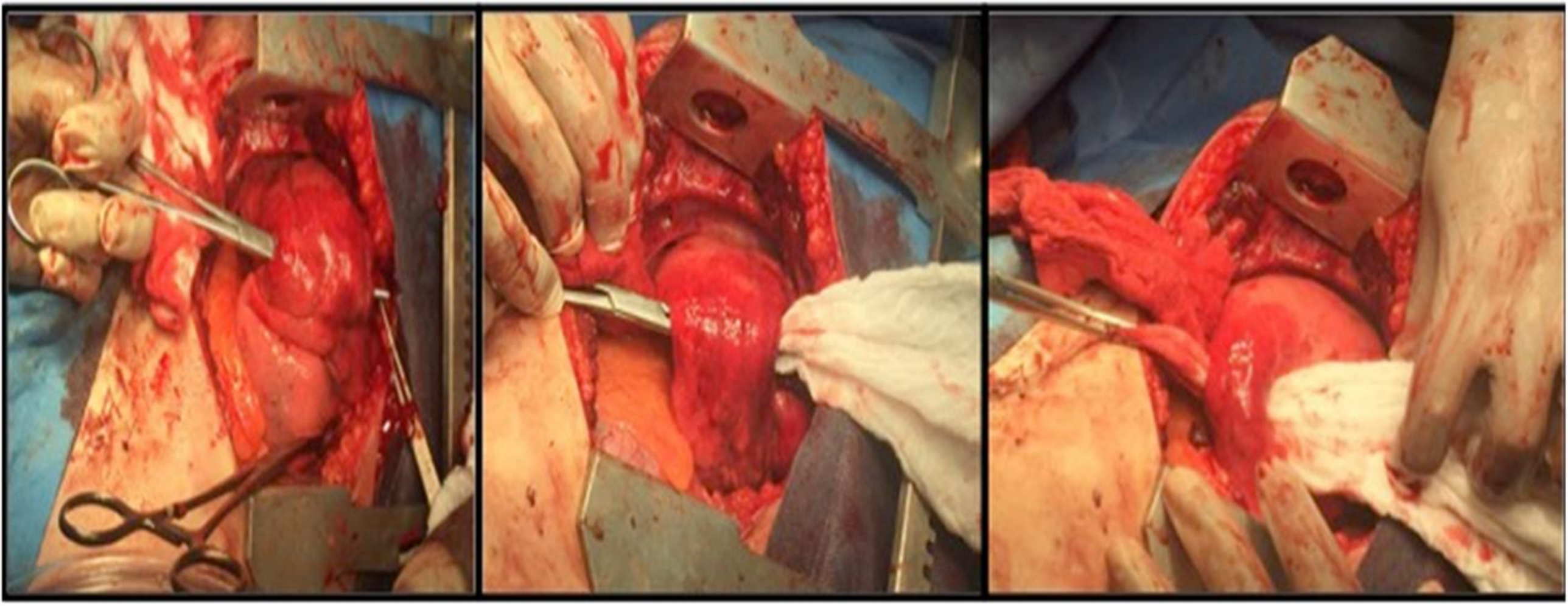
* Tractotomy using the Penrose drain guide for deep lung injury caused by chest drainage: a case report. surg case rep 7, 134 (2021).



* A clinical series of packing the wound tract for arresting traumatic hemorrhage from injuries of the lung parenchyma as a feasible damage control technique. *World J Emerg Surg* **14**, 52 (2019).



* A clinical series of packing the wound tract for arresting traumatic hemorrhage from injuries of the lung parenchyma as a feasible damage control technique. *World J Emerg Surg* **14**, 52 (2019).

Damage Control Thoracic

Chest wall

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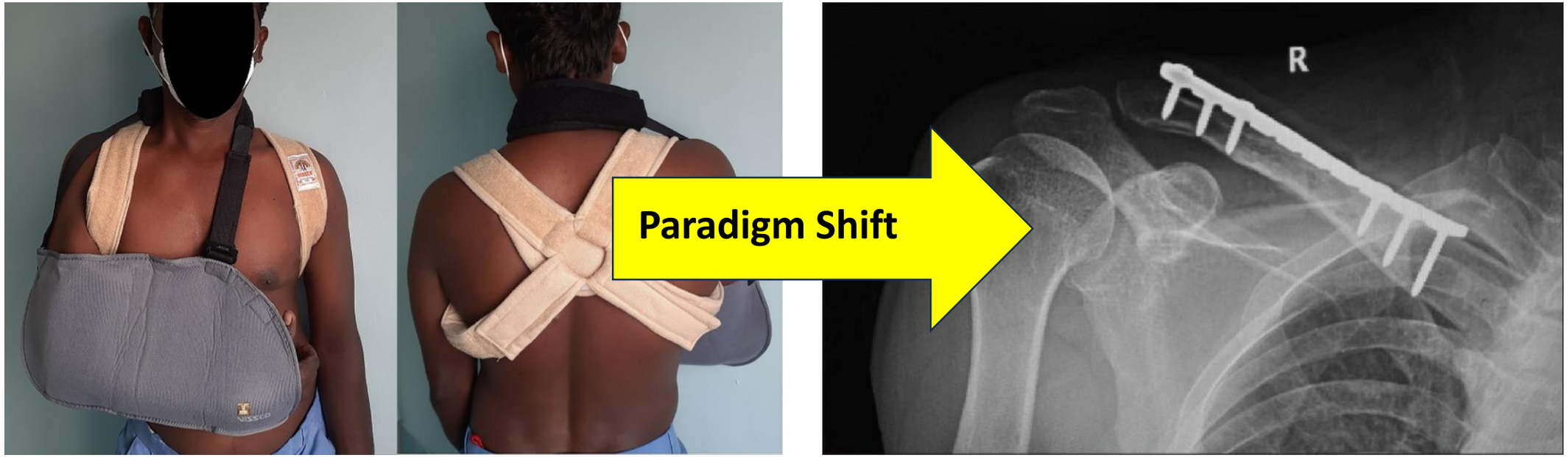
Clavicle Fracture



* Subramanyam, Koushik Narayan et al. “Displaced midshaft clavicle fractures in adults - is non-operative management enough?.” Injury vol. 52,3 (2021): 493-500.

* Schneider, Prism et al. “Operative treatment of displaced midshaft clavicle fractures: has randomised control trial evidence changed practice patterns?.” BMJ open vol. 9,9 e031118. 4 Sep. 2019

* Sepehri, Aresh et al. “Assessing the Change in Operative Treatment Rates for Acute Midshaft Clavicle Fractures: Incorporation of Evidence-Based Surgery Results in Orthopaedic Practice.” JB & JS open access vol. 8,2 e22.00096. 26 Apr. 2023

Clavicle Fracture

Randomized Controlled Trial > J Bone Joint Surg Am. 2007 Jan;89(1):1-10.

doi: 10.2106/JBJS.F.00020.

Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomized clinical trial

Canadian Orthopaedic Trauma Society

Rate of surgery for midshaft clavicular fracture

- ~ 2007 : **2.2-3.7%**
- 2007 ~ : **6.9-34.1**% (more than 3x)

Review > Injury. 2020 Nov;51(11):2368-2378. doi: 10.1016/j.injury.2020.07.009. Epub 2020 Jul 3.

Operative versus nonoperative treatment of multiple simple rib fractures: A systematic review and meta-analysis

Mathieu M E Wijffels [1], Jonne T H Prins [2], Eva J Perpetua Alvino [3], Esther M M Van Lieshout [4]

Pneumonia ⬇
Mortality ⬇
Hospital length of stay ⬇

Review > Ann R Co
Epub 2021 Dec 20.

Surgical man
trauma: a sy
randomised controlled trials

ICU length of stay ⬇

S Craxford [1], D Owyang [1], B Marson [2], K Rowlins [1], T Coughlin [1], D Forward [1], B Ollivere [2]

> J Trauma Acute Care Surg. 2023 Apr 1;94(4):538-545. doi: 10.1097/TA.0000000000003828.
Epub 2022 Nov 15.

Outcomes of surgical versus nonsurgical treatment for multiple rib fractures: A US hospital matched cohort database analysis

Adam M Shiroff [1], Simone Wolf, Alex Wu, Mollie Vanderkarr, Manoranjith Anandan, Jill W Ruppenkamp, Thibaut Galvain, Chantal E Holy

Home discharge ⬇
Lung-related readmissions ⬇

Benefit ≥ Risk

Stabilization, NOT Fixation

Fixation

- Anatomical reduction
- Mechanical fixation
- Traditional orthopedic concept

→ Restoration of structural continuity at the fracture site

Stabilization

- Restoration of chest wall stability
- Re-establishment of respiratory physiology
- Comprehensive concept

→ Restoration of the biomechanical stability of the chest wall

Surgical Stabilization of Rib Fractures (SSRF)

늑골골절 관혈적 정복술의 급여기준

2019년 1월 1일 신설

1. 적응증

가. **3개 이상의 늑골골절**이 편측에 있으며, 다음의 1)~4) 중 하나에 해당되는 경우

- 다 음 -

1) 동요흉으로 **인공호흡기** 제거(weaning)가 72시간 이내에 불가능한 것으로 확인된 경우

2) 2개 이상의 늑골에 **중복분절골절**이 존재하여 기호흡(paradoxical respiration)을 보이는 동요흉(flail chest)인 경우

3) **양측** 전방(bilateral costochondral separation) 또는 전측방(antero–lateral)의 다발성 불안정 골절이 확인된 경우

4) **전위**가 심하여 불유합(nonunion) 또는 부정유합(malunion)이 흉곽기형을 초래할 경우로써 급성기 **통증**조절에 실패*한 경우

* IV PCA, PCEA, IV/PO NSAID 등 통증조절을 충분히 하였음에도 6점 이상의 Pain score가 수상 후 3일(72시간)을 초과하여 지속되는 경우

나. 늑골골절로 인한 **흉강 내 장기 손상**으로 개흉술을 시행한 경우

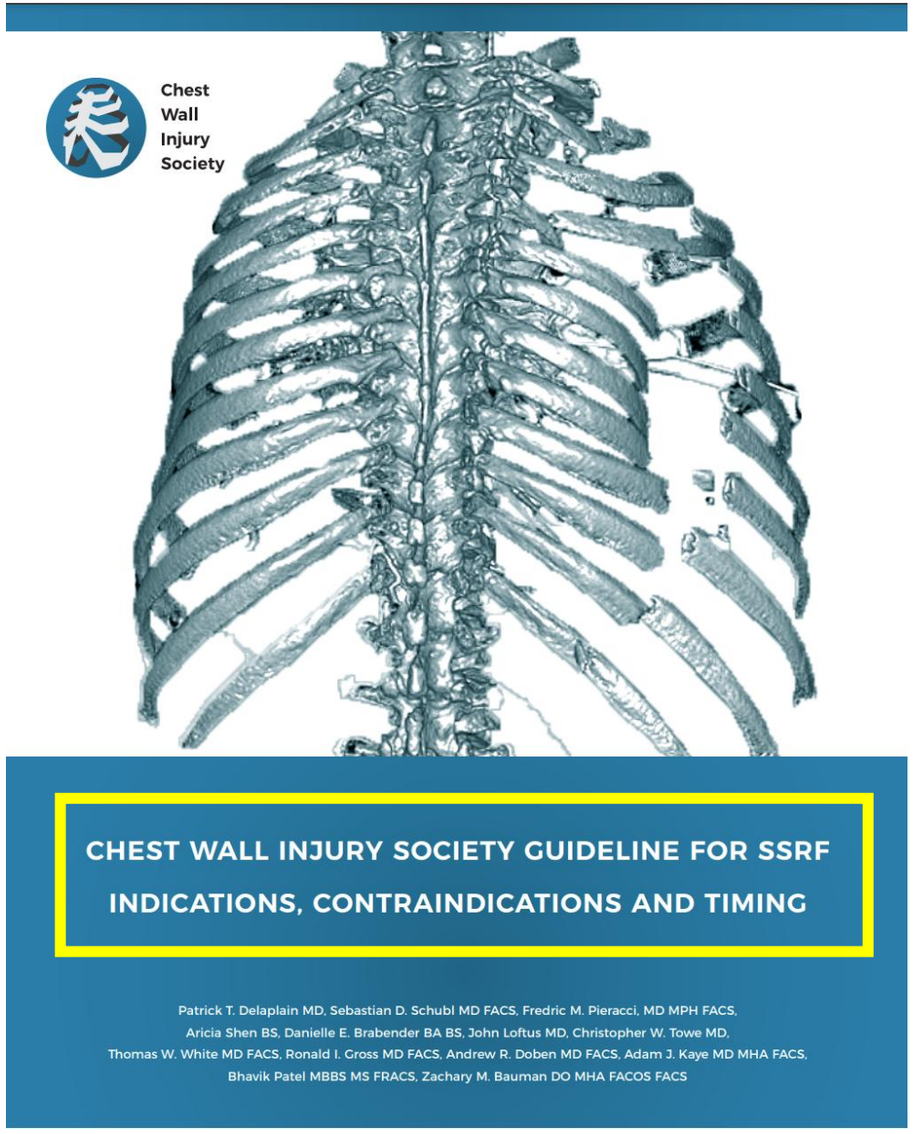
다. 흉부 둔상에 의한 흉강 내 장기 손상으로 개흉술 시행 시 동반된 늑골골절이 해당 늑골의 폭 이상 벗어나 전위가 심한 경우

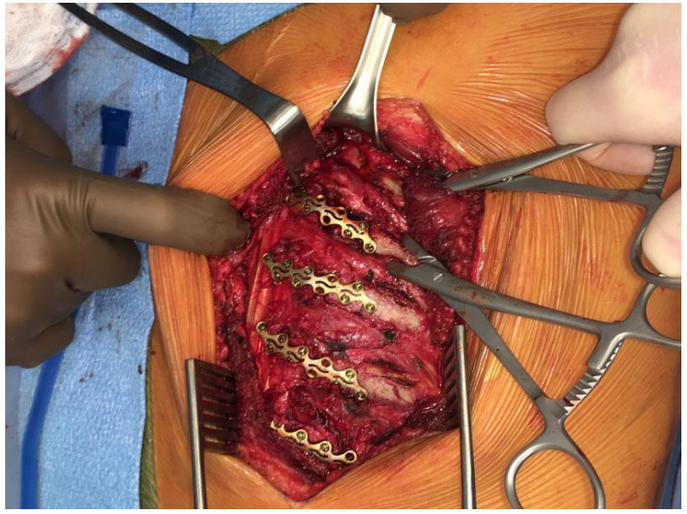
라. 자154-1 흉골골절 관혈적정복술 시행 시 동반된 전방 늑골골절이 있는 경우

2. 자53나 늑골골절 관혈적정복술은 편측 당 **최대 3부위까지만 산정함**

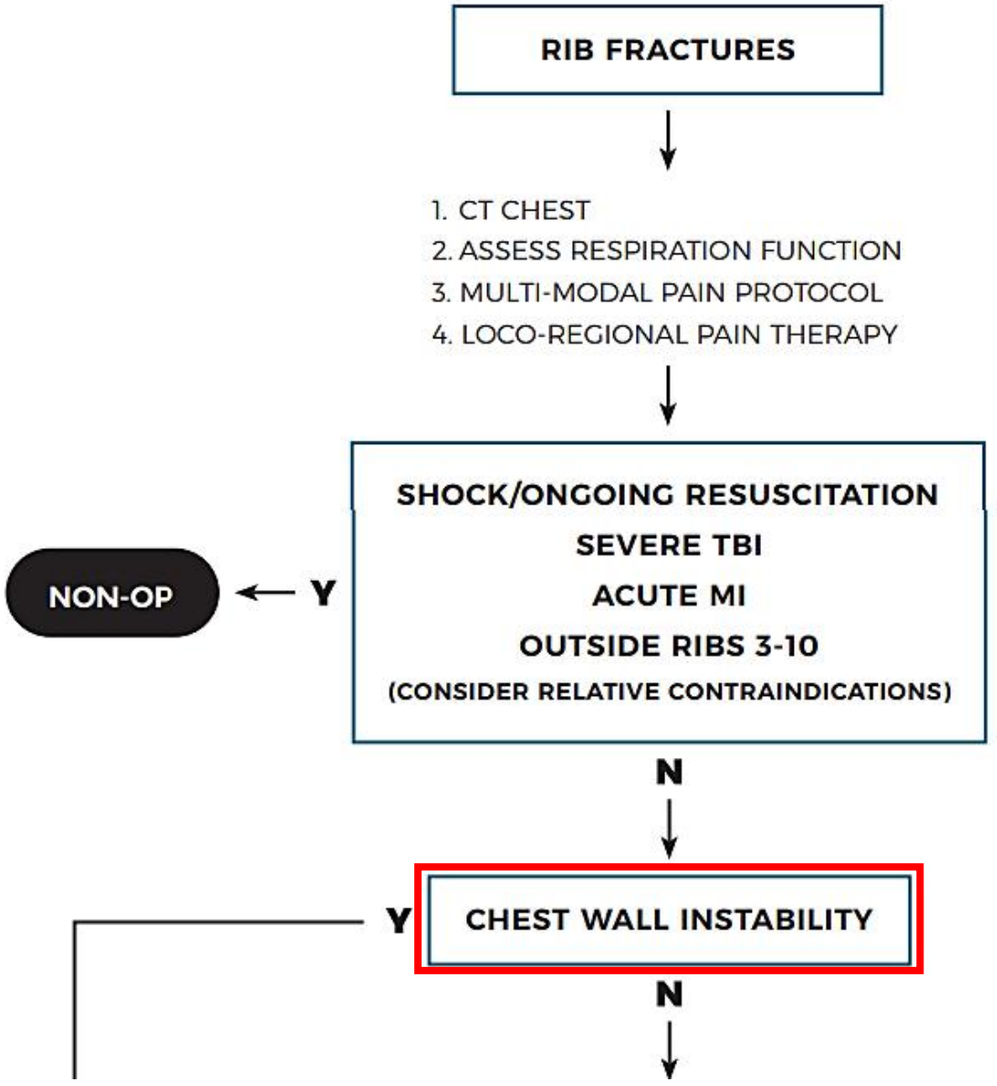
Surgical Stabilization of Rib Fracture (SSRF)

Chest
Wall
Injury
Society





SSRF ALGORITHM



DEFINITIONS OF TERMS

SEVERE TBI
- Any GCS <8
- Signs of intracranial hypertension

RELATIVE CONTRAINDICATIONS
- Age <18 years
- Significant comorbidities
- Unstable Spine injury
- Empyema
- Prior chest wall radiation
- Mild/moderate TBI

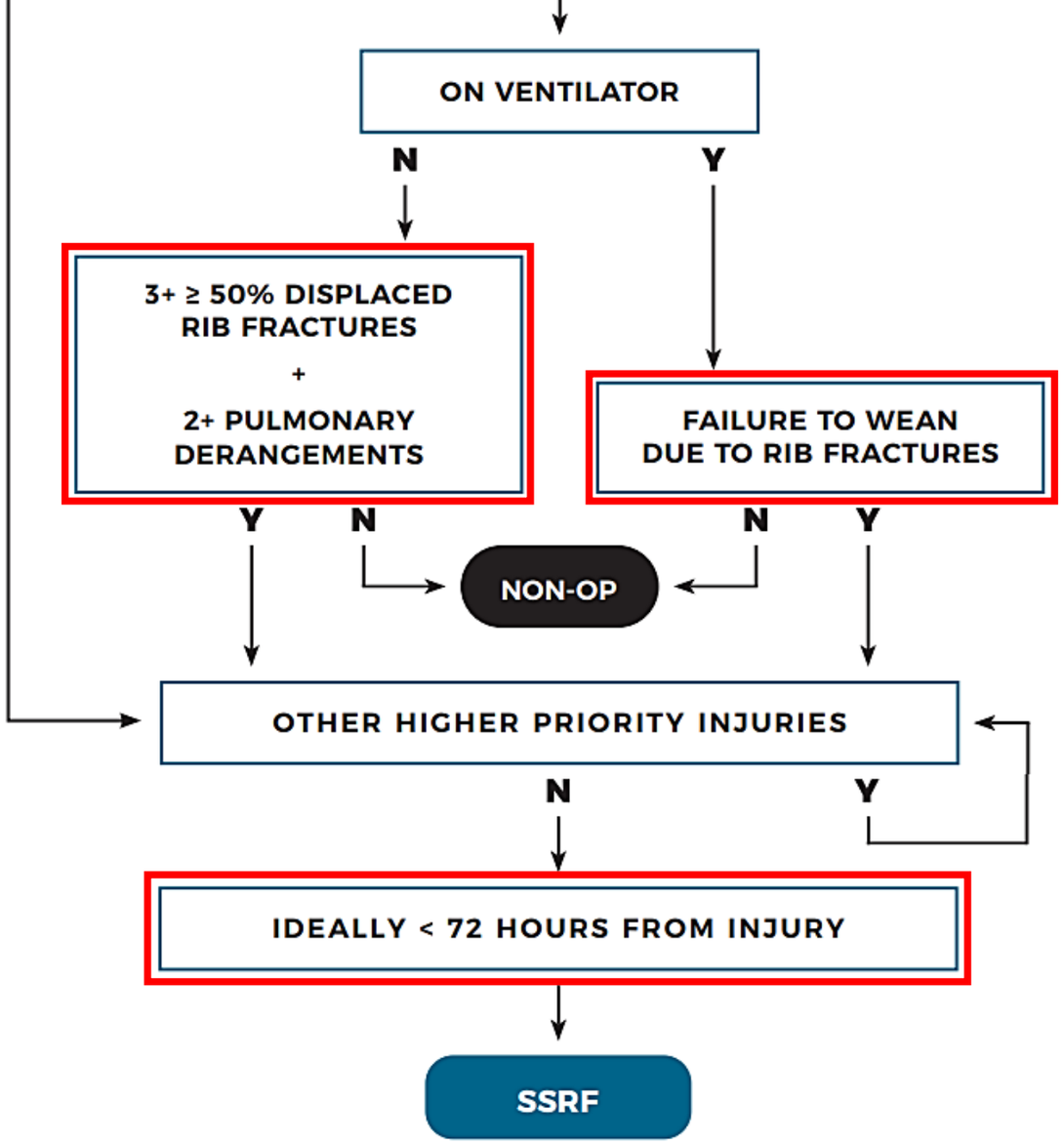
CHEST WALL INSTABILITY

Flail Segment
- 3+ ipsilateral consecutive ribs with fractures in 2 locations
- Clinical finding of paradoxical motion

Offset fractures
- 3+ ipsilateral rib fractures with displacement of 100% of rib width on axial CT

Instability or "clicking" on palpation or reported by the patient

3+ > 50% DISPLACEMENT
- Three ipsilateral consecutive or non-consecutive ribs each with a fracture displaced 50% of the rib width on axial CT



PULMONARY DERANGEMENTS

- Respiratory rate >20
- Incentive spirometry <50% of predicted
- Numerical pain score >5/10
- Poor cough

FAILURE TO WEAN

Must be clinically determined to be related to the rib fractures

Unable to progress to spontaneous breathing trial after 48 hours

Able to obtain spontaneous breathing trial for 60 minutes but develops >2 of the following

- Increased resp. rate >35
- Increased heart rate >140
- Oxygen saturation <90%
- RSBI >105
- Anxiety
- Diaphoresis
- Agitation

Of note: Ventilator weaning should be at the discretion of the treating bedside physician.

HIGHER PRIORITY INJURIES

- Pre-operative spinal injury
- Open Abdomen
- Significant vascular trauma
- Pelvic external fixation

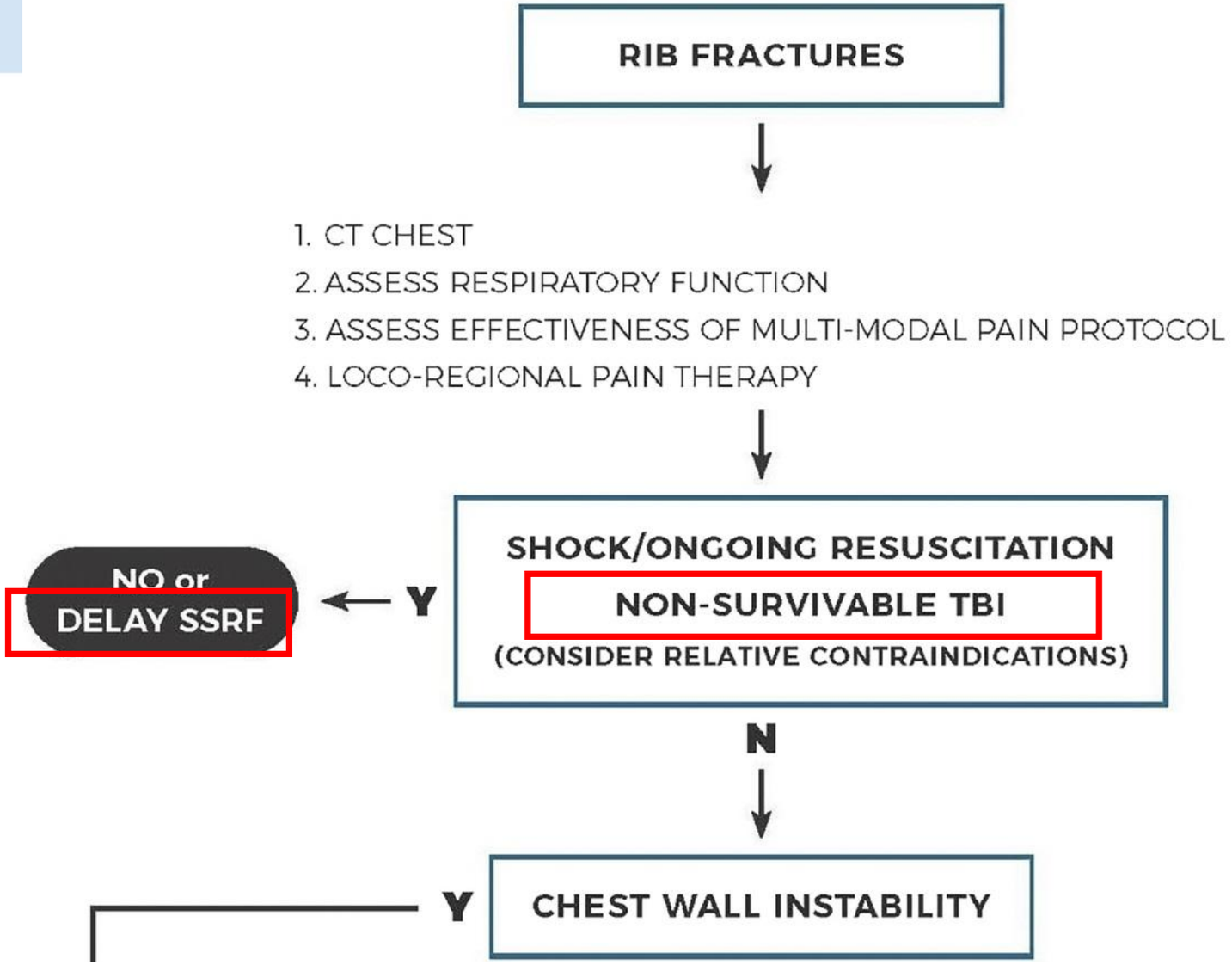
Brand NEW guideline! (2025/08/13)

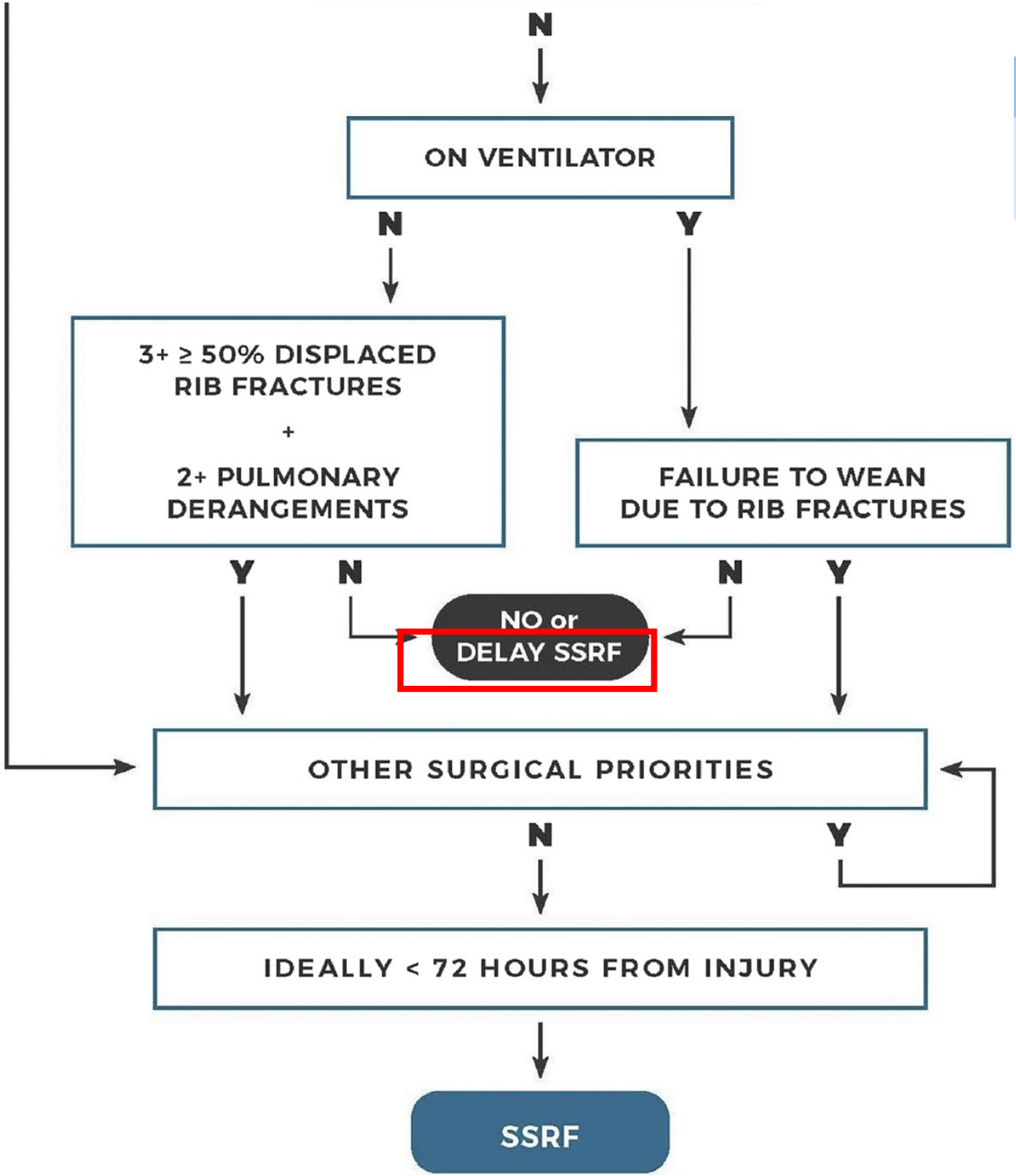
J Trauma Acute Care Surg. 2025 Aug 13. doi: 10.1097/TA.0000000000004750. Online ahead of print.

Chest Wall Injury Society guidelines for surgical stabilization of rib fractures: Indications, contraindications, and timing

Zachary M Bauman [1], Yuqian Tian, Andrew R Doben, Sebastian D Schubl, Fredric M Pieracci, Adam J Kaye, Christopher W Towe, Bhavik Patel, Susan Kartiko, Sarah Ann Whitbeck, Babak Sarani, Thomas W White

SSRF ALGORITHM




N
ON VENTILATOR
N
Y
3+ ≥ 50% DISPLACED RIB FRACTURES
+
2+ PULMONARY DERANGEMENTS
FAILURE TO WEAN DUE TO RIB FRACTURES
Y
N
N
Y
NO or DELAY SSRF
OTHER SURGICAL PRIORITIES
N
Y
IDEALLY < 72 HOURS FROM INJURY
SSRF

Review > World J Emerg Surg. 2024 Oct 18;19(1):33. doi: 10.1186/s13017-024-00559-2.

Surgical stabilization of rib fractures (SSRF): the WSES and CWIS position paper

Giacomo Sermonesi [1], Riccardo Bertelli [1], Fredric M Pieracci [2], Zsolt J Balogh [3], Raul Coimbra [4], Joseph M Galante [5], Andreas Hecker [6], Dieter Weber [7], Zachary M Bauman [8], Susan Kartiko [9], Bhavik Patel [10], SarahAnn S Whitbeck [11], Thomas W White [12], Kevin N Harrell [13], Daniele Perrina [1], Alessia Rampini [1], Brian Tian [14], Francesco Amico [15], Solomon G Beka [16], Luigi Bonavina [17], Marco Ceresoli [18], Lorenzo Cobianchi [19 20], Federico Coccolini [21], Yunfeng Cui [22], Francesca Dal Mas [20 23], Belinda De Simone [24], Isidoro Di Carlo [25], Salomone Di Saverio [26], Agron Dogjani [27], Andreas Fette [28], Gustavo P Fraga [29], Carlos Augusto Gomes [30], Jim S Khan [31], Andrew W Kirkpatrick [32], Vitor F Kruger [29], Ari Leppäniemi [33], Andrey Litvin [34], Andrea Mingoli [35], David Costa Navarro [36], Eliseo Passera [37], Michele Pisano [37], Mauro Podda [38], Emanuele Russo [1], Boris Sakakushev [39], Domenico Santonastaso [1], Massimo Sartelli [40], Vishal G Shelat [41], Edward Tan [42], Imtiaz Wani [43], Fikri M Abu-Zidan [44], Walter L Biffl [45], Ian Civil [46], Rifat Latifi [47], Ingo Marzi [48], Edoardo Picetti [49], Manos Pikoulis [50], Vanni Agnoletti [1], Francesca Bravi [51], Carlo Vallicelli [1], Luca Ansaloni [19], Ernest E Moore [2], Fausto Catena [1]