Emergency Department Thoracotomy & Damage Control Resuscitation

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Resuscitative Thoracotomy

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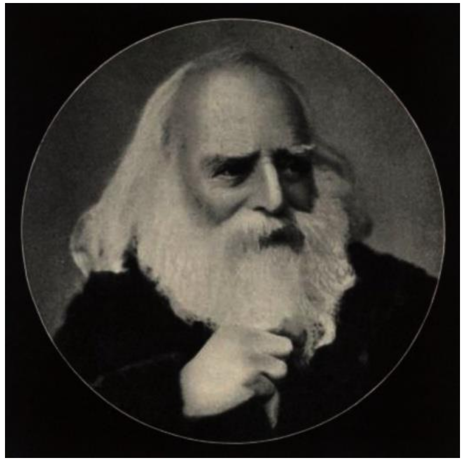
Emergency Department Thoracotomy

History

- In 1874, Schiff promoted the concept of thoracotomy for open cardiac massage.
- Block first suggested the potential application of this technique for penetrating chest wounds and heart laceration in 1882.
- In 1901, at Tromsø Hospital in Norway, Kristian Igelsrud performed the first successful direct heart compression in history.



Moritz Schiff (1823–1896)

Kristian Igelsrud (1867–1940)

History

- Initially, **cardiovascular collapse from medical causes** was the most common reason for thoracotomy in the early 1900s.

- Beck, **using internal defibrillation** in 1947, made open chest cardiac massage no longer a rare occurrence.

- The demonstrated efficacy of **closed-chest compression** by **Kouwenhoven** et al. in 1960 and the introduction of **external defibrillation** in 1965 by Zoll et al. virtually eliminated the practice of open-chest resuscitation for medical cardiac arrest.

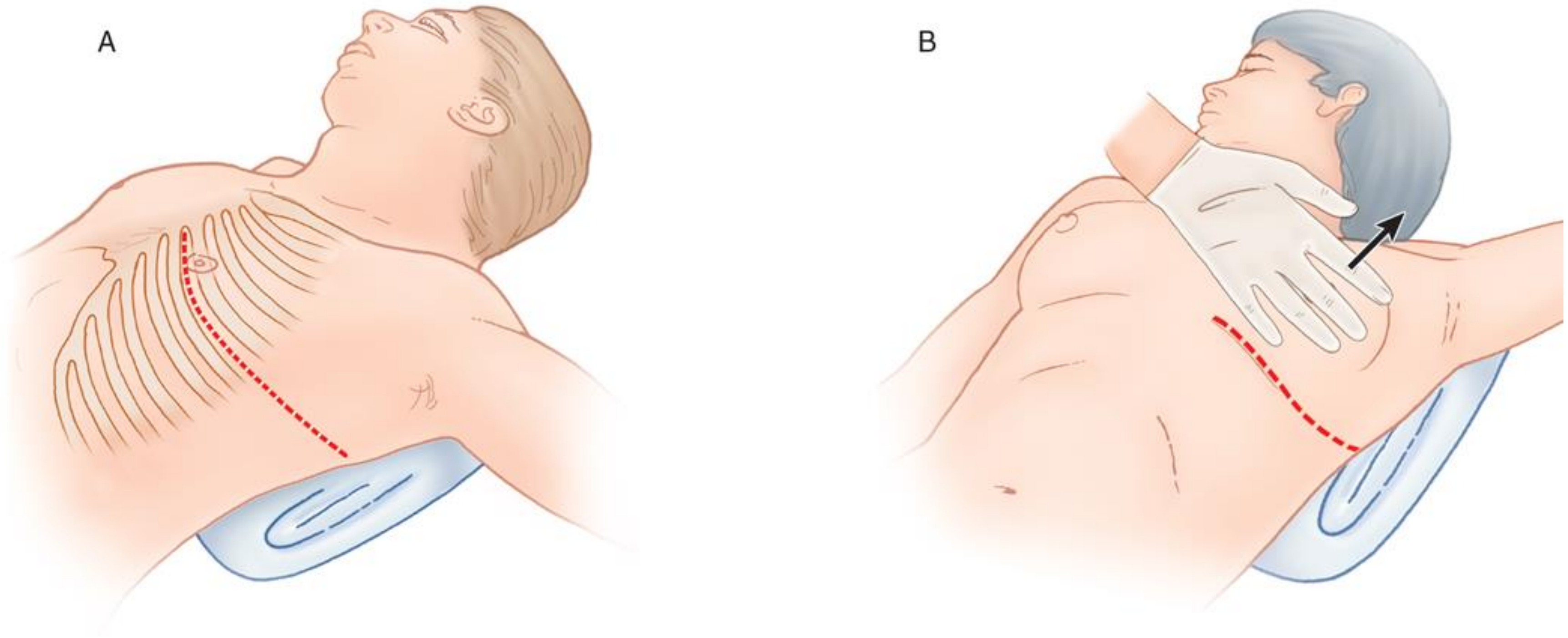
- However, in the late 1960s, the pendulum swung again toward emergent thoracotomy, promulgated by the Ben Taub group for resuscitation of the moribund patient with penetrating cardiovascular injuries.

- In the 1970s, **the Denver General Hospital** and the San Francisco General Hospital challenged the appropriate role and clinical indications for RT.

Physiologic Rationale

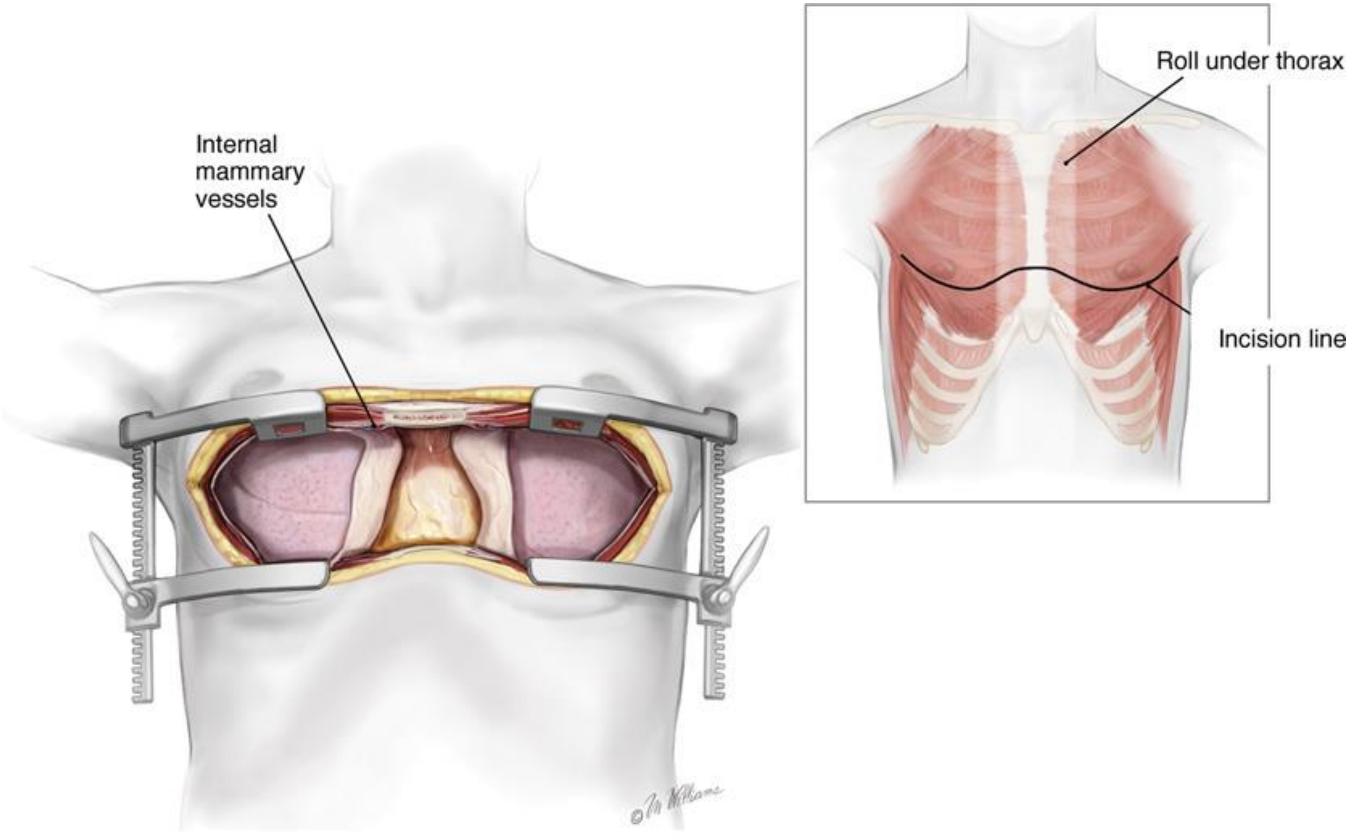
- Perform open cardiac massage
- Release pericardial tamponade and control cardiac hemorrhage
- Control intrathoracic hemorrhage
- Achieve thoracic aortic cross-clamping
- Evacuate bronchovenous air embolism

Anterolateral Thoracotomy



Source: Reichman EF: *Emergency Medicine Procedures, Second Edition:* www.accessemergencymedicine.com

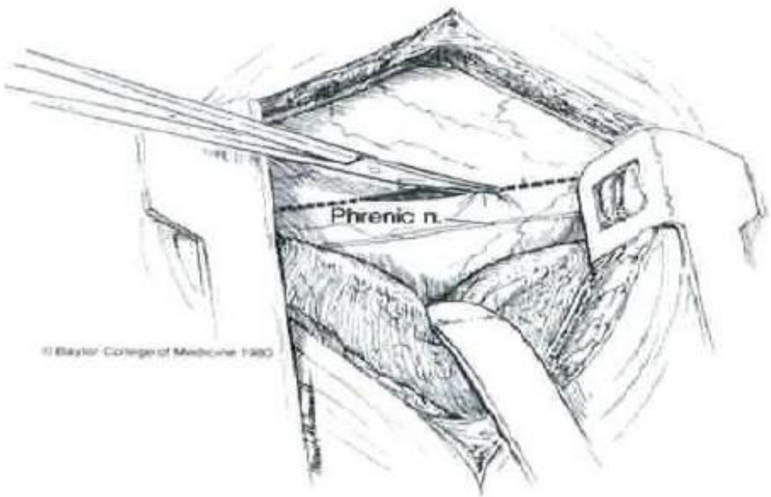
Clamshell Incision
(Bilateral anterolateral thoracotomy)



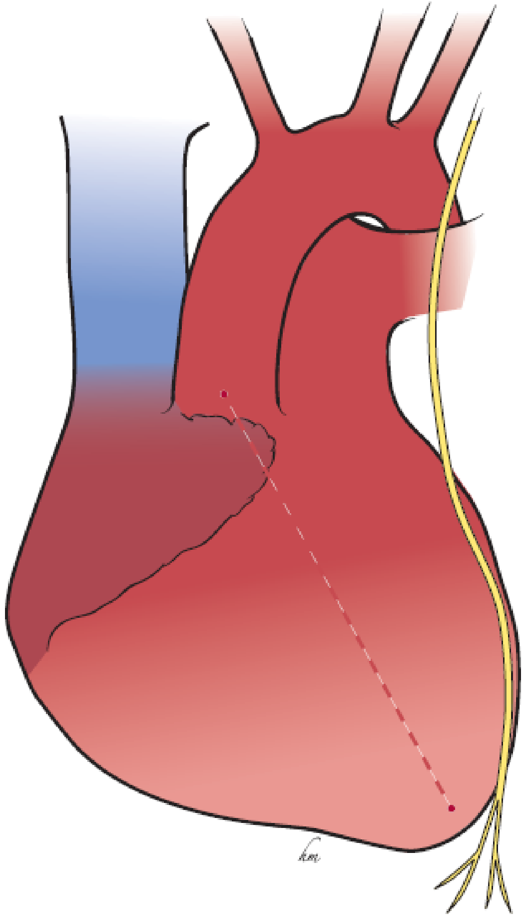
Source: Sugarbaker DJ, Bueno R, Krasna MJ, Mentzer SJ, Zellos L: *Adult Chest Surgery*:
http://www.accesssurgery.com


GOM Mix Pro

Pericardiotomy



Pericardiotomy above left phrenic nerve



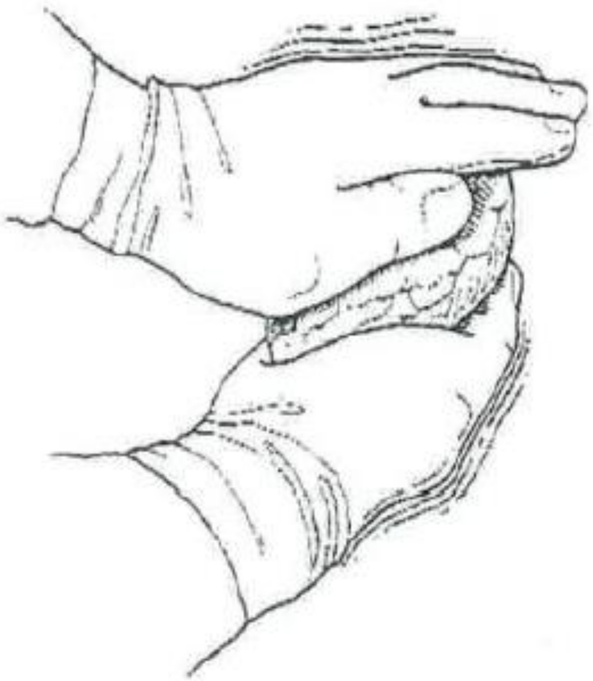
Open cardiac massage

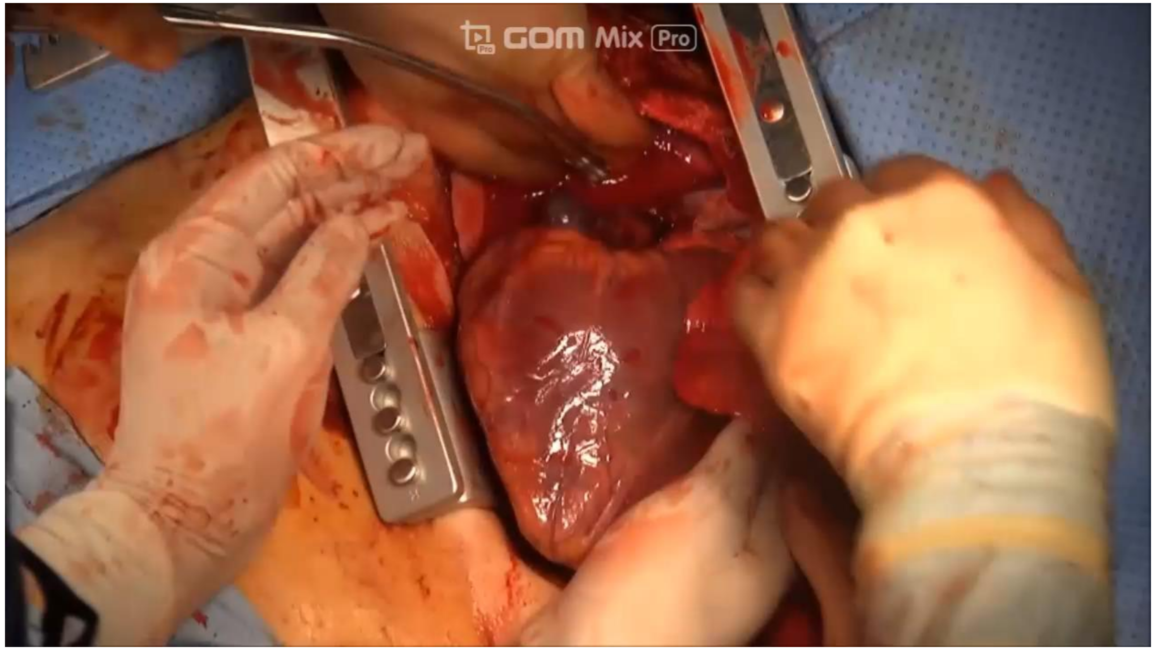
- Extrenal chest compression
  cardiac output : 20-25%
  cerebral perfusion : 10-20%

- In models of **inadequate intravascular volume(hypovolemic shock) or restricted ventricular filling(pericardial tamponade)**, external chest compression fails to augment arterial pressure or provide adequate systemic perfusion.

- Cardiac output with open chest massage is approximately **double** that obtained by closed chest massage.

- Cerebral blood flow during open chest massage approaches physiologic values.





2 cupped hands, opposed at the wrist and avoiding thumb pressure.

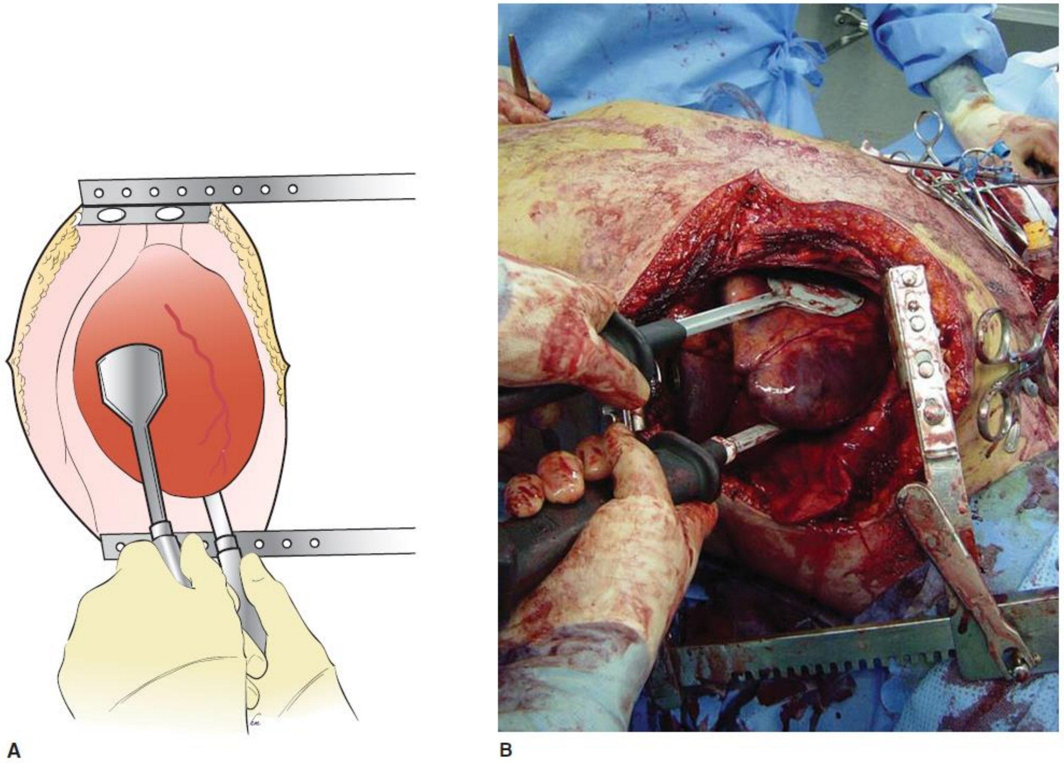
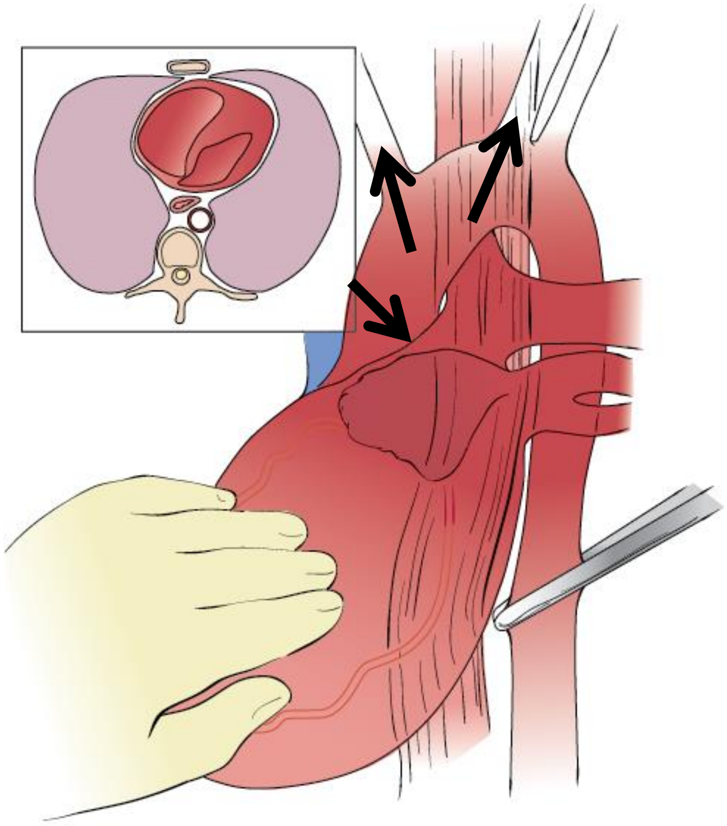


FIGURE 14-6 (**A**) and (**B**) Internal paddles for defibrillation are positioned on the anterior and posterior aspects of the heart.

Defibrillation

Thoracic aortic cross-clamping



Source: Mattox KL, Moore EE, Feliciano DV: *Trauma, 7th Edition:*
www.accesspharmacy.com

- In patients with hemorrhage shock, aortic cross-clamping redistributes the paitent's limited blood volume to the **myocardium and brain.**

- Patients sustaining intra-abdominal injury may benefit from aortic cross-clamping due to **reduction in subdiaphragmatic blood loss.**

Complications

- **Ischemia to distal organs**
  - Gut's tolerance to normothermic ischemia : **30-45min.**
  - Renal tolerance : **30min**
- **Iatrogenic injury to the Thoracic aorta**
- Thoracic sepsis
- **Esophageal injury** during aortic clamping

Complications

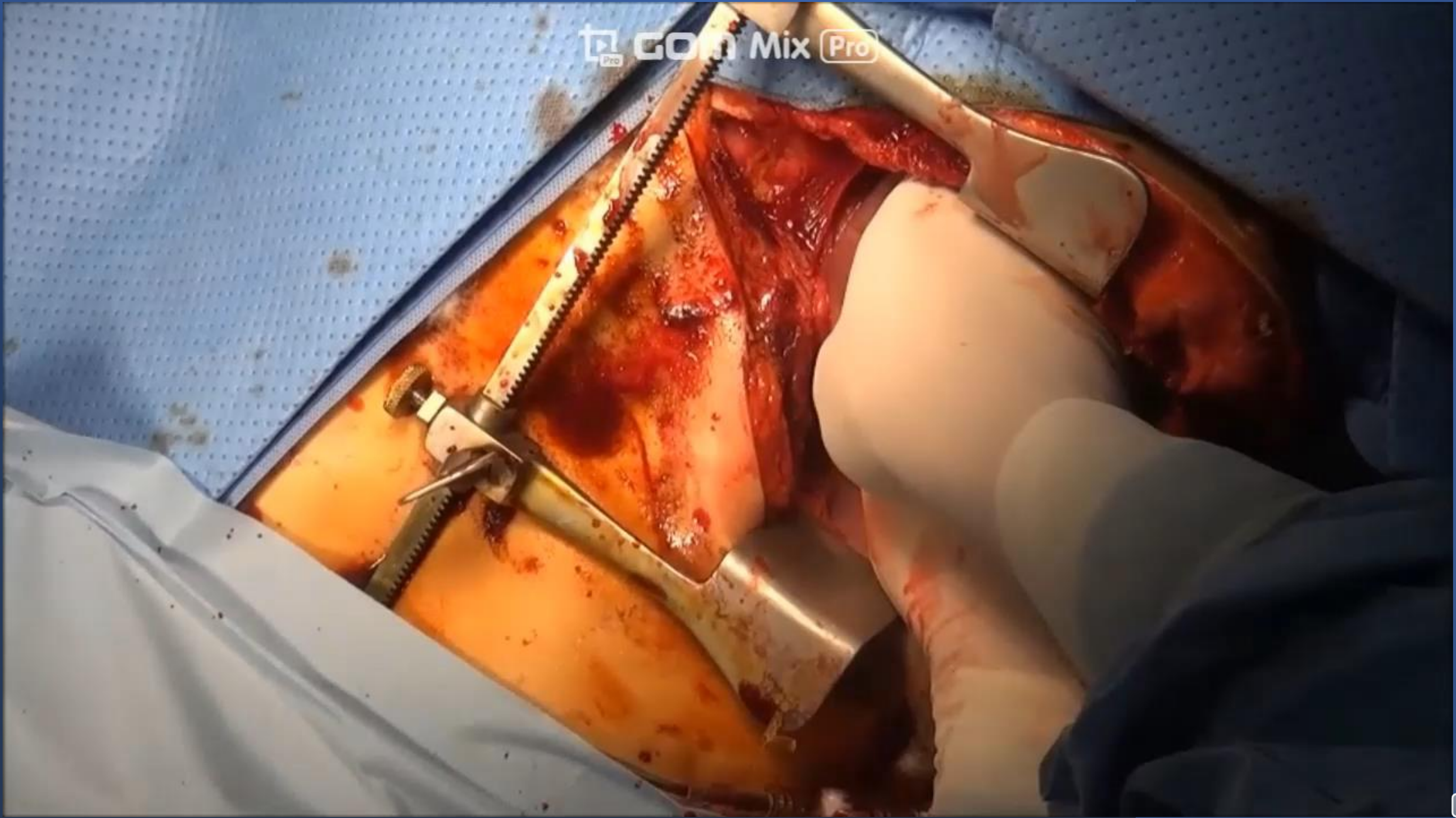
- **Acute left heart failure**
  - Sudden overloading of the Lt. heart
  - Careful monitoring
  - Partially releasing the clamp maintain SBP 120~200 mmHg

- Paraplegia
  - Due to spinal cord ischemia.

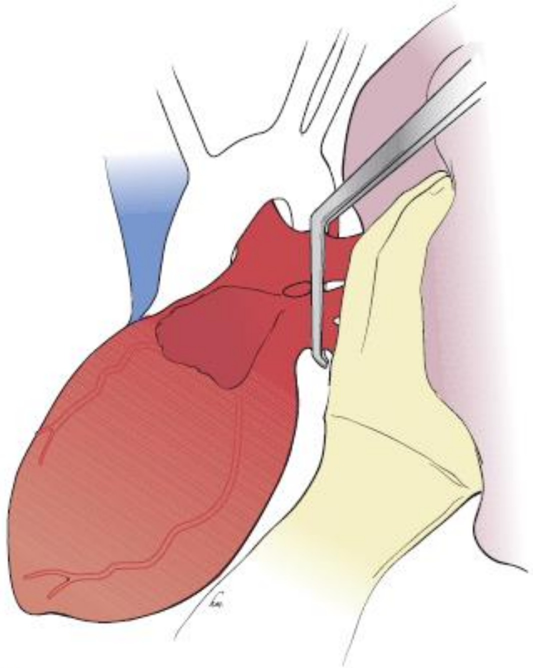
Release pericardial tamponade and control cardiac hemorrhage

- The patient in the third phase of tamponade, with profound hypotension(SBP < 60mm Hg), **should undergo EDT rather than pericardiocentesis** as the management for evacuation of pericardial blood.

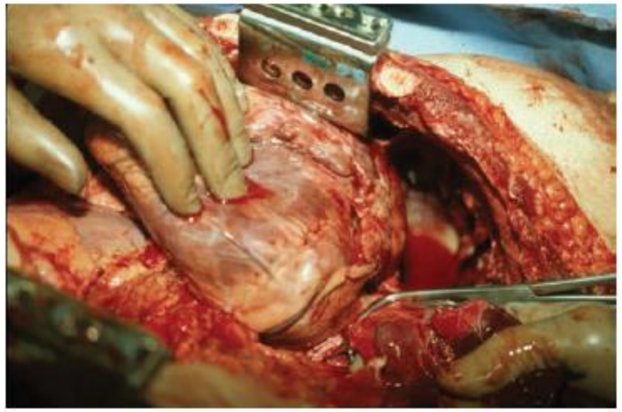
- Following release of tamponade, **the source of tamponade can be directly controlled** with appropriate interventions based on the underlying injury.

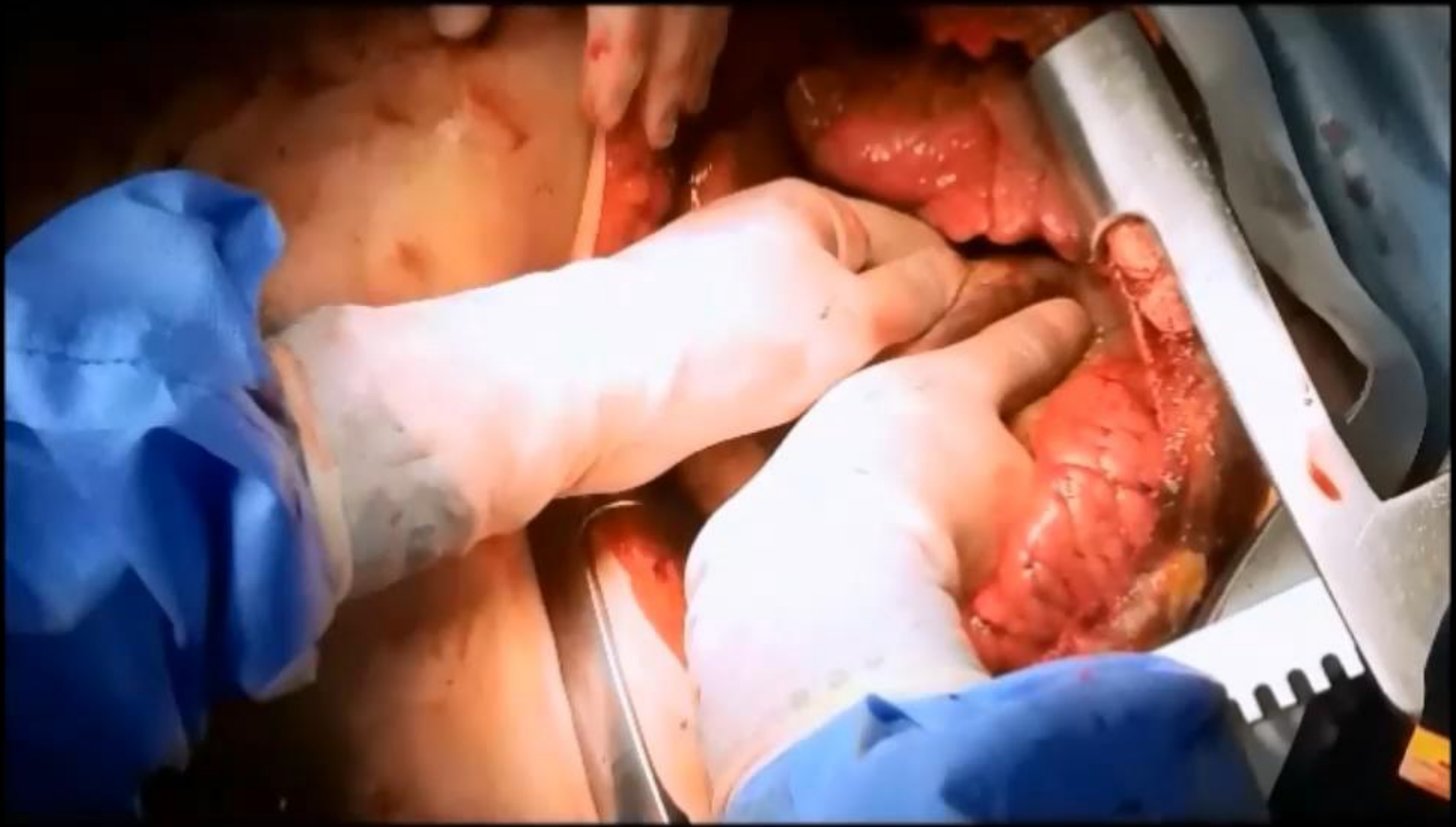

GOM Mix Pro

Evacuate Bronchovenous Air Embolism



A





Resuscitative Thoracotomy Outcomes

J Am Coll Surg. 2001 Sep;193(3):303-9.

Practice management guidelines for emergency department thoracotomy. Working Group, Ad Hoc Subcommittee on Outcomes, American College of Surgeons-Committee on Trauma.(ACSCOT)

Working Group, Ad Hoc Subcommittee on Outcomes, American College of Surgeons. Committee on Trauma.

Practice Management Guidelines for Emergency Department Thoracotomy

Working Group, Ad Hoc Subcommittee on Outcomes, American College of Surgeons–Committee on Trauma

STATEMENT OF THE PROBLEM

Emergency department thoracotomy remains a formidable tool within the trauma surgeon's armamentarium. Since its introduction during the 1960s, the use of this procedure has ranged from sparing to liberal. In many urban trauma centers this procedure has found a niche as part of the resuscitative process because of the great improvements in Emergency Medical Services (EMS) systems, allowing many patients to arrive in either impending or full cardiopulmonary arrest.

Indications for the use of emergency department thoracotomy that appear in the literature range from vague to quite specific. It has been used in a variety of settings including penetrating thoracic and thoracoabdominal injuries, and cardiac and exsanguinating abdominal vascular injuries. It has also been used in exsanguinating peripheral vascular injuries arriving in full cardiopulmonary arrest and also in pediatric trauma. Many studies in the literature have also reported its use in patients presenting in full cardiopulmonary arrest secondary to blunt trauma. The ever-present questions in the back of many surgeons' minds regarding performing or withholding this procedure loom large, ie, should I have performed this procedure? Could this patient have been saved? What if . . . ?

Use of emergency department thoracotomy has raised issues of professional competence and has created "turf battles." Questions regarding the qualifications of those performing this procedure have sparked vigorous debate between surgeons and emergency medicine physicians.

The risk-to-benefit ratio and ethics of this procedure have also been the subject of in-depth analysis in the literature, with many reports focusing on the cost of the procedure and the low rate of success (ie, survival). Others believe that no price is too high to pay for saving a life. The question of quality of life remains very valid. What is the benefit in saving a patient who survives with severe neurologic impairment or even a persistent vegetative state? Finally, concerns over the transmission of viral diseases, such as hepatitis and HIV have ranged from serious and scientific to paranoic and phobic.

The literature is rich with series describing the use of emergency department thoracotomy.[1-92] Great difficulties, however, exist in evaluating the results of these series. Close scrutiny reveals several flaws; most series have been retrospective reviews, many from institutions using this technique infrequently. Many institutions report serial and overlapping studies that encompass their experience of many years. Although some series have selected outcomes-oriented physiologic parameters, only three[42,87,88] have statistically validated their predictive values. The majority of these series omit data pertaining to the physiologic status of the patient on initial presentation. As a result, there are still many questions to be answered.

Important questions include:

1) Which patients should be subjected to this procedure?
2) Are there any prospectively validated physiologic predictors of outcomes that can safely and accurately identify patients who will benefit from the procedure and also safely exclude those that will not?
3) What are the true survival rates of this procedure?
4) Of the surviving patients, how many survive with severe neurologic impairment or remain in a persistent vegetative state?
5) How can we ensure that individuals performing this procedure are qualified?

PROCESS

Identification of references

A computerized search of the National Library of Medicine and Medline using the OVID software program of

No competing interests declared.

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Analysis

Series dealing with emergency department thoracotomy

In the 42 series dealing with emergency department thoracotomy[1-42] (see Table 1), there were a total of 7,035 emergency department thoracotomies and 551 survivors, for a survival rate of 7.83%. Stratified by mechanism of injury, there were 4,482 thoracotomies for penetrating injuries; 500 patients survived, yielding a survival rate of 11.16%. There were 2,193 thoracotomies performed for blunt injuries; 35 patients survived, for a survival rate of 1.6%.

Series dealing with penetrating cardiac injuries

In the series dealing with penetrating cardiac injuries[43-88] (see Table 2), 363 patients survived a total of 1,165 emergency department thoracotomies, yielding a survival rate of 31.1%.

World Journal of Emergency Surgery

BioMed Central

Table 2: Survival Following Emergency Department Thoracotomy in Adults

Injury Pattern	Shock	No Vital Signs	No Signs Of Life	Total
Cardiac				
Denver (57)	3/9 (33%)	0/7 (0%)	1/53 (2%)	4/69 (6%)
Detroit (58)	9/42 (21%)	3/110 (3%)		12/152 (8%)
Johannesburg (59)				13/108 (12%)
Los Angeles (60)	2/5 (40%)	6/11 (55%)	2/55 (4%)	10/71 (14%)
New York (61)	7/20 (35%)	18/53 (32%)	0/18 (0%)	24/91 (26%)
San Francisco (62)	18/37 (49%)	0/25 (0%)		18/63 (29%)
Seattle (63)	4/11 (36%)	11/47 (23%)		15/58 (26%)
Overall	**43/124 (35%)**	**47/254 (19%)**	**4/126 (3%)**	**96/612 (16%)**
Penetrating				
Denver (15)	19/78 (24%)	14/399 (4%)		33/477 (7%)
Detroit (58)	9/42 (21%)	3/110 (3%)		12/152 (8%)
Houston (64)	14/156 (9%)	18/162 (11%)		32/318 (10%)
Indianapolis (65)	3/7 (43%)	1/50 (2%)	0/80 (0%)	4/137 (3%)
Johannesburg (59)	31/413 (8%)	10/149 (7%)	1/108 (1%)	42/670 (6%)
Los Angeles (60)	2/5 (40%)	6/11 (55%)	2/55 (4%)	10/71 (14%)
New York (66)	8/32 (25%)	8/77 (10%)	0/25 (0%)	16/134 (12%)
Oakland (67)	8/24 (33%)		2/228 (1%)	10/252 (4%)
San Francisco (62)				32/198 (30%)
Seattle (63)	4/11 (36%)	11/47 (23%)		15/58 (25%)
Washington (68)	7/13 (54%)	3/47 (6%)		10/60 (17%)
Overall	**145/1007 (14%)**	**100/1252 (8%)**	**6/615 (1%)**	**283/2986 (10%)**
Blunt				
Denver (15)	4/86 (5%)	4/311 (1%)		8/397 (2%)
Houston (64)	0/42 (0%)	0/27 (0%)		0/69 (0%)
Johannesburg (59)	1/109 (1%)	0/39 (0%)	0/28 (0%)	1/176 (1%)
San Francisco (62)				1/60 (2%)
Seattle (63)				1/88 (1%)
Overall	**5/237 (2%)**	**4/377 (1%)**	**0/28 (0%)**	**11/790 (1.4%)**

Establishing Benchmarks for Resuscitation of Traumatic Circulatory Arrest: Success-to-Rescue and Survival among 1,708 Patients

Hunter B Moore, MD, Ernest E Moore, MD, FACS, Clay C Burlew, MD, FACS, Walter L Biffl, MD, FACS, Fredric M Pieracci, MD, FACS, Carlton C Barnett, MD, FACS, Denis D Bensard, MD, FACS, Gregory J Jurkovich, MD, FACS, Charles J Fox, MD, FACS, Angela Sauaia, MD, PhD

Table 2. Trends in Emergency Department Thoracotomy Outcomes over Time

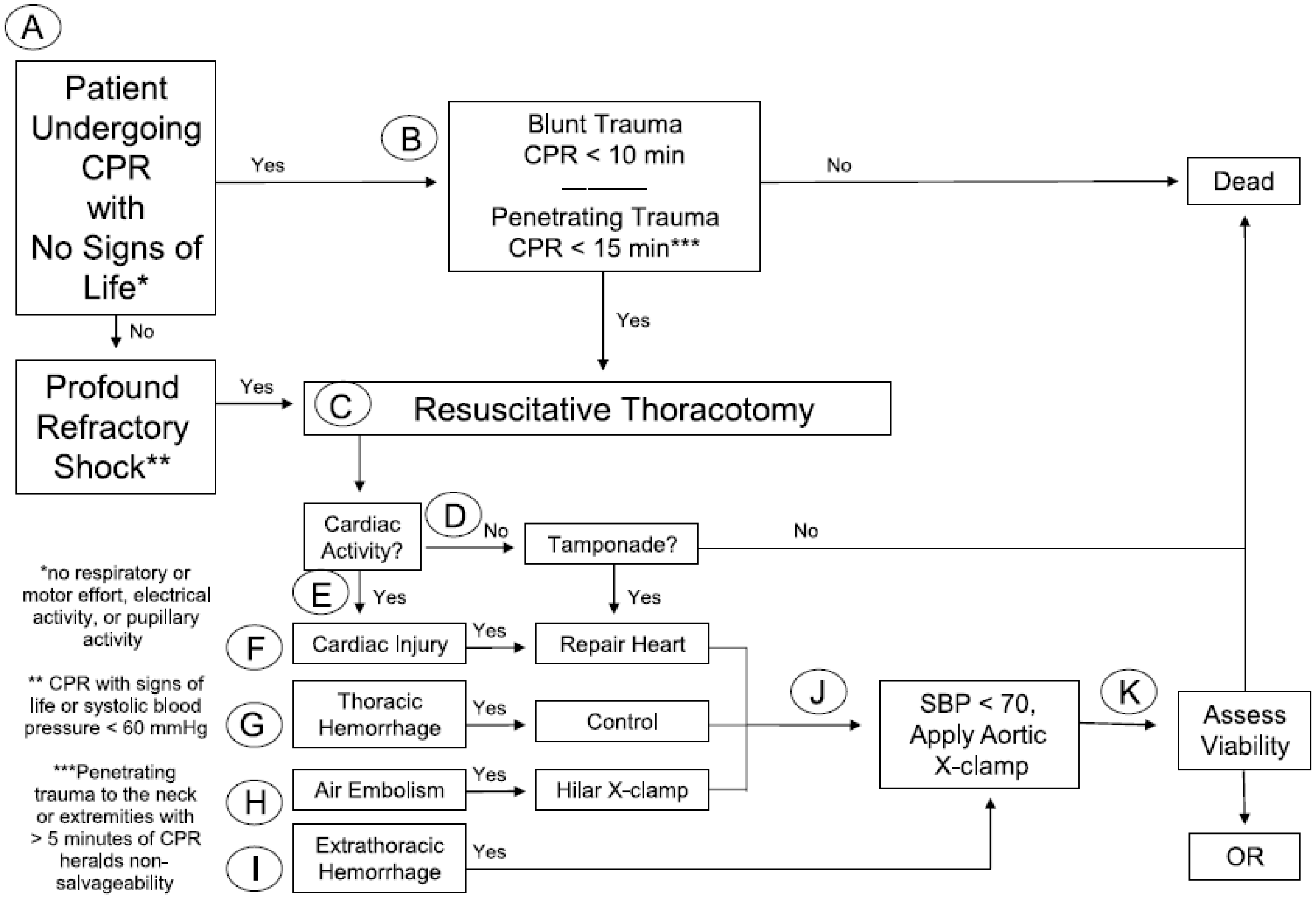
Quin-quennial, 5-y	EDT/y, average	Success-to-rescue, %	Survive OR, %	Penetrating injury survivors, %	Blunt injury survivors, %	Survivors per 5 y, n	Overall survival, %
1975–1979	50	23	6	8	1	12	5
1980–1984	52	27	6	6	2	10	4
1985–1989	57	19	6	7	3	13	5
1990–1994	39	22	7	7	3	9	5
1995–1999	37	17	7	9	3	11	6
2000–2004	38	28	10	13	2	16	8
2005–2009	33	30	10	8	4	11	7
2010–2014	35	35	18	13	15	24	14

EDT, emergency department thoracotomy; OR, operating room.

(27%), and multisystem without head (21%). Penetrating injury was associated with higher survival than blunt trauma (9% vs 3% $p < 0.001$). Success-to-rescue increased from 22% in 1975 to 1979 to 35% over the final 5 years ($p < 0.001$); survival increased from 5% to 14% ($p < 0.001$).

CONCLUSIONS: Outcomes of EDT have improved over the past 40 years. In the last 5 years, STR was 35% and overall survival was 14%. These prospective observational data provide benchmarks to define the role of EHC as an alternative approach for patients arriving in extremis. (J Am Coll Surg 2016;223:42–50. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

WTA 2012 Algorithm



*no respiratory or motor effort, electrical activity, or pupillary activity

** CPR with signs of life or systolic blood pressure < 60 mmHg

***Penetrating trauma to the neck or extremities with > 5 minutes of CPR heralds non-salvageability

KEY WORDS: Thoracotomy; resuscitative thoracotomy; emergency department thoracotomy; cardiopulmonary resuscitation; algorithm.

An evidence-based approach to patient selection for emergency department thoracotomy: A practice management guideline from the Eastern Association for the Surgery of Trauma

Question	Recommendation
PICO #1	In patients who present pulseless to the Emergency Department with signs of life after penetrating thoracic injury, we **strongly recommend** resuscitative Emergency Department thoracotomy. **Strong Recommendation**
PICO #2	In patients who present pulseless to the Emergency Department without signs of life after penetrating thoracic injury, we **conditionally recommend** resuscitative Emergency Department thoracotomy. **Conditional Recommendation**
PICO #3	In patients who present pulseless to the Emergency Department with signs of life after penetrating extra-thoracic injury, we **conditionally recommend** resuscitative Emergency Department thoracotomy. **Conditional Recommendation**
PICO #4	In patients who present pulseless to the Emergency Department without signs of life after penetrating extra-thoracic injury, we **conditionally recommend** resuscitative Emergency Department thoracotomy.[1] **Conditional Recommendation**
PICO #5	In patients who present pulseless to the Emergency Department with signs of life after blunt injury, we **conditionally recommend** resuscitative Emergency Department thoracotomy. **Conditional Recommendation**
PICO #6	In patients who present pulseless to the Emergency Department without signs of life after blunt injury, we **conditionally recommend against** resuscitative Emergency Department thoracotomy.[2] **Conditional Recommendation**

geably with vital signs, defined by American auma in 2001.[84] Signs any of the following: lation, presence of ca- ood pressure, extremity /.

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The reviewers have nothing to disclose.

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Abstract

Background: The effectiveness and indications of open-chest cardiopulmonary resuscitation (OCCPR) have been

Table 5 Comparative effectiveness of OCCPR, compared to CCCPR, for survival to hospital discharge evaluated by the logistic regression analysis, instrumental variable analysis, and propensity score matching analysis

Models	Number of survivors		Adjusted odds ratio [95% confidence interval]	*p* value
	OCCPR	CCCPR		
Logistic regression analysis	157/1032 (15.2%)	293/1650 (11.7%)	1.99 [1.42–2.79]	< 0.001
Instrumental variable analysis	157/1032 (15.2%)	293/1650 (11.7%)	1.16 [1.02–1.31]	0.021
Propensity score matching analysis	89/531 (16.8%)	58/531 (10.9%)	1.66 [1.13–2.42]	0.009

Abbreviations: OCCPR open-chest cardiopulmonary resuscitation, *CCCPR* closed-chest cardiopulmonary resuscitation

instrumental variable analysis, and propensity score matching analysis adjusting for potential confounders.

Results: A total of 2682 patients (OCCPR 1032; CCCPR 1650) were evaluated; of those 157 patients (15.2%) in the OCCPR group and 193 patients (11.7%) in the CCCPR group survived. OCCPR was significantly associated with higher survival to hospital discharge in both the logistic regression analysis (adjusted odds ratio [95% confidence interval] = 1.99 [1.42–2.79], $p < 0.001$) and the instrumental variable analysis (adjusted odds ratio [95% confidence interval] = 1.16 [1.02–1.31], $p = 0.021$). In the propensity score matching analysis, 531 matched pairs were generated, and the OCCPR group still showed significantly higher survival at hospital discharge (89 patients [16.8%] in the OCCPR group vs 58 patients [10.9%] in the CCCPR group; odds ratio [95% confidence interval] = 1.66 [1.13–2.42], $p = 0.009$).

Conclusions: Compared to CCCPR, OCCPR was associated with significantly higher survival at hospital discharge in severe trauma patients with SOL upon ED arrival. Further studies to confirm these results and to assess long-term neurologic outcomes are needed.

Keywords: Polytrauma, Resuscitation, Resuscitative thoracotomy, Cardiac arrest, Shock, Registry, Open-chest cardiopulmonary resuscitation, Closed-chest cardiopulmonary resuscitation

Abstract

Background Resuscitative thoracotomy (RT) can be a lifesaving treatment, but it has not yet been performed in Korea. In this study, we review our experience of RT after a regional trauma center was constructed.

Methods This is a retrospective study of RT conducted at a single Korean trauma center from May 2014 to March 2018. The primary outcome was survival, and the secondary outcome was return of spontaneous circulation (ROSC). The clinical characteristics of the patients were compared between the ROSC and non-ROSC groups. Survivors were also reviewed.

Results A total of 62 patients were reviewed, and 60 patients had experienced blunt injury. Thirty-nine patients had ROSC. The ROSC group had short cardiopulmonary resuscitation (CPR) time (6 [2–10] min vs 11 [8–12] min, $p < 0.001$), the presence of sign of life at the trauma bay [32 (86.5%) vs 7 (28.0%), $p < 0.001$], and a low Injury Severity Score [26 (25–39) vs 37 (30–75), $p = 0.038$] compared to the non-ROSC group. On multivariate analysis, only the presence of sign of life was significantly associated with ROSC [11.297 (1.496–85.309) OR (95% CI), $p = 0.019$]. The 24-h survival rate was 8.1%, and the successful discharge rate was 4.8%.

Conclusion The outcome of RT in a Korean trauma center was favorable. ROSC after RT was strongly associated with the presence of sign of life, and RT may be performed in the presence of sign of life regardless of prehospital CPR time.

Damage Control Resuscitation

DAMAGE CONTROL?

The term damage control comes from the US Navy and was described in the 1940s for control of battle damage to ships.

Rapid repairs to keep the ship afloat,

Return to port,

and finally definitive repairs.

“bloody vicious cycle” - unattended core **hypothermia** and persistent **metabolic acidosis** as key events promoting a lethal **coagulopathic state.**

Elerding SC, Aragon GE, Moore EE. Fatal hepatic hemorrhage after trauma. Am J Surg. 1979;138:883-888.

Kashuk JL, Moore EE, Millikan JS, Moore JB. Major abdominal vascular trauma-a unified approach. J Trauma. 1982;22:672-679.

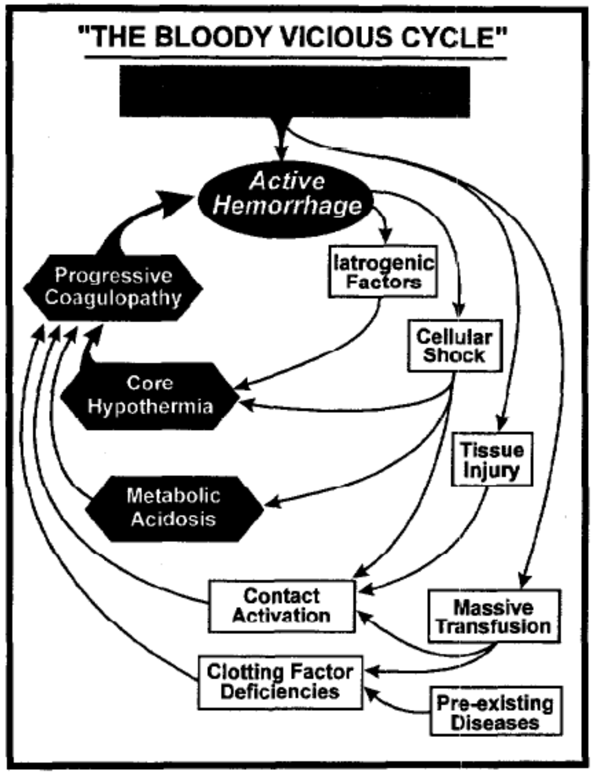


Figure 1. The pathogenesis of the bloody vicious cycle following major torso injury is multifactorial, but usually manifests as a triad of refractory coagulopathy, progressive hypothermia, and persistent metabolic acidosis.

Am J Surg. 1996;172:405-410.

In 1993, Rotondo et al.

0022-5282/93/3503-0375$03.00/0
THE JOURNAL OF TRAUMA

‘DAMAGE CONTROL’: A
IN EXSANGUINATING P

Michael F. Rotondo, MD, C. William Sch
Gordon R. Phillips, III, MD, Todd M. Fruc
and Peter A. Angood, MD

Definitive laparotomy (DL) for penetrating a
vascular and visceral injury is a difficult sur
derangements such as dilutional coagulopa
preclude completion of the procedure. “Dar
control of hemorrhage and contamination fo
rapid closure, allows for resuscitation to no
and subsequent definitive re-exploration. T
the damage control technique with definitiv
patients with penetrating abdominal injuries
transfusion of greater than 10 units packed
Medical records were retrospectively review
probability of survival, actual survival, trans
and postoperative phases, resuscitation an
temperature, pH, and HCO_3. No significant
and 24 DC patients and actual survival rate
However, in a subset of 22 patients with ma
visceral injuries (maximum injury subset), o
survival was markedly improved in patients
77%*) vs. DLM (1 of 9, 11%) (Fisher's exac
to the operating room, DC survivors averag
transfused and 10.3 units fresh frozen plasma over a mean ICU stay of 31.7 hours.
Resolution of coagulopathy (mean prothrombin time/partial thromboplastin time 19.5/70.4 to 13.3/34.9), normalization of acid-base balance (mean pH/HCO_3 7.37/20.6 to 7.42/24.2), and core rewarming (mean 33.2°C to 37.7°C) were achieved. All patients had gastrointestinal procedures at reoperation (mean operative time, 4.3 hours). We conclude that damage control is a promising approach for increased survival in exsanguinating patients with major vascular and multiple visceral penetrating abdominal injuries.

Table 6
Injury scoring and survivorship for patients with one or more major vascular injury and two or more visceral injuries—the maximum injury subset (n = 22)

	DLM (n = 9)	DCM (n = 13)
RTS	5.29 ± 2.8	6.22 ± 2.6
ISS	23.8 ± 10.8	22.9 ± 6.2
Ps	0.670 ± 0.396	0.810 ± 0.295
PATI	40.9 ± 12.4	43.6 ± 11.0
Actual Survival	1 (11%)	10 (77%)

Reported as mean ± standard deviation.
* Fisher's exact test, $p < 0.02$.

abdominal injury

Damage Control Surgery

DCS

Severely injured patients

Control **hemorrhage** and **contamination**

DCR

continued resuscitation and **aggressive correction** of their **coagulopathy, hypothermia, and acidosis in the ICU**

returning to the operating room

;definitive repair of their injuries

Damage Control Surgery = Only Staged Laparotomy?

Originally implemented for injured patients with " metabolic failure" or "physiologic exhaustion"(hypothermia, metabolic acidosis, coagulopathy), damage control surgery quickly became a technique used by multiple surgical specialties including the following : **general surgery, thoracic surgery, vascular surgery, orthopedic surgery, gynecologic surgery**, etc.

- Trauma 8th ed. -

Indication for Damage Control Surgery

TABLE 38-1 Patients Likely to Need Damage Control Operations

Thoracic trauma

- Penetrating thoracic wound and systolic blood pressure <90 mm Hg
- Pericardial fluid on surgeon-performed ultrasound after blunt or penetrating thoracic trauma
- S/p emergency department thoracotomy for penetrating thoracic wound

Abdominal or pelvic trauma

- Penetrating abdominal wound and systolic blood pressure <90 mm Hg
- Blunt abdominal trauma, systolic blood pressure <90 mm Hg, and peritoneal fluid on surgeon-performed ultrasound or gross blood on diagnostic peritoneal tap
- Closed pelvic fracture, systolic blood pressure <90 mm Hg, and peritoneal fluid on surgeon-performed ultrasound or gross blood on diagnostic peritoneal tap
- Open pelvic fracture

Trauma to an extremity

- Shotgun wound to femoral triangle of thigh
- Mangled extremity from blunt trauma

General

- Emergency laparotomy to be followed by emergent craniotomy for compressive lesion, emergent thoracotomy for repair of ruptured descending thoracic aorta, or therapeutic embolization of pelvic bleeder related to fracture

TABLE 38-3 Intraoperative Indications to Perform Damage Control Operations[49,69,74,75,77]

Factor	Level
1. Initial body temperature	<35°C (95.0°F)[69]
2. Initial acid–base status	
• Arterial pH	<7.2[69]
• Base deficit	<−15 mmol/L in patient <55 years of age[74,75] or <−6 mmol/L in patient >55 years of age[75,77]
• Serum lactate	>5 mmol/L[77]
3. Onset of coagulopathy	Prothrombin time and/or partial thromboplastin time >50% of normal[8,55]

Modified from Brasel KJ, Ku J, Baker CC, Rutherford EJ. Damage control in the critically ill and injured patient. *New Horizons*. 1999;7:73.

Thoracic Damage Control Surgery

- **Abdominal damage control surgery**
  - hemorrhage & immediate infection exposed by the GI tract

- **Thoracic damage control surgery**
  - exsanguination
  - space occupying and lung-compression events

=> **Arrest of hemorrhage and maintaining oxygenation by relieving intrathoracic positive pressures.**

Techniques of Thoracic Damage Control Surgery

- **Pulmonary hilum control**

(twisting or clamping pulmonary hilum)

- **Lung sparing technique**

(Pulmonary tractotomy, Pneumonorrhaphy, Wedge resection)

- **Intrathoracic Guaze Packing**

HILAR CONTROL

Fig. 3. *Manual control of right pulmonary hilum by primary surgeon.*

Fig. 4. *Lower lobe retraction and inferior pulmonary ligament division by first assistant.*

Fig. 5. *Hand-over-hand transfer of manual hilar control from first assistant back to primary surgeon, with preparation for hilar cross clamping by the primary surgeon.*

Fig. 6. *Noncrushing clamp securely across right pulmonary hilum.*

Timothy L, Van Natta , Brian R Smith, Scott D Bricker, Brant A Putnam. Hilar control in penetrating chest trauma: a simplified approach to an underutilized maneuver. J Trauma. 2009;66:1564 –1569.

PULMONARY HILUM TWIST

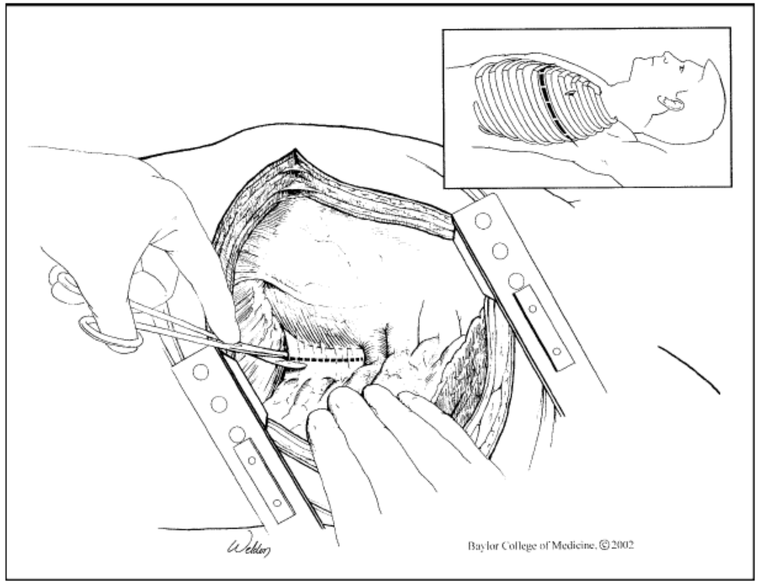


Fig. 1. Sharply divide the inferior pulmonary ligament. The ligament should be divided to the level of the inferior pulmonary vein.

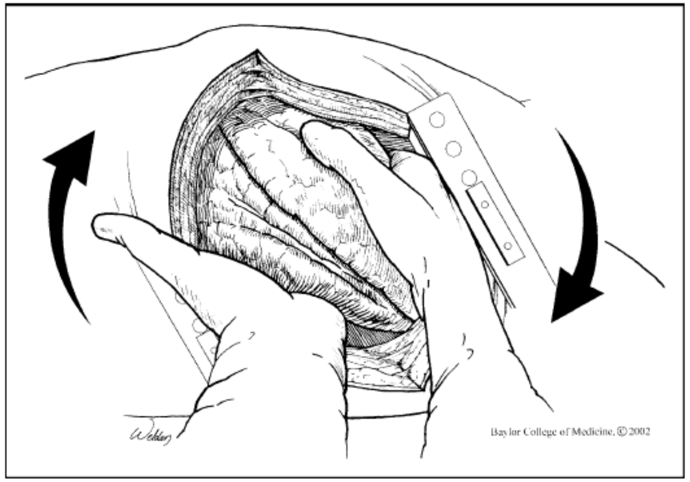


Fig. 2. Place one hand on the anterior aspect of the upper lobe and the other hand on the posterior aspect of the lower lobe. Rotate the lower lobe anteriorly and the upper lobe posteriorly 180 degrees.

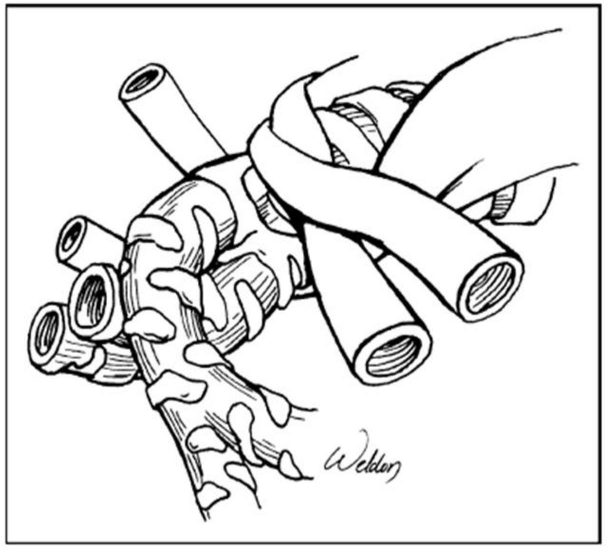
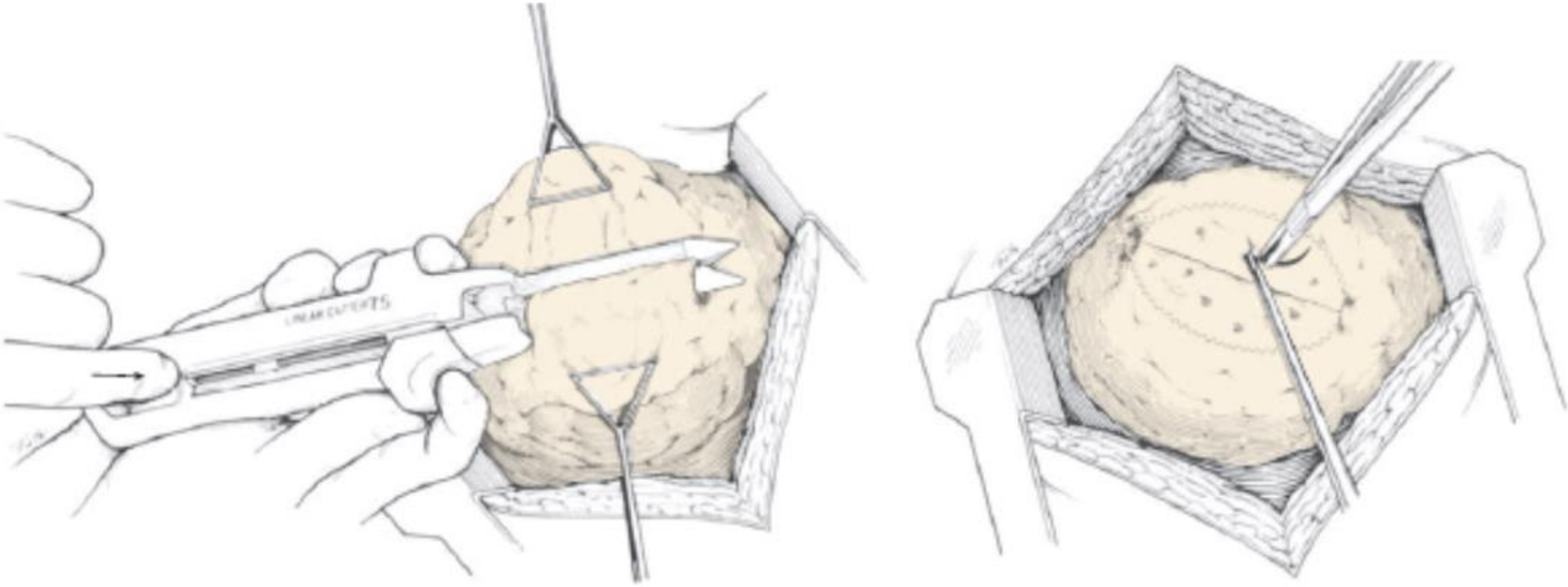


Fig. 4. The vascular structures will be twisted around the bronchus with effective occlusion.

Wilson A, Wall MJ Jr, Maxson R, Mattox K. The pulmonary hilum twist as a thoracic damage control procedure. Am J Surg. 2003 Jul;186(1):49-52.

Lung Sparing Technique

Stapled pulmonary tractotomy



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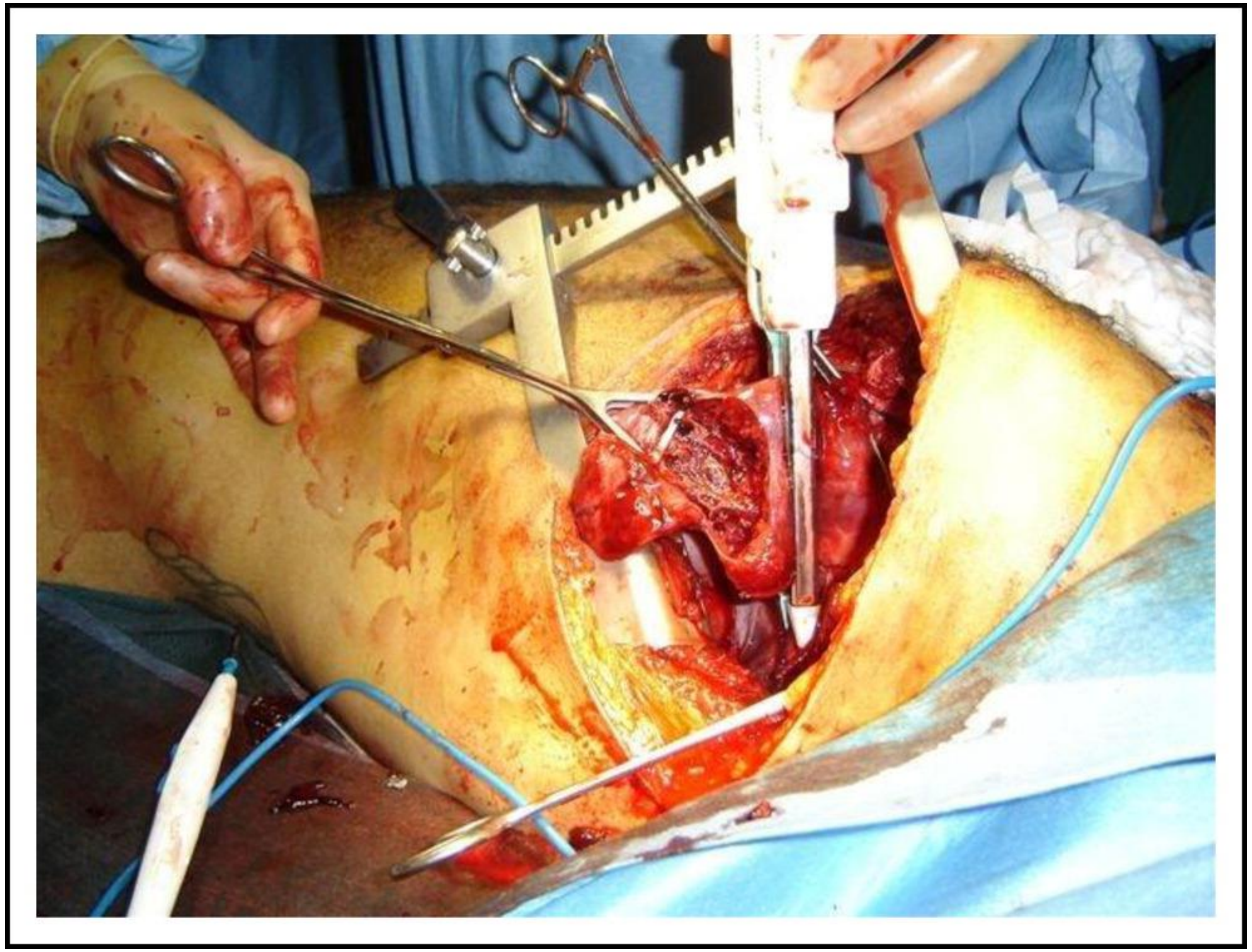
Wedge resection



Intrathoracic Guaze Packing

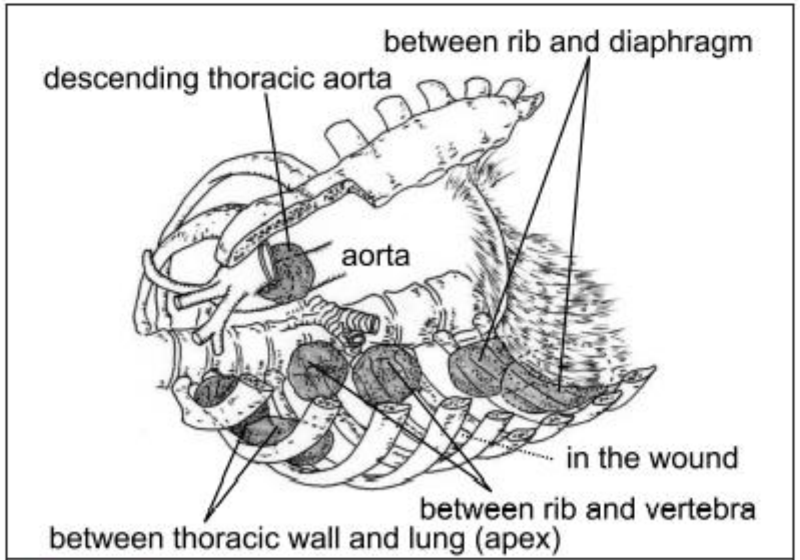


Figure 1 Schema of the packing site in the thoracic cavities of the six successful cases

- Intrathoracic packing may be effective in particular locations in the thoracic cavity such as the space enclosed between bones, around vertebrae, at the lung apex, and between the diaphragm and thoracic wall.
- It is advisable to wait for at least three hours after packing if the vital signs of the patient can be maintained with appropriate blood transfusion.
- The physician should continue to wait if the volume of the thoracic tube discharge decreases to <200ml/hr within 4 or 5 hours.
- 96–120 hours is an acceptable duration in terms of the risk of infection.
- Packed gauze should be removed within three or four days.

Y Moriwaki, H Toyoda, N Harunari, M Iwashita, T Kosuge, S Arata, N Suzuki
Gauze packing as damage control for uncontrollable haemorrhage in severe thoracic Trauma.
Ann R Coll Surg Engl 2013; 95: 20–25

THANK YOU FOR YOUR ATTENTION