Damage Control Resuscitation

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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.

HISTROY

- **Idea originated from major hepatic trauma.**

Pringle JH. **V. Notes on the Arrest of Hepatic Hemorrhage Due to Trauma.** Ann Surg. 1908 Oct;48(4):541-9.

NOTES ON THE ARREST OF HEPATIC HEMORRHAGE DUE TO TRAUMA.

BY J. HOGARTH PRINGLE, F.R.C.S.,

OF GLASGOW,

Lecturer on Surgery in Queen Margaret College, Surgeon to the Glasgow Royal Infirmary.

RUPTURE of the liver is fortunately an accident not often met with, but one which, when it is seen, may be associated with a condition of the patient as serious as any one can meet with in surgical practice. While small lacerations of the liver substance may be, and, no doubt are, recovered from without surgical interference; if the laceration be extensive and vessels of any magnitude are torn, hemorrhage will, owing to the structural arrangement of the liver, go on continuously, and by the time such a patient comes under the care of a surgeon the general state is almost invariably bound to be extremely grave, from the hemorrhage alone or from hemorrhage and shock combined, and this is perhaps specially the case in that class of injury due to contusing violence in which there is often gross injury inflicted on parts other than the liver and when shock is liable to be more severe than in localized injuries caused by sharp instruments.

Lethal Triad

"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.

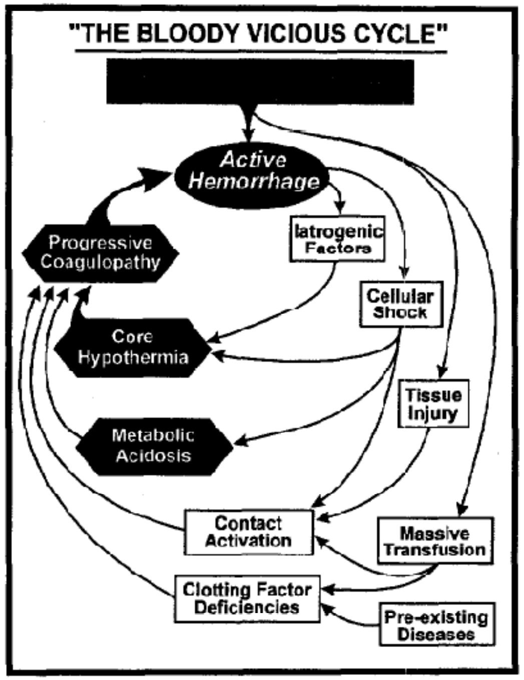


Figure 1. The pathogenesis of the bloody vicious cycle following major torso injury is multifactorial, but usually manifests as a triad of refractory coagulopathy, progressive hypothermia, and persistent metabolic acidosis.

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

Management of the Major Coagulopathy with Onset during Laparotomy

H. HARLAN STONE, M.D., PRISCILLA R. STROM, M.D., RICHARD J. MULLINS, M.D.

From the Department of Surgery, Emory University School of Medicine, Atlanta, Georgia

An experience with 31 patients who developed major bleeding diatheses during laparotomy was reviewed. Management of the initial 14 patients was by standard hematologic replacement, completion of all facets of operation, and then closure of the peritoneal cavity, usually with suction drainage; only one patient survived.

The subsequent 17 patients had laparotomy terminated as rapidly as possible to avoid additional bleeding. Major vessel

The bleeding diathesis was controlled in only two

This technique of initial abortion of laparotomy, establishment of intra-abdominal pack tamponade, and then completion of the surgical procedure once coagulation has returned to an acceptable level has proven to be lifesaving in previously nonsalvageable situations.

Throughout the centuries of recorded medicine, direct pressure has been the most reliable means of gaining

wound in a patient whose blood will not clot and cannot be made to clot. By far the most extreme example is a bleeding diathesis complicating laparotomy. This event is an all-too-common occurrence in the patient who has sustained a major intraabdominal injury or who has a disease process or operation which has been attended by a massive hemorrhage. The coagulopathy can seldom be reversed satisfactorily. Thus, the usual outcome is continued bleeding and thereby death through exsanguination.

Presented at the Ninety-Fourth Annual Meeting of the Southern Surgical Association, December 6–8, 1982, Palm Beach, Florida.

Reprint requests: H. Harlan Stone, M.D., Department of Surgery, University of Maryland Hospital, 22 South Greene Street, Baltimore, Maryland 21201.

Submitted for publication: January 3, 1983.

Between July 1, 1976, and June 30, 1982, a major coagulopathy developed during laparotomy in 31 patients on the Trauma Surgical Service at Grady Memorial Hospital. During the first three years of review, 14 patients were managed by standard procedures directed toward reversal of the bleeding diathesis plus completion of all details in the operative procedure. In the ensuing three years, once a coagulopathy was noted in the following 17 patients, operation was immediately aborted, abdominal tamponade was effected through packing and closure under tension, and later, reexploration was performed, once the patient's blood adequately clotted, to complete the initial operative procedure.

Patient ages ranged from 17 to 67 years, with an average of 28 years. There were 22 blacks and nine whites, 25 men and six women.

0003-4932/83/0500/0532 $01.00 © J. B. Lippincott Company

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 reviev
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), c
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

Trauma Induced Coagulopathy(TIC)

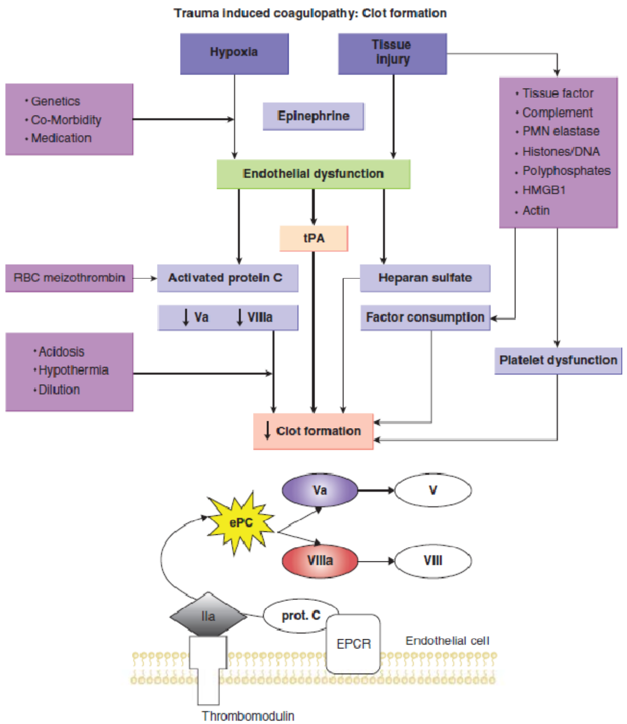


FIGURE 13-3 Ineffective clot formation is the dominant manifestation of TIC. Hypoxia and tissue injury provoke endothelial dysfunctions which activates protein C and releases anticoagulants from the glycocalyx. Platelet dysfunction, factor consumption, and acidosis further impair thrombin generations and clot formation.

HYPOTHERMIA

- The effects of hypothermia include altered platelet function, impaired coagulation factor function, enzyme inhibition and fibrinolysis.
- **1 °C drop** in temperature is associated with a **10% drop in function**
- Hypothermia **below 34 °C** inhibits the initiation phase of clotting.
- Most of the coagulation enzymes are **slowed** by hypothermia.
- **While moderate hypothermia delays the onset of thrombin generation, the total amount of thrombin generation is unaffected.**

ACIDOSIS

- A reduction of pH from 7.4 to 7.0 has been shown in vitro to reduce
- **FVIIa activity by 90%,**
- **prothrombin complex (Xa/Va) activity by 70%**
- **FVIIa-TF complex activity by 55%.**

- **pH 7.1** -> a pronounced inhibition of the propagation phase of thrombin generation

-> **clot strength ↓ & fibrinogen degradation two-fold ↑**

- **pH <7 -> impaired platelet aggregation and adhesion**

-> the correction of pH with bicarbonate or trishydroxymethylaminomethane (THAM) does not restore platelet function.

Damage Control Resuscitation

Damage Control Resuscitation
Minimize crystalloids during early resuscitation
Permissive hypotension (palpable pulse or SBP~90 mmHg)
Transfusion of blood products in ratios similar to whole blood (1:1:1)

Figure 1. The 3 tenants of damage control resuscitation.

+

Damage Control Surgery(immediate control of hemorrhage)

Large volume crystalloid resuscitation

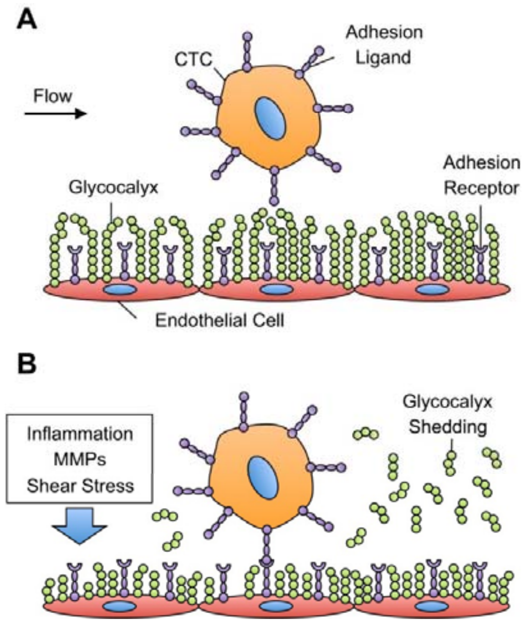
- Macrophage release of tumor necrosis factor ά↑↑ & proinflammatory cytokines ↑↑

⇒ **Capillary leak ↑↑**

⇒ **endothelial glycocalyx thinning ↑↑ =>** third space fluid losses and intravascular volume depletion.

- Pulmonary edema, cardiac dysfunction, bowel edema

- Dilusional coagulopathy



HEMODILUTION

- Overzealous crystalloid resuscitation can exaggerate an existing coagulopathy.

- Interestingly, acute hemodilution to 50% in vitro does not impair clot formation, but this magnitude of hemodilution **enhances the sensitivity to tPA** due to the dilution of endogenous antifibrinolytics.

PERMISSIVE HYPOTENSION

- become hemostatic on their own as become more hypotensive
- **clot disrupted by the increased pressure**

Table 1 Relationship of Punch Size with Initial Hemorrhage Volume

Punch size (mm)	All pigs including non resuscitated		No NE		NE	
	Hem. Vol. (ml/kg)	n	Rebleed MAP (mmHg)	n	Rebleed MAP (mm Hg)	n
1.5	10.5 ± 1.1*	14	62 ± 5	9	126 ± 13	3
2.0	16.6 ± 0.8	38	66 ± 3	20	134 ± 8	12
2.8	19.3 ± 1.4	10	61 ± 5	9	(none)	

NE, norepinephrine.

made by Cannon from WWI and Beecher from WWII. Therefore, we recommend that patients without definitive hemorrhage control should not be resuscitated beyond a MAP of 60 mm Hg or a systolic pressure of 80–90 mm Hg.

J Trauma. 2003;54:S110 –S117

The New England
Journal of Medicine

Volume 331 OCTOBER 27, 1994 Number 17

IMMEDIATE VERSUS DELAYED FLUID RESUSCITATION FOR HYPOTENSIVE PATIENTS WITH PENETRATING TORSO INJURIES

William H. Bickell, M.D., Matthew J. Wall, Jr., M.D., Paul E. Pepe, M.D., R. Russell Martin, M.D., Victoria F. Ginger, M.S.N., Mary K. Allen, B.A., and Kenneth L. Mattox, M.D.

Methods. We conducted a prospective trial comparing immediate and delayed fluid resuscitation in 598 adults with penetrating torso injuries who presented with a prehospital systolic blood pressure ≤90 mm Hg. The study setting was a city with a single centralized system of prehospital emergency care and a single receiving facility for patients with major trauma. Patients assigned to the im-

Table 2. Systemic Arterial Blood Pressure and Laboratory Findings on Arrival at the Trauma Center in Patients with Penetrating Torso Injuries, According to Treatment Group.*

Variable	Immediate Resuscitation (N = 309)	Delayed Resuscitation (N = 289)	P Value
Systolic blood pressure (mm Hg)	79±46	72±43	0.02
Hemoglobin (g/dl)	11.2±2.6	12.9±2.2	<0.001
Platelet count (×10⁻³/mm³)	274±84	297±88	0.004
Prothrombin time (sec)	14.1±16	11.4±1.8	<0.001
Partial-thromboplastin time (sec)	31.8±19.3	27.5±12	0.007
Systemic arterial pH	7.29±0.17	7.28±0.15	0.46
Serum bicarbonate concentration (mmol/liter)	20±10	20±11	0.82

*Plus–minus values are means ±SD. To convert values for hemoglobin to millimoles per liter, multiply by 0.62.

Table 4. Total Volumes of Fluids Administered to Patients with Penetrating Torso Injuries, According to Treatment Group.*

Variable	Immediate Resuscitation (N = 309)	Delayed Resuscitation (N = 289)	P Value
Before arrival at the hospital			
Ringer's acetate (ml)	870±667	92±309	<0.001
Trauma center			
Ringer's acetate (ml)	1608±1201	283±722	<0.001
Packed red cells (ml)	133±393	11±88	<0.001
Operating room†			
Ringer's acetate (ml)	6772±4688	6529±4863	0.31
Packed red cells (ml)	1942±2322	1713±2313	0.07
Fresh-frozen plasma or platelet packs (ml)	357±1002	307±704	0.45
Autologous-transfusion volume (ml)	95±486	111±690	0.76
Hetastarch (ml)	499±717	542±696	0.41
Rate of intraoperative fluid administration (ml/min)	117±126	91±88	0.008

*Plus–minus values are means ±SD.

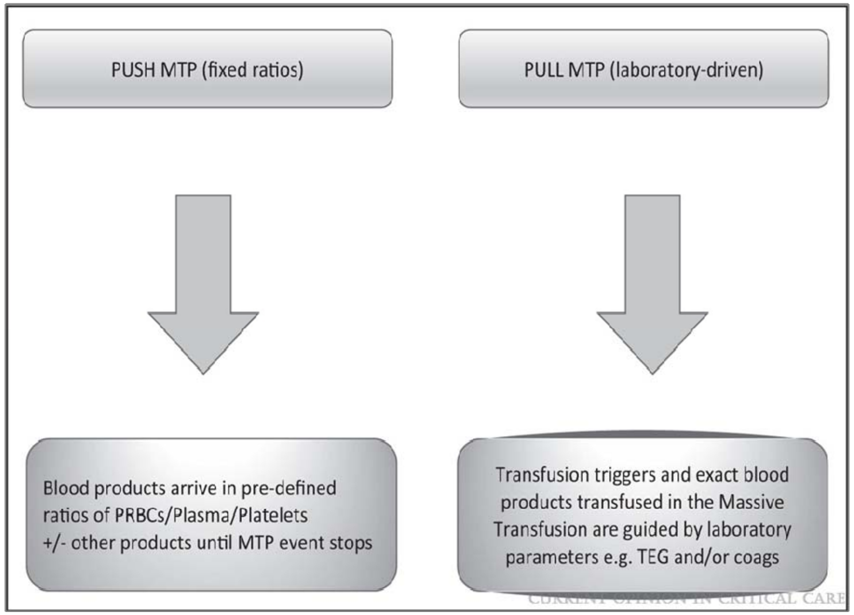
†For these analyses there were 268 patients in the immediate-resuscitation group and 260 patients in the delayed-resuscitation group.

Table 5. Outcome of Patients with Penetrating Torso Injuries, According to Treatment Group.

Variable	Immediate Resuscitation	Delayed Resuscitation	P Value
Survival to discharge — no. of patients/total patients (%)	193/309 (62)*	203/289 (70)†	0.04
Estimated intraoperative blood loss — ml‡	3127±4937	2555±3546	0.11
Length of hospital stay — days§	14±24	11±19	0.006
Length of ICU stay — days§	8±16	7±11	0.30

Massive Transfusion Protocols

- The development and implementation of massive transfusion protocols (MTPs) have been associated with a reduction in mortality and overall blood product use in trauma centers.
- **The optimal goal is early communication to the blood bank of the urgent need of a large volume of blood products**.
- The content of MT protocols should be based on the principles of damage control resuscitation.
- As such, they should provide for ratio-based blood products that are empirically delivered (hemostatic resuscitation) and have a process for the immediate availability of RBC, plasma, and platelets.
- Protocols should also include standardization of the assessment of coagulopathy and include assessment and treatment of acidosis, hypothermia, and hypocalcemia.



ONLINE FIRST

The Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) Study

Objective: To relate in-hospital mortality to early transfusion of plasma and/or platelets and to time-varying plasma:red blood cell (RBC) and platelet:RBC ratios.

Design: Prospective cohort study documenting the timing of transfusions during active resuscitation and patient outcomes. Data were analyzed using time-dependent proportional hazards models.

Setting: Ten US level I trauma centers.

Patients: Adult trauma patients surviving for 30 minutes after admission who received a transfusion of at least 1 unit of RBCs within 6 hours of admission (n=1245, the original study group) and at least 3 total units (of RBCs, plasma, or platelets) within 24 hours (n=905, the analysis group).

Main Outcome Measure: In-hospital mortality.

Results: Plasma:RBC and platelet:RBC ratios were not constant during the first 24 hours ($P < .001$ for both). In a multivariable time-dependent Cox model, increased ratios of plasma:RBCs (adjusted hazard ratio=0.31; 95% CI, 0.16-0.58) and platelets:RBCs (adjusted hazard ratio=0.55; 95% CI, 0.31-0.98) were independently associated with decreased 6-hour mortality, when hemorrhagic death predominated. In the first 6 hours, patients with ratios less than 1:2 were 3 to 4 times more likely to die than patients with ratios of 1:1 or higher. After 24 hours, plasma and platelet ratios were unassociated with mortality, when competing risks from non-hemorrhagic causes prevailed.

Conclusions: Higher plasma and platelet ratios early in resuscitation were associated with decreased mortality in patients who received transfusions of at least 3 units of blood products during the first 24 hours after admission. Among survivors at 24 hours, the subsequent risk of death by day 30 was not associated with plasma or platelet ratios.

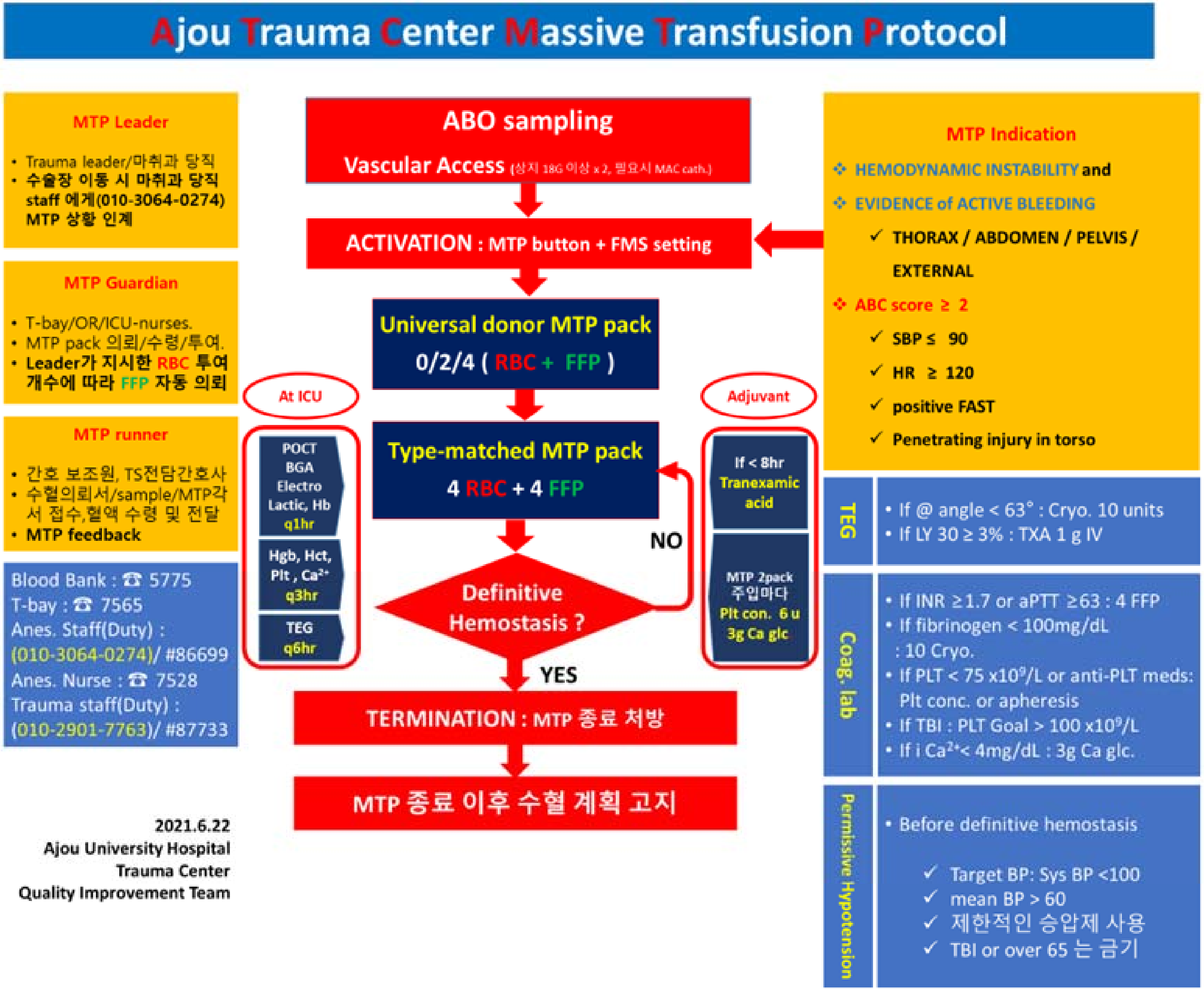
JAMA Surg. 2013;148(2):127-136. Published online October 15, 2012. doi:10.1001/2013.jamasurg.387

Original Investigation

Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma
The PROPPR Randomized Clinical Trial

John B. Holcomb, MD; Barbara C. Tilley, PhD; Sarah Baraniuk, PhD; Erin E. Fox, PhD; Charles E. Wade, PhD; Jeanette M. Podbielski, RN; Deborah J. del Junco, PhD; Karen J. Brasel, MD, MPH; Eileen M. Bulger, MD; Rachael A. Callcut, MD, MSPH; Mitchell Jay Cohen, MD; Bryan A. Cotton, MD, MPH; Timothy C. Fabian, MD; Kenji Inaba, MD; Jeffrey D. Kerby, MD, PhD; Peter Muskat, MD; Terence O'Keeffe, MBChB, MSPH; Sandro Rizoli, MD, PhD; Bryce R. H. Robinson, MD; Thomas M. Scalea, MD; Martin A. Schreiber, MS; Deborah M. Stein, MD; Jordan A. Weinberg, MD; Jeannie L. Callum, MD; John R. Hess, MD, MPH; Nena Matijevic, PhD; Christopher N. Miller, MD; Jean-Francois Pittet, MD; David B. Hoyt, MD; Gail D. Pearson, MD, ScD; Brian Leroux, PhD; Gerald van Belle, PhD; for the PROPPR Study Group

	1:1:1	1:1:2	
Mortality at 24 hours	12.7%	17%	P=0.12
Mortality at 30 days	22.4%	26.1%	P=.26
Exsanguination	9.2%	14.6%	P=0.03*
Hemostasis achieved	86%	78%	p=0.006*


Ajou Trauma Center Massive Transfusion Protocol
MTP Leader
• Trauma leader/마취과 당직
• 수술장 이동 시 마취과 당직 staff 에게(010-3064-0274) MTP 상황 인계
MTP Guardian
• T-bay/OR/ICU-nurses.
• MTP pack 의뢰/수령/투여.
• Leader가 지시한 RBC 투여 개수에 따라 FFP 자동 의뢰
MTP runner
• 간호 보조원, TS전담간호사
• 수혈의뢰서/sample/MTP각서 접수,혈액 수령 및 전달
• MTP feedback
Blood Bank : ☎ 5775
T-bay : ☎ 7565
Anes. Staff(Duty) :
(010-3064-0274)/ #86699
Anes. Nurse : ☎ 7528
Trauma staff(Duty) :
(010-2901-7763)/ #87733
ABO sampling
Vascular Access (상지 18G 이상 x 2, 필요시 MAC cath.)
ACTIVATION : MTP button + FMS setting
Universal donor MTP pack
0/2/4 (RBC + FFP)
At ICU
POCT BGA Electro Lactic, Hb q1hr
Hgb, Hct, Plt , Ca2+ q3hr
TEG q6hr
Type-matched MTP pack
4 RBC + 4 FFP
Definitive Hemostasis ?
NO
YES
Adjuvant
If < 8hr Tranexamic acid
MTP 2pack 주입마다 Plt con. 6 u 3g Ca glc
TERMINATION : MTP 종료 처방
MTP 종료 이후 수혈 계획 고지
MTP Indication
❖ HEMODYNAMIC INSTABILITY and
❖ EVIDENCE of ACTIVE BLEEDING
✓ THORAX / ABDOMEN / PELVIS / EXTERNAL
❖ ABC score ≥ 2
✓ SBP ≤ 90
✓ HR ≥ 120
✓ positive FAST
✓ Penetrating injury in torso
TEG
• If @ angle < 63° : Cryo. 10 units
• If LY 30 ≥ 3% : TXA 1 g IV
Coag. lab
• If INR ≥1.7 or aPTT ≥63 : 4 FFP
• If fibrinogen < 100mg/dL : 10 Cryo.
• If PLT < 75 x10⁹/L or anti-PLT meds: Plt conc. or apheresis
• If TBI : PLT Goal > 100 x10⁹/L
• If i Ca2+< 4mg/dL : 3g Ca glc.
Permissive Hypotension
• Before definitive hemostasis
✓ Target BP: Sys BP <100
✓ mean BP > 60
✓ 제한적인 승압제 사용
✓ TBI or over 65 는 금기
2021.6.22
Ajou University Hospital
Trauma Center
Quality Improvement Team

Damage Control Surgery

DCS

Severely injured patients

↓

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

DCR

↓

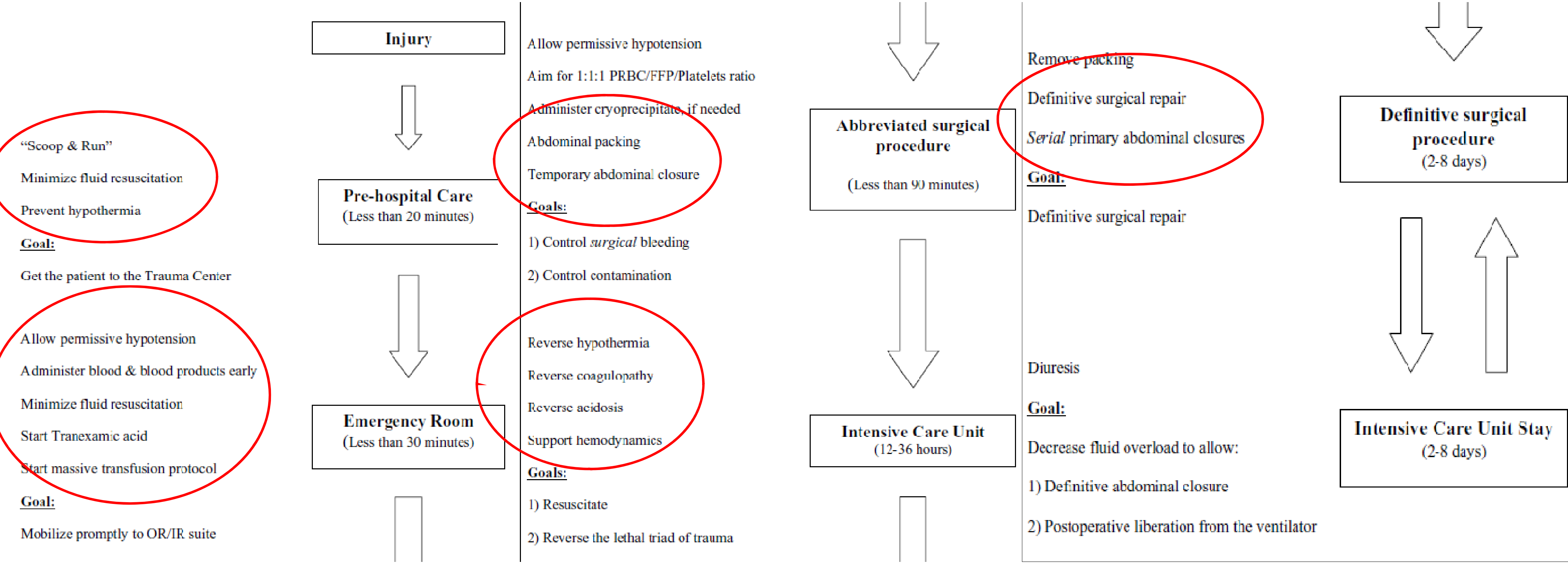
continued resuscitation and **aggressive correction** of their **coagulopathy, hypothermia, and acidosis in the ICU**

↓

returning to the operating room

;definitive repair of their injuries

Damage Control Resuscitation



Scandinavian Journal of Surgery 103: 81–88, 2014

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

OBJECTIVES

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DISCUSSION

We found no published or pending randomised controlled trials that compared DCS with immediate and definitive repair in patients with major abdominal trauma for inclusion in this review.

Most of the current information relating to DCS comes from case studies (Colombo 2005; Kudera 2004) and observational studies (Bach 2008; Cotton 2008; Feliciano 1988; Hirshberg 1994; Rotondo 1993; Saifi 1990; Sharp 1992).

In light of the paucity of studies, evidence that supports efficacy of DCS compared to immediate, traditional laparotomy is limited. Good quality randomised controlled trials comparing DCS and

Indication for Damage Control

Staged Laparotomy for the Hypothermia, Acidosis, and Coagulopathy Syndrome

Ernest E. Moore, MD, *Denver, Colorado*

The recent history, indications, physiologic objectives, and technical aspects of staged laparotomy are discussd in this overview. While postinjury refractory coagulopathy is the most common scenario for this life-saving concept, there are many other potential applications during both emergency and elective procedures in the neck, chest, pelvis, and extremities as well as the abdomen. © *1996 by Excerpta Medica, Inc. Am J Surg.* 1996;172:405–410.

"disasterous hemorrhage, abscesses, and hepatic necrosis" coupled with increasing success at direct operative control of hepatic bleeding led Madding and Kennedy[4] to censor packing during World War II. This military doctrine prevailed throughout the Korean and Vietnam conflicts, and extended to civilian practice as reflected in the statement of a recognized authority in liver trauma that "there is virtually no place in modern surgery for gauze packing of the liver as sepsis and recurrent bleeding are almost inevitable sequelae" (*Annals of the Royal College of Surgical Engineers,*

1) **inability to achieve hemostasis** due to a recalcitrant coagulopathy, ie, the bloody vicious cycle

(2) **inaccessible major venous injury**, eg, retrohepatic vena caval disruption

(3) **anticipated need for a time-consuming procedure**, eg, pancreaticoduodenectomy, in the patient with a suboptimal response to resuscitation

(4) **Demand for nonoperative control of extra-abdominal life-threatening injury**, eg, ruptured pelvic fracture hematoma requiring selective arterial embolization;

(5) **Inability to approximate the abdominal incision due to extensive splanchnic reperfusion induced visceral edema**, eg, following protracted shock requiring massive fluid administration;

(6) **desire to reassess abdominal contents**, eg, compromised intestinal blood supply due to extensive mesenteric wound.

Degree of physiologic insult in the pre- or intraoperative setting
Persistent systolic BP <90 mm Hg or a successfully resuscitated cardiac arrest during transport to hospital
Persistent systolic BP <90 mm Hg in the preoperative setting or during operation
Preoperative core body temperature <34°C, arterial pH <7.2, or INR/PT >1.5 times normal (with or without a concomitant PTT >1.5 times normal)
Core body temperature <34°C and arterial pH <7.2 at the beginning of operation
Persistent core body temperature <34°C or persistent arterial pH <7.2 during operation
INR/PT and PTT >1.5 times normal during operation
Clinically observed coagulopathy during operation
Core body temperature <34°, arterial pH <7.2, and laboratory-confirmed (INR/PT and/or PTT >1.5 times normal) or clinically observed coagulopathy in the preoperative setting, at the beginning of operation, or during the conduct of operation

Estimated blood loss and amount or type of resuscitation provided

Estimated blood loss >4 L in the operating room

>10 units of PRBCs were administered to the patient in the preoperative or preoperative and intraoperative settings

Injury pattern identified during operation

An expanding and difficult-to-access pelvic hematoma

A juxtahepatic venous injury

An abdominal vascular injury and at least one major associated abdominal solid or hollow organ injury

A proximal (ie, Fullen zone I or II) superior mesenteric artery injury

Devascularization or destruction of the pancreas, duodenum, or pancreaticoduodenal complex with involvement of the ampulla/proximal pancreatic duct and/or distal CBD

Multiple blunt or penetrating injuries spanning across more than one anatomic region or body cavity that each require surgery with or without angioembolization

No Definite Selection Criteria

- Too Liberal -> Unnecessary staged operation -> complication ↑
- Too Strict -> Adverse physiological outcome -> Too late to salvage

Impact of Closure at the First Take Back
Burden and Potential Overutilization
Control Laparotomy

Quinton M. Hatch, MD, Lisa M. Osterhout, BS, Jeanette Podbielski, BSN,
Charles E. Wade, PhD, John B. Holcomb, MD, and Bryan A.

Background: Damage control laparotomy (DCL) is a lifesaving technique initially employed to minimize the lethal triad of coagulopathy, hypothermia,

admission.

Conclusion: Early fascial closure is an independent predictor of reduced complications in DCL patients. One in five patients closed at initial take back did not meet any of the traditional indications for DCL upon initial ICU admission. This may represent an overutilization of this valuable technique, exposing patients to increased complications. Further efforts should be directed at achieving bot appropriate indications fo

Key Words: Trauma, La failure.

uma. 2011;71: 1503

TABLE 3. Logistic Regression Model Predicting the Development of Abdominal Infections (Intra-Abdominal Abscess, Retroperitoneal Abscess, and Pelvic Abscess)

	Odds Ratio	95% Confidence Interval	p
Age, yr	1.00	0.98–1.03	0.461
Male gender	1.06	0.46–2.40	0.891
ISS	0.97	0.95–1.00	0.061
Large bowel injury	1.88	0.96–3.67	0.063
Intraoperative transfusions, units	0.99	0.97–1.02	0.975
Closed at initial take back	0.28	0.12–0.66	0.004*

* Statistical significance at $p < 0.05$.

Management of changed marke Surgery, followi ndo et al.[1,2] Bef al closure were rdless of the pa , however, ten sed popularity a auma continues ection of physic age control lapa revent (or at lea coagulopathy, nt. During the i is performed a rol of contamin ormal physiolog porary abdomin nd-look operati partment syndro s at the next o increasing knowled in the resuscitation employed quite freq

Several authors DCL is employed fo tients.[1,16,17] Furtherm ing the sequelae of D in mortality when c been postulated tha improved intensive experience with the many new techniqu are being overutiliz

Although the may be an accepta

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From the Department of Surgery and The Center for Translational Injury Research, The University of Texas Health Science Center, Houston, Texas.
Presented in oral form at the 41st Annual Meeting of the Western Trauma Association, February 27-March 5, 2011, Big Sky, Montana.
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DOI: 10.1097/TA.0b013e31823cd78d

TABLE 4. Logistic Regression Model Predicting the Development of Noninfectious Abdominal Complications (Ileus, Bowel Obstruction, Ischemic Bowel, and Anastomotic Breakdown)

	Odds Ratio	95% Confidence Interval	p
Age, yr	0.99	0.97–1.02	0.867
Male gender	1.68	0.67–4.22	0.266
ISS	0.96	0.93–0.98	0.006*
Large bowel injury	1.27	0.63–2.53	0.493
Intraoperative transfusions, units	1.00	0.97–1.03	0.760
Closed at initial take back	0.23	0.09–0.56	0.001*

* Statistical significance at $p < 0.05$.

TABLE 5. Logistic Regression Model Predicting the Development of Abdominal Wound Complications (Surgical Site Infection, Incisional Hernia, and Dehiscence)

	Odds Ratio	95% Confidence Interval	p
Age, yr	0.98	0.96–1.01	0.281
Male gender	0.62	0.28–1.33	0.219
ISS	0.98	0.96–1.01	0.362
Large bowel injury	1.87	0.96–3.66	0.065
Intraoperative transfusions, units	0.99	0.97–1.02	0.848
Closed at initial take back	0.31	0.13–0.72	0.007*

* Statistical significance at $p < 0.05$.

TABLE 6. Logistic Regression Model Predicting the Development of Pulmonary Complications (Ventilator-Dependent Respiratory Failure, Ventilator-Associated Pneumonia, and Empyema)

	Odds Ratio	95% Confidence Interval	p
Age, yr	1.01	0.99–1.02	0.282
Male gender	1.05	0.54–2.04	0.870
Chest AIS	1.20	1.03–1.40	0.014*
Urgent thoracotomy/sternotomy	1.38	0.57–3.31	0.473
Intraoperative transfusions, units	0.97	0.91–1.04	0.484
Closed at initial take back	0.35	0.20–0.62	<0.001*

* Statistical significance at $p < 0.05$.

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Morbidity.

Morbidity	DEF (n = 16)	pDEF (n = 16)	p value
Abdominal Complications			
Major abdominal complication or death	3 (19%)	9 (56%)	0.066
Enteric suture line failure	1/6 (17%)	4/9 (44%)	0.580
Fascial dehiscence	0 (0%)	6 (38%)	0.018
Organ/space SSI	3 (19%)	9 (56%)	0.066
Reopened	0 (0%)	6 (38%)	0.018
Death	0 (0%)	0 (0%)	–
Superficial SSI	0/15 (0%)	4/8 (50%)	0.008
Ileus	7 (44%)	7 (44%)	1.000
GI bleed	0 (0%)	2 (13%)	0.484
Non-Abdominal Complications			
Pulmonary embolus	0 (0%)	3 (19%)	0.226
Deep vein thrombosis	0 (0%)	2 (13%)	0.484
Pneumonia	2 (13%)	6 (38%)	0.102
Urinary tract infection	3 (19%)	3 (19%)	1.000
Sepsis	3 (19%)	10 (63%)	0.029
Acute renal failure	1 (6%)	7 (44%)	0.037

DEF- definitive laparotomy; pDEF – potentially safe for definitive laparotomy; SSI – surgical site infection; GI – gastrointestinal.

The effect of (complications

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A R T I C L E I N F

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12 September 2017
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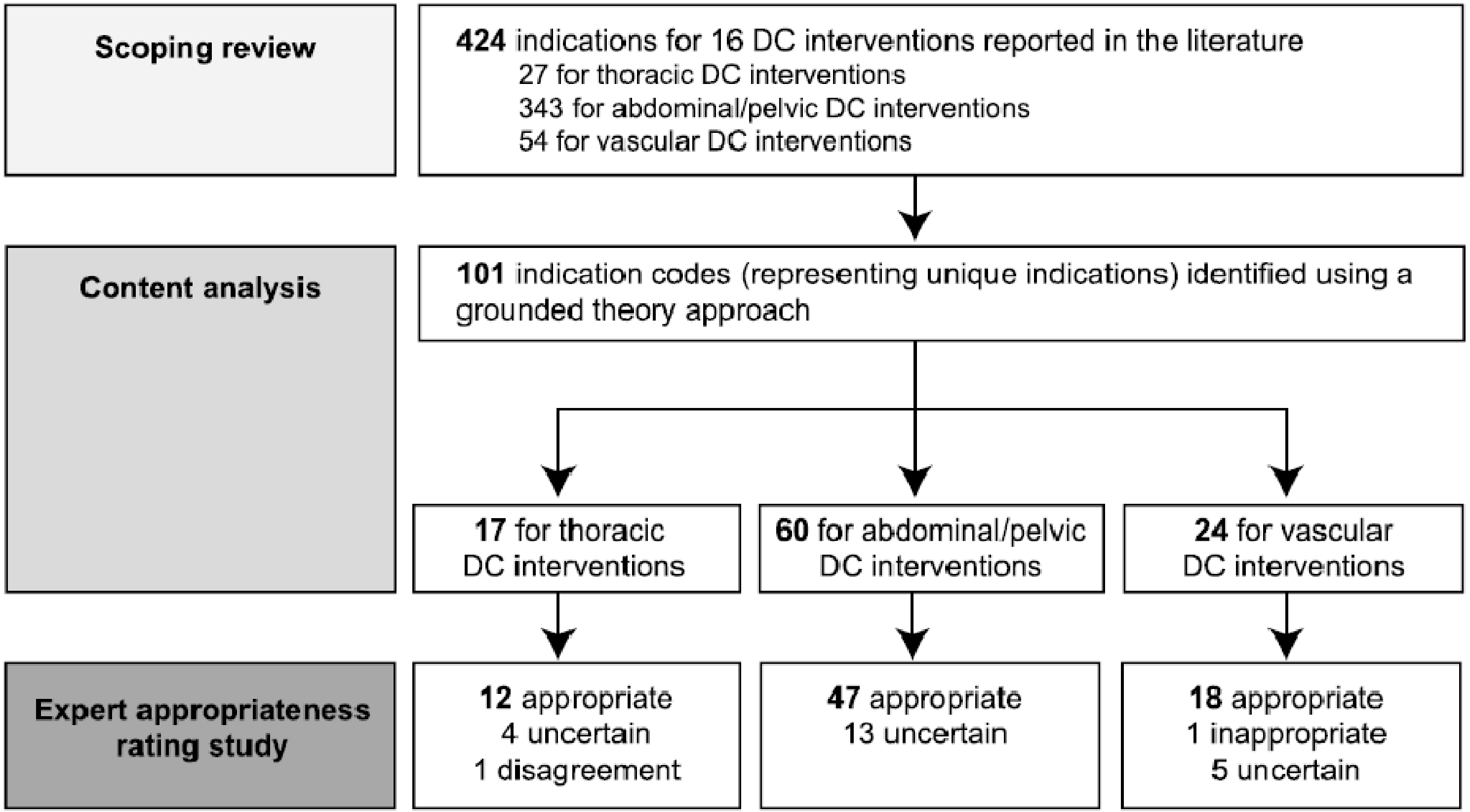
Keywords:
Damage control laparotomy
Definitive laparotomy
Morbidity
Mortality
Trauma

...sociated with increased ...t of DCL on abdominal ...vho were prospectively ...or pDEF) and those who

...sm of injury, abdominal ...n. The primary outcome

...dominal complications, ... likely to have a fascial dehiscence (38% versus 0%, p = 0.018), and to be re-opened after fascial closure (38% versus 0%, p = 0.018).

Conclusion: Damage control laparotomy was associated with clinically but not statistically significant increase in rates of MAC. Increased numbers of patients to analyze in this fashion is needed.



packing (n = 5); balloon catheter tamponade (n = 6); and temporary intravascular shunting (n = 11).

CONCLUSION: This study identified a list of candidate appropriate indications for use of 12 different DC interventions that were suggested by authors of peer-reviewed articles and assessed by a panel of independent experts to be appropriate. These indications may be used to focus future research and (in the interim) guide surgical practice while studies are conducted to evaluate their impact on patient outcomes. (*J Trauma Acute Care Surg*. 2015;79: 568–579. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.)

KEY WORDS: Content analysis; damage control surgery; expert appropriateness rating study; indications; wounds and injuries.

Indication(s) for
Thoracic DC interventions in patients undergoing thoracotomy
Rapid lung-sparing surgery (pneumonorrhaphy, pulmonary tractotomy, and pulmonary wedge resection)
Whenever possible when an emergent thoracotomy is required for thoracic trauma
Pulmonary tractotomy
Through-and-through pulmonary parenchymal injuries that do not involve the hilar structures
Rapid, simultaneously stapled pneumonectomy
An irreparable main bronchus injury and significant hemodynamic instability in the OR
Therapeutic mediastinal and/or pleural space packing
Inability to control bleeding with conventional methods (due to a coagulopathy or for other reasons)
Temporary thoracic closure
Signs of thoracic compartment syndrome develop during attempted thoracic wall closure**
Hypothermia, acidosis, and coagulopathy in the OR
Temporary thoracic closure with a silo/Bogota bag
Signs of thoracic compartment syndrome develop during attempted thoracic wall closure en masse or with towel clips

Opinions of Practicing Surgeons on the Appropriateness of Published Indications for Use of Damage Control Surgery in Trauma Patients: An International Cross-Sectional Survey

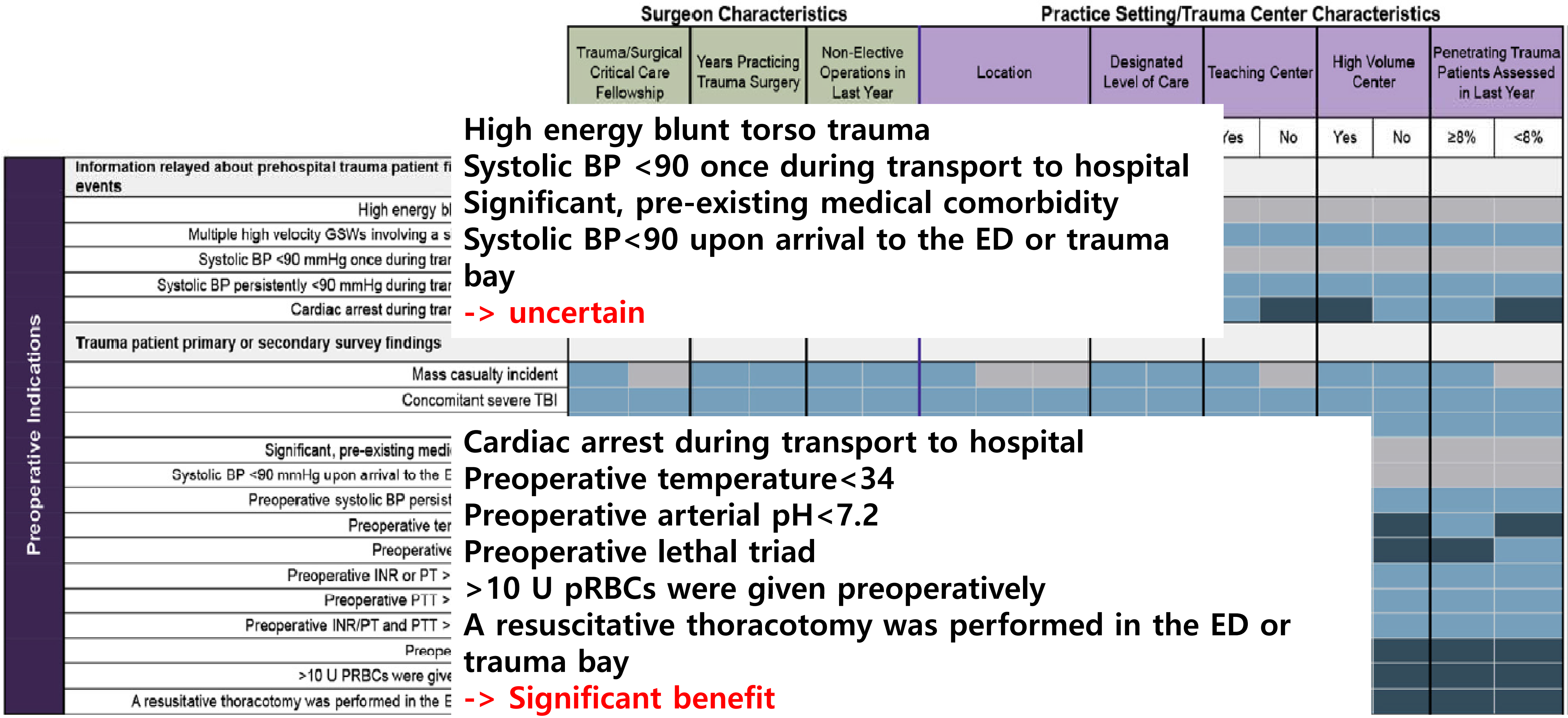
Derek J Roberts, MD, PhD, David A Zygun, MD, MSc, Peter D Faris, PhD, Chad G Ball, MD, MSc, FACS, Andrew W Kirkpatrick, MD, MHSc, FACS, Henry T Stelfox, MD, PhD, Indications for Trauma Damage Control Surgery International Study Group

BACKGROUND: Variation in use of damage control (DC) surgery across trauma centers may be partially driven by surgeon uncertainty as to when it is appropriately indicated. We sought to determine opinions of practicing surgeons on the appropriateness of published indications for trauma DC surgery.

STUDY DESIGN: We asked 384 trauma centers in the United States, Canada, and Australasia to nominate 1 to 3 surgeons at their center to participate in a survey about DC surgery. We then asked nominated surgeons their opinions on the appropriateness (benefit-to-harm ratio) of 43 literature-derived indications for use of DC surgery in adult civilian trauma patients.

RESULTS: In total, 232 (64.8%) trauma centers nominated 366 surgeons, of whom 201 (56.0%) responded. Respondents rated 15 (78.9%) preoperative and 23 (95.8%) intraoperative indications to be appropriate. Indications respondents agreed had the greatest expected benefit included a temperature <34°C, arterial pH <7.2, and laboratory-confirmed (international normalized ratio/prothrombin time and/or partial thromboplastin time >1.5 times normal) or clinically observed coagulopathy in the pre- or intraoperative setting; administration of >10 units of packed red blood cells; requirement for a resuscitative thoracotomy in the emergency department; and identification of a juxtahepatic venous injury or devascularized or destroyed pancreas, duodenum, or pancreaticoduodenal complex during operation. Ratings were consistent across subgroups of surgeons with different training, experience, and practice settings.

CONCLUSIONS: We identified 38 indications that practicing surgeons agreed appropriately justified the use of DC surgery. Until further studies become available, these indications constitute a consensus opinion that can be used to guide practice in the current era of changing trauma resuscitation practices. (J Am Coll Surg 2016;223:515–529.

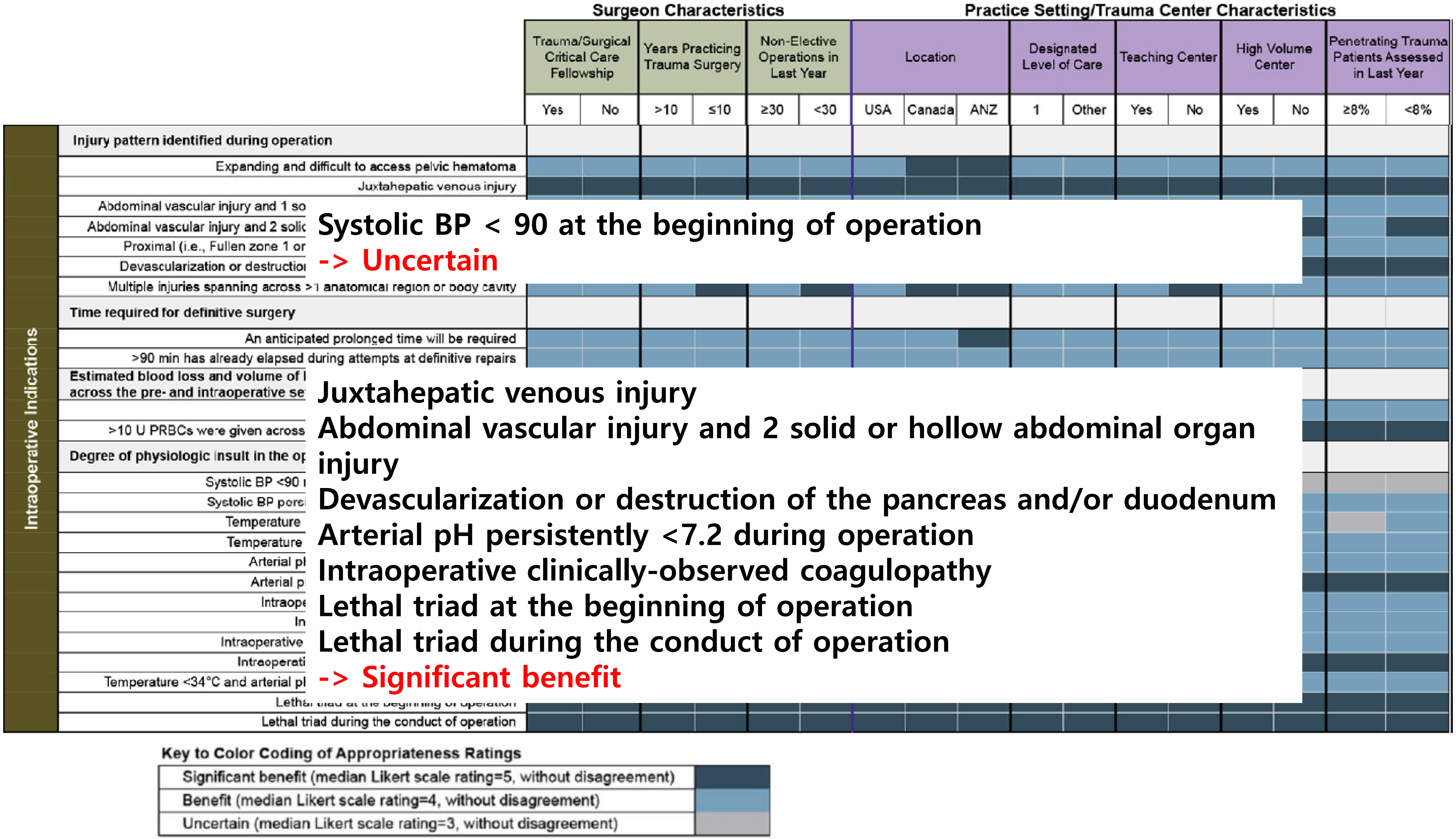


High energy blunt torso trauma
Systolic BP <90 once during transport to hospital
Significant, pre-existing medical comorbidity
Systolic BP<90 upon arrival to the ED or trauma bay
-> uncertain

Cardiac arrest during transport to hospital
Preoperative temperature<34
Preoperative arterial pH<7.2
Preoperative lethal triad
>10 U pRBCs were given preoperatively
A resuscitative thoracotomy was performed in the ED or trauma bay
-> Significant benefit

Key to Color Coding of Appropriateness Ratings

Significant benefit (median Likert scale rating=5, without disagreement)	
Benefit (median Likert scale rating=4, without disagreement)	
Uncertain (median Likert scale rating=3, without disagreement)	



Systolic BP < 90 at the beginning of operation
-> Uncertain

Juxtahepatic venous injury
Abdominal vascular injury and 2 solid or hollow abdominal organ injury
Devascularization or destruction of the pancreas and/or duodenum
Arterial pH persistently <7.2 during operation
Intraoperative clinically-observed coagulopathy
Lethal triad at the beginning of operation
Lethal triad during the conduct of operation
-> Significant benefit

Thoracic Damage Control Surgery

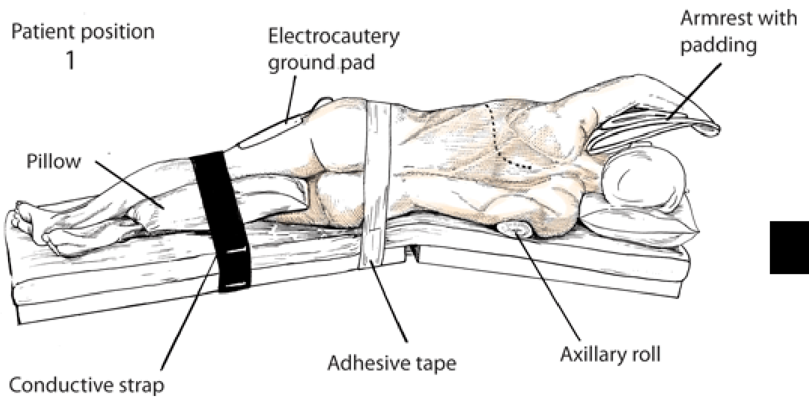
Thoracic Damage Control Surgery

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

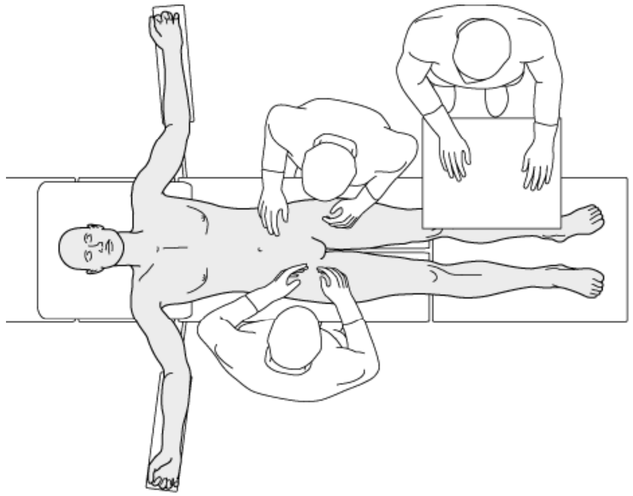
- **Thoracic damage control surgery**
  - exsanguination
  - space occupying and lung-compression events

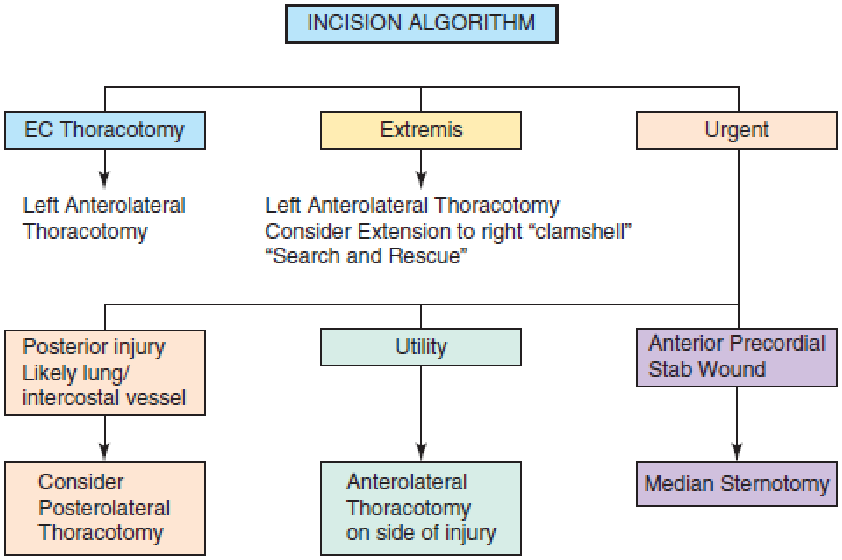
=> **Arrest of hemorrhage and maintaining oxygenation by relieving intrathoracic positive pressures.**

POSITION?



Source: Zollinger RM, Ellison EC: *Zollinger's Atlas of Surgical Operations, 9th Edition*: http://www.accesssurgery.com

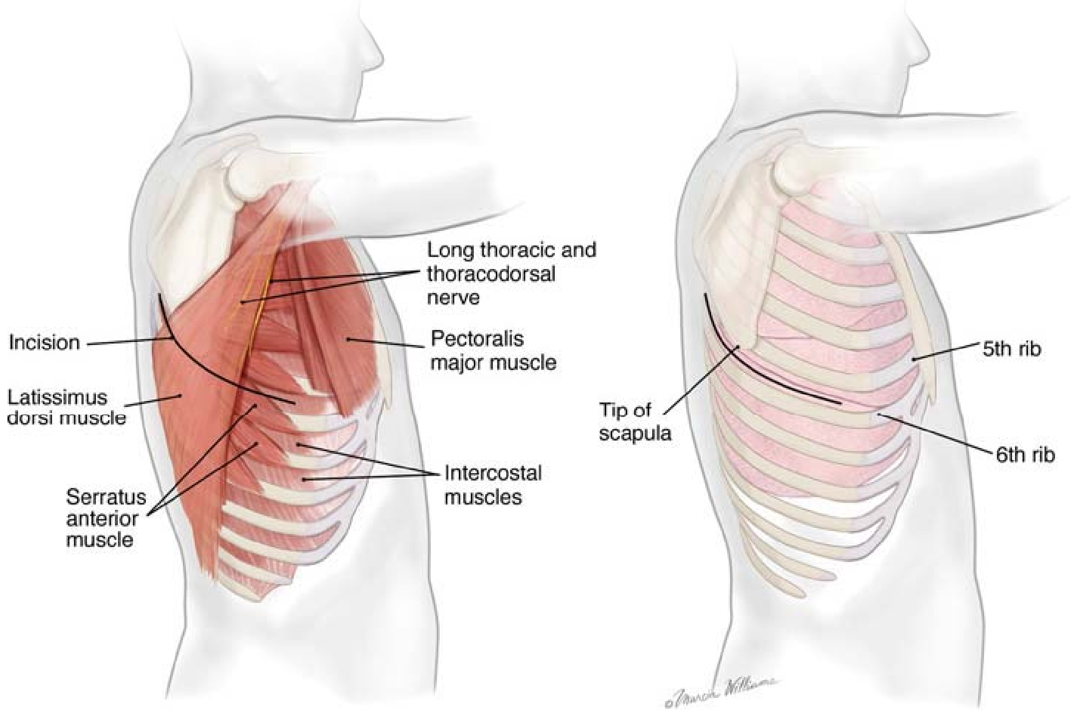




Incision algorithm.

Trauma 7th ed chapter 24

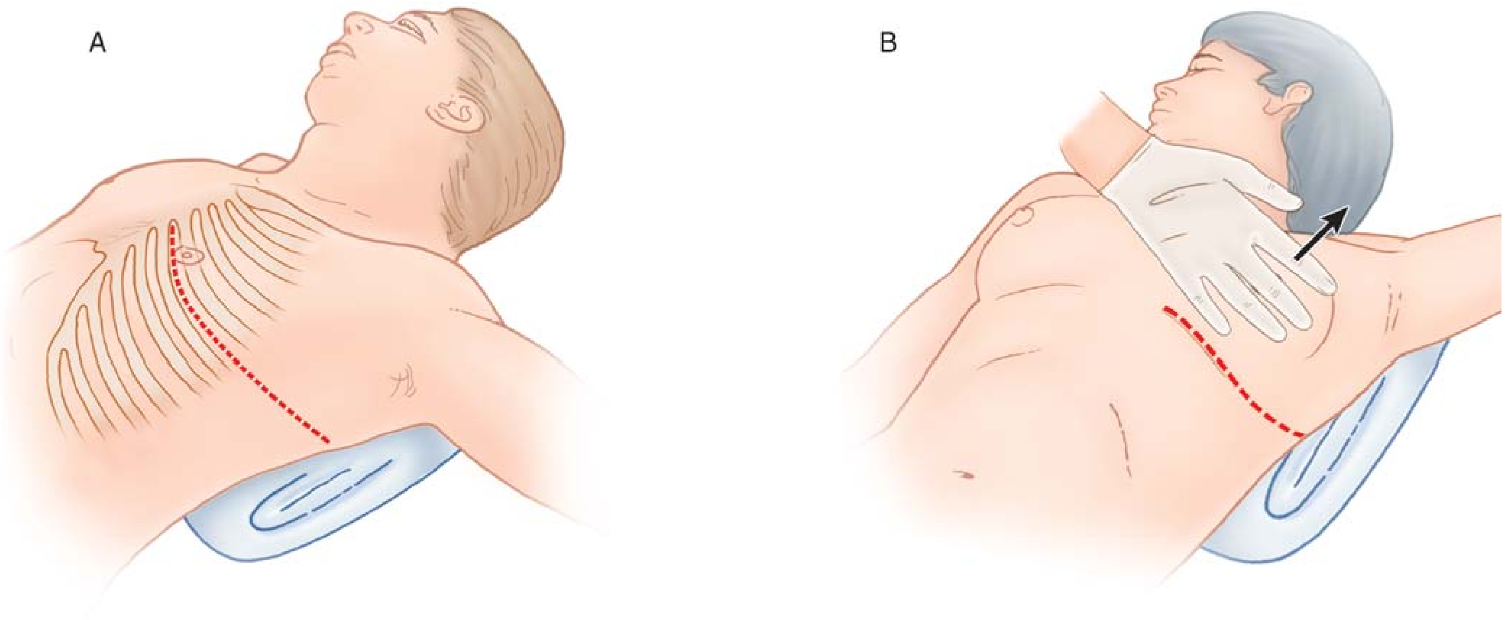
Posterolateral Thoracotomy



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

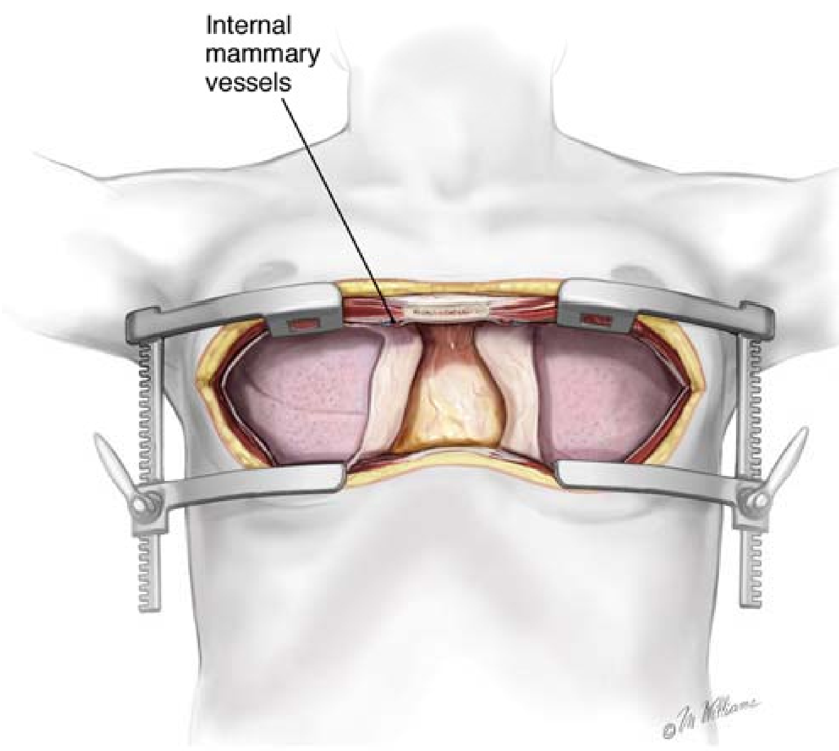
descending thoracic aorta, esophagus, azygous vein, and the mediastinal trachea and bronchi

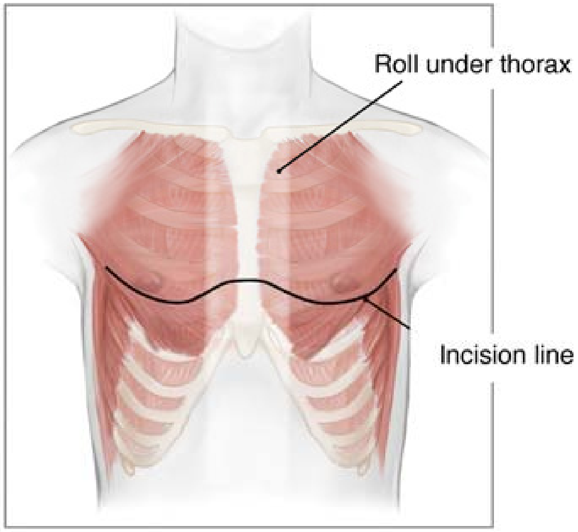
Anterolateral Thoracotomy



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

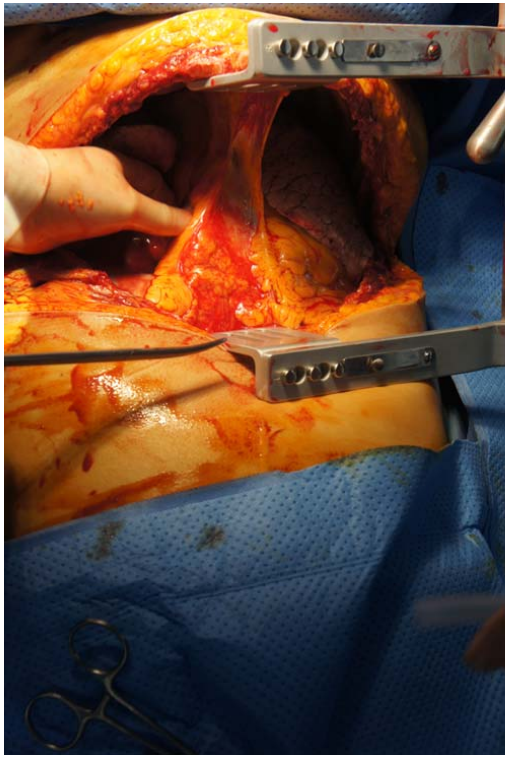
Transverse Thoracosternotomy (Clamshell)

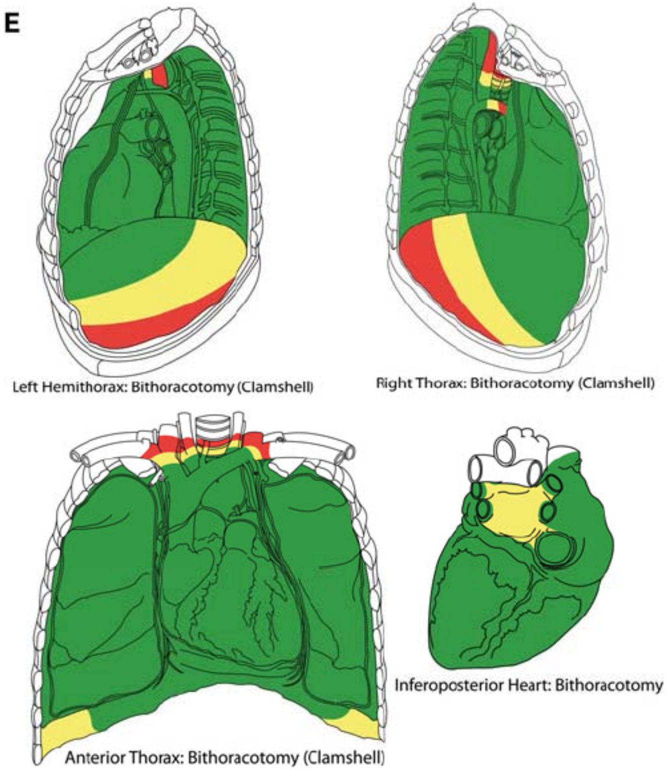




Source: Sugarbaker DJ, Bueno R, Krasna MJ, Mentzer SJ, Zellos L: *Adult Chest Surgery:*
http://www.accesssurgery.com

Clamshell Thoracotomy



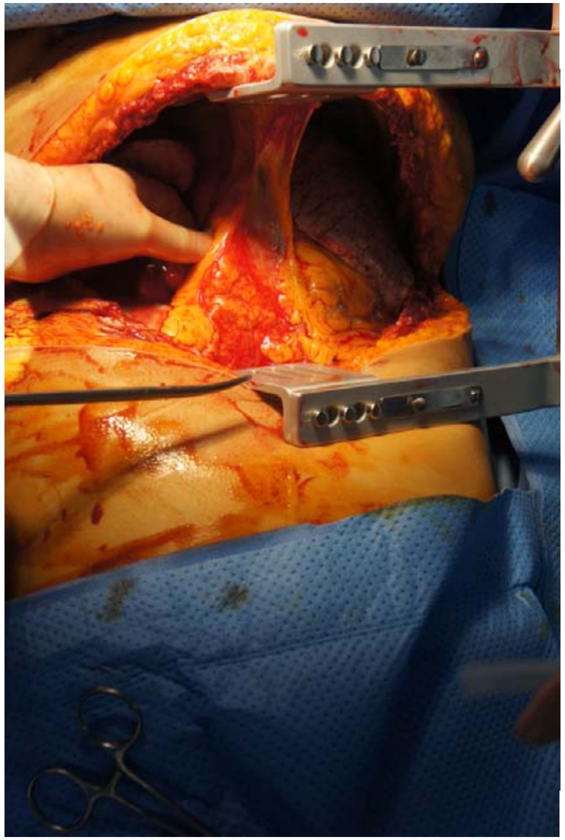


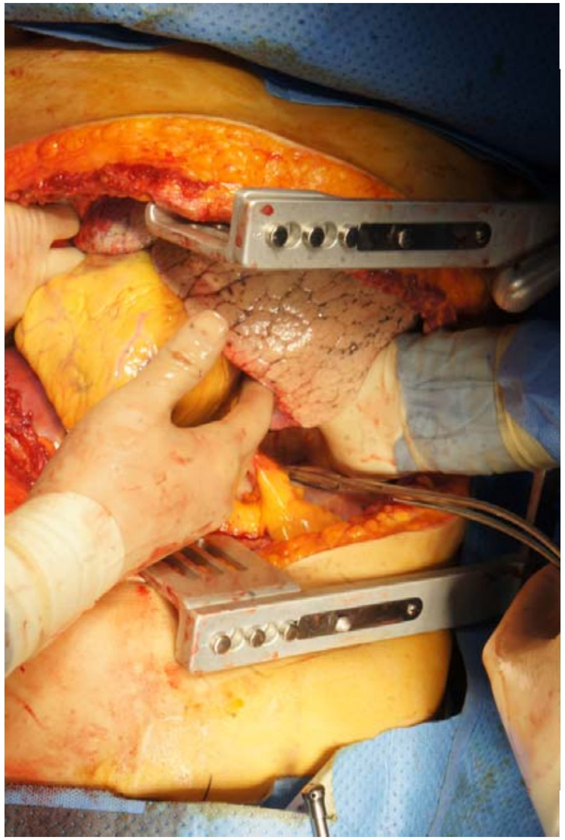
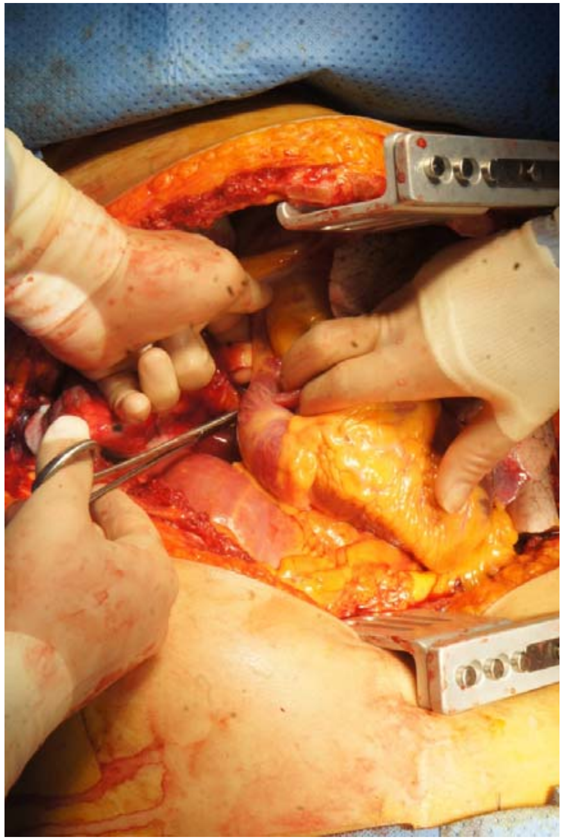
Bilateral Anterior Thoracotomy (Clamshell Incision) Is the Ideal Emergency Thoracotomy Incision: An Anatomic Study

Eric R. Simms · Alexandros N. Flaris · Xavier Franchino · Michael S. Thomas · Jean-Louis Caillot · Eric J. Voiglio

Conclusions In severe thoracic trauma, specific injuries are unknown, even if they can be anticipated. The best incision is therefore one that provides the most rapid and definitive access to all thoracic structures for assessment and control. While the right and left anterolateral incisions may be successfully employed by surgeons with extensive experience in ET, the clamshell incision remains the superior incision choice.

World J Surg (2013) 37:1277–1285



Thoracic Damage Control Surgery Technique

HILAR CONTROL

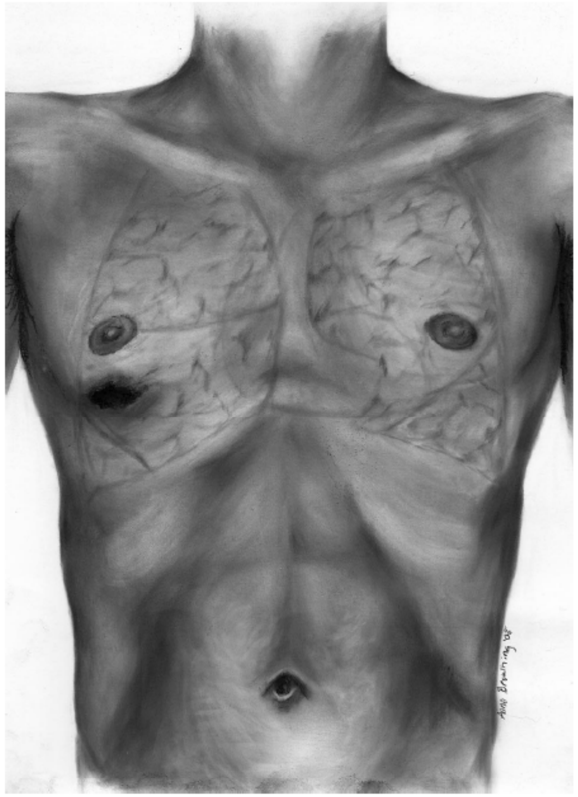


Fig. 1. *Gunshot wound to the right anterior chest.*

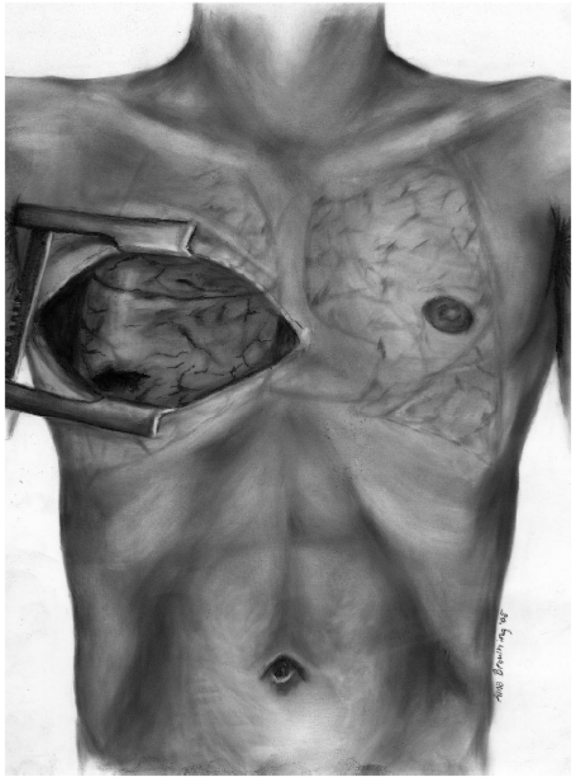


Fig. 2. *Right anterolateral thoracotomy with transsternal extension.*

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.*

PULMONARY HILUM TWIST

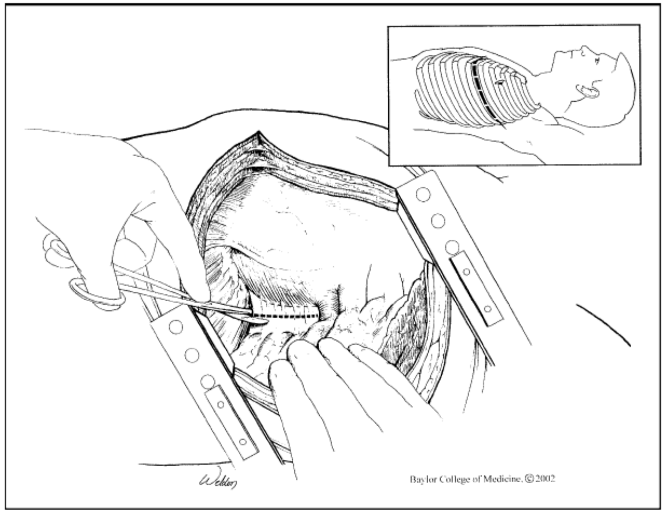


Fig. 1. Sharply divide the inferior pulmonary ligament. The ligament should be divided to the level of the inferior pulmonary vein.

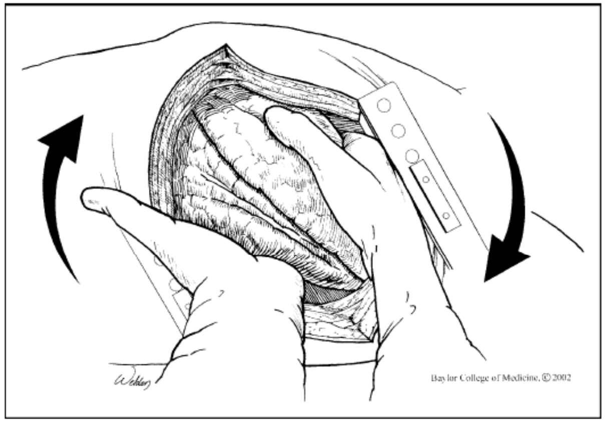


Fig. 2. Place one hand on the anterior aspect of the upper lobe and the other hand on the posterior aspect of the lower lobe. Rotate the lower lobe anteriorly and the upper lobe posteriorly 180 degrees.

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.

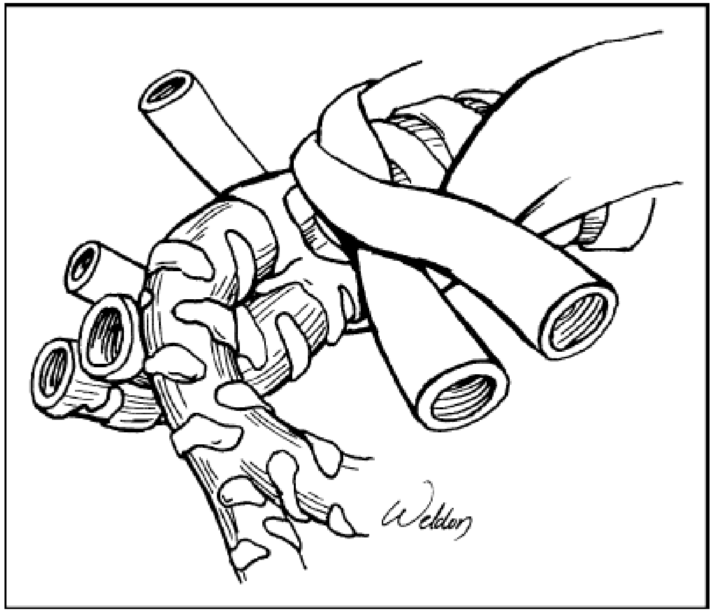


Fig. 4. The vascular structures will be twisted around the bronchus with effective occlusion.

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

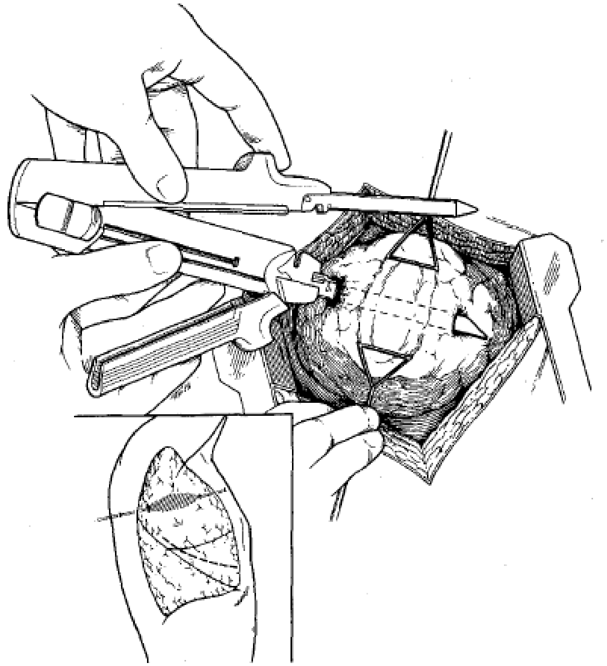


FIG 1. Missile penetrating the pulmonary parenchyma, creating description of pulmonary tissue and deep intraparenchymal bleeding. Stapling device is placed into the orifices of the entrance and exit wounds.

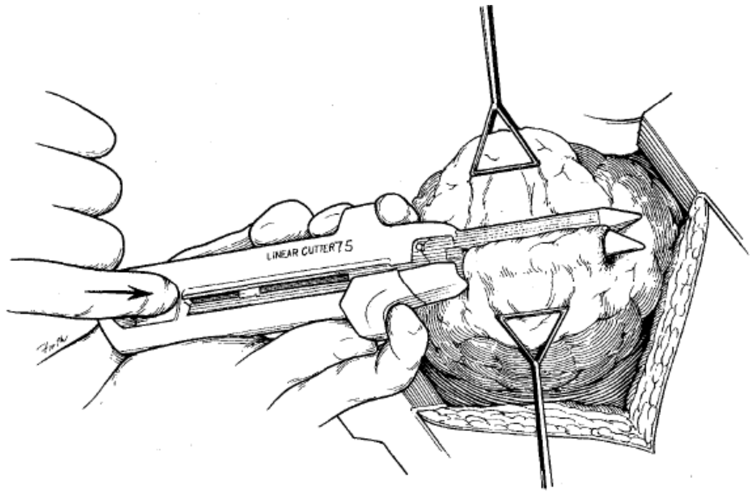


FIG 2. Stapling device is closed and fired to create the tractotomy.

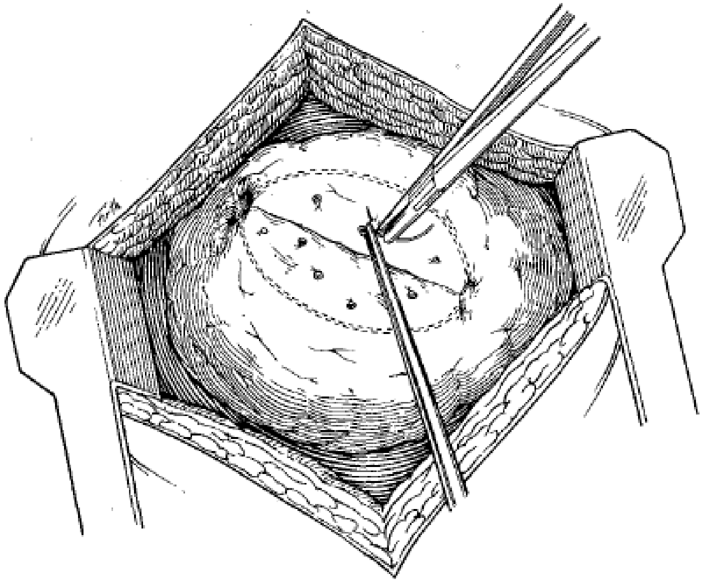
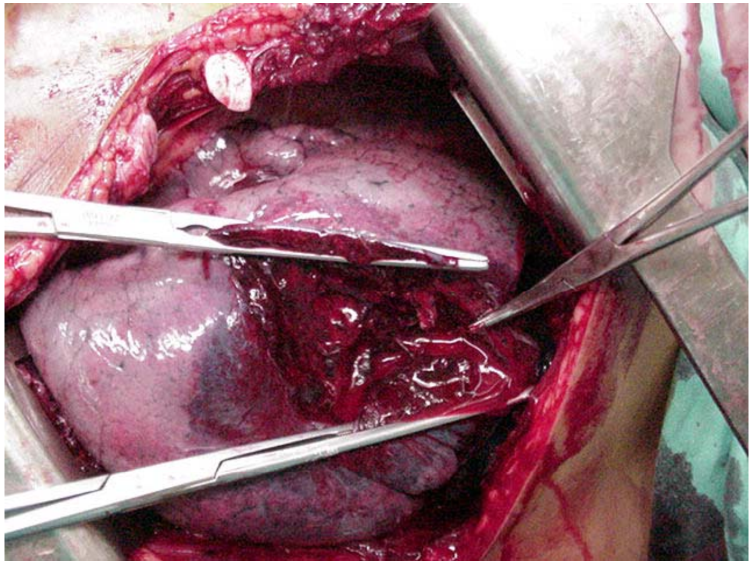
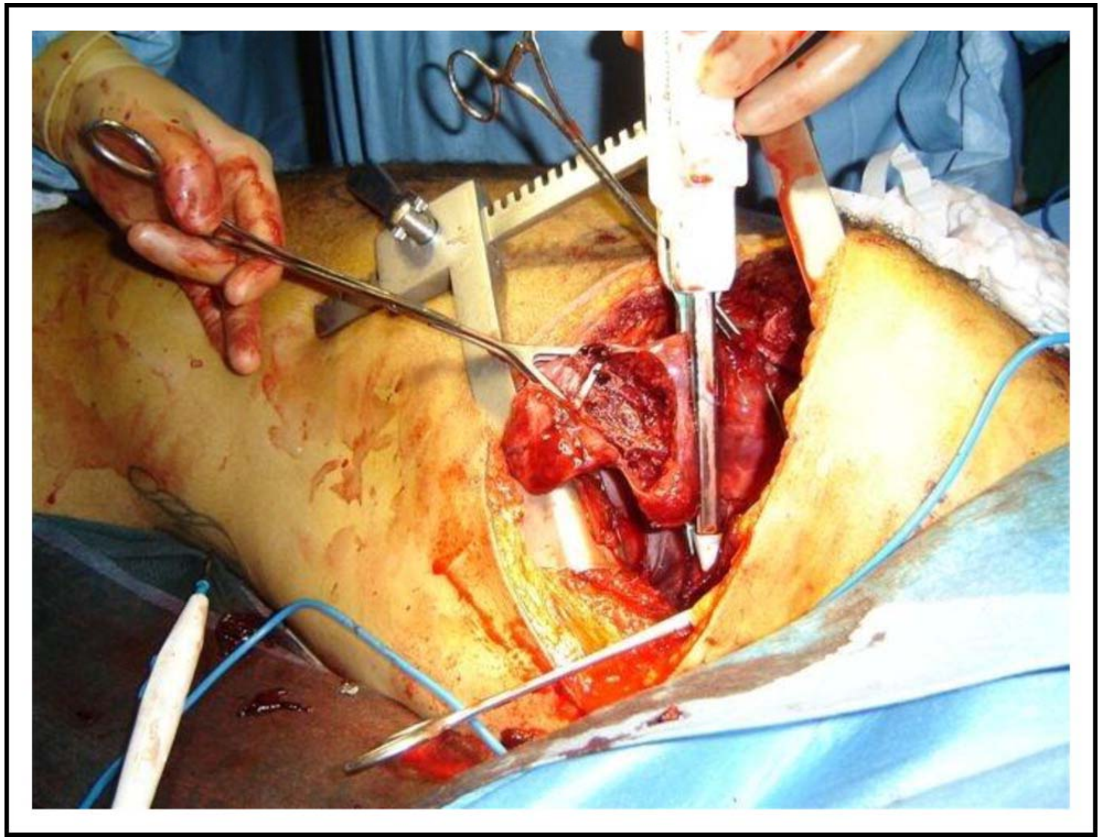


FIG 3. Tractotomy exposes the bleeding vessels, which are then selectively ligated.



Wedge resection



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

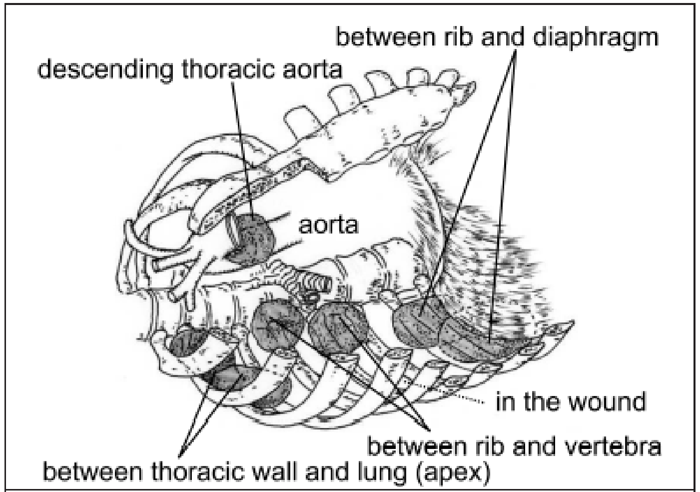


Figure 1 Schema of the packing site in the thoracic cavities of the six successful cases

- 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.

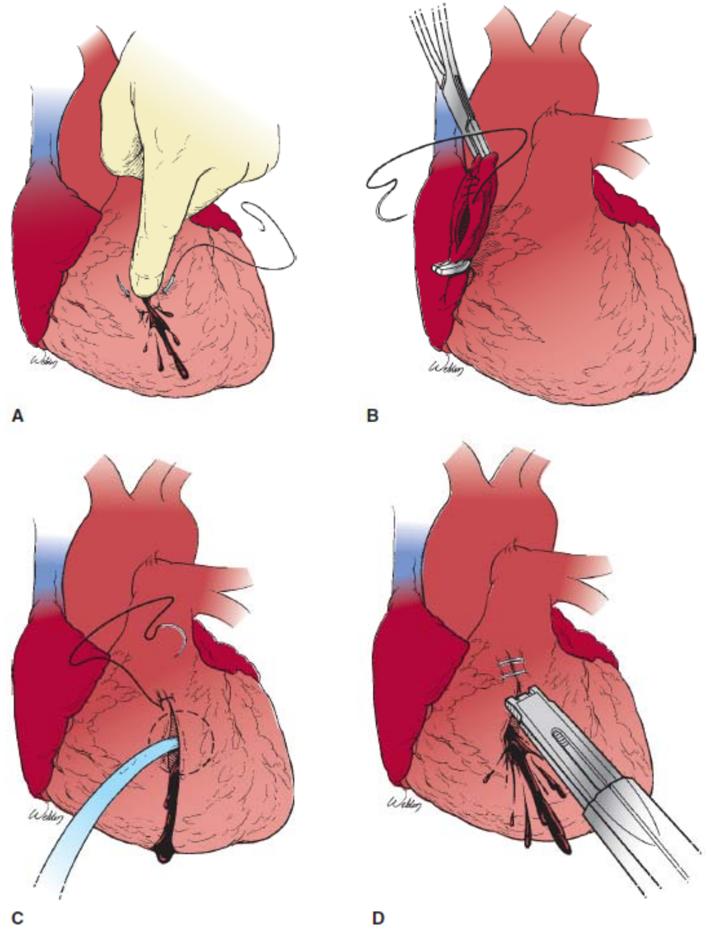


FIGURE 26-3 Temporary techniques to control bleeding. (**A**) Finger occlusion; (**B**) partial occluding clamp; (**C**) Foley balloon catheter; (**D**) skin staples. (*Copyright © Baylor College of Medicine, 2005.*)

Table 1. Demographic Data, Injury Severity, Operation, and Reason for Using Abbreviated Thoracotomy in 12 Patients*

Table 2. Physiological Data Upon Arrival at ICU and at Time of Definitive Chest Closure in 11 Patients Who Underwent an Abbreviated Thoracotomy*

	Arrival at ICU					Before Chest Closure					
Patient No.	T, °C									…$_2$/FIO$_2$	PIP, cm H_2O
1	32.8									…10	37
2	37.0									…64	29
3	32.5									…fore closure	
4	32.1									…fore closure	
5	36.0									…14	35
6	35.7									…sure	
7	34.6									…83	30
8	35.2									…76	33
9	35.0	1.56	7.26	49	40	1	36.4	1.26	7.49	375	31
10	37.4	0.99	7.30	77	40	1	36.7	1.08	7.39	243	32
11	33.1	1.40	7.26	541	30	Died in ICU of CHI before closure					

Based on their Trauma and Injury Severity Score (TRISS), predicted survival[21] was 41% for our patients in whom an abbreviated thoracotomy was performed; their actual survival rate was 64% (7 of 11 patients). The 24-hour ICU scores[22] predicted a 45% mortality rate for the 7 survivors. The TRISS-predicted survival rate for all trauma

*ICU indicates intensive care unit; T, temperature; INR, international normalized ratio of prothrombin time; PaO_2/FIO_2, ratio of arterial partial pressure of oxygen to fraction of inspired oxygen; PIP, peak inspiratory pressure; POD, postoperative day; DIC, disseminated intravascular coagulation; and CHI, closed head injury.

*RTS indicates Revised Trauma Score; ISS, Injury Severity Score; GSW, gunshot wound; R, right; L, left; MVC, motor vehicle crash; Auto-ped, auto-pedestrian crash, and SW, stab wound.

istics were normalized.

Damage-control techniques in the management of severe lung trauma

Alberto Garcia, MD, Juan Martinez, MD, Julio Rodriguez, MD, Mauricio Millan, MD, Gustavo Valderrama, MD, Carlos Ordoñez, MD, *and* **Juan Carlos Puyana, MD,** *Cali, Colombia*

DCT mortality in pulmonary trauma was 6 (24%) of 25 because of coagulopathy, or persistent bleeding in 5 patients and multiorgan failure in 1 patient.

RESULTS: A total of 840 trauma thoracotomies were performed. DC thoracotomy (DCT) was performed in 31 patients (3.7%). Pulmonary trauma was found in 25 of them. The median age was 28 years (interquartile range [IQR], 20–34 years), Revised Trauma Score (RTS) was 7.11 (IQR, 5.44–7.55), and Injury Severity Score (ISS) was 26 (IQR, 25–41). Nineteen patients had gunshot wounds, four had stab wounds, and two had blunt trauma.

Pulmonary trauma was managed by pneumorrhaphy in 3, tractotomy in 12, wedge resection in 1, and packing as primary treatment in 8 patients. Clamping of the pulmonary hilum was used as a last resource in seven patients. Five patients returned to the intensive care unit with the pulmonary hilum occluded by a vascular clamp or an en masse ligature. These patients underwent a deferred resection within 16 hours to 90 hours after the initial DCT. Four of them survived.

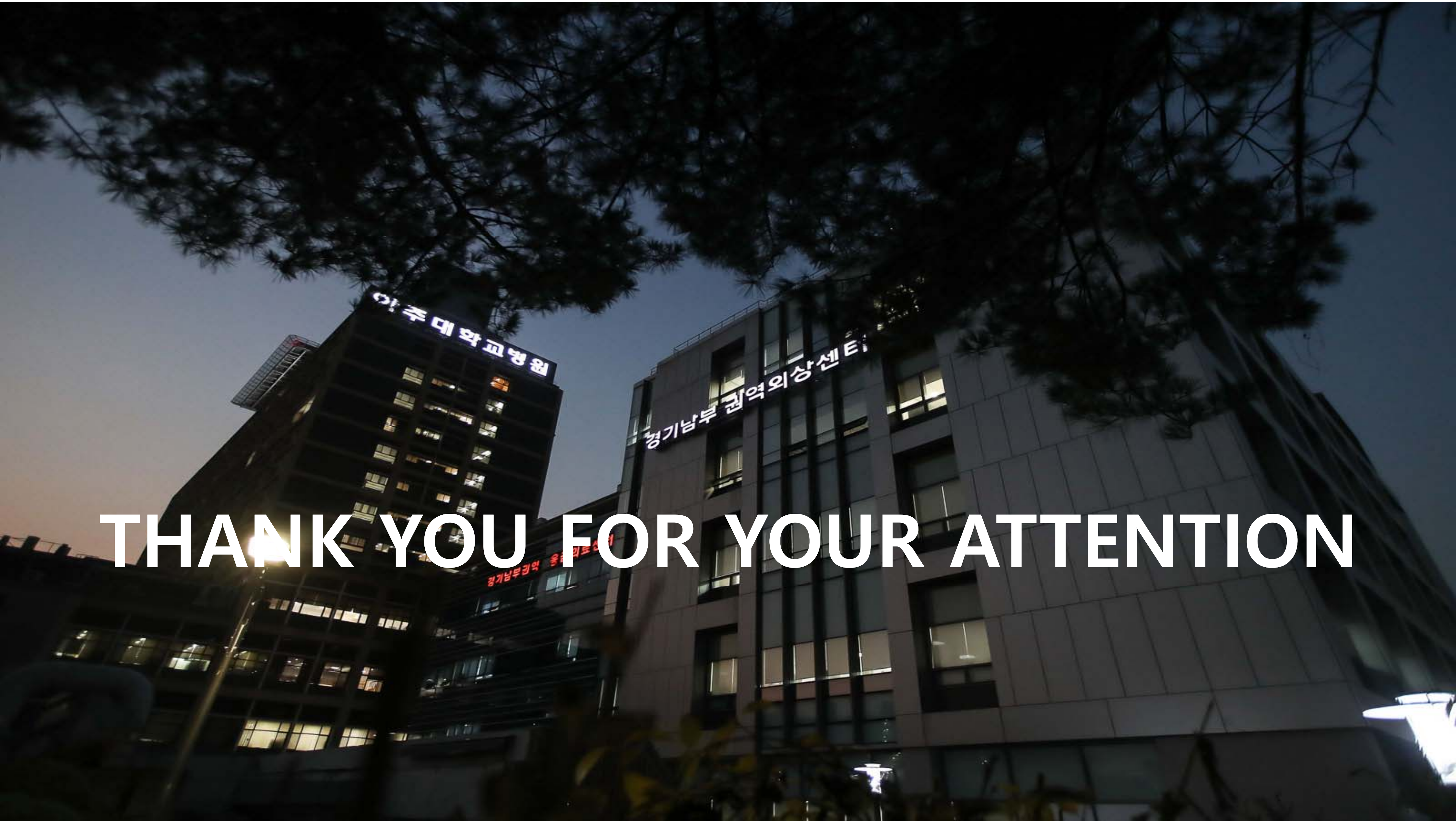
Bleeding from other intrathoracic sources was found in 20 patients: major vessels in nine, heart in three, and thoracic wall in nine.

DCT mortality in pulmonary trauma was 6 (24%) of 25 because of coagulopathy, or persistent bleeding in 5 patients and multiorgan failure in 1 patient.

CONCLUSION: This series describes our experience with DCT in severe lung trauma. We describe pulmonary hilum clamping and deferred lung resection as a viable surgical alternative for major pulmonary injuries and the use of packing as a definitive method for hemorrhage control. (*J Trauma Acute Care Surg*. 2015;78: 45–51.

LEVEL OF EVIDENCE: Epidemiologic study, level V.

KEY WORDS: Thoracic injuries; lung injury; penetrating; damage control; deferred pneumonectomy.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경기남부 권역외상센터
THANK YOU FOR YOUR ATTENTION