CEEA

Specific Domains of Perioperative Medicine

"Damage Control Anesthesia" in Multiple Trauma Patients

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European Society of Anaesthesiology ESA

World Federation of Societies of Anaesthesiologists

Epidemiology

- Every day 70-80 persons/million are victims of a traumatic injury;
- 50% address to a medical service, from which, 20-30% have potential lethal injuries and 5% are critical, unstable patients
- Trauma causes more death among children and adolescents (ages 1 to 19) than all the other diseases combined.

Tintinalli, Emergency Medicine, 2000
Fildes. J. National Trauma Data Bank™ Report 2003

- Trauma is the leading cause of death between 15-44 years

Trauma and Critical Care; Traumatologie et soins critique
Acute resuscitation of the unstable adult trauma patient: bedside diagnosis and therapy
Andrew W Kirkpatrick. MD; Chad G Bati MD, Scott K Amours MD. CM David Avaun MD

Multiple Trauma

Syndrome of multiple injuries exceeding a defined severity

with consecutive systemic reactions which may lead to

dysfunction or failure of remote of primarily not injured organs or vital systems.

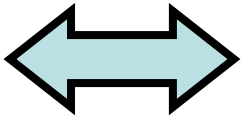
Otmar Trentz, Reto Stocker

Pathophysiology

"Genomic storm" : activation of inflammation and coagulation, microvascular dysfunction

1.Wijesuriya, J.D. and Keogh, S., 2017:..
2.MacGoey, P., Lamb, C.M., Navarro, A.P. and Brooks, A.J., 2016..

Organ and systems lesions

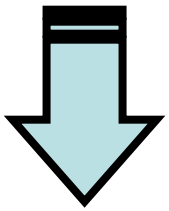


Systemic response

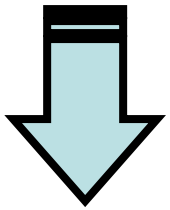
- SIRS; Shock
- Coagulopathy,

Aggravating factors

acidosis,hypothermia



Surgical treatment



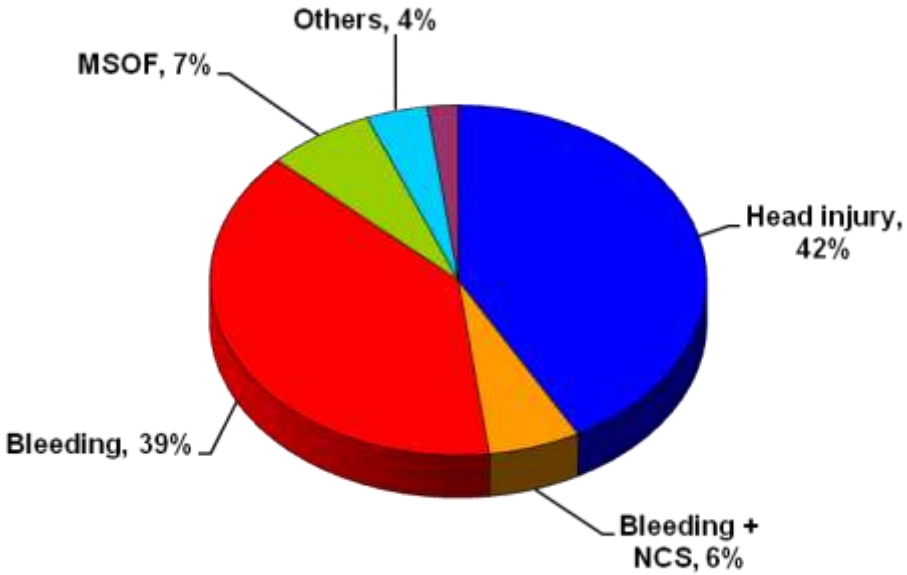
Resuscitation
Supportive therapy

Trauma Mortality
- temporal distribution-

mortality	moment of death	cause of death
30%	within first 30 min.	complex and severe injuries, **masive bleeding**, survival impossible
50%	within 48 hours	Severe TBI **major blood losses**, failure to provide and maintain airway and ventilation
20%	days and weeks after trauma	Sepsis, multiple organ failure, pulmonary embolism

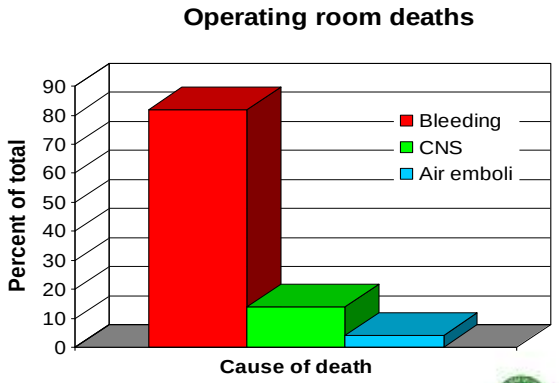
Bleeding Is the Leading Cause of Death in Trauma*

* Hospital deaths in the first 48 hr



bleeding ...

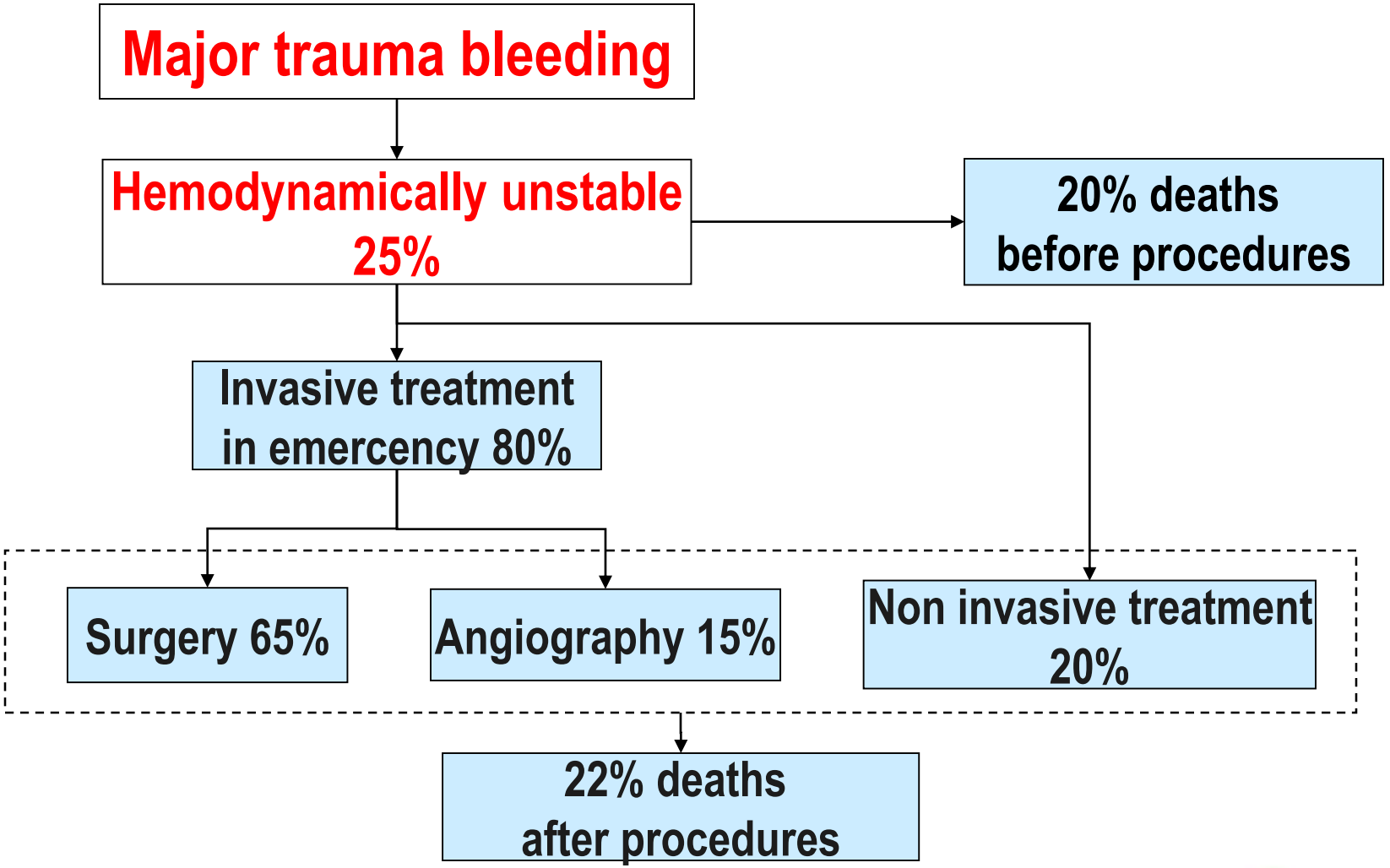
- is the 1st cause of death in trauma
- is directly responsible for 40% of all trauma-related deaths
- major potentially treatable cause of death in the initial 48h



Sauaia A, Moore FA, Moore EE, et al. J Trauma 1995;38(2):185–93

Hoyt DB et al. J Trauma. 2004;37:426–432.

Statistics



Chiara O et al. "Critical Bleeding in Blunt Trauma patients"; data from trauma registry of the Niguara Hospital in Milan, 2005

"Damage Control"
Modern Concept

The 1970's – "the Golden Hour"

- Rapid diagnosis, surgery and resuscitation

The 1980's – a "fix everything now" mentality

- Advantages: early fracture fixation improved patient mobilization and reduced the incidence of pulmonary complications; early diagnosis and treatment of aortic injuries doubtlessly saved lives.
- Disadvantages: prolonged procedures may have done more harm than good

The 1990's – Damage control surgery

- A plan of care for the badly injured patient
- Limiting prolonged surgical procedures that increased blood loss, and with it the potential for hypothermia, coagulopathy and acidosis

The Concept Origin

The term *"Damage control"* is coined by the US Navy and refers to keeping afloat a badly damaged ship by procedures to limit flooding, stabilize the vessel, isolate fires and explosions and avoid their spreading.

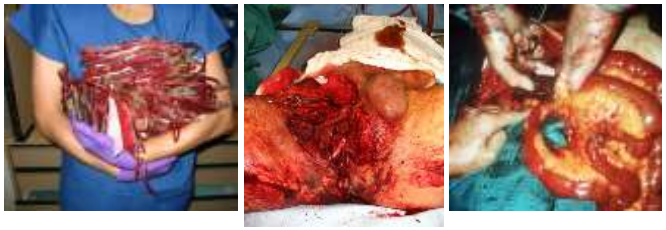
.

These measures permit damage assessment and gain time to establish plans for definitive salvag

Rationale

Saving life by deferring repair of anatomical lesions and focussing on restoring physiology.

Definition



Rapid abbreviated laparotomy to stop hemorrhage and peritoneal soiling and staged sequential repair after ongoing resuscitation and recovery from hypothermia, coagulopathy, and acidosis.

"The Bloody Vicious Cycle"

Rotondo et al. "Damage control": An approach for improved survival in exsanguinating penetrating abdominal injury. J Trauma 1993;35:375-383

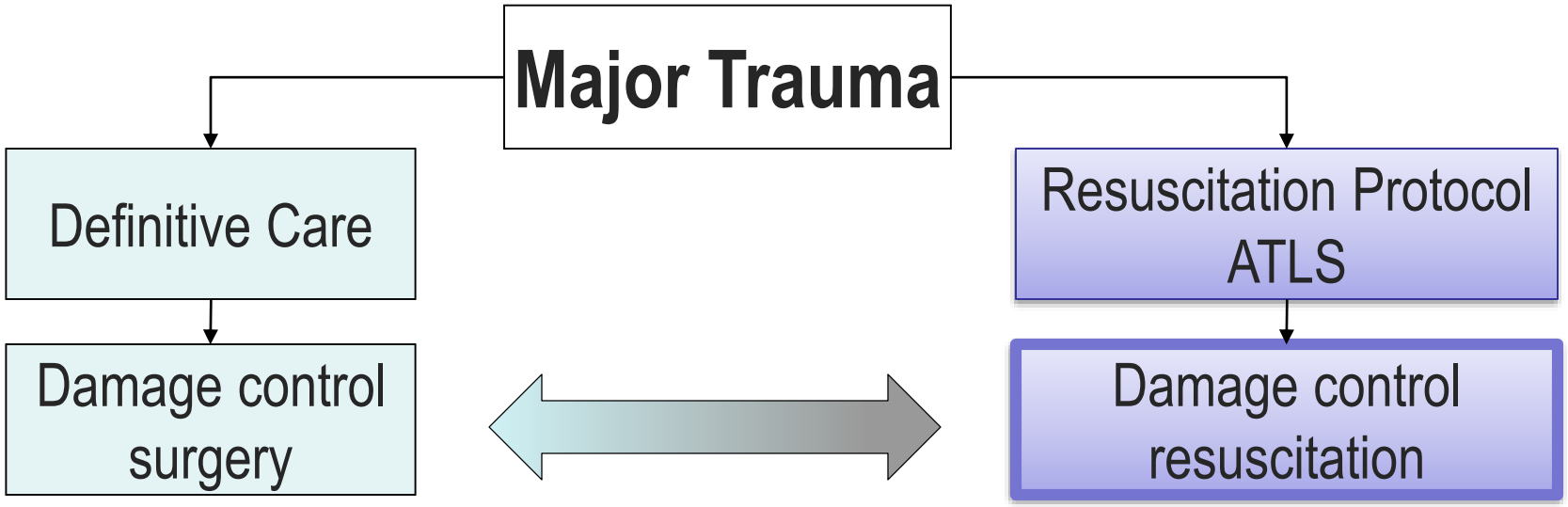
Moore EE. Staged laparotomy for the hypothermia, acidosis, and coagulopathy syndrome. *Am J Surg* 1996;172:405-410

Moore et al. Staged physiologic restoration and damage control surgery. *World J Surg* 1998;22:1184-1191

Bailout-procedure: Aborted termination of surgery in a patient at imminent risk of death.

Preemptive intervention: Calculated early decision to accomplish definitive correction of injuries in staged sequential procedures.

Major shift in trauma care



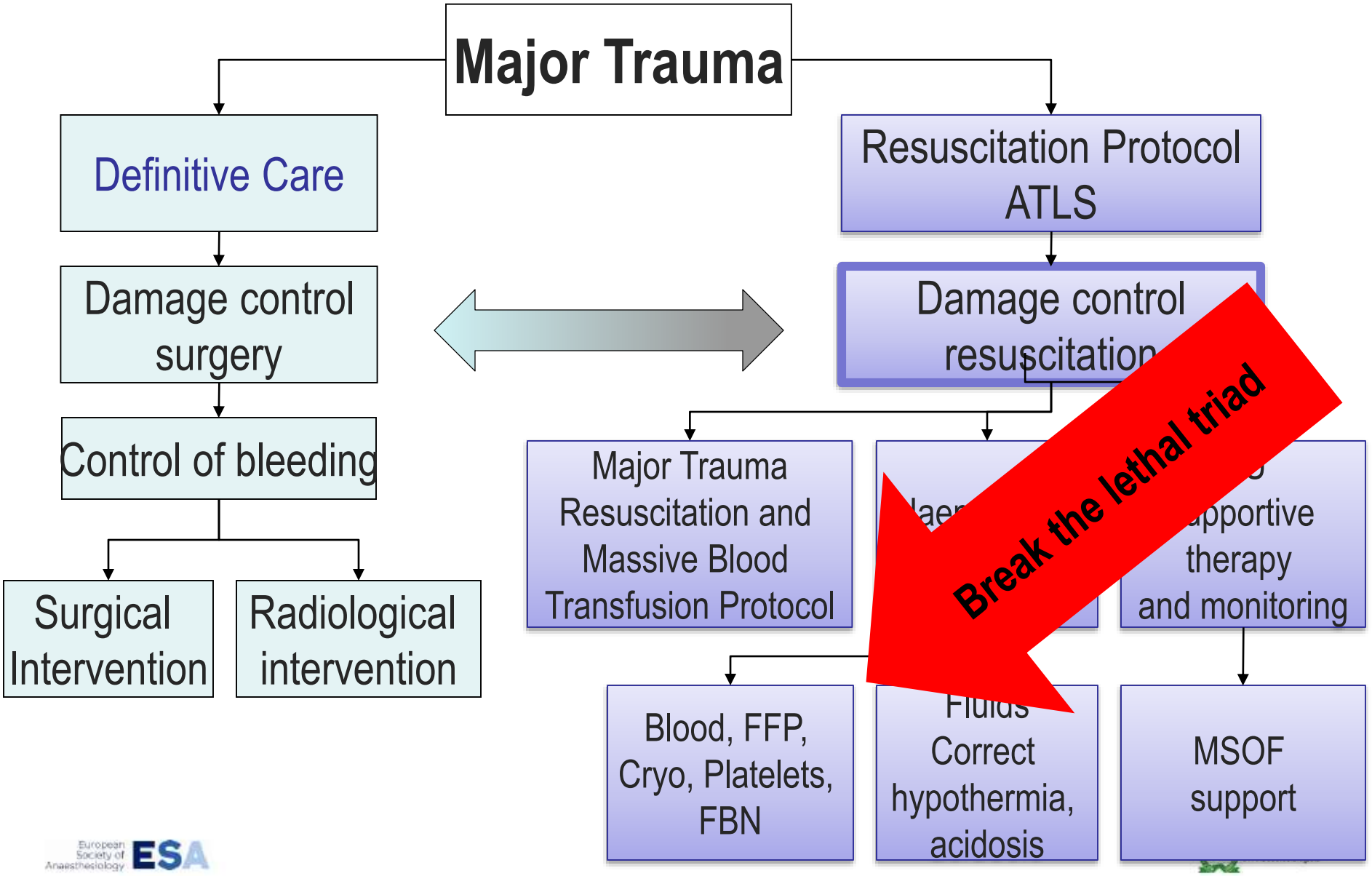
"Damage Control Surgery" "Damage Control Resuscitation"

The primacy of hemorrhage control to prevent **the "lethal triad"**

Modern paradigm : appropriate damage control resuscitation and *together with* appropriate damage control surgery

Damage control resuscitation *proposes a series of early and aggressive strategies to treat or prevent early trauma-associated coagulopathy*

Major shift in trauma care



“Damage Control”
Modern Concept

The new millenium – the concept of damage control has extended

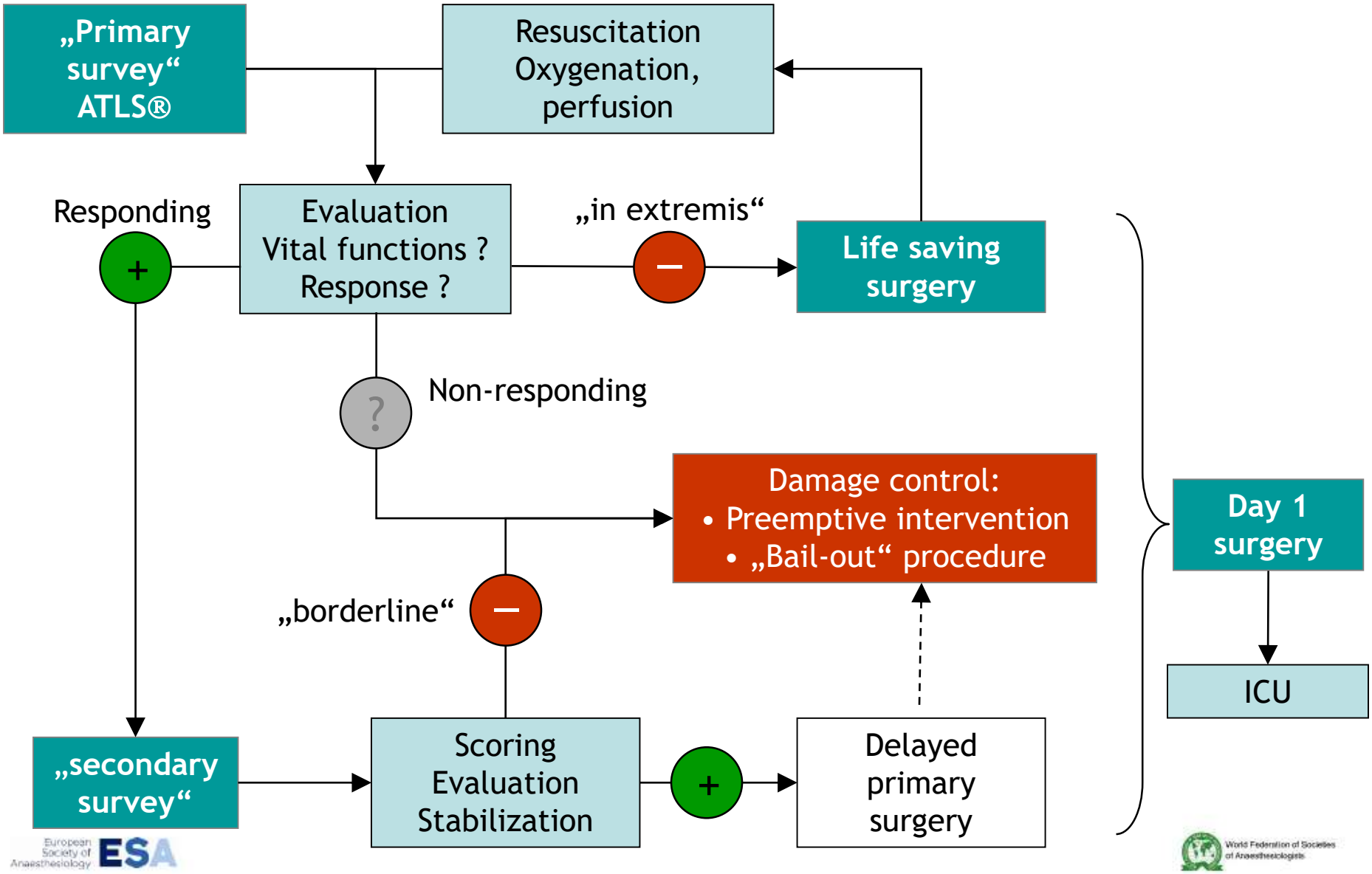
- Even in the absence of hypoperfusion and coagulopathy.
- Prevents the effects caused by the “second hit”, leading to fatal exacerbation of TBI, to SIRS, to ARDS or to early sepsis

Nowadays, damage control applies on:

- Resuscitation
- Anaesthesia
- Surgery
- Orthopaedic procedures
- Intrathoracic surgery
- Neurosurgery

Trauma-Management

Keel, Stoker; Labler, Trentz. Eur J Trauma. 2009



Damage Control Resuscitation

Patient selection for ”damage control”

Coagulopathy

Hypothermia: < 34° C

Acidosis: pH < 7.2,

Serum Lactate > 5 mmol / L

Blood Pressure < 70 mm Hg

Transfusion approaching 15 Units

Injury Severity Score > 36

Damage Control Resuscitation (DCR)

- “ABC” resuscitation
- Permissive hypotension
- Limitation of crystalloid with early use of blood products
- Early use of tranexamic acid (TXA)
- Early and appropriate use of damage control surgery

1.Wijesuriya, J.D. and Keogh, S., 2017. Integrated major haemorrhage management in the retrieval setting: Damage control resuscitation from referral to receiving facility. Emergency Medicine Australasia.

First Step: the “ABC” Haemorrhage Control

control the external haemorrhage as the first intervention

prior to the airway management **??**

approaches to control external haemorrhage:

- direct pressure, elevation of bleeding limb, application field dressing
- limb tourniquets
- haemostatic agents
- pelvic binder – pelvic trauma
- resuscitative endovascular balloon occlusion of the aorta

Step II:
Permissive Hypotension

Attempts to normalize blood pressure in cases of uncontrolled bleeding may result in increased blood loss and worse outcomes

In contrast, the concept of "***permissive hypotension***" does not exclude therapy by means of IV fluids, inotropes and vassopressors, but avoids completely normalizing blood pressure in a context where blood loss can be enhanced

Hypotensive ressuscitation limits blood losses⇒less acidemia, improves survival

Determing the optimum target blood pressure -*the depth and duration of hypotension that can be tolerated*

Still an issue with traumatic brain injury

(Bickell WH, PepePe, New England Journal of Medicine, 1994)
(SafarP, Capone AC, J.Am Coll Surg, 1995)

Ressuscitation Goals

Systolic blood pressure	90 mmHg* (MAP 50-60)
Heart rate	< 120 b/min
Puls oximeter functioning	SaO_2 > 95%
Urine output	present
$PaCO_2$	< 50 mmHg
Hematocrit	> 25%
Lactate	stable or decreasing
Ionized calcium	> 1.0
International normalized ratio	< 1.6
Platelets	> 50,000
Normothermia	
Deep anesthesia	

Permissive hTA

** lower blood pressure may be tolerated as long as acidosis is not worsening*

Limitation of Crystalloid with Early Use of Blood Products

Step III:

Fluids should be replaced **“like for like”**

The “Assessment of Blood Consumption Score” **(ABC Score)**

The parameters include

- Penetrating mechanism (0 = no, 1 = yes)
- ED SBP of 90 mm Hg or less (0 = no, 1 = yes)
- ED HR of 120 bpm or greater (0 = no, 1 = yes)
- Positive FAST (0 = no, 1 = yes)

ED emenrgency Departament

ABC score of 2 or greaterf predicting MT ,

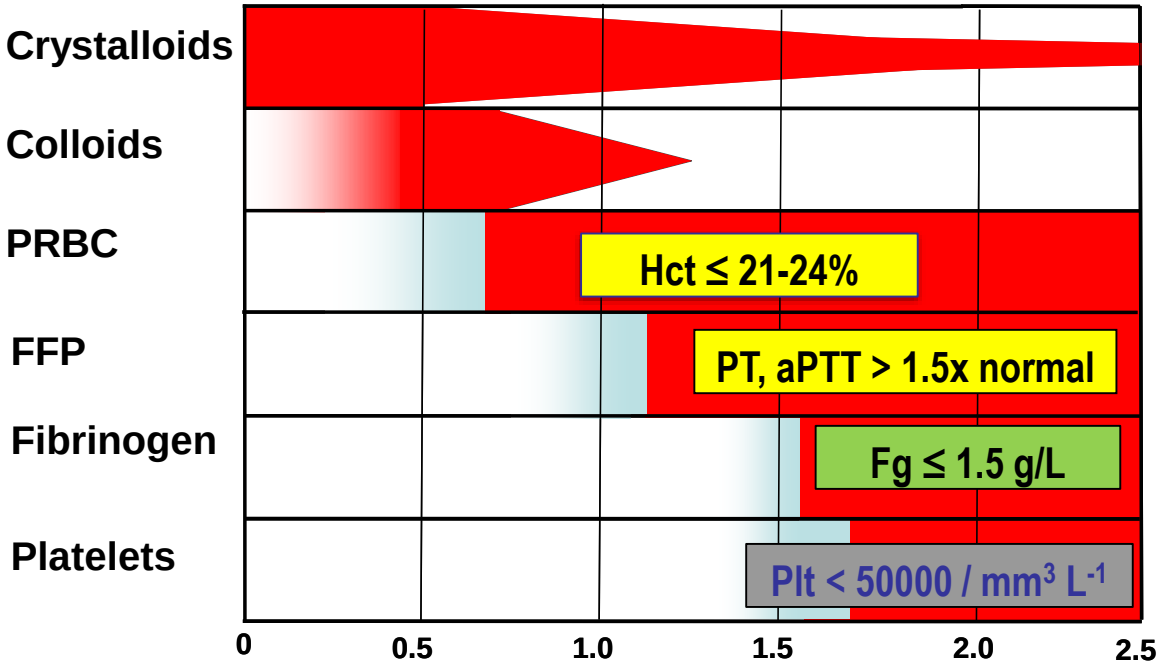
Early Prediction of Massive Transfusion in Trauma: Simple as ABC (Assessment of Blood Consumption)?
Timothy C. Nunez, MD, et all. J Trauma. 2009;66:346 –352

Limitation of Crystalloid with Step III: Early Use of Blood Products

Component blood therapy

The use of thrombelastometry **(ROTEM)** to guide blood product usage

Early infusion of fresh frozen plasma and platelets decreased mortality within 6 h of admis.



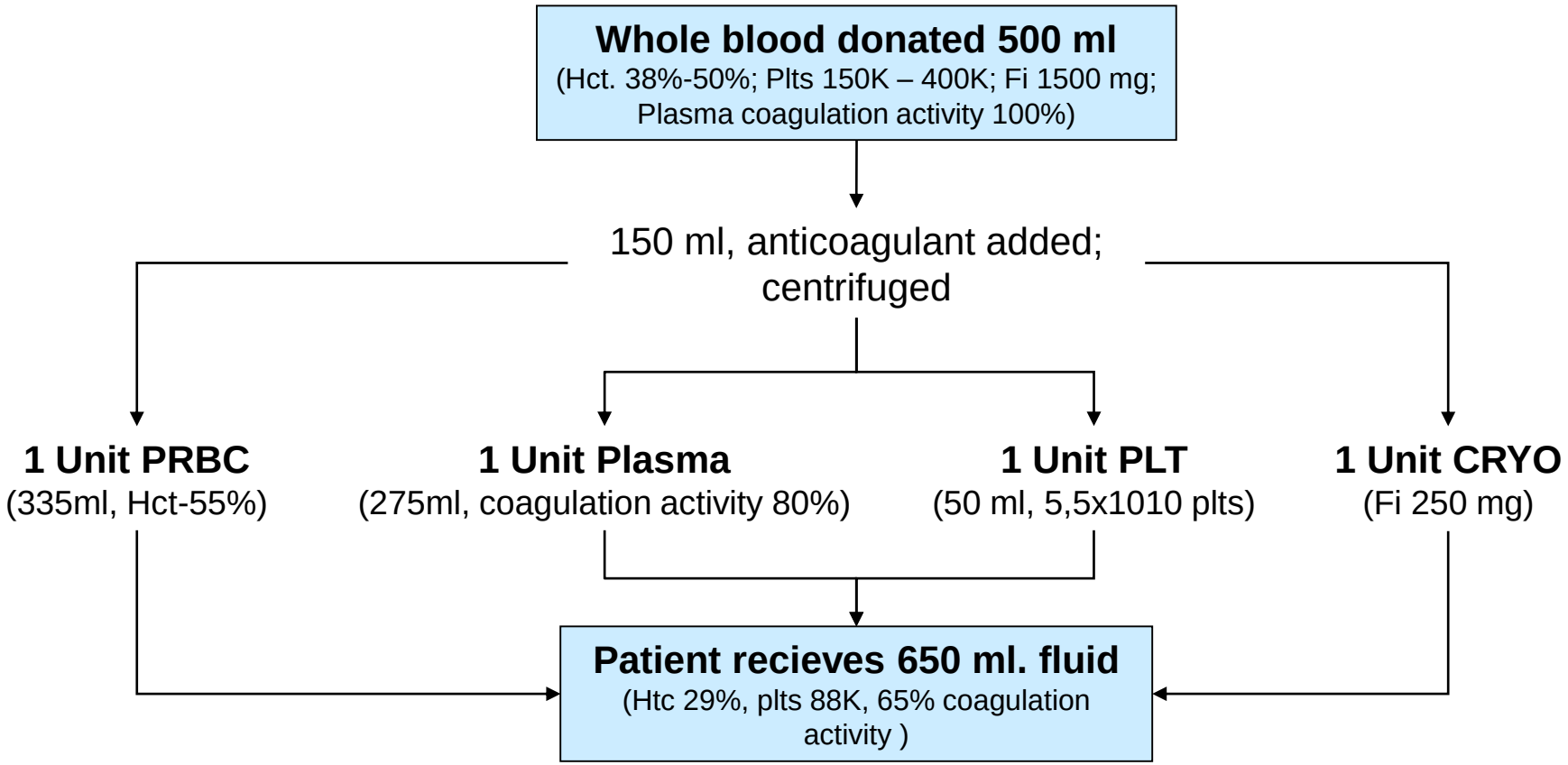
Fluids and Transfusion

Spahn DR. "Coagulopathy and blood component transfusion in trauma", Br J Anesth 95: 130-139, 2005

Limitation of Crystalloid with Step III: Early Use of Blood Products

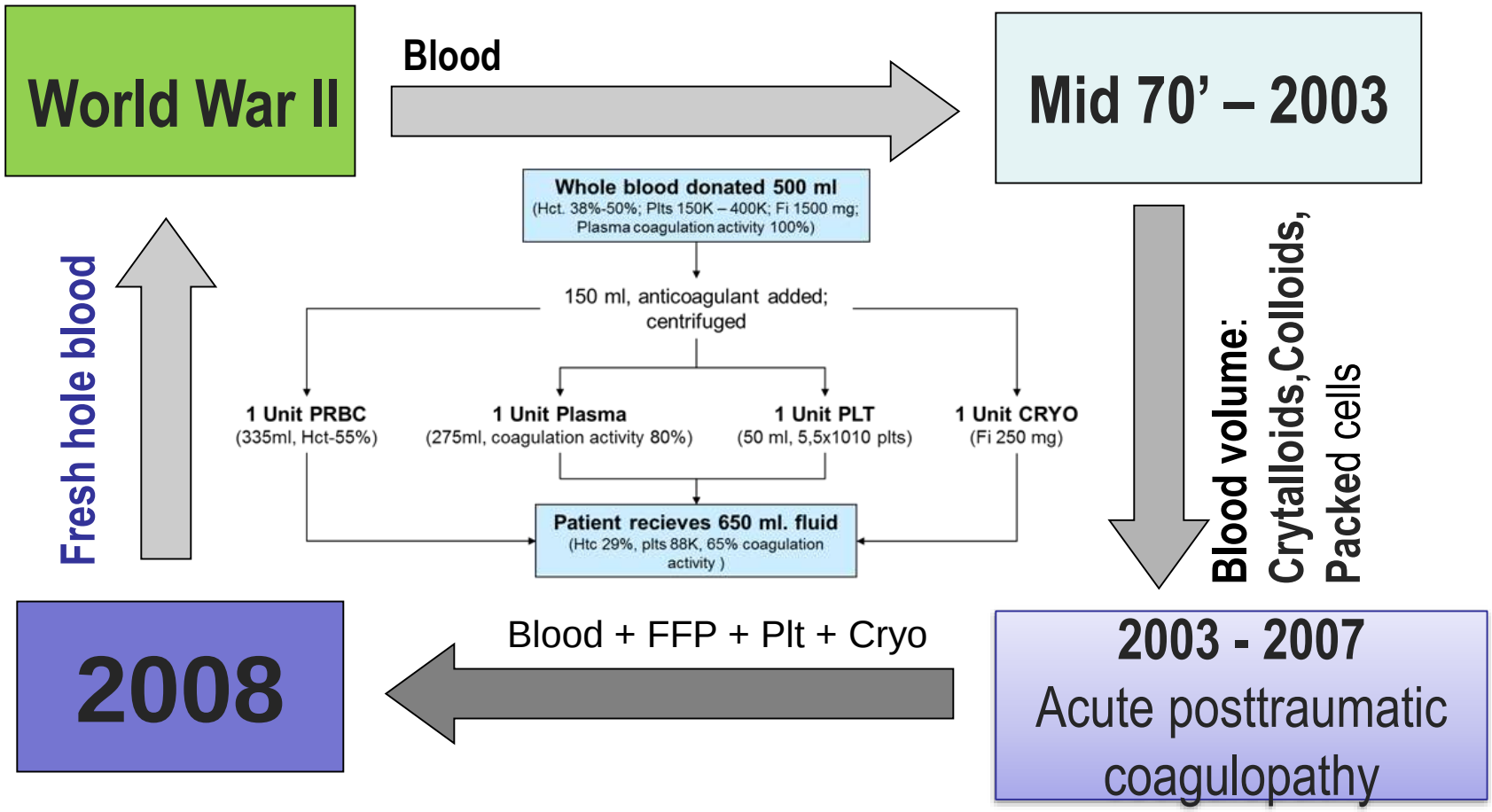
Fresh Whole Blood vs Component Therapy

Transfusion with plasma, platelets and packed red blood cells in a **1:1:1 ratio**



Dutton RP: Damage Control Anesthesia. International Trauma Care 2005;15(4):197-201

Step III: Limitation of Crystalloid with Early Use of Blood Products



"Back To Square One"

Attention !

!! Each 500 mL of cold blood transfused reduces patient core temperature by **0.5–1.0°C**

For all trauma patients, transfused blood products should be administered via an appropriate **warming device** so as not to worsen hypothermia

Step IV:
Early Use of Tranexanic Acid (TXA)

good quality randomized trail evidence of reduction in **mortality - CRASH 2**

Maximal benefits appears when TXA is administered within 1 hour of injury and there may be a potential harm when administered > 3 hours post injury *

Inhibition of fibrinolysis

It may modulate the plasmin-mediated inflammation and neurotoxicity

Crash-2 Collaborators, 2011. The importance of early treatment with tranexamic acid in bleeding trauma patients: an exploratory analysis of the CRASH-2 randomized controlled trial. The Lancet, 377(9771), pp.1096-1101.

Tranexamic Acid

CRASH-2 trial

- 274 hospitals in 40 countries
- 20 211 adult trauma patients with, or at risk of, significant bleeding
- tranexamic acid (loading dose 1 g over 10 min then infusion of 1 g over 8 h) or placebo
- 10 096 patients were allocated to tranexamic acid and 10 115 to placebo

Tranexamic acid safely reduced the risk of death in bleeding trauma patients in this study. On the basis of these results, tranexamic acid should be considered for use in bleeding trauma patients.

http://www.crash2.LSHTM.ac.uk

CRASH II

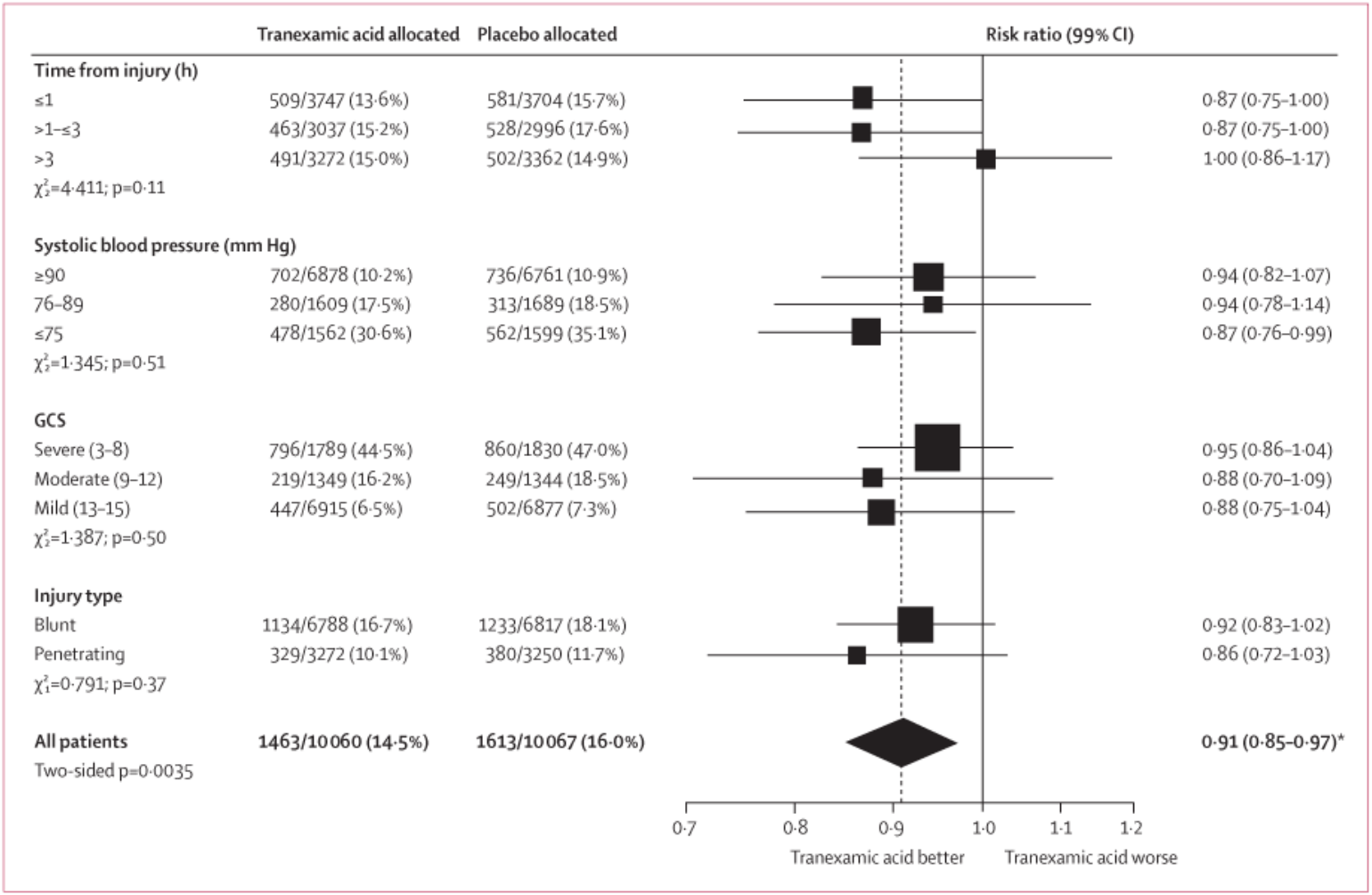


Figure 3: **All-cause mortality by subgroups**
GCS=Glasgow Coma Score. *95% CI.

http://www.crash2.LSHTM.ac.uk

RECOMBINANT factor VIIa (NovoSeven)

Activated recombinant factor VII

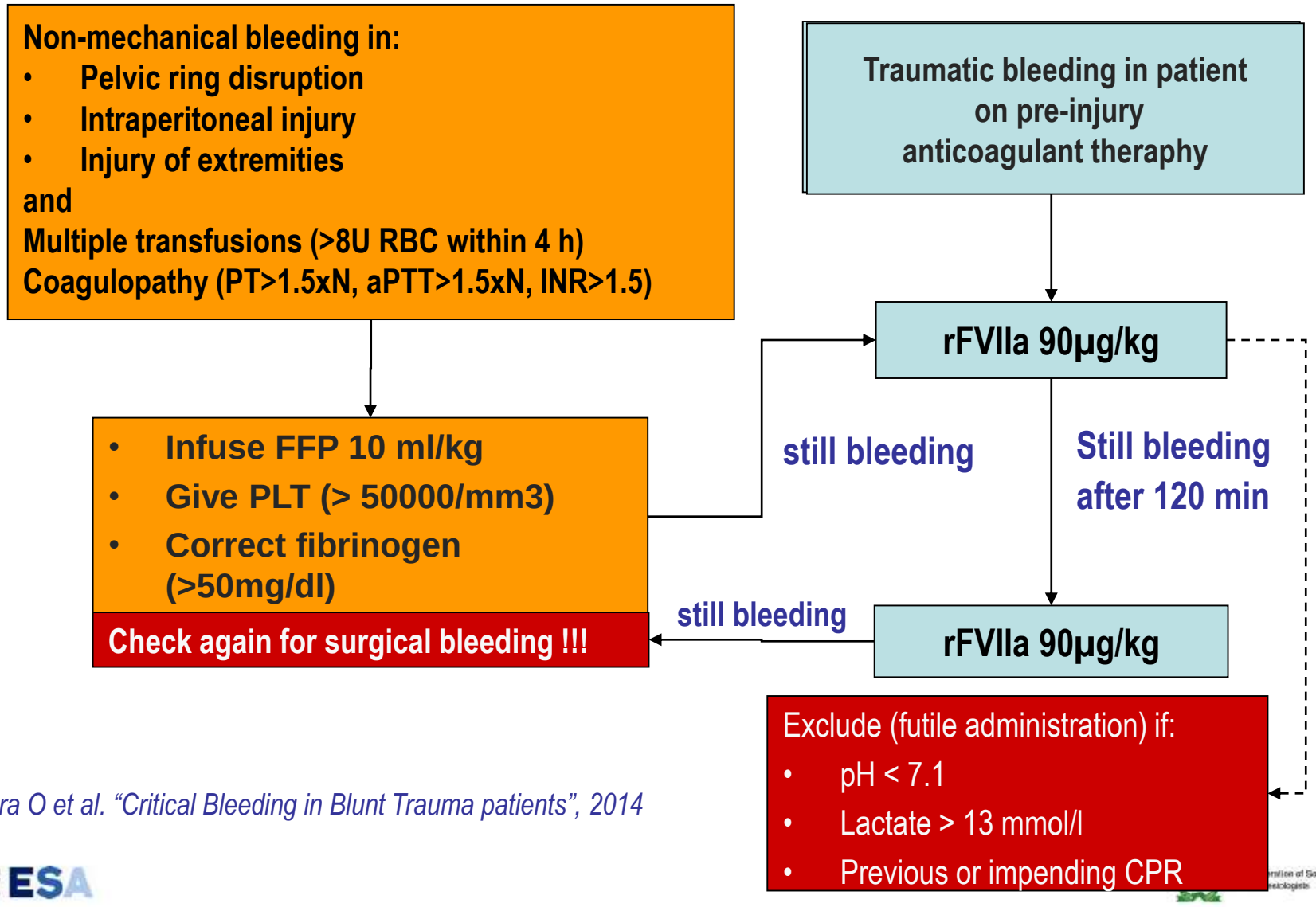
Treatment of patients with haemophilia A and B with antibodies against factor VIII and factor IX

No longer recommended for trauma patients due to the **arterial thrombotic events**

case series suggest that it should be considered **for life-threatening, non-surgical hemorrhage**

**Levi M, Peters M, Buller HR. Efficacy and safety of recombinant factor VIIa for treatment of severe bleeding: a systematic review. Crit Care Med. 2005;33:883-890.*

Protocol for the Use of rFVIIa in Trauma



Chiara O et al. "Critical Bleeding in Blunt Trauma patients", 2014

Early and Appropriate Use of Step V: Damage Control Surgery (DCS)

abdominal trauma, thoracic trauma, penetrating neck trauma, peripheral vascular injuries

Early and **appropriate** application of damage control surgery

- a cornerstone of the modern DCR paradigm
- surgical strategy to restore physiology are required to save life for a subset of the most severely injured patients

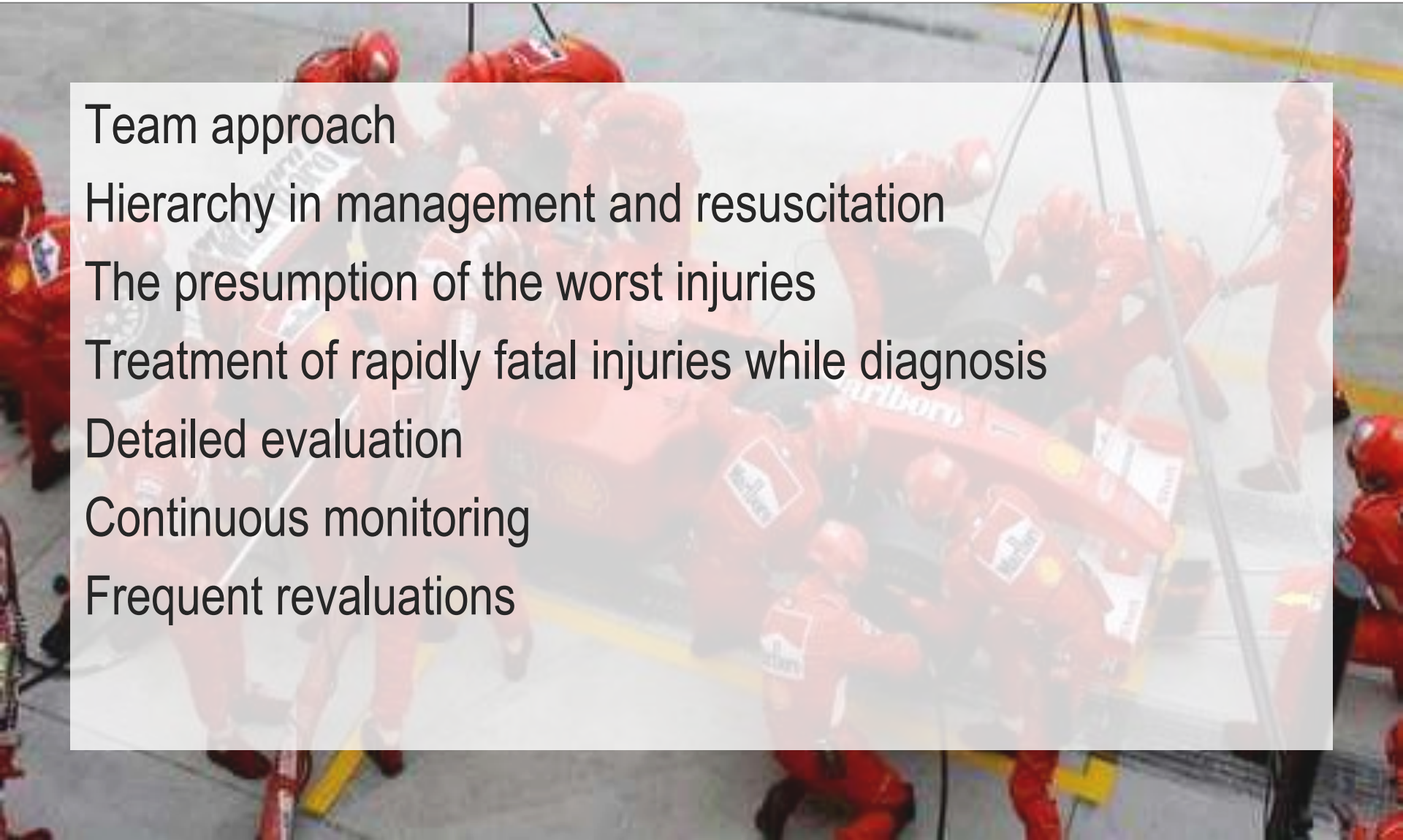
Rapid control of haemorrhage

- Repair or ligation for accessible blood vessels
- Inflow-occlusion by cross- clamping or balloon-tamponade
- Packing: 4 quadrants, perihepatic packing
- Intravascular shunting or stenting

Limitation of contamination / Ligation, suture or stapling of bowels / Resection of damaged segments (clips, clamps or staples) / Anastomoses and stomas have to be deferred

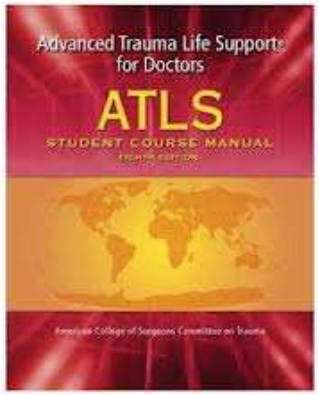
The Modern Damage Control Sequence Can be Considered in Five Phases

Polytrauma.
Specific Principles of Approach



- Team approach
- Hierarchy in management and resuscitation
- The presumption of the worst injuries
- Treatment of rapidly fatal injuries while diagnosis
- Detailed evaluation
- Continuous monitoring
- Frequent revaluations

Phase 0



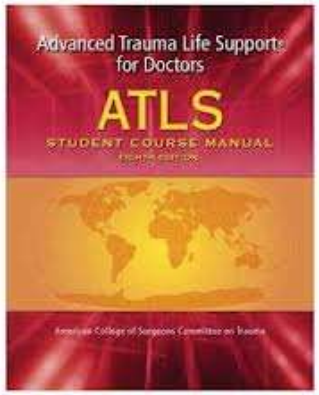
Pre-operative phase

injury-pattern recognition

ATLS

direct transport to a trauma center

Phase 0



Pre-operative phase

injury-pattern recognition

ATLS

early selection of candidates likely to benefits from damage control surgery

Lethal six
(immediately lethal)

- airway obstructuion
- tension pneumothorax
- cardiac tamponads
- open pneumotharax
- massive hemothorax
- fail chest

Combined vascular, solid and hollow organ injury

Inaccessible major venous injury

Anticipated need for a time consuming procedure

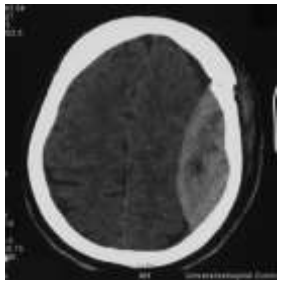
Demand for operative control of other injuries

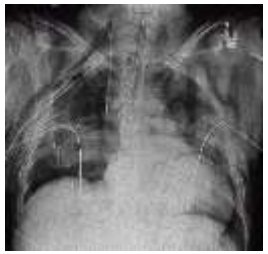
Inability to close the abdominal incision

Desire to reassess the intraabdominal contents

direct transport to a trauma center

Phase 0

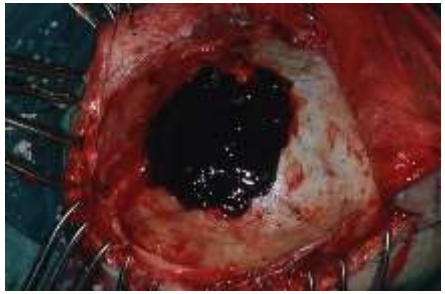




DCR

localize the site of bleeding by using imaging

expedient transport to the operating theatre

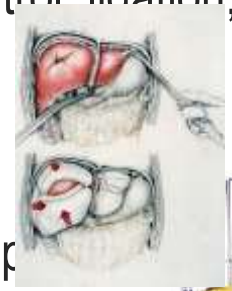


Phase 1

Rapid control of “mechanical haemorrhage” and visceral contamination

Rapid haemorrhage control: ligation,

- packing,
- vascular shunts,
- stapling devices,
- balloon catheter tamp



Use of cell salvage machines

Haemostatic agents

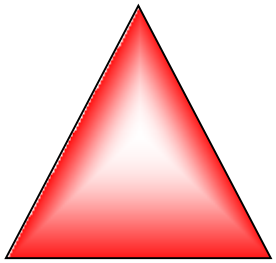
Contamination control:

- ligation, suture or stapling of bowels
- resection of damaged segments(
- vascular shunts,
- stapling devices,
- balloon catheter tamponade

Temporary wound closure / Adjunctive angioembolism for high-grade liver injury

- towel clips
- Bogota Bag (temporary, silo)
- Opsite – sandwich or (VAC)
- Mesh closure / Ethizip

Phase 2



the ICU resuscitative phase:

“Inter-rellation Acidosis, Hypothermia, Coagulopathy in Trauma”

- re-warming and restoration of physiology
- the lactate level
- transfusion of blood products according to thromelastography or conventional laboratory indices

The Lethal Triade Correction

1. HYPOTERMIA

first step - providing a temporary closure of the abdominal wall

Patient should be warmed to 37°C within 4 hours of arrival to the ICU !

- preheat the ICU suite
- aluminum foil cap
- the ventilator circuit should be warmed

all transfusion lines should have a dedicated fluid-warming device attached to them – **LEVEL 1**

pleural lavage with warm saline via multiple chest tube

warming device

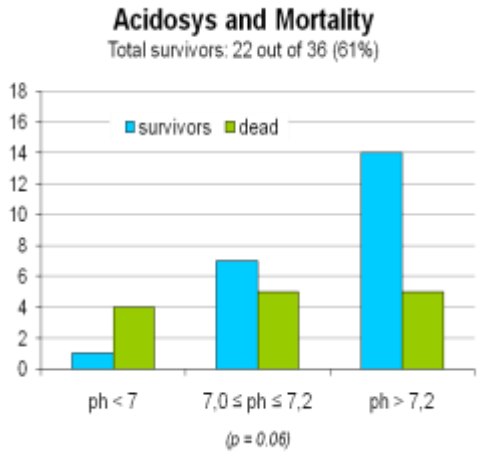
The Lethal Triade Correction

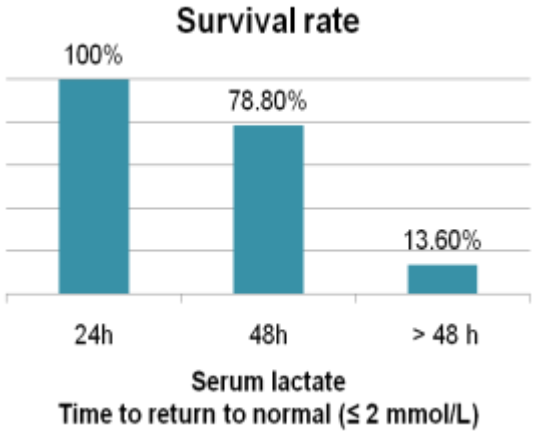
2. ACIDOSIS

Usually corrects itself once patient is adequately rewarmed and resuscitated

Sodium bicarbonate only **if pH is < 7.2**

the lactate level





The Lethal Triade Correction

3. COAGULOPATHY

transfusion of blood products according to:

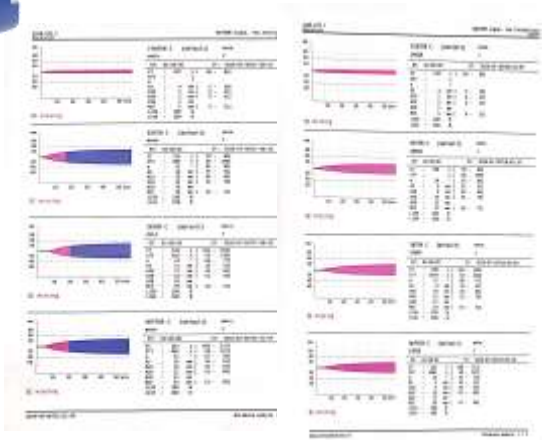
conventional laboratory indices

Rutine tests:

PT, aPTT
Fbn, D-dimer
Plt,

thromelastography

- CT (R = CT
- CFT (k = CFT
- Unghiul α
- MCF – MA = FMC
- LI 60 – (MA60 = CLI 60-



the 10-unit rule – transfusion guide

- prothrombin time < 15 seconds
- platelet counts > 100.000/mm3
- cryoprecipitate when fibrinogen level < 100 mg/dl

Masive Blood Transfusion in the First 24h Is an Independent Predictor for ...

increase by ...

- Mortality 10 x
- ICU admission 3 x
- ICU LOS 6 x
- SIRS 3 – 5 x

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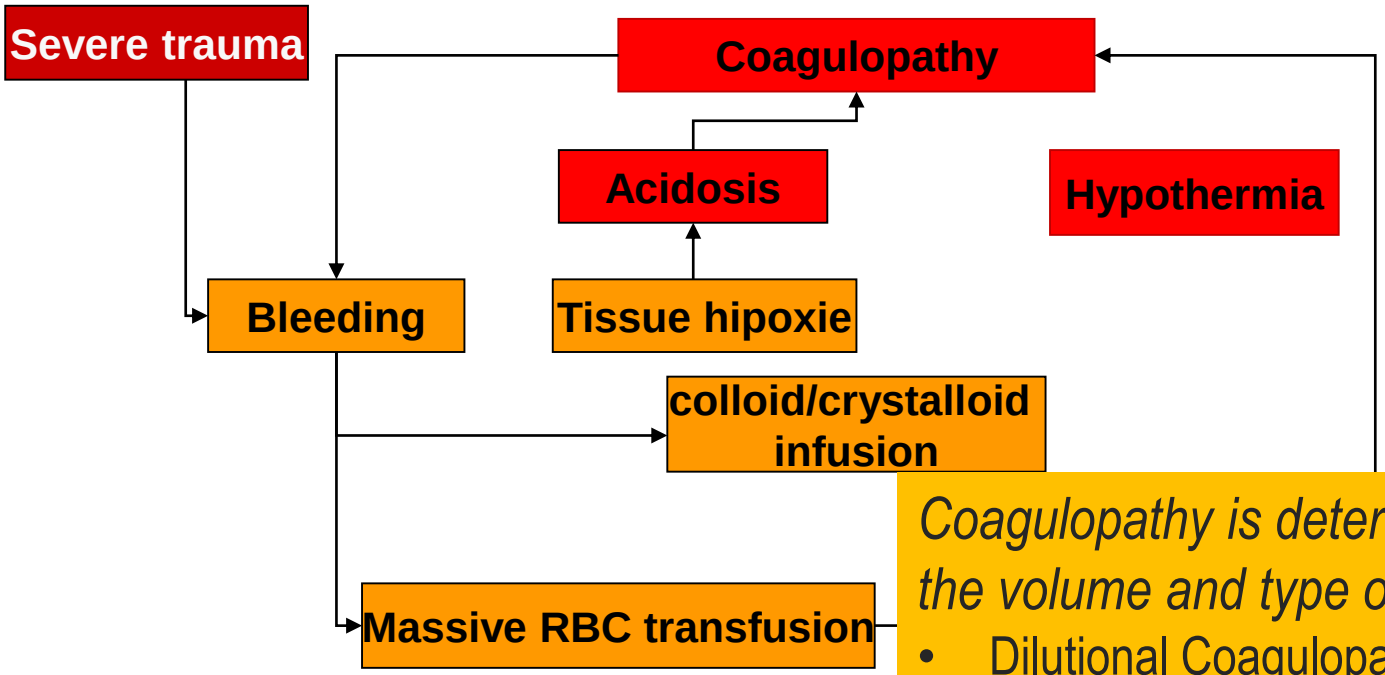
The Lethal Triade Correction

3. COAGULOPATHY

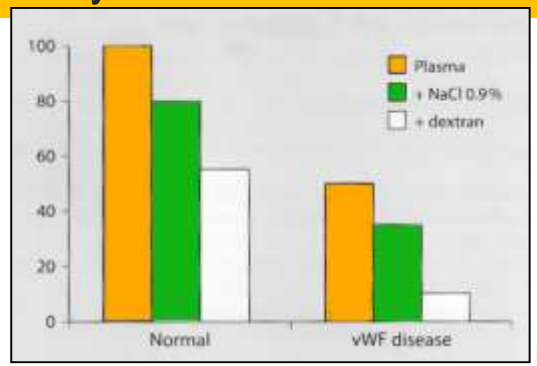


Coagulopathy is determined by both the volume and type of fluid infused

- Dilutional Coagulopathy
- Crystalloids / Colloides effects

initiation of fluid resuscitation

There is no evidence to support the superiority of any crystalloid or colloid over another in trauma patients !!



Phase 2

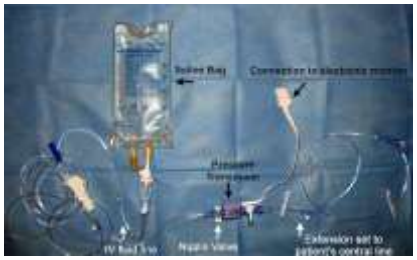
the ICU resuscitative phase….

return to operating theatre / angioembolisation

detailed examination and review of available imaging

Persisting bleeding

Increasing intraabdominal pressure (ACS)



Scheduled reoperation after repacking and entensive gut distension due to reperfusion

Physiological restoration

Removal of packs and definitive repair

Phase 3

Definitive repair of all injuries

- The timing depends on the individual patient's physiology
- definitive procedures where possible
- intra-operative evaluation – the incidence of missed injuries is high
- may require several separate visit to theatre to complete the defects

Phase 3

Definitive repair of all injuries

Physiological status		*Surgical intervention*	*Timing*
Response to resuscitation:	(-)	→ **Life saving surgery**	***Day 1***
	(?)	→ **"Damage control"**	
	(+)	→ **Early total care**	
Hyper-inflammation		**"Second look", only!**	**Day 2-3**
"Window of opportunity"		**Scheduled definitive surgery**	***Day 5-10***
Immunosuppression		***No surgery!***	
Recovery		**Secondary reconstructive surgery**	**Week 3**

Phase 4

Reconstruction of abdominal wall

Final abdominal closure without tension

aggressive diuresis is implemented to reduce bowel and body wall oedema for facilitating early definitive closure

Direct closure – only without gut distension

After fascial retraction subsequent gradual V.A.C. (Vacuum-Assisted Closure)

Mesh repair

In an hostile abdomen: gauze packing, secondary granulation and skin grafting

Secondary plastic reconstruction

Damage Control Anesthesia

Anesthetic considerations in multiple trauma – general anaesthesia

The Essentials of Anaesthesia in multiple trauma patients

1. **Airway and ventilator management**
   - Rapid sequence intubation
   - Titration of ventilation
2. **Control of bleeding**
   - Deliberate hypotensive resuscitation
   - Maintenance of blood composition
3. **Preservation of homeostasis**
   - Normothermia
   - Restored and sustained end-organ perfusion
4. **Anaesthesia**

Anaesthetic Problems Specific to the Trauma Patient

hemodynamic instability traumatic, hemorrhagic, cardiogenic or septic shock

Shock in multiple trauma

Hypovolemic shock: ↓circulation volume

Cardiogenic shock: ineffective pump function (myocardic contusion)

Vasogenic shock: ↓SVR

- Neurogenic shock
- Septic shock
- Obstructive shock: mechanical obstruction (cardiac tamponade, tension pneumothorax)

Traumatic shock: combination of above causes (hypovolemia, tissue injury-SIRS)

Harbrecht BG, Billiar TR: Shock in The Trauma Manual: Trauma and Acute Care Surgery, 2008, Ed. Lippincot Williams and Wilkins,3rd edition:29-34

Anaesthetic Problems Specific to the Trauma Patient

MULTIPLE TRAUMA

Full stomach

Existing patient history?

Actual/potential injury of the cervical spine

Rapid Sequence of Intubation

Manually inline stabilization of the cervical spine by an assistant

Removal of the devices stabilizing the spine

Preoxigenation for 2-3 minutes

Administration of an iv anaesthetic (etomidate/ketamina)

Application of cricoid pressure by a separate assistant (Sellick maneouvre)

Administration of a rapidly acting neuromuscular blocking drug (suxametoniu/rocuronium)

Intubation of the trachea

Check of position of the tracheal tube

Release of cricoid pressure

Securing the tracheal tube

Reapplication of the stabilizing devices to the neck

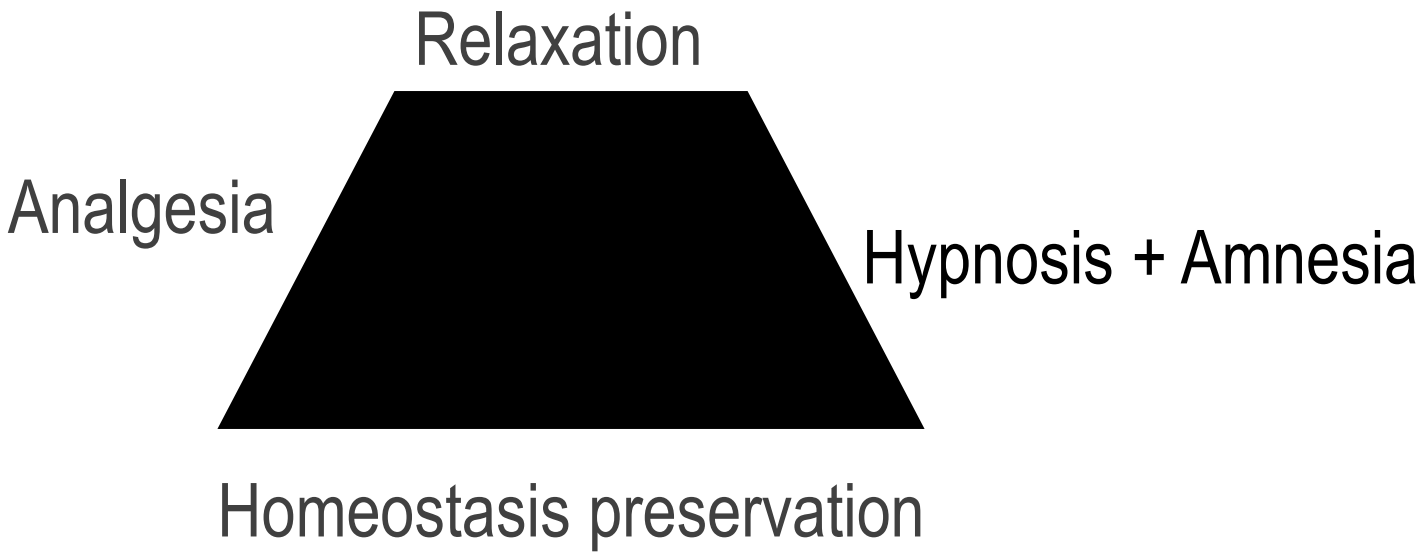
Maryland Institute for Emergency Medical Services Systems Shock Trauma Center (Criswell et all., 1994)

Induction doses and characteristics

Drug	Dose [mg/kg]	Onset [s]	Duration [min]	Excitation	Pain
Etomidate	0.2 - 0.4	15 - 45	3 - 12	+++	+++
Propofol	1.5 - 3.0	15 - 45	5 - 10	+	++
Midazolam	0.2 - 0.4	30 - 60	15 - 30	0	0
Ketamine	1 - 3	45	10 - 20	+	0

Anaesthesia's Goals

The anaesthesia quadrilateral



Maintenance

opioids

↓serum catecholamine

Pain relief

Propofol,midazolam, volatile agents

(-)inotropism and vasodilatation (hTA)

Unconsciousness patient

Over-utilisation of the Damage Control Concept

Selecting “Damage control” too careless may mean an unnecessarily premature termination of surgery in patients who would otherwise have recovered from a single definitive procedure.

It would subject the patients to risks and expenses of multiple surgical interventions.


Happy Holidays!
Sărbători Fericite!