Severe trauma, severe bleeding and therapy, brain injury, intracranial hypertension, brain death, donor program

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Severe trauma

Definition

- Multiple trauma: injury of at least two organ systems, of which at least one is life-threatening
- Severe trauma is defined by an Injury Severity Score (ISS) >15

Injury severity score

Trauma scale used to grade severity of multiple injuries and based on AIS (abbreviated injury score)

- Evaluation based on anatomical injury
- Anatomical regions:

  Head or neck,Face ,Chest ,Abdomen or pelvic contents,

  Extremities or pelvis, Surface of the body
- Severity: none=1(contusion of back), minor=2 (forearm fracture), moderate=3(fracture of the skull base without likvorea), serious=4(burn of 3th degree on 30% of the body surface), severe=5(fracture of the cervical vertebra with quadruplegic), critical=6(decapitation)
- Calculation: ISS = $A^2 + B^2 + C^2$ (3 the most injured)

Injury Severity Score; ISS

Region	Injury Description	AIS	Square Top Three
Head & Neck	Cerebral Contusion	3	9
Face	No Injury	0	
Chest	Flail Chest	4	16
Abdomen	Minor Contusion of Liver Complex Rupture Spleen	2 5	 25
Extremity	Fractured femur	3	
External	No Injury	0	
		Injury Severity Score:	50

AIS Score	Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Survivable

ISS	
1-8	Minor
9-15	Moderate
16-24	Serious
25-49	Severe
50-74	Critical
75	Maximum

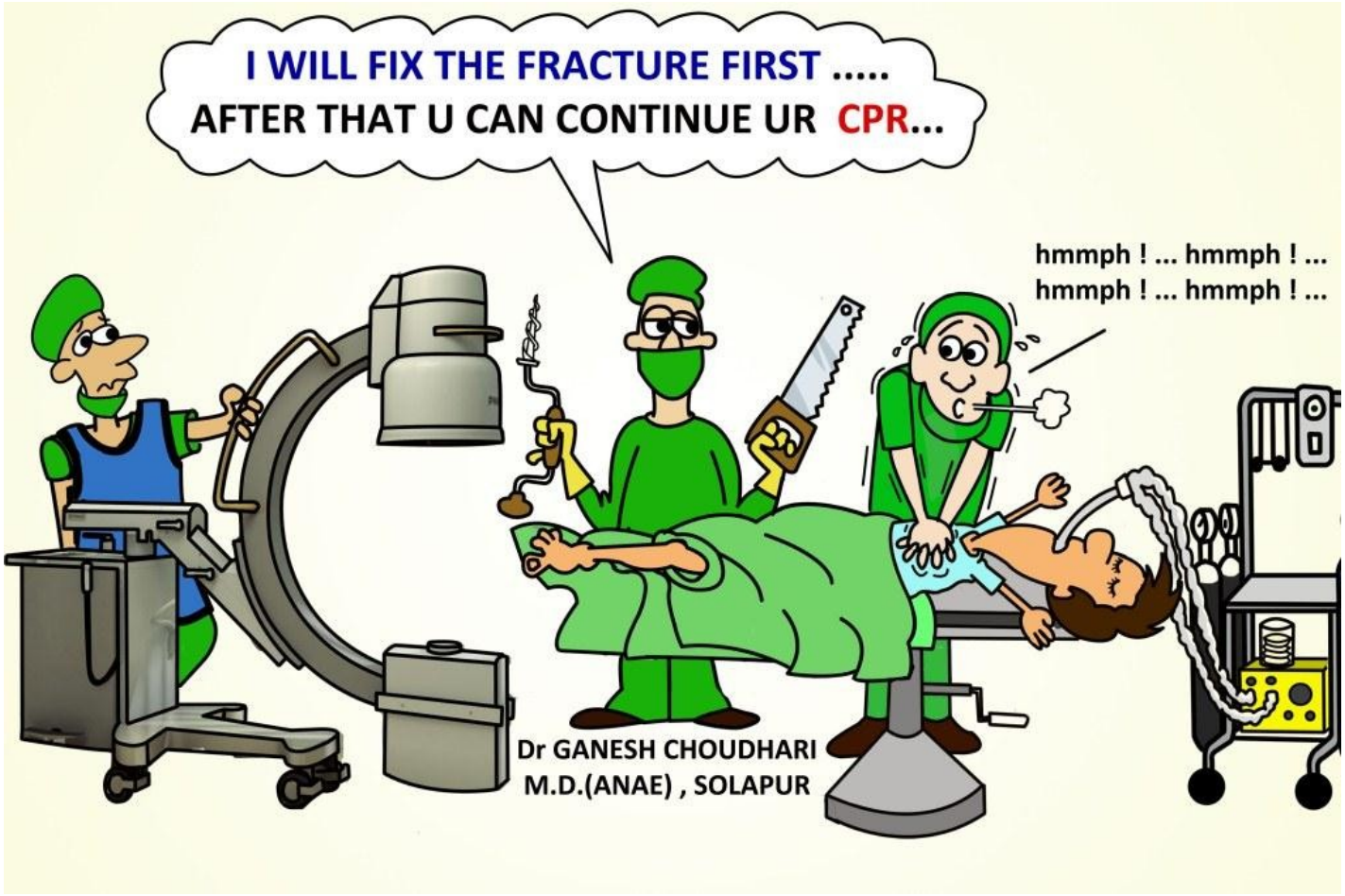
Mechanisms of injury

- Blunt
- Penetrating
- Thermal (burns and cold injury)
- Blast

Epidemiology and ATLS

- 250 per million population per year
- **Advanced trauma life support** (**ATLS**)
  - training program for medical providers in the management of acute trauma cases, developed by the American College of Surgeons
  - its goal is to teach a simplified and standardized approach to trauma patients
  - widely accepted as the standard of care for initial assessment and treatment in trauma centers
  - The premise of the ATLS program is to treat the greatest threat to life first (A, B, C, D, E…..)

ATLS, the way of thinking



The team approach in trauma centers

- Team leader (anesthesist intensivist, surgeon…)
- Trauma surgeon, general surgeon
- Intensivist, anesthesist
- Radiologist
- Optional:
  - Neurosurgeon, neurologist, urologist, neck-, face surgeon, urologist…

Generic approach to trauma care

- Detection and treatment of life-threatening injuries during a primary assessment and intervention phase.
- Detection of all the other injuries during a secondary assessment (head to toe examination) when a more detailed clinical examination is combined with investigations such as imaging. Definitive care plans are then made.
- Detection of missed injuries and early sequelae or complications (i.e. compartment syndrome after tibial fracture) in a tertiary assessment, performed within the next 24 hours.

Assumption of severe trauma

- Falls >2 metres
- Pedestrian or cyclist hit by a car at speed >30 km/hr (18 miles/hr)
- Death or severe injury of another occupant in the same vehicle/accident
- Ejection from a vehicle
- Major deformity of the vehicle or intrusion into the passenger space, especially bent columns around the front doors
- Extrication time >20 minutes
- Vehicle roll-over
- Penetrating injury to the head or trunk

Bases of the ABCDE approach

Table 1: *Basics of the ABCDE approach*

Letter	Life-threatening condition
A – Airway	Airway blockage, cervical spine injury
B – Breathing	Tension pneumothorax, pulmonary oedema, bronchospasm
C – Circulation	Shock (hypovolaemic, obstructive, distributive, cardiogenic)
D – Disability	Seizure, hypoglycaemia, meningitis, intracranial haemorrhage or infarction, intoxication
E – Exposure	Hypothermia or hyperthermia, critical skin conditions such as fasciitis or urticaria

A- Airway maintainence with C spine protection

- fiO2 need
- Airway patency-
  - Obstruction
  - coma
- Spontaneous ventilatory activity
- Airway obstruction signs:
  - Stridor
  - Ineffective breathing attempts
- Causes of obstruction
  - Foreign body
  - Trauma to the neck
  - Burns- inhalation trauma

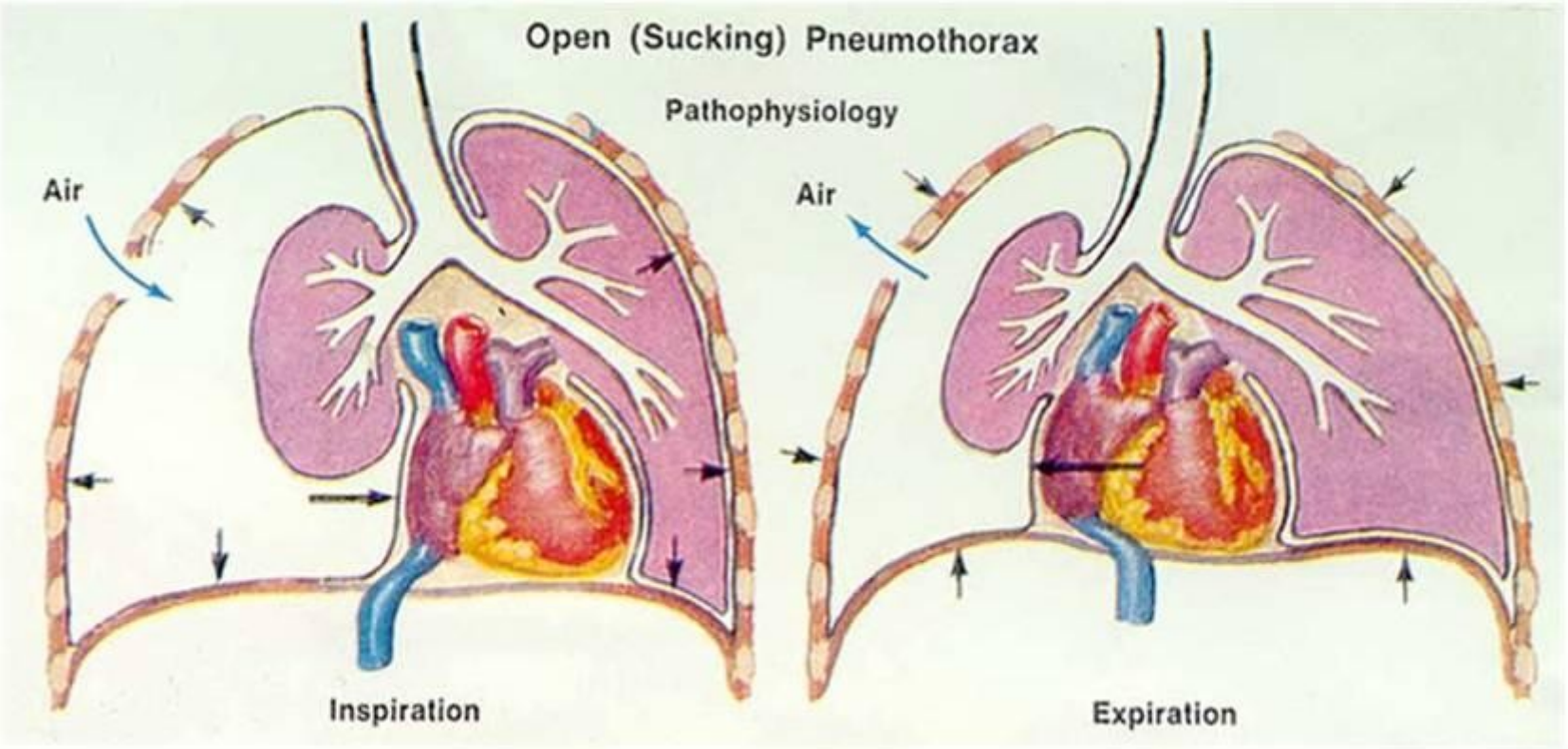
B- Breathing and ventilation

- Tension pneumothorax
- Open pneumothorax
- Massive haemothorax
- Flail chest +pulmonary contusion

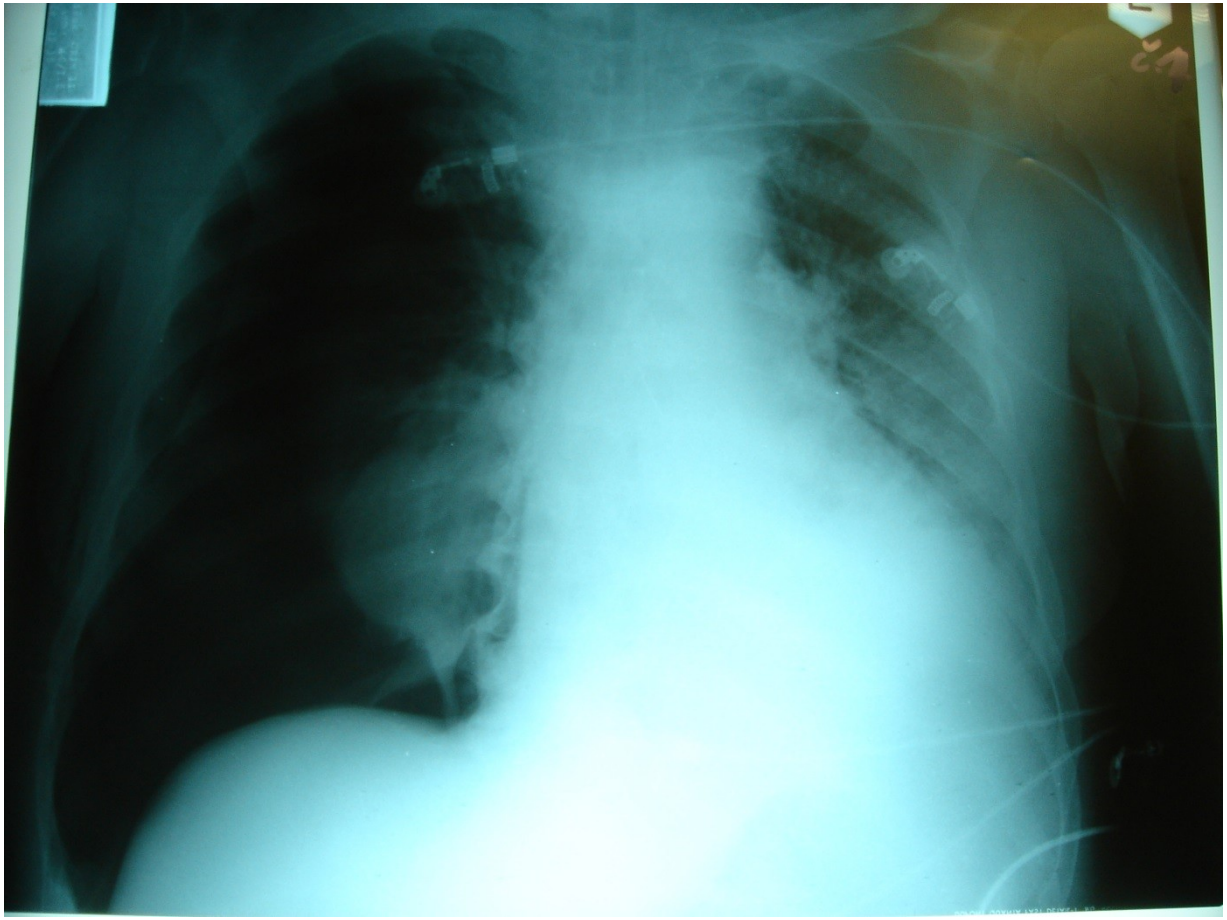
Open Pneumothorax

- collection of air in the pleural cavity resulting in collapse of the lung on the affected side
- follows a penetrating chest trauma such as a stab wound, gunshot injury of fractured rib
- breathing shallow,rapid,laboured.Reduced expansion of the hemithorax
- sucking chest wound – visibly bubbling
- first aid:cover the wound with non-occlusive dressing,definitive: chest drain insertion

Open Pneumothorax



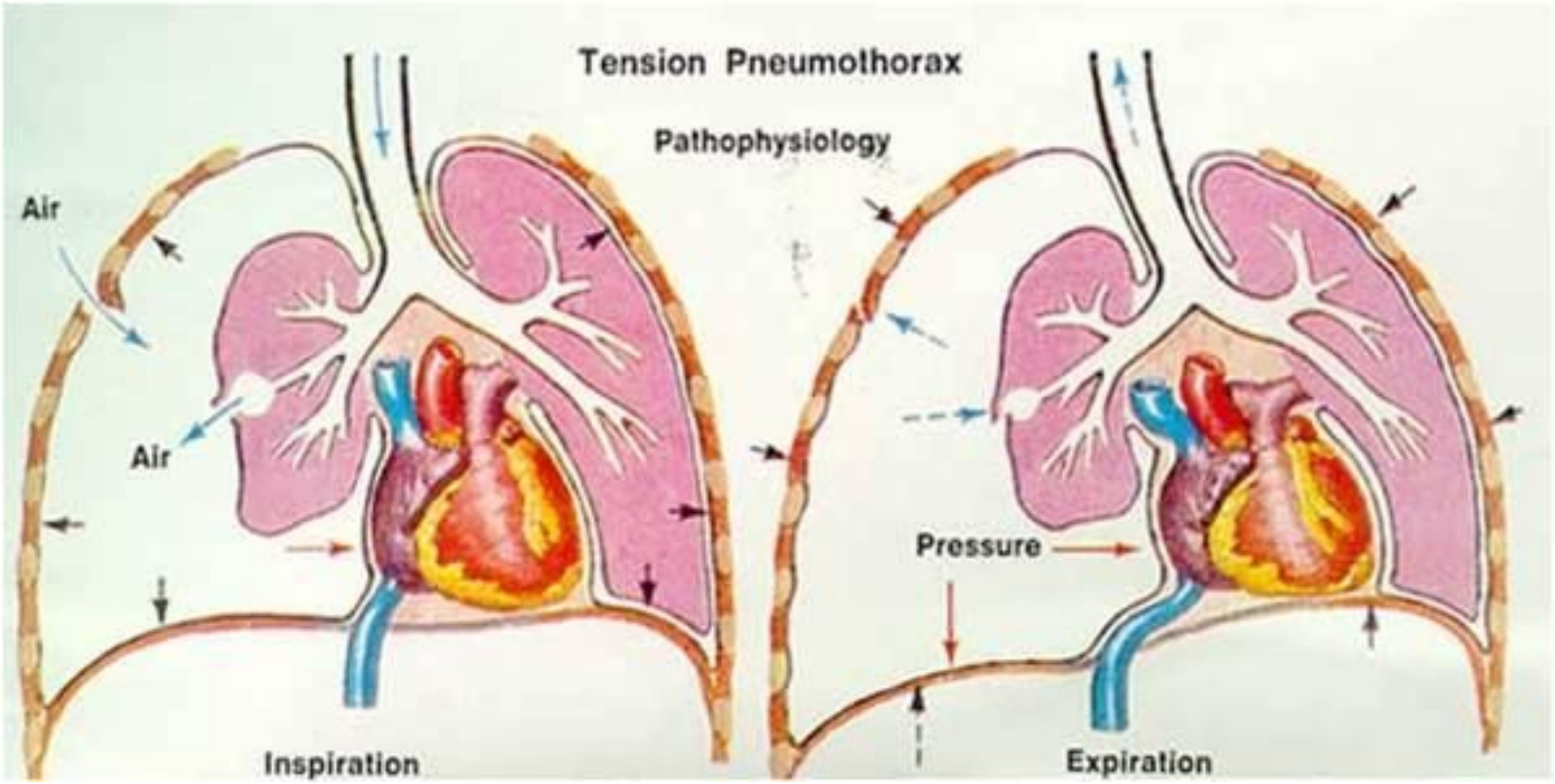
Pneumothorax



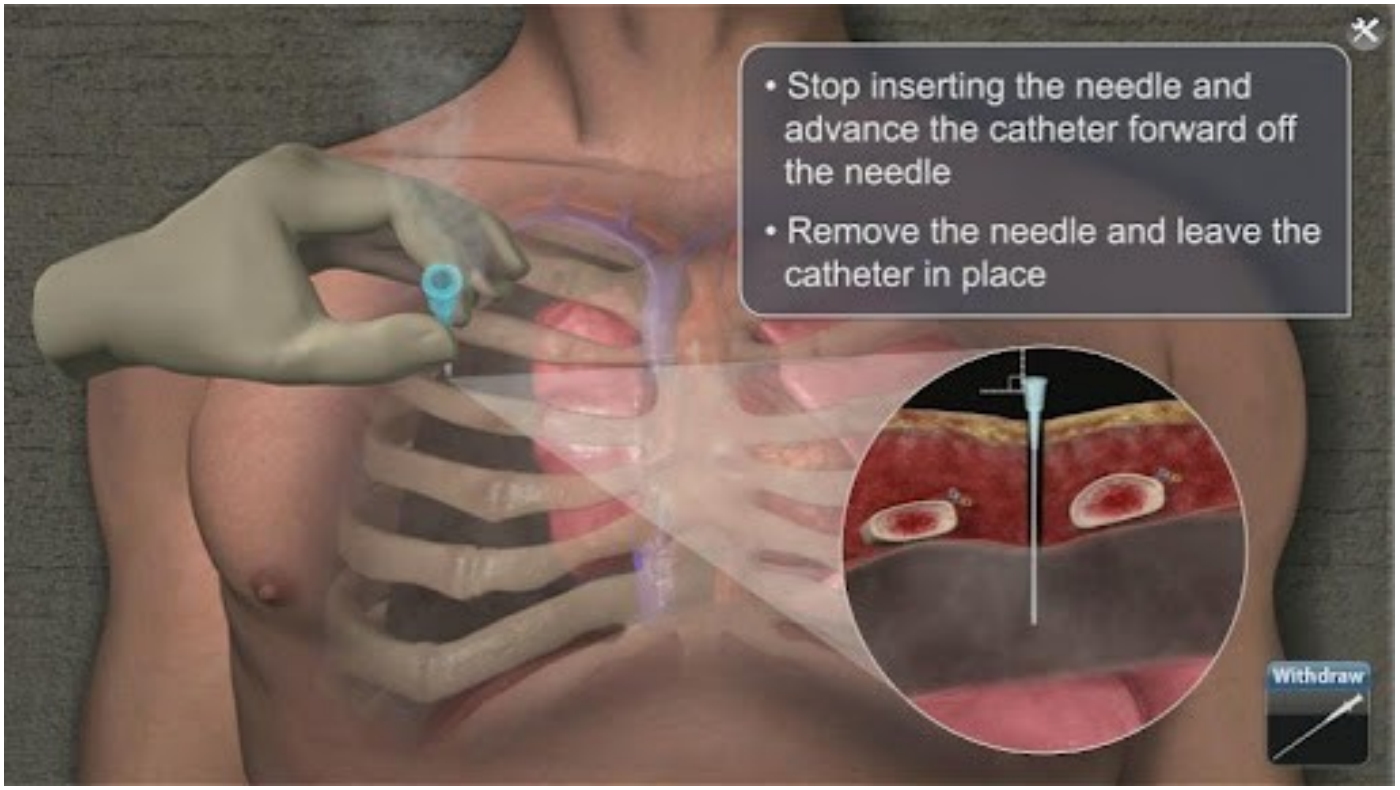
Tension Pneumothorax

- develops when a one-way valve air leak occurs from the lung or through the chest wall
- air is forced into the thoracic cavity without any means of escape
- mediastinum is displaced to the opposite side, decreasing venous return and compromising the opposite lung
- chest pain,air hunger, tachycardia, hypotension, tracheal deviation, cyanosis, neck vein distention, unilateral absence of breath sounds
- requires immediate decompression and chest drain insertion

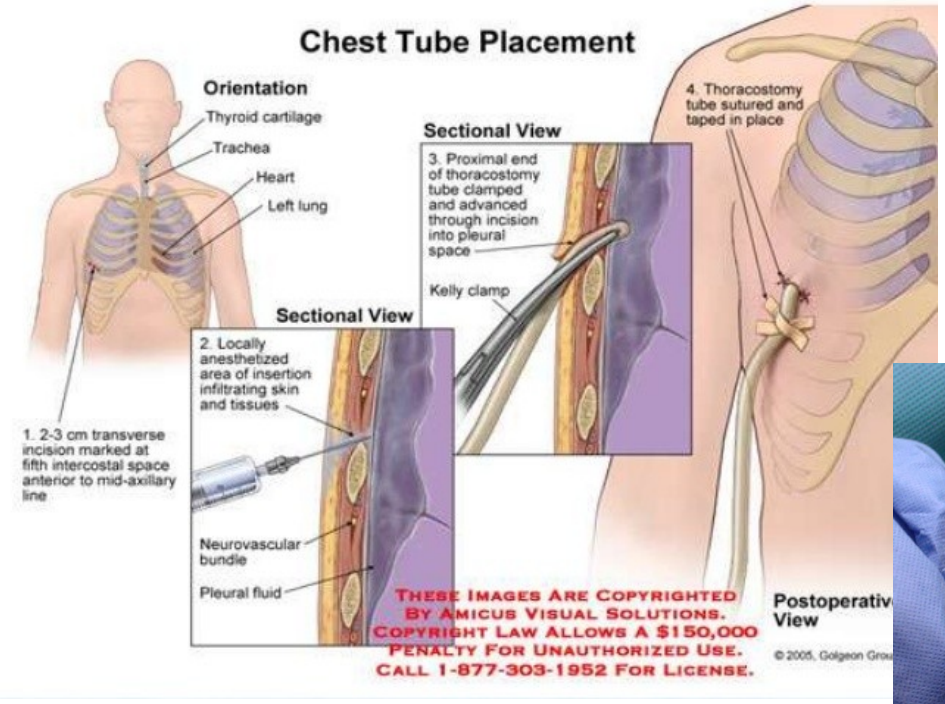
Tension Pneumothorax



Needle Decompression



Chest Drain Insertion



Flail Chest and Pulmonary Contusion

- chest wall does not have bony continuity with the rest of the thoracic cage
- unilateral fractures of four or more ribs or bilateral
- chest wall instability leads to paradoxical motion of the chest wall
- underlying lung injury- **pulmonary contusion**

Massive Hemothorax

- **accumulation of blood in a hemithorax (>1500ml)**
- may significantly compromise respiratory efforts by compromising the lung and preventing adequate ventilation
- **C**-more dramatically present as hypotension and shock
- decreased breath sounds,signs of shock (pulse rate, respiratory rate,skin circulation)

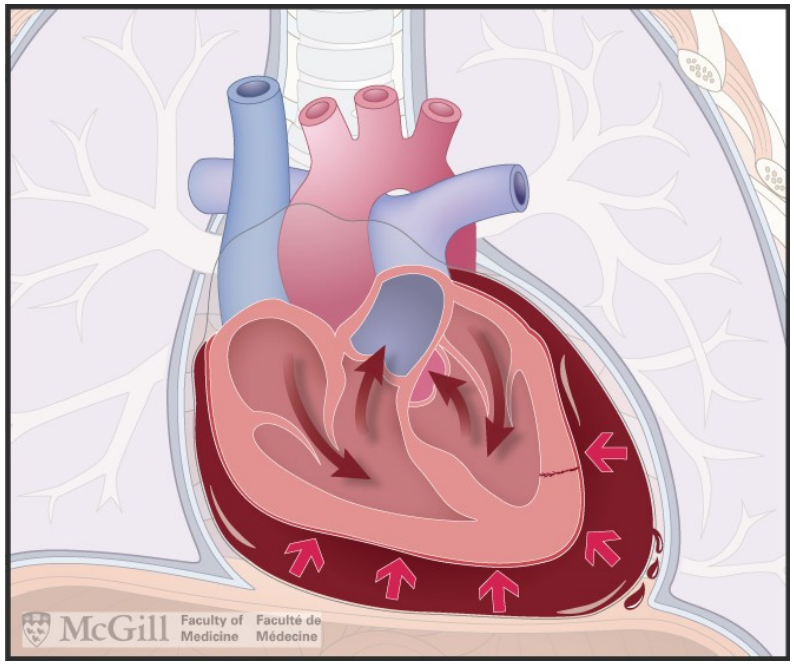
- it is necessary to **place the chest tube** and **check the bood loss**

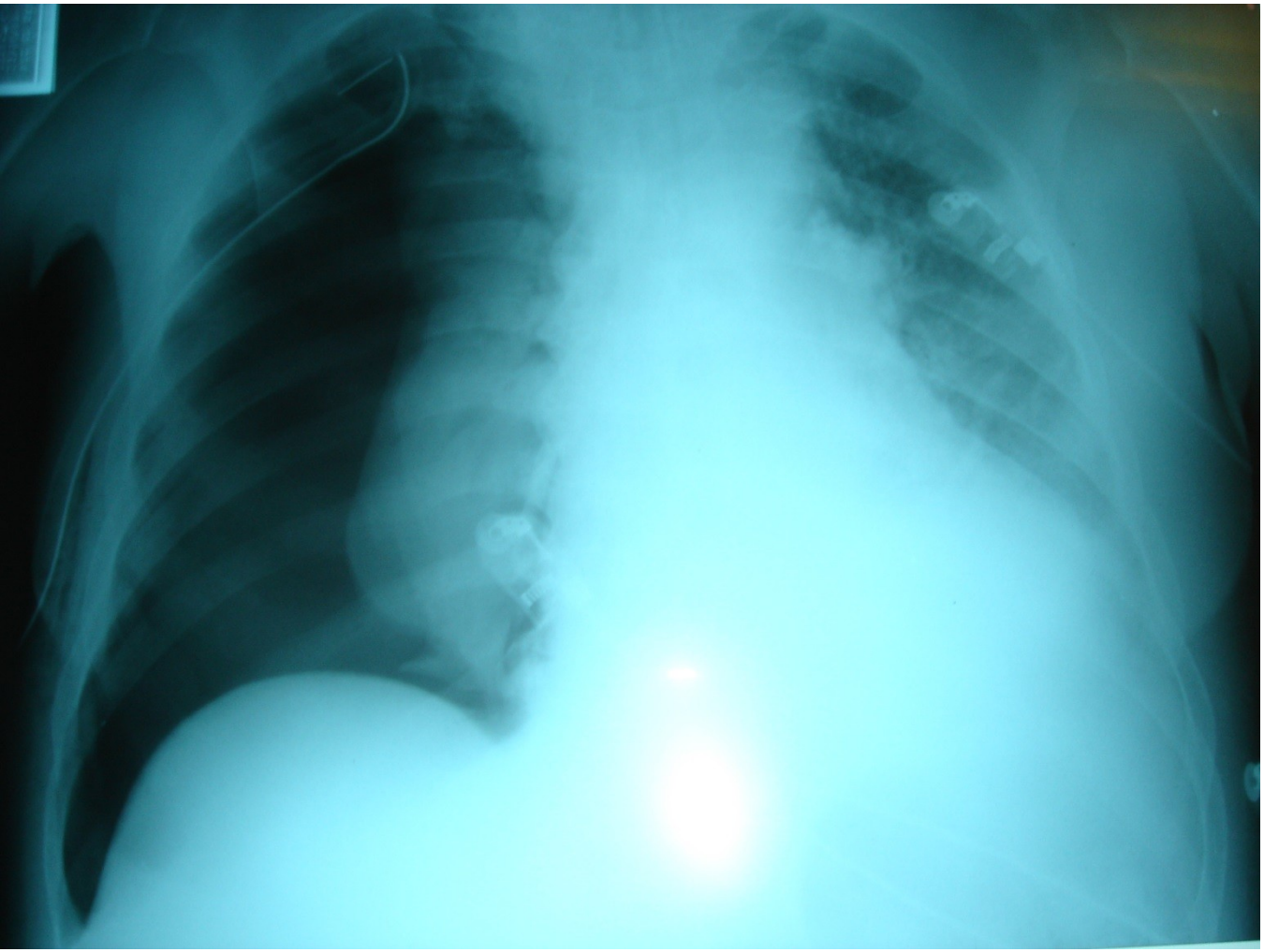
Hemothorax

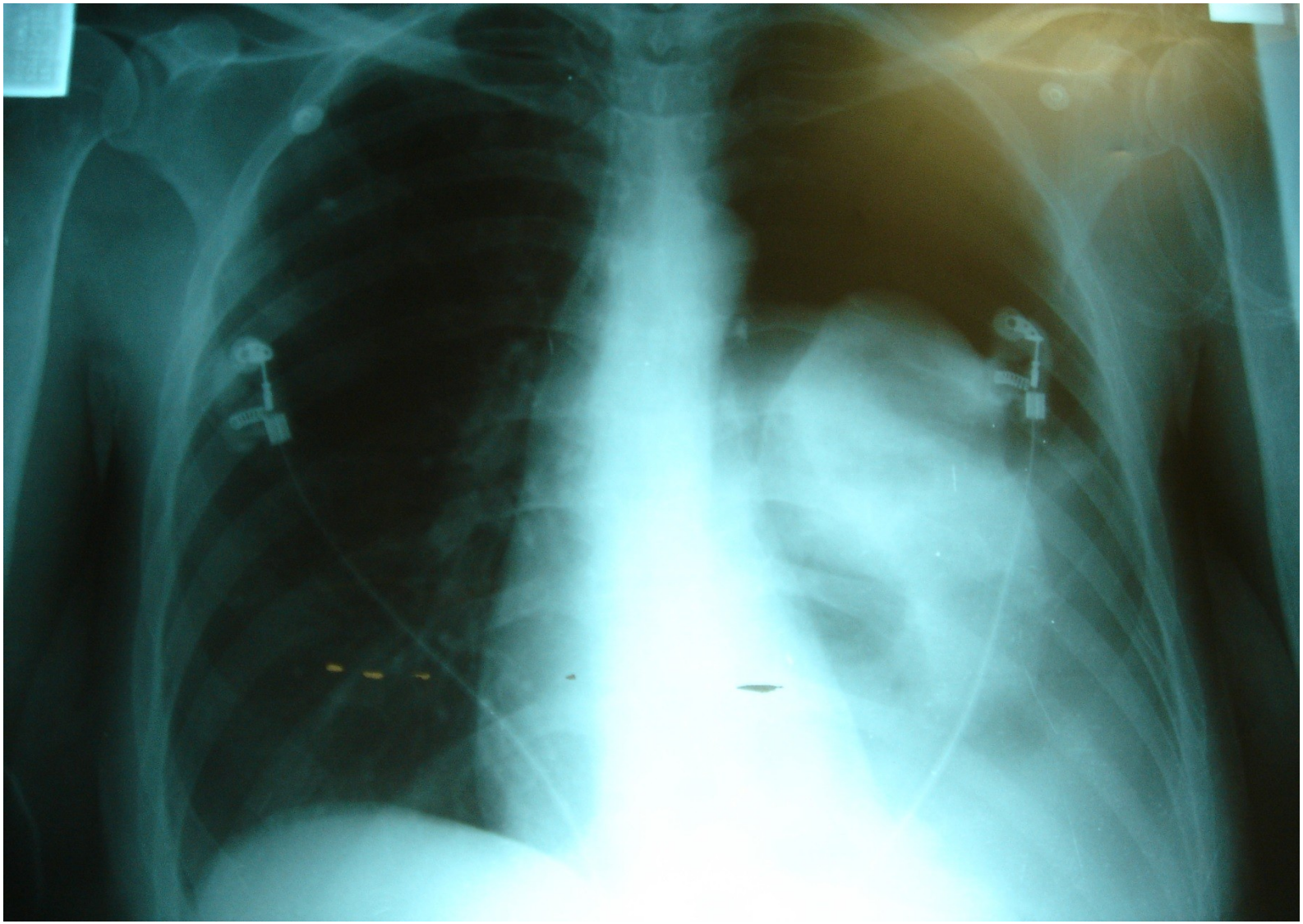
Cardiac Tamponade

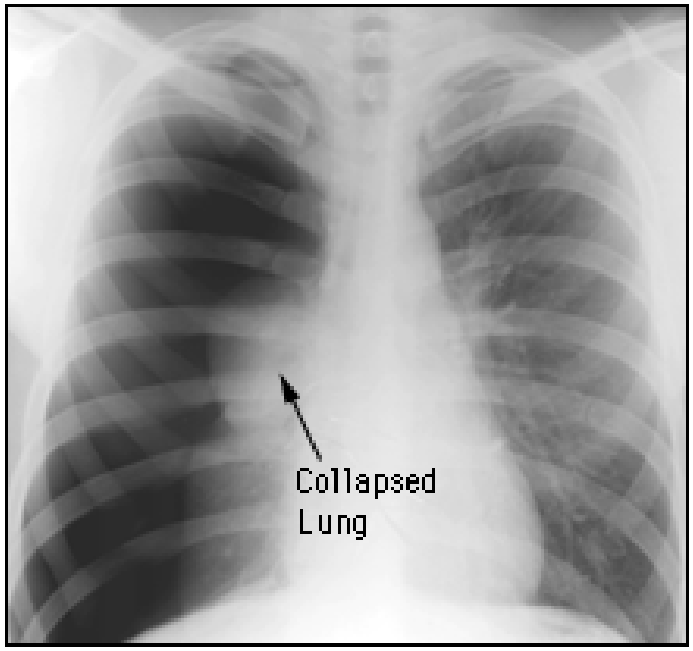
- penetrating injuries
- small amount of blood in the pericardial sac will restrict cardiac activity
- pericardiocentesis

- Hypotension with a narrowed pulse pressure
- Jugular venous distention
- Muffled heart sounds

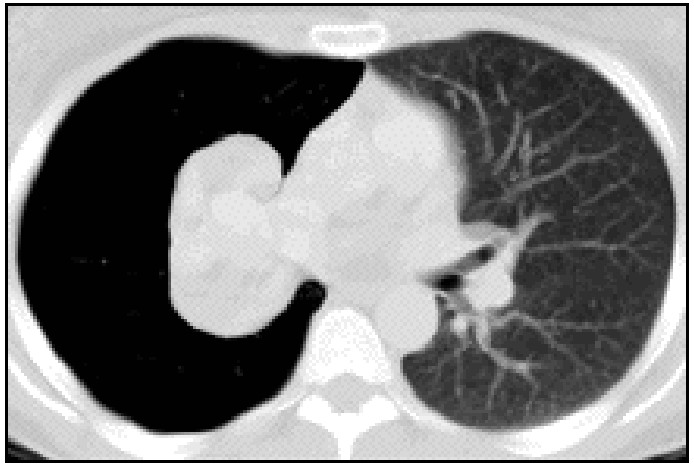








Right lung pneumothorax - Radiograph



Right lung pneumothorax - CT

Treating breathing problems

- Oxygen
- Intubation, mechanical ventilation
- Chest tubes
- Analgesia

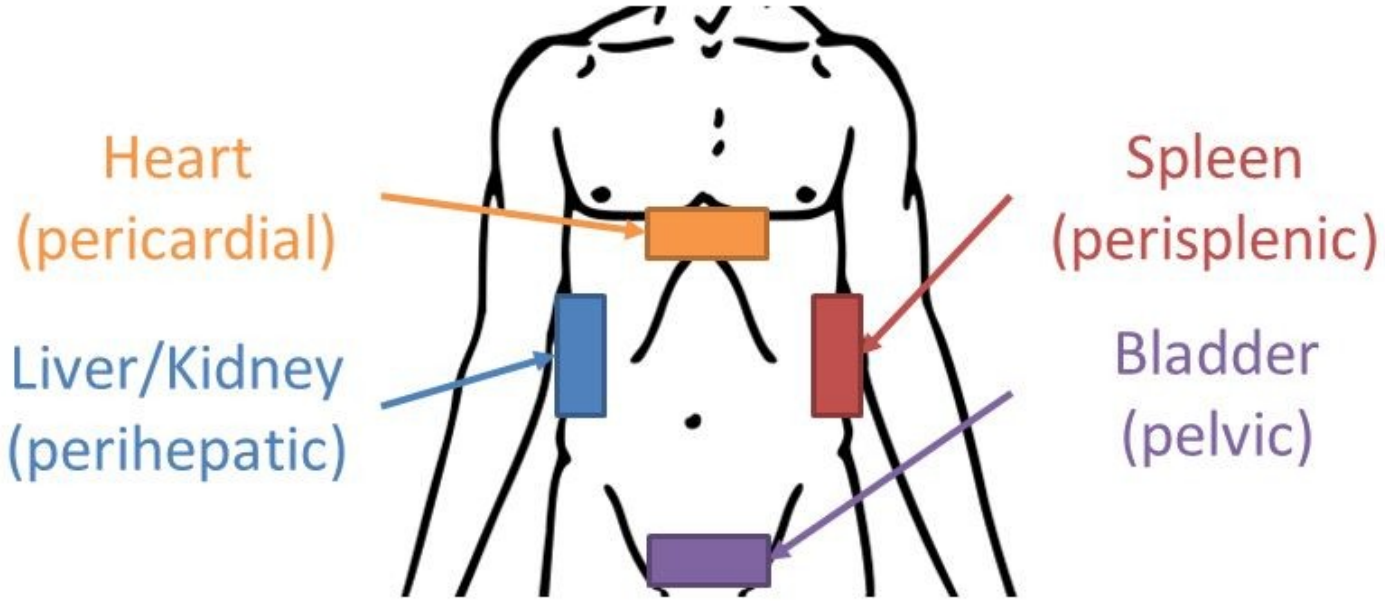
C- Circulation with haemorrhage control

- *Hypotension following injury must be considered to be hypovolemic in origin until proven otherwise*
- Skin color,pulse,level of consciousness
- FAST (Focused Assessment with Sonography for Trauma)

- Types of shock: ??????
  - Hypovolemic Haemorrhagic shock
  - Obstructive tension pneumothorax
  - Cardiogenic Cardiac contusion-
  - Distributive - SIRS

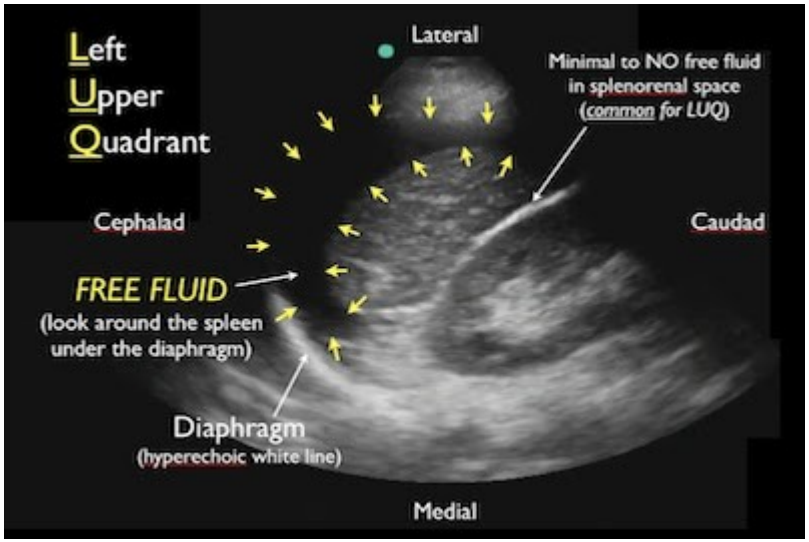
FAST Examination

- Diagnostic examination for internal bleeding



FAST scan

Fig. 1. Right upper quadrant view depicting a positive FAST scan obtained during the study period with free fluid visible in Morrison's pouch.



- fast,non-invasive
- rules in,not out
- can be repeated

Severe bleeding

American College of Surgeons Classes of Acute Hemorrhage

Factors	I	II	III	IV
Blood loss	<15% (<750ml)	15-30% (750-1500ml)	30-40% (1500-2000ml)	>40% (>2000ml)
Pulse	>100	>100	>120	>140
B.P.	Normal	Normal	↓	↓↓
Pulse pressure	N or ↓	↓	↓↓	↓↓
Capillary refill	<2s	2-3s	3-4s	>5s
Resp. rate	14-20	20-30	30-40	>40
Urine output ml/hr	30 or more	20-30	5-10	Negligible
Mental status	Slightly anxious	Mildly anxious	Anxious & confused	Confused Lethargic

Treating circulation

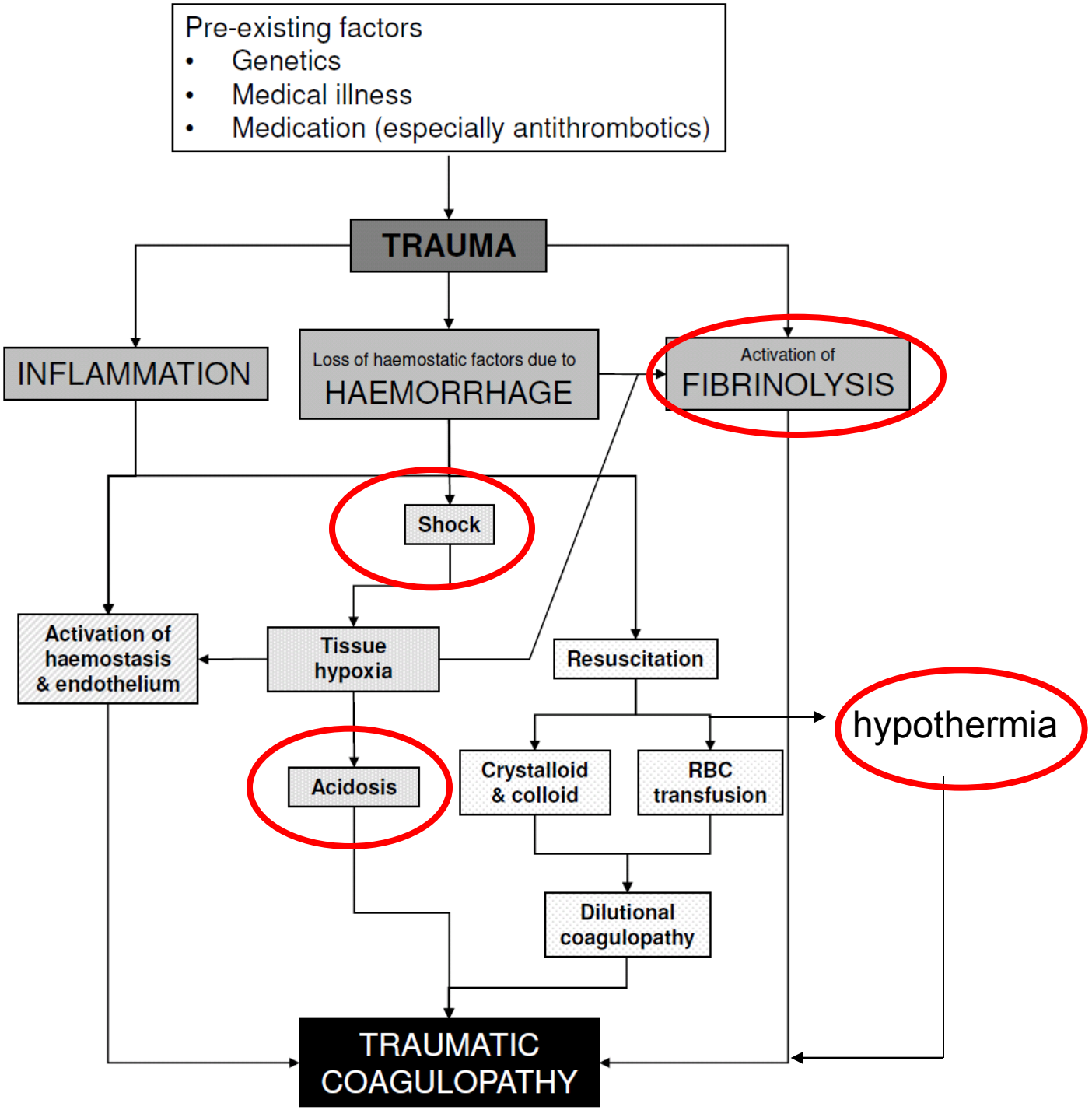
- Two large peripheral intravenous lines
- Fluid resuscitation
- Beware of over-resuscitation
- Accept a lower pressure target - SBP 80-90mmHg (without brain injury)
- Haemotherapy

Life-threatening haemorhage

- **Definition:**
  Blood loss associated with the impairment of tissue perfusion, severe hypotension, shock and multiple organ failure
  a) loss of total circulating blood volume with the need of substitution with as much as 10 TU erytrocyte concentrates in 24 hodin.
  b) loss of 50% of total circulating blood volume in 3 hours
  c) bleeding exceeding 150 ml/min
  d) depending on the localization: bleeding into vital organs, regardless of quantity (eg. CNS bleeding, airway bleeding, pericardial bleeding, aortic dissection…)

Table I: Potential Blood Loss by Injured Bone

BONE	ESTIMATED BLOOD LOSS
Rib	125mL
Radius or ulna	250-500mL
Humerus	500-750mL
Tibia or fibula	500-1000mL
Femur	1-2 liters
Pelvis	At least 1 liter, likely >2L


Pre-existing factors
• Genetics
• Medical illness
• Medication (especially antithrombotics)
TRAUMA
INFLAMMATION
Loss of haemostatic factors due to
HAEMORRHAGE
Activation of
FIBRINOLYSIS
Shock
Activation of haemostasis & endothelium
Tissue hypoxia
Resuscitation
hypothermia
Acidosis
Crystalloid & colloid
RBC transfusion
Dilutional coagulopathy
TRAUMATIC COAGULOPATHY

Heamostasis disorders treatment

- Damage control surgery
- Treat:
  - Shock
  - Acidosis
  - Hypothermia
- Substitution of thrombocytes and heamocoagulation factors
- Antifibrinolytics

Management of Coagulopathy of trauma

- *Hypothermia, electrolyte disorders:*
  – hypotermia underpod 35°C has a negative influence on coagulation cascade and platelet aggregation. Patient rewarming, infusion warming…
  - correction of Na, K, Cl, Mg, P, HC03, especially Ca2+ and pH
- *Treating coagulopathy:*
  -Fresh frozen plasma – in a ratio of ER to FFP 1:1
  -platelets – target value of >100. Therapeutic dose 1 TU from aferesis, or 6-8 TU of pooled Tr.
  -fibrinogen
  - PCC protrombin complex concentrate
  -activated recombinant factor VII (rFVIIa)
  - after failure of standard management

Management of Coagulopathy of trauma

- Coagulation monitoring implemented as early as possible following traumatic injury and used to guide haemostatic therapy.
- A damage control approach to surgical procedures should guide patient management, including closure and stabilisation of pelvic ring disruptions, packing, embolisation and local haemostatic measures.
- Use appropriate physiological targets and use and dosing of fluids, blood products and pharmacological agents in the bleeding trauma patient.
- The growing number of older patients requires special attention to appropriately manage the inherent thromboembolic risk profiles and possible pre-treatment with antiplatelet agents and/or oral anticoagulants.
- A multidisciplinary approach to the management of the traumatically injured patient remains the cornerstone of optimal patient care, and each institution needs to develop, implement and adhere to an evidence-based management protocol that has been adapted to local circumstances.

INTRODUCTION

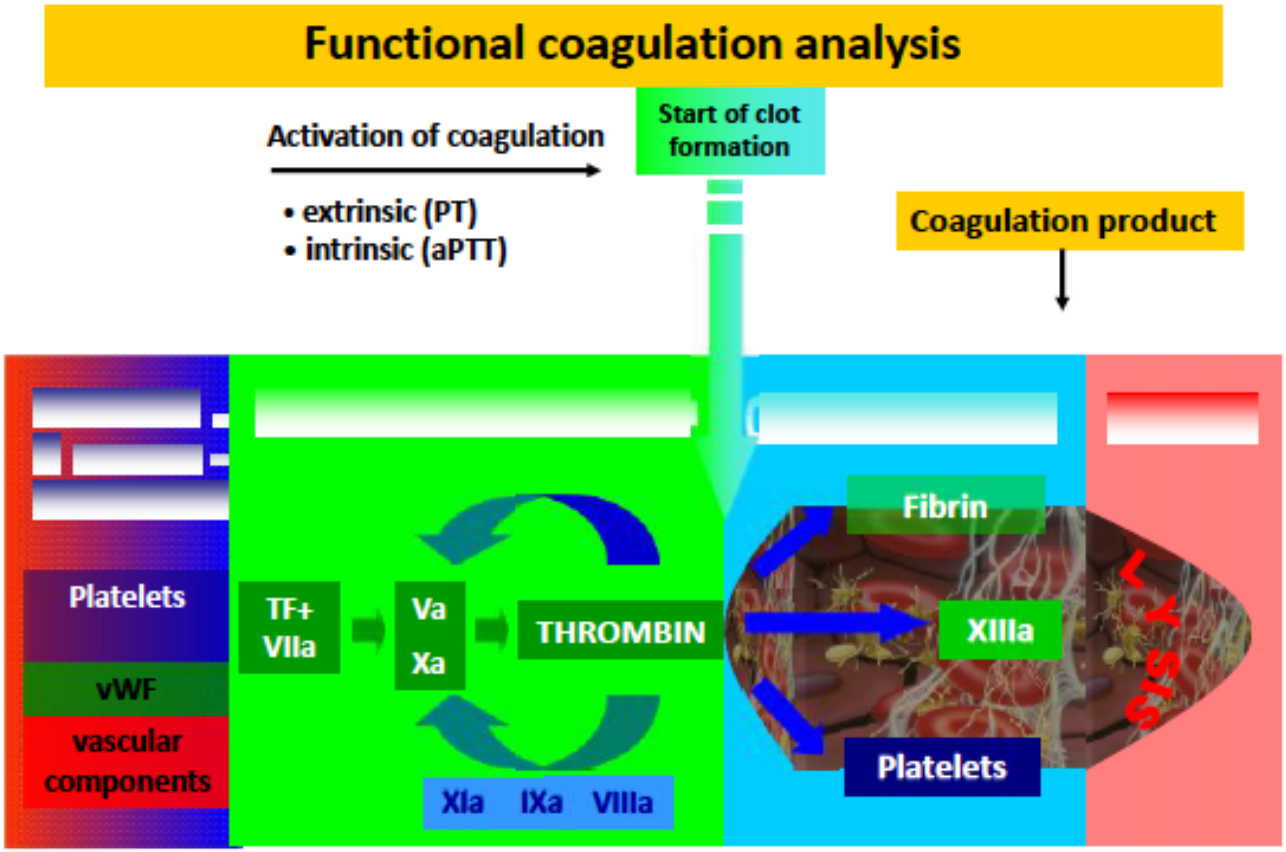
The management of acute bleeding is a complex challenge

- Bleeding mostly occurs during and after surgical intervention or trauma where secondary alterations are added (haemodilution,hypothermia,acidosis,anemia,hypoperfusion)

- clinical significance of the routine coagulation tests is rather weak

- interest in methods, which better reflect haemostasis

ROTEM® shaped view….



The ideal coagulation test should capture the entire process of clot formation

TROMBOELASTOMERY

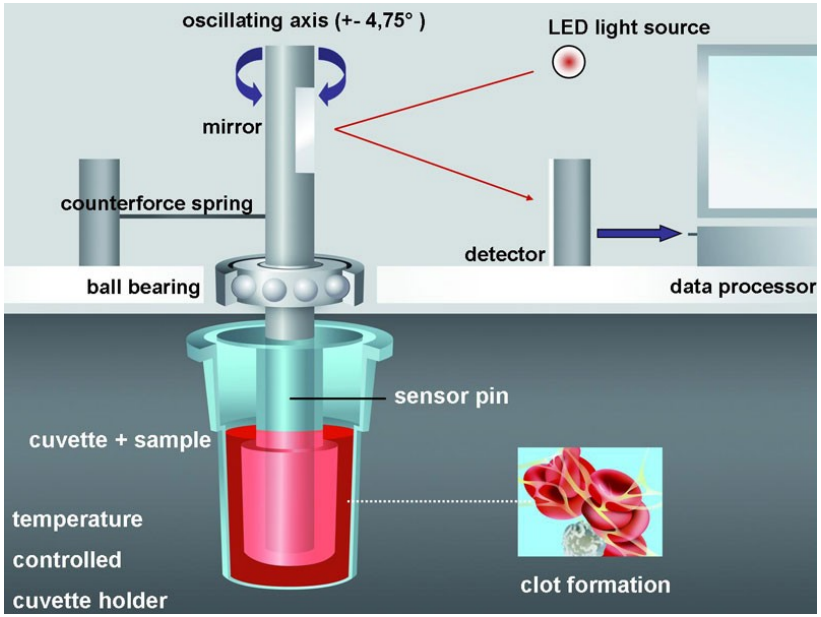
ROTEM® delta

overview

- viscoelastometric method
- point – of – care testing
- whole blood analysis
  - time to clot formation
  - speed of clot formation
  - clot lysis

DETECTION METHOD

basic principle



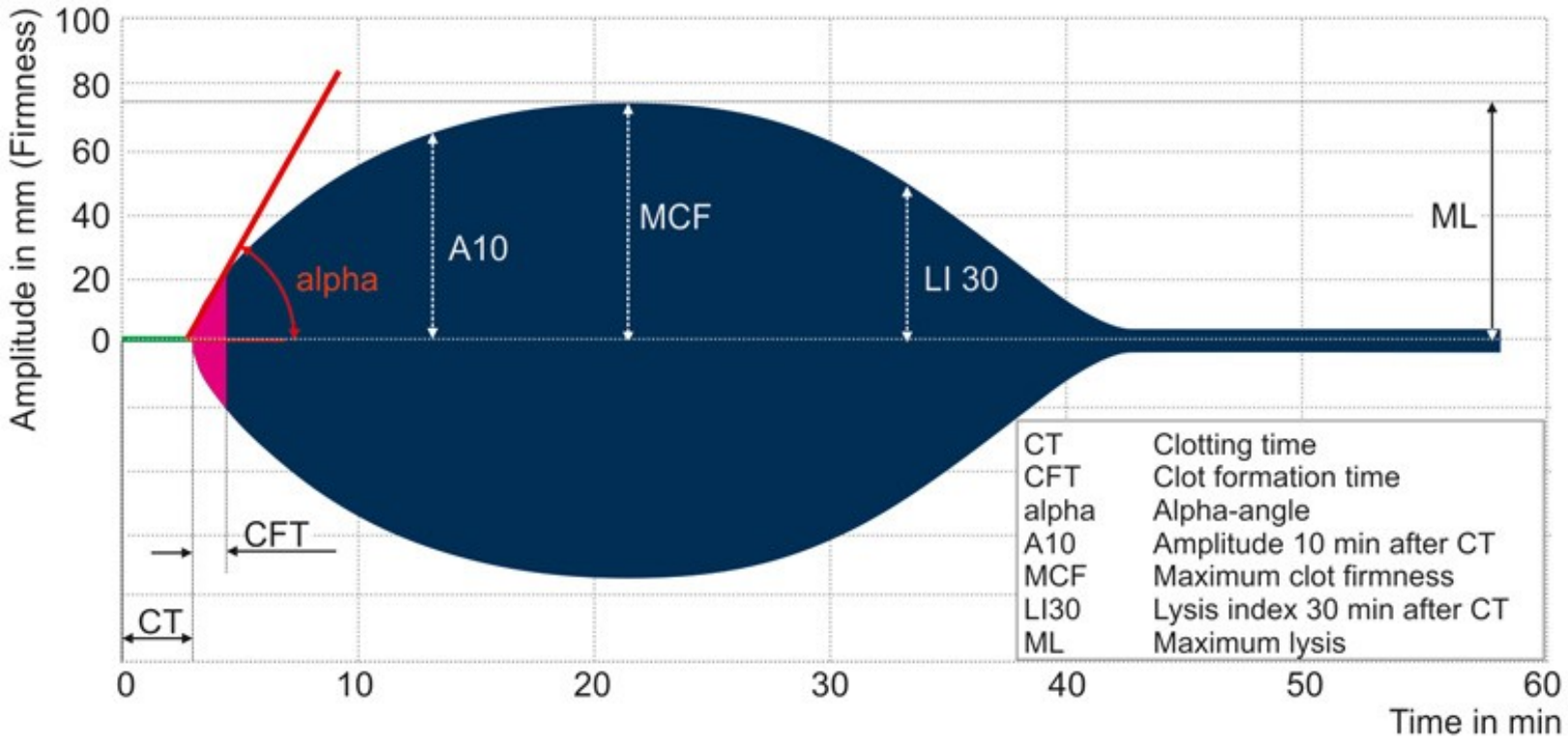
ROTEM® curve

- citrated blood into a cuvette
- cylindrical pin immersed
- gap bridged by the blood
- pin rotated by a spring
- clot restricts the rotation
- optical detection

The parameters of ROTEM®

PARAMETR	DESCRIPTION
CT- clotting time	initiation of clotting,trombin formation, start of clot polymerisation
CFT- clot formation time	fibrin polymerisation, stabilisation of the clot with plt and XIII
MCF – max clot firmness	increasing stabilisation of the clot by the polymerised fibrin,plt and XIII
ALFA-angle	describes the kinetic of the clotting
A10- amplitude 10 min after CT	fast prediction of clot firmness
ML – maximum lysis	stability of the clot or fibrinolysis (15%)
LI30 – lysis index 30min after CT	fast prediction of lysis

ROTEM® analysis



ROTEM® tests

ASSAY	INFORMATION PROVIDES
EXTEM	activation of clot formation by tromboplastin assessment of the factors: **VII**,X,V,II,I,plt,fibrinolysis
INTEM	activation of the clot formation via the contact phase assessment of the factors:XII,XI,IX,VIII,X,V,II,I,plt,fibrinolysis
FIBTEM	as EXTEM+platelets blocking substance assessment of fbg level and fibrin polymerisation
APTEM	as EXTEM+fibrinolysis inhibitor hyperfibrinolysis can be recognised within 10-20 min
HEPTEM	as INTEM+heparinase heparin related coagulopathy can be recognised

> Reference Ranges (Lang *et al.* 2006)

	CT	CFT	MCF	ML
	clotting time [s]	clot formation time [s]	maximum clot firmness [mm]	maximum lysis [% of MCF]
EXTEM	38-79	34-159	50-72	< 15
INTEM	100-240	30-110	50-72	< 15
HEPTEM	A significantly shortened CT in HEPTEM as compared to INTEM is indicative to a heparin effect.			
APTEM	An improved clotting (shortening of CFT, higher MCF) in APTEM as compared to EXTEM is a sign for fibrinolysis.			
FIBTEM			9-25	
	MCF < 9 mm reduced fibrinogen level or impaired polymerisation. Therapy: infusion of fibrinogen (or larger quantities of FFP). MCF > 25 mm increased fibrinogen level. This may lead to normal clot formation in EXTEM or INTEM in spite of thrombocytopenia.			

> INTEM/EXTEM Results – Clinical Interpretation

MCF

MCF > 72 mm: enhanced haemostatic reserve
MCF 50 - 72 mm: normal range
MCF 46 - 49 mm: usually unimpaired haemostasis with reduced reserve
MCF 40 - 45 mm: bleeding risk
MCF 30 - 39 mm: high bleeding risk
MCF < 30 mm: usually no effective haemostasis

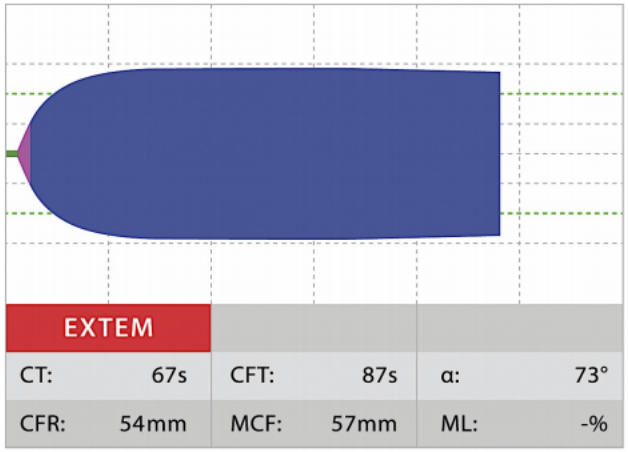
CFT

CFT 34 - 159 s: normal range
CFT 160 - 220 s: usually unimpaired haemostasis with reduced reserve
CFT 221 - 300 s: bleeding risk
CFT 301 - 400 s: high bleeding risk
CFT > 400 s: usually no effective haemostasis

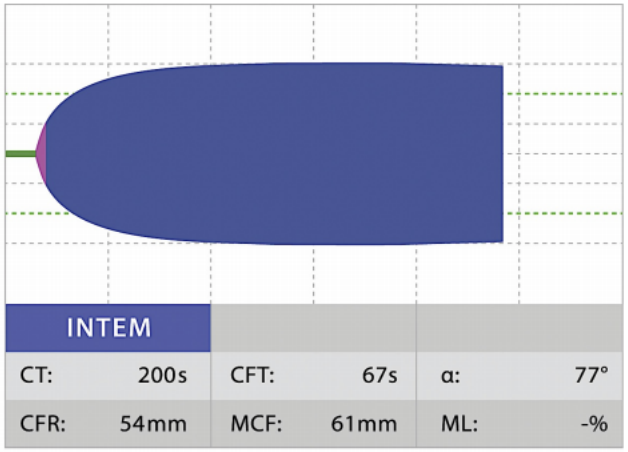
Fibrinolyse

Lysis of the clot within 20 minutes (fulminant lysis):
usually acute bleeding
Lysis of the clot within 20 – 40 minutes:
high bleeding risk
Lysis of the clot after more than 40 minutes:
frequently clinically insignificant, may however raise to fulminant lysis

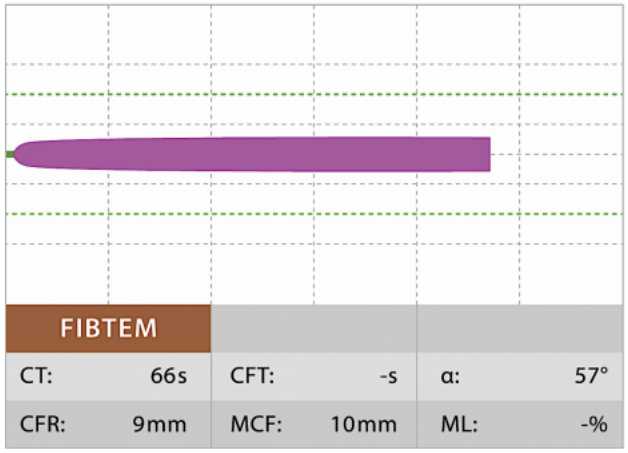
NORMAL PATIENT



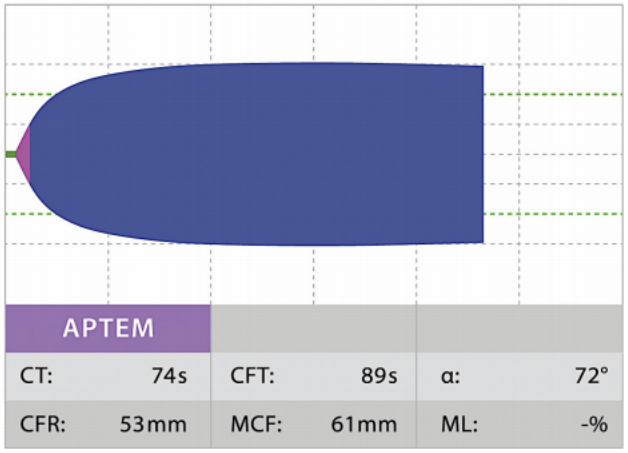
EXTEM					
CT:	67s	CFT:	87s	α:	73°
CFR:	54mm	MCF:	57mm	ML:	-%



INTEM					
CT:	200s	CFT:	67s	α:	77°
CFR:	54mm	MCF:	61mm	ML:	-%

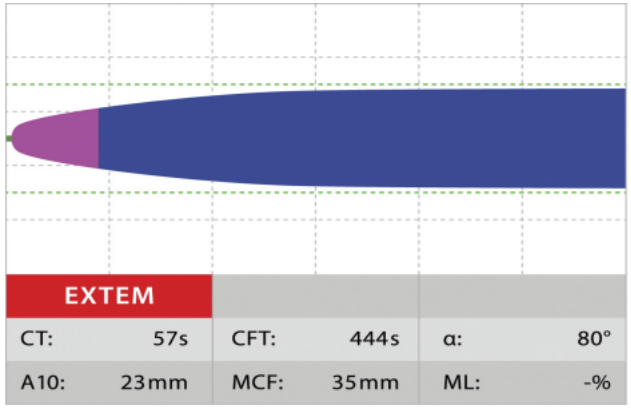


FIBTEM					
CT:	66s	CFT:	-s	α:	57°
CFR:	9mm	MCF:	10mm	ML:	-%

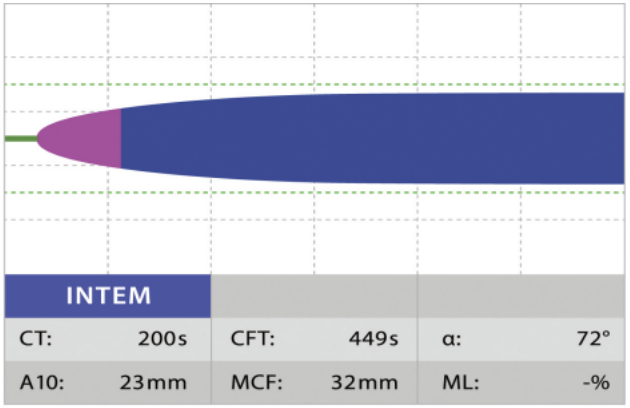


APTEM					
CT:	74s	CFT:	89s	α:	72°
CFR:	53mm	MCF:	61mm	ML:	-%

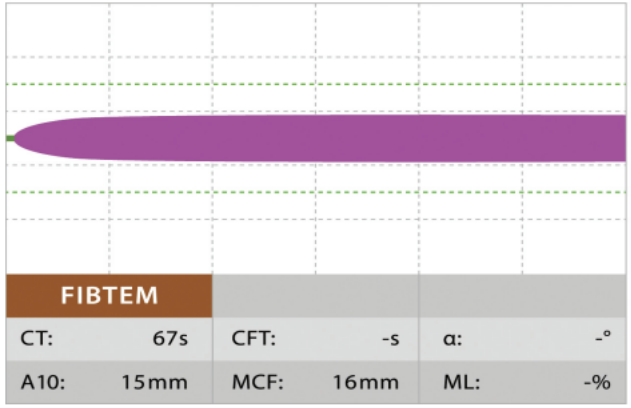
PLATELETS DEFICIENCY



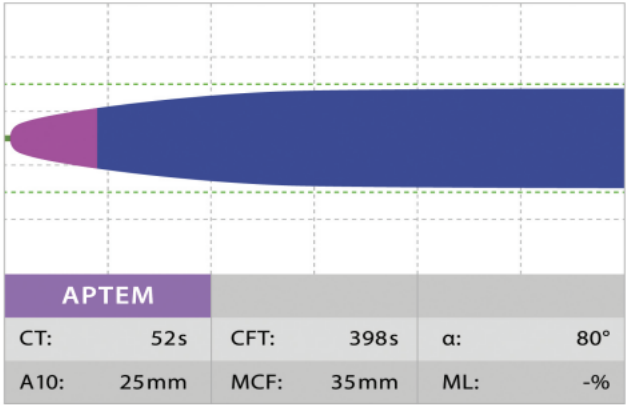
EXTEM					
CT:	57s	CFT:	444s	α:	80°
A10:	23mm	MCF:	35mm	ML:	-%



INTEM					
CT:	200s	CFT:	449s	α:	72°
A10:	23mm	MCF:	32mm	ML:	-%

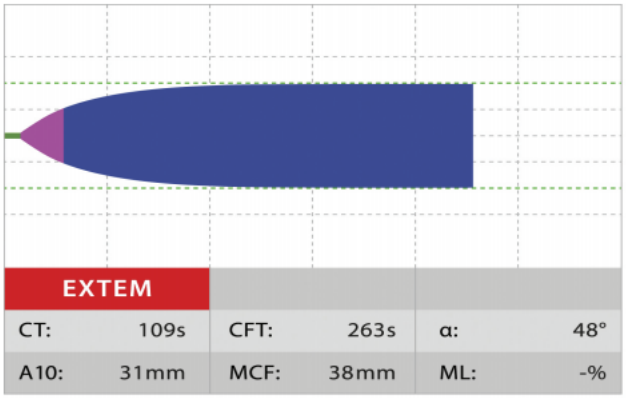


FIBTEM					
CT:	67s	CFT:	-s	α:	-°
A10:	15mm	MCF:	16mm	ML:	-%

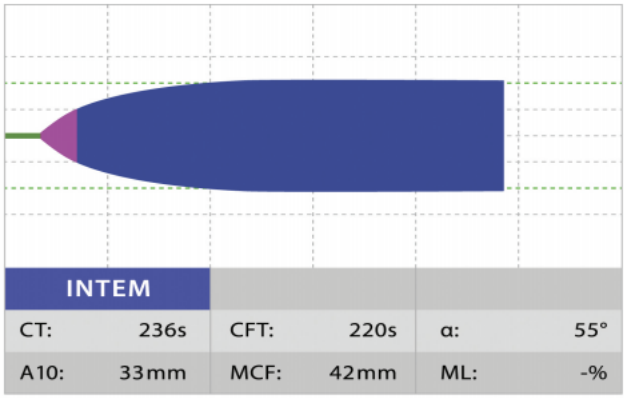


APTEM					
CT:	52s	CFT:	398s	α:	80°
A10:	25mm	MCF:	35mm	ML:	-%

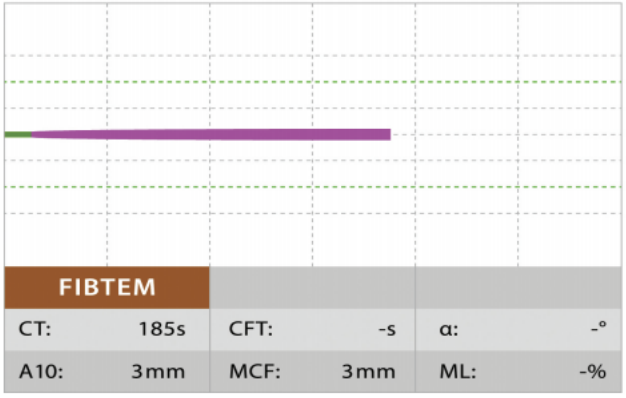
FIBRINOGEN DEFICIENCY



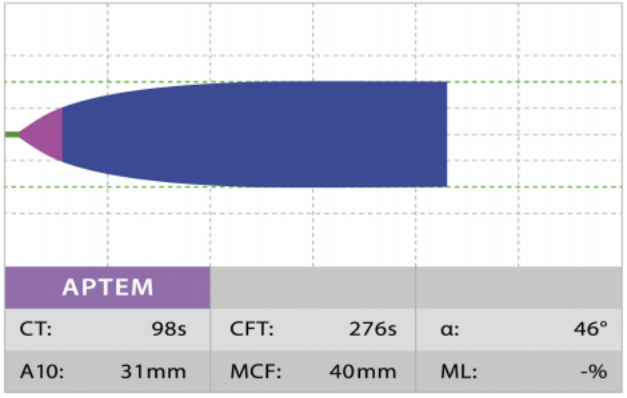
EXTEM					
CT:	109s	CFT:	263s	α:	48°
A10:	31mm	MCF:	38mm	ML:	-%



INTEM					
CT:	236s	CFT:	220s	α:	55°
A10:	33mm	MCF:	42mm	ML:	-%

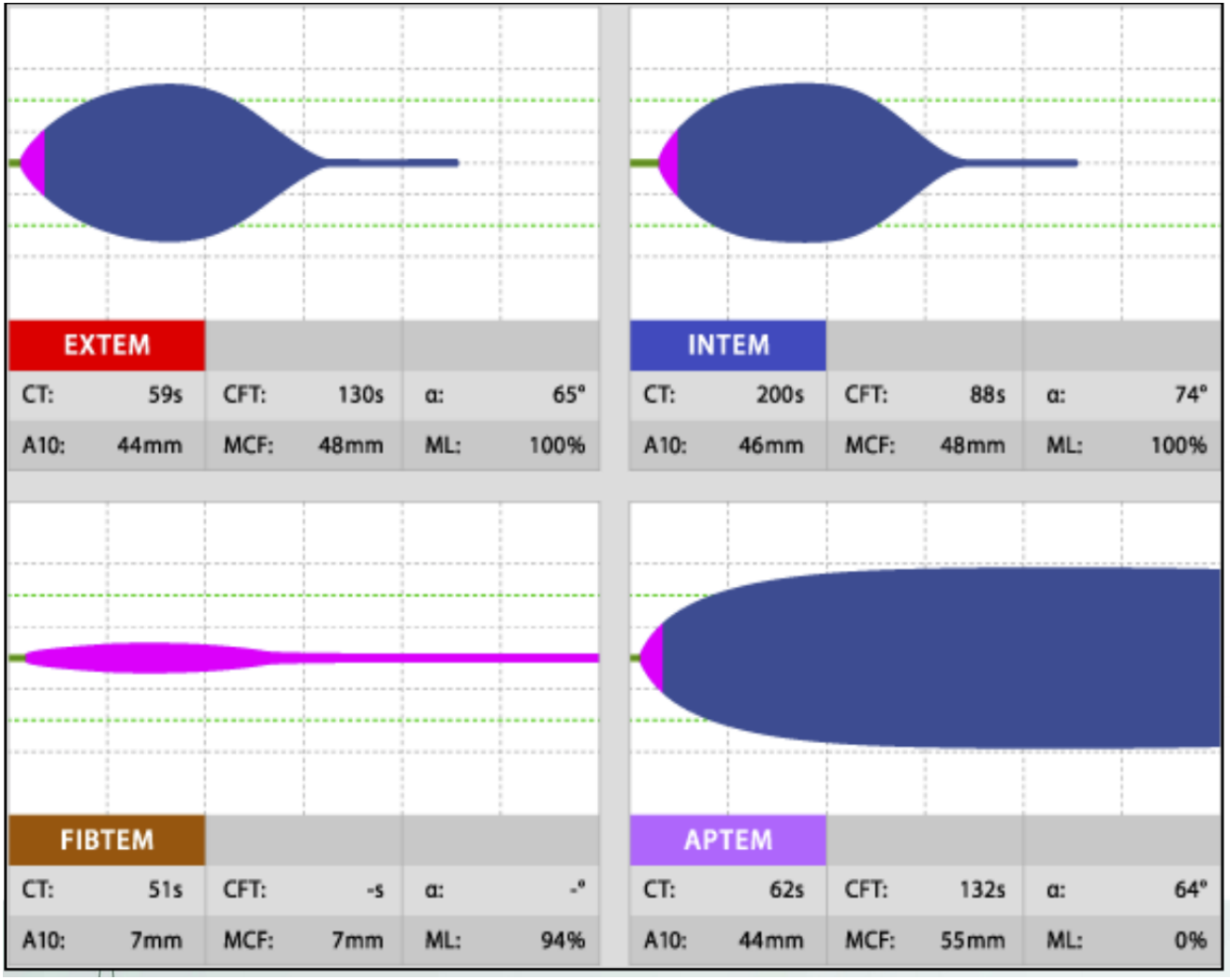


FIBTEM					
CT:	185s	CFT:	-s	α:	-°
A10:	3mm	MCF:	3mm	ML:	-%

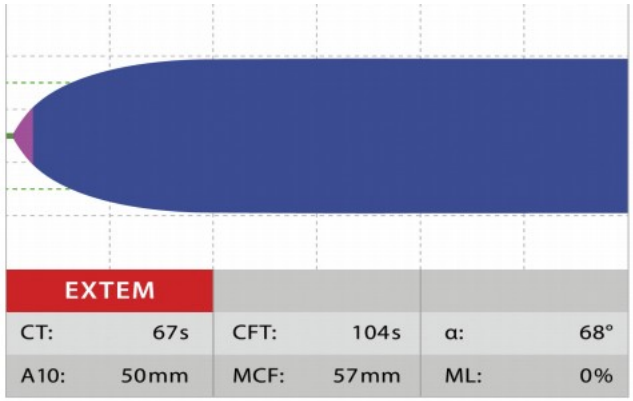


APTEM					
CT:	98s	CFT:	276s	α:	46°
A10:	31mm	MCF:	40mm	ML:	-%

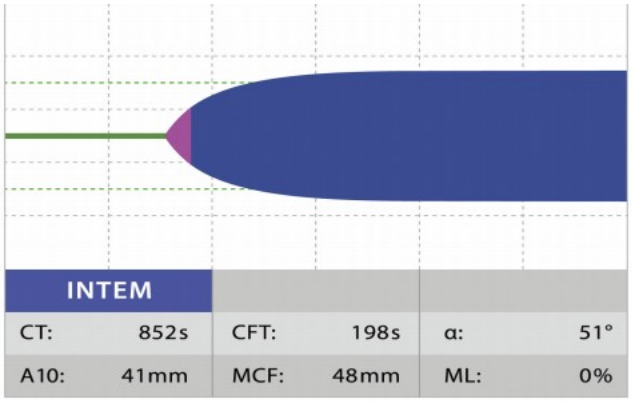
HYPERFIBRINOLYSIS



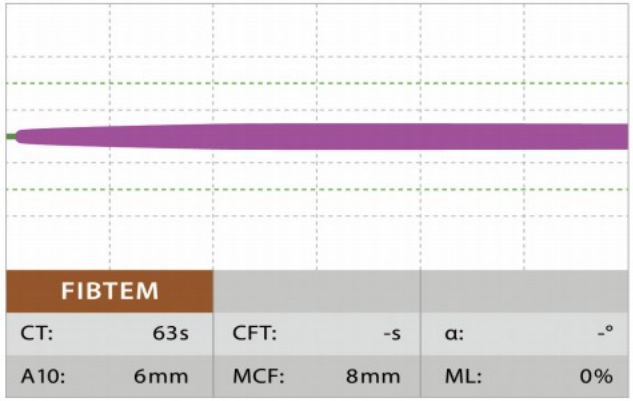
HEPARIN INFLUENCE



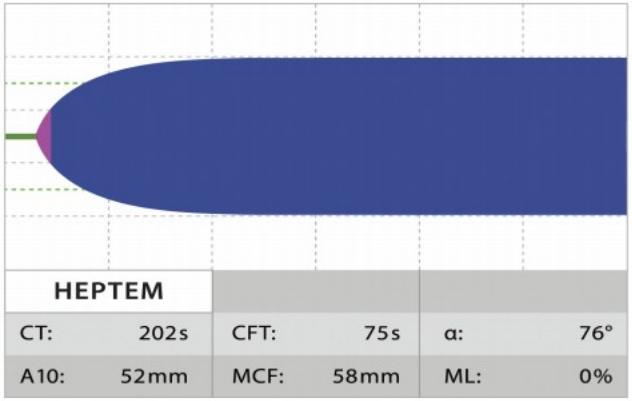
EXTEM					
CT:	67s	CFT:	104s	α:	68°
A10:	50mm	MCF:	57mm	ML:	0%



INTEM					
CT:	852s	CFT:	198s	α:	51°
A10:	41mm	MCF:	48mm	ML:	0%



FIBTEM					
CT:	63s	CFT:	-s	α:	-°
A10:	6mm	MCF:	8mm	ML:	0%



HEPTEM					
CT:	202s	CFT:	75s	α:	76°
A10:	52mm	MCF:	58mm	ML:	0%

LIMITATIONS

- drug induced plt dysfunction (ASA,CLOPIDOGREL)
- impairment of primary hemostasis (vWD)
- direct thrombin and fXa inhibitors :
  (DABIGATRAN,RIVAROXABAN)
- coagulation under conditions of flow and impaired haemostasis due to disturbed preconditions of haemostasis
  (Hg,ion.Ca,pH,core temperature)

RECOMMENDATION

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Critical Care

RESEARCH Open Access

The European guideline on management of major bleeding and coagulopathy following trauma: fourth edition

Rolf Rossaint[1], Bertil Bouillon[2], Vladimir Cerny[3,4,5,6], Timothy J. Coats[7], Jacques Duranteau[8], Enrique Fernández-Mondéjar[9], Daniela Filipescu[10], Beverley J. Hunt[11], Radko Komadina[12], Giuseppe Nardi[13], Edmund A. M. Neugebauer[14], Yves Ozier[15], Louis Riddez[16], Arthur Schultz[17], Jean-Louis Vincent[18] and Donat R. Spahn[19*]

Coagulation monitoring

Recommendation 12 **We recommend that routine practice include the early and repeated monitoring of coagulation, using either a traditional laboratory determination [prothrombin time (PT), activated partial thromboplastin time (APTT) platelet counts and fibrinogen] (Grade 1A) and/or a viscoelastic method. (Grade 1C)**

COAGULATION MONITORING

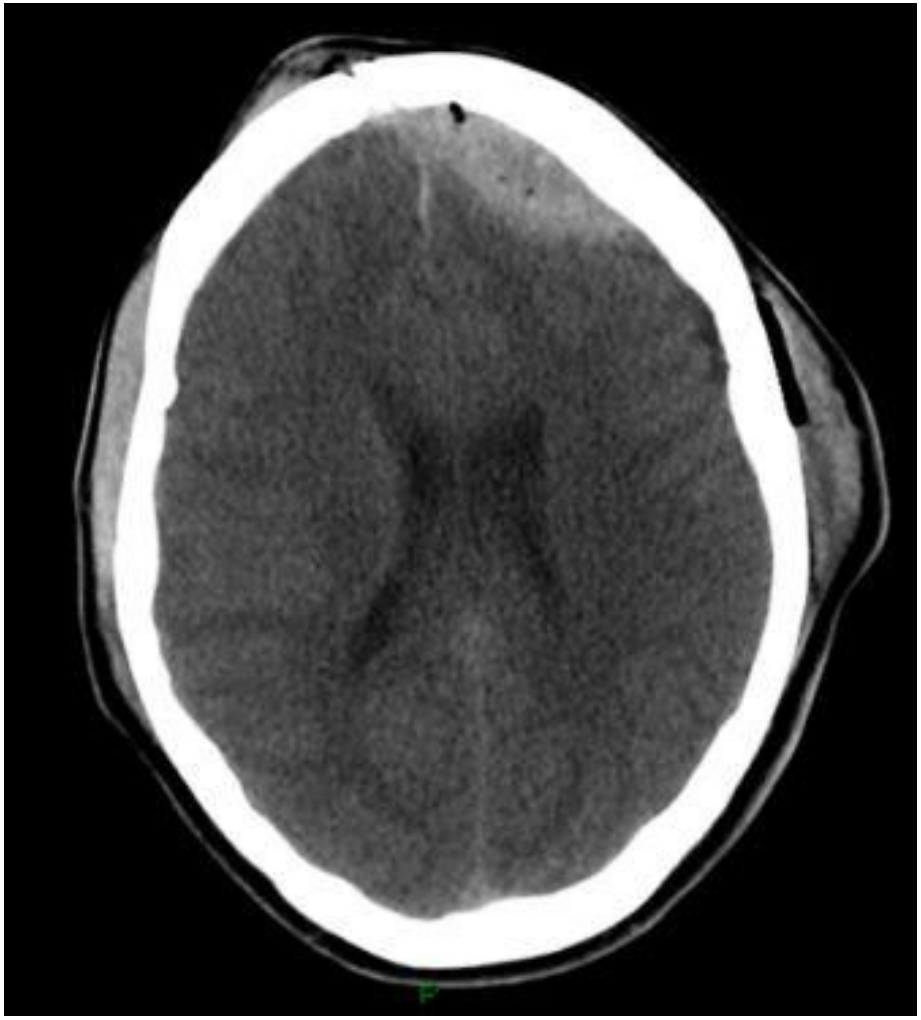
- standard laboratory tests were designed to test for factor deficiencies, not for predicting risk of bleeding or guiding haemostatic management

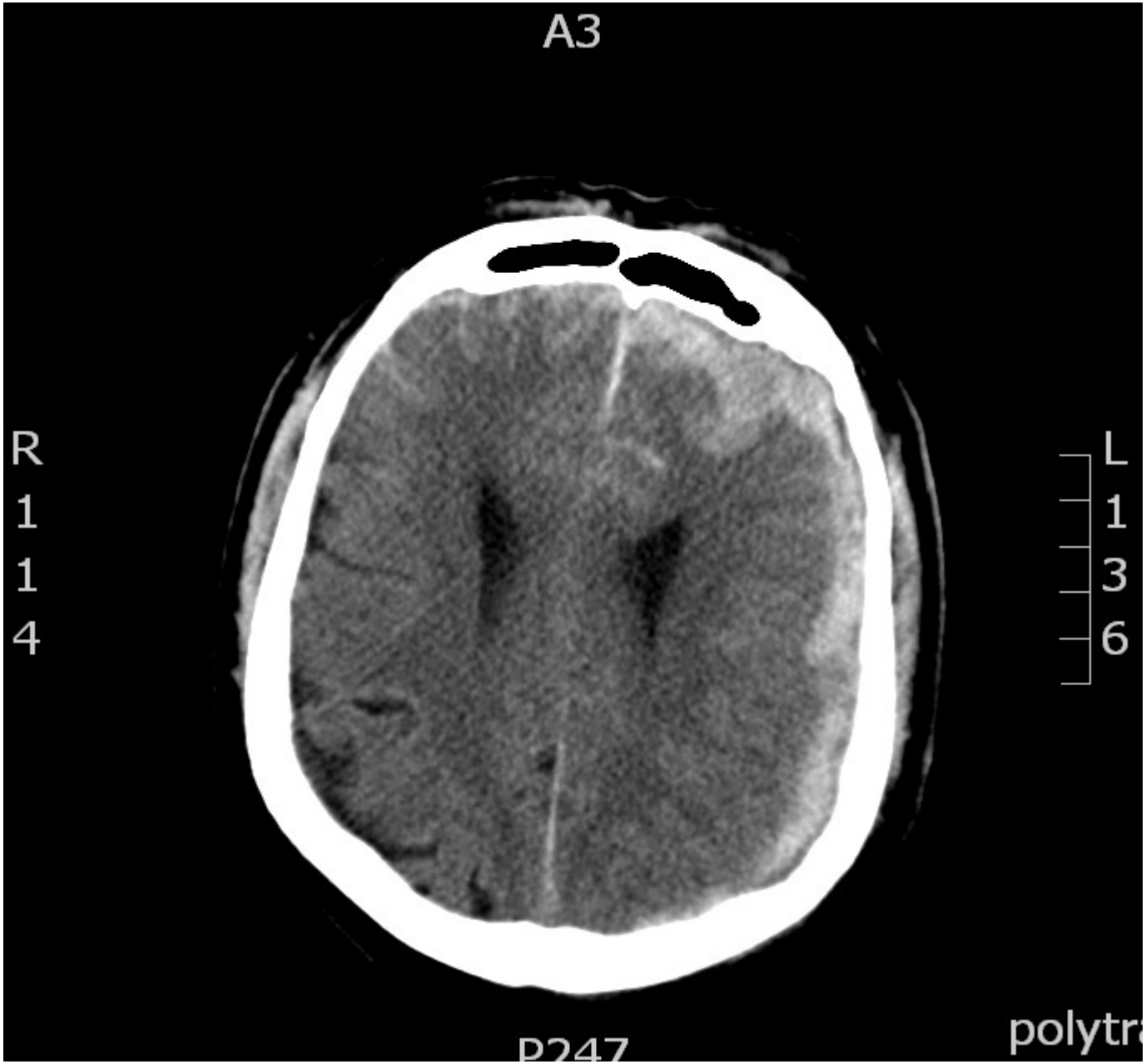
- viscoelastic monitoring enables rapid intraoperative diagnosis of the cause of bleeding

D - DISABILITY

- Level of consciousnes
- Pupillary size and reaction
- Lateralizing signs
- Spinal cord injury level

Traumatic brain injury




A3
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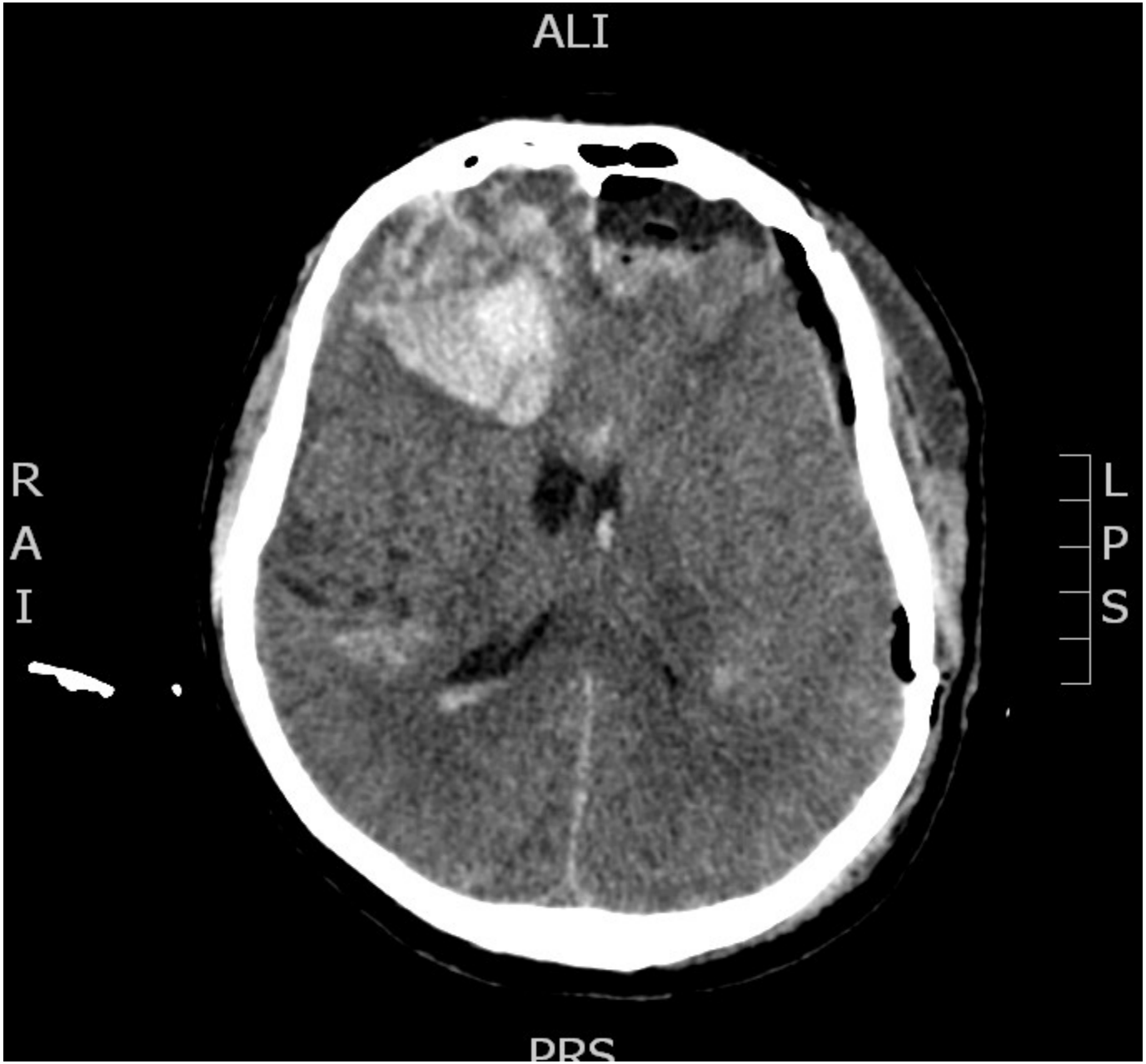
6
P247
polytr


ALI
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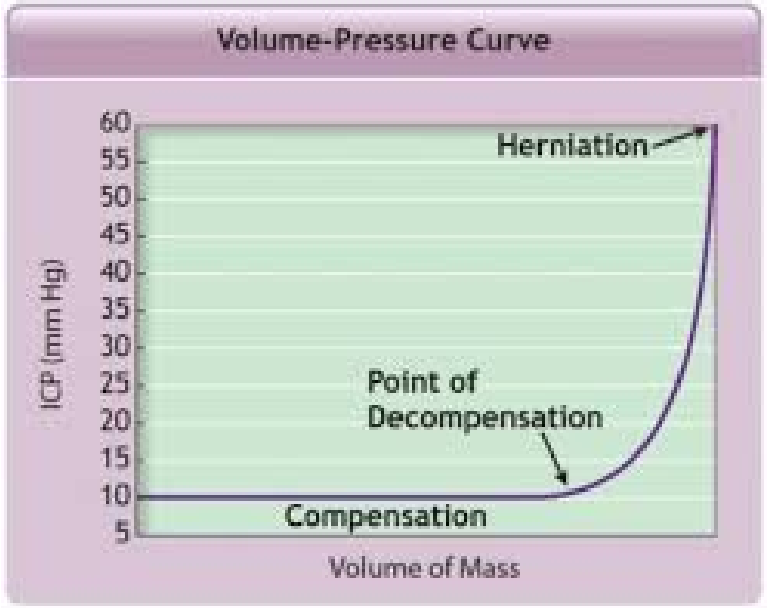
PRS

ICP

- Elevated IPC may reduce cerebral perfusion and cause ischemia

- Monro-Kellie Doctrine (three noncompressive parts enclosed in the skull – liquor, blood and brain tissue
- CPP=MAP-ICP

  (50-70mmHg)



Principles of TBI treatment

- ABCD
- Evacuation of mass-lesion
- Prevention of secondary injury – intracranial hypertension treatment
  - ICP monitoring
  - Head elevation
  - sedation
  - osmotic therapy (concentrated NaCl, manitol)
  - ventriculostomy
  - Mild therapeutic hypothermia
  - hypocapnia (hyperventilation)
  - Barbiturate coma
  - Decompressive craniectomy

D - DISABILITY

Spinal cord injury:

- **respiratory arrest- Q: why?**
  - Interruption of the the phrenic nerve supply
- **neurogenic shock**:
  - hypotension but with warm extremities- Q: why?
    - loss of sympathetic (vasoconstrictor) tone
  - Bradycardia- Q: why?
    - Loss of the sympathetic nerve supply to the myocardium

Damage control

- Addresses bleeding and contamination promptly
- Objective: interrupt the downward spiral of acidosis, coagulopathy and hypothermia
- Involves rapid surgery to stop bleeding and decontaminate wounds, deliberately postponing definitive repair until physiological stability has been re-established

The phases of damage control

- **Initial assessment and stabilisation in the Emergency Department**
- **Immediate, limited surgical intervention:** haemorrhage and contamination are controlled using temporary methods- closure and stabilisation of pelvic ring disruptions, packing, embolisation and local haemostatic measures.
- **Continuing stabilisation on the ICU:** physiological system control, monitoring for wound complications (e.g. abdominal compartment syndrome, if the abdomen has been closed) and continual vigilance for missed injuries.
- **Re-operation:** definitive repair can now take place. If the original wound was left open at the initial operation, wound closure and definitive repair may be possible now.

Brain death

- Irreversible absence of brain stem function despite arteficial maintanence of circulation and gas exchange
- Guidelines for withdrawal of artificial support and, where possible, preparation of organ donors

Clinical signs of brain death

- The pupils don’t respond to light.
- The person shows no reaction to pain.
- The eyes don’t blink when the eye surface is touched (corneal reflex).
- The eyes don’t move when the head is moved (oculocephalic reflex).
- The eyes don’t move when ice water is poured into the ear (oculo-vestibular reflex).
- There is no gagging reflex when the back of the throat is touched.
- The person doesn’t breathe when the ventilator is switched off.
- An electroencephalogram test shows no brain activity at all.

CONFIRMATION OF BRAIN STEM DEATH

- Loss of all brain stem refexes
  - examination by two doctors independent of each other

- Diagnosis of brain death have to be confirmed by examination
  - Angiography of brain artheries
  - CT angiography
  - Brain perfusion scintigraphy
  - BAEP brain stem auditory evoked potentials
  - Transcranial doppler ultrasonography

Rules for Organ donor (Czech republic)

- Controlled by law (no.285/2002)
- Organ removal is possible 2 hours after confirmation of deathIt
- Is necessary follow ethical principles
- Everybody in the Czech republic is potential donor

Thanks for your attention

…..be careful and protect yourself