



Hemorrhage, blood loss, replenishment of blood loss

MD, PhD, Dr. Kirill Lobastov

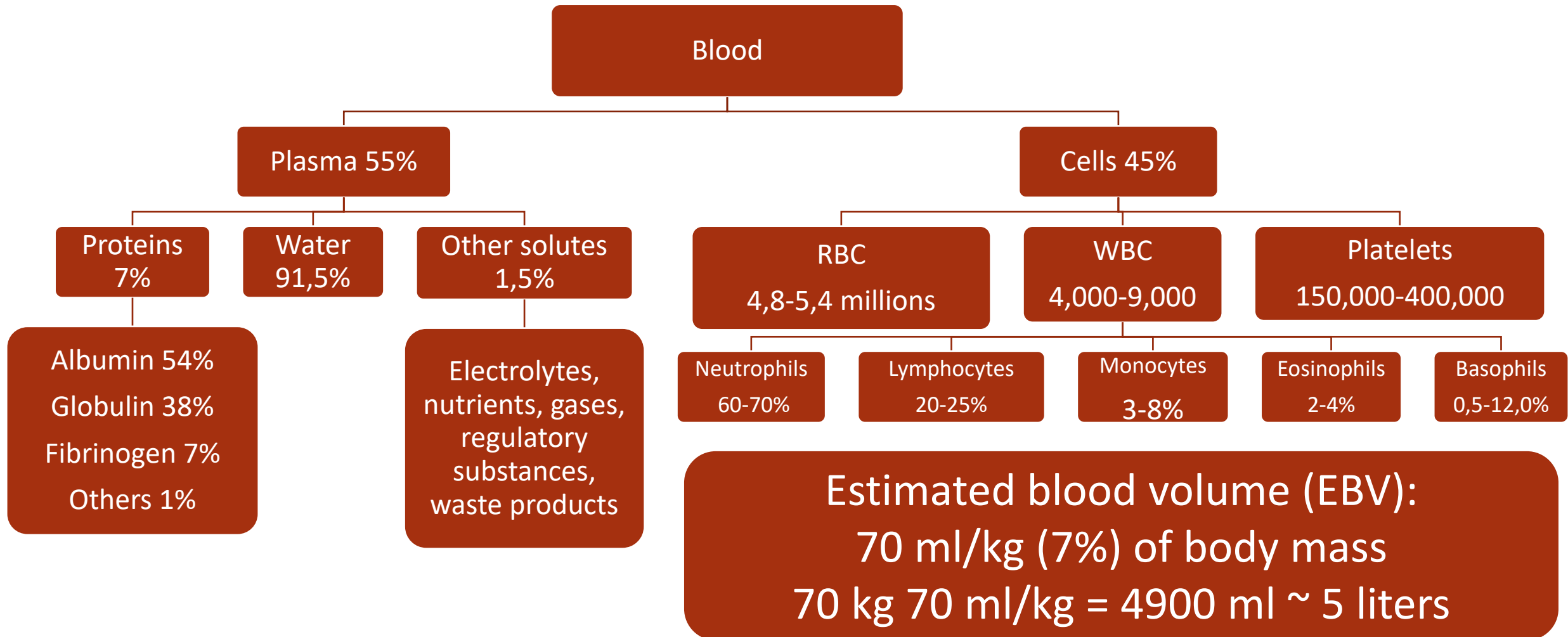
Introduction

- Haemorrhage is the loss of blood escaping from the circulatory system.
- Bleeding can occur internally, where blood leaks from blood vessels inside the body, or externally, either through a natural opening such as mouth, nose, ear, urethra, vagina or anus, or through a break in the skin.
- Uncontrolled bleeding can rapidly lead to shock and death.
- **Potentially lethal condition.**

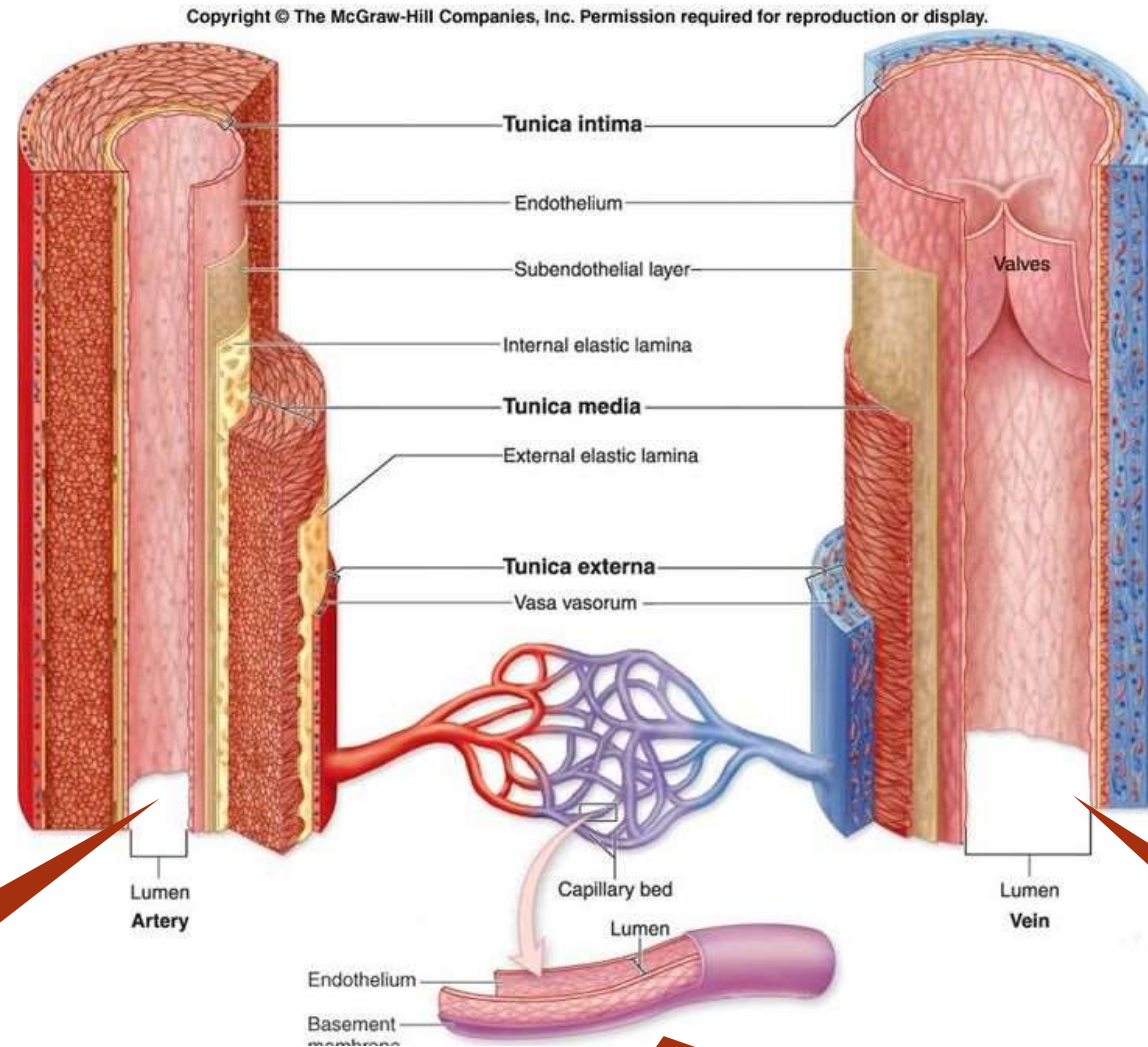
Definition

- The term haemorrhage refers to a large amount of bleeding in a short time. (Thygerson, Gulli & Krohmer 2006; pp:23)
- An escape of blood from a ruptured blood vessel. (Weller & Wells 1990; pp:217)
- Haemorrhage is the loss of blood from a vessel. (Malcolm R. Colmer 1986 ; pp:98)

Blood composition



Circulatory
system
contains
80% of EBV



Parenchyma
tous organs
contain 20%
of EBV

Arteries contain
15-20% of EBV

Capillaries contains
5-7,5% of EBV

Veins contain
70-80% of EBV

Anatomical classification

CAPILLARY



- Slow, even flow
- Bright red color

VENOUS



- Steady, slow flow
- Dark red color

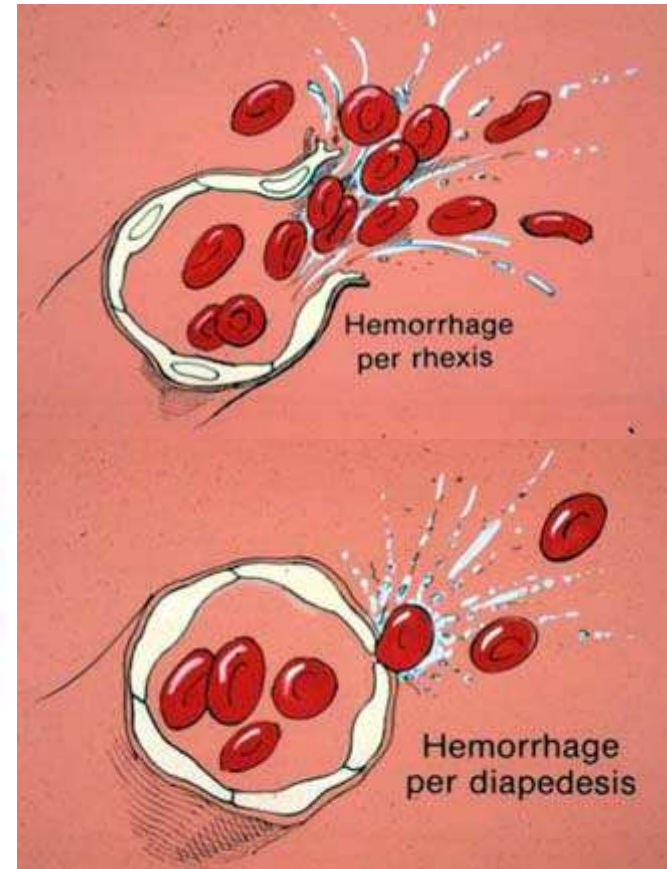
ARTERIAL



- Spurting blood
- Pulsating flow
- Bright red color

Etiological classification

- **Per rhexis** – bleeding due to mechanical damage of the vessel
- **Per diabrosis** – bleeding due to abrasion of the vessel by proteolytic enzymes, tumor, necrosis, aneurism and other pathological process
- **Per diapedesis** – bleeding due to increase of vascular permeability in cases of coagulopathy, platelets level decrease, vit. C deficiency etc.



Classification according to the environment

REVEALED OR EXTERNAL

- Bleeding can be seen
- From an open wound e.g.; abrasion, laceration, avulsion, amputation etc.
- Through natural opening like mouth, nose, anus, vagina etc.

CONCEALED OR INTERNAL

- Bleeding cannot be seen
- Occurs in one of the body cavities such as abdomen
- Can result from
 - Blunt trauma or penetrating injury
 - Acute or chronic medical illness

Bleeding

External

Internal

From the
wound

To the hollow
organs

To the tissues

To the
cavities

Pure blood

Pure or modified blood:
Hematemesis, Hemoptysis,
Melena, Hematochezia,
Hematuria, Pulmonary
hemorrhage, Vaginal bleeding

petechia, hematoma,
ecchymosis

hemoperitoneum, hemothorax,
hemopericardium,
hemarthrosis, hemorrhosis

Hematemesis



Hemoptysis



Hematuria



petechia



Melena



Hematochezia



ecchymosis



hematoma



Pulmonary
hemorrhage



Classification according the time of occurrence

PRIMARY

- Occurs immediately
- A cut finger or an operation incision

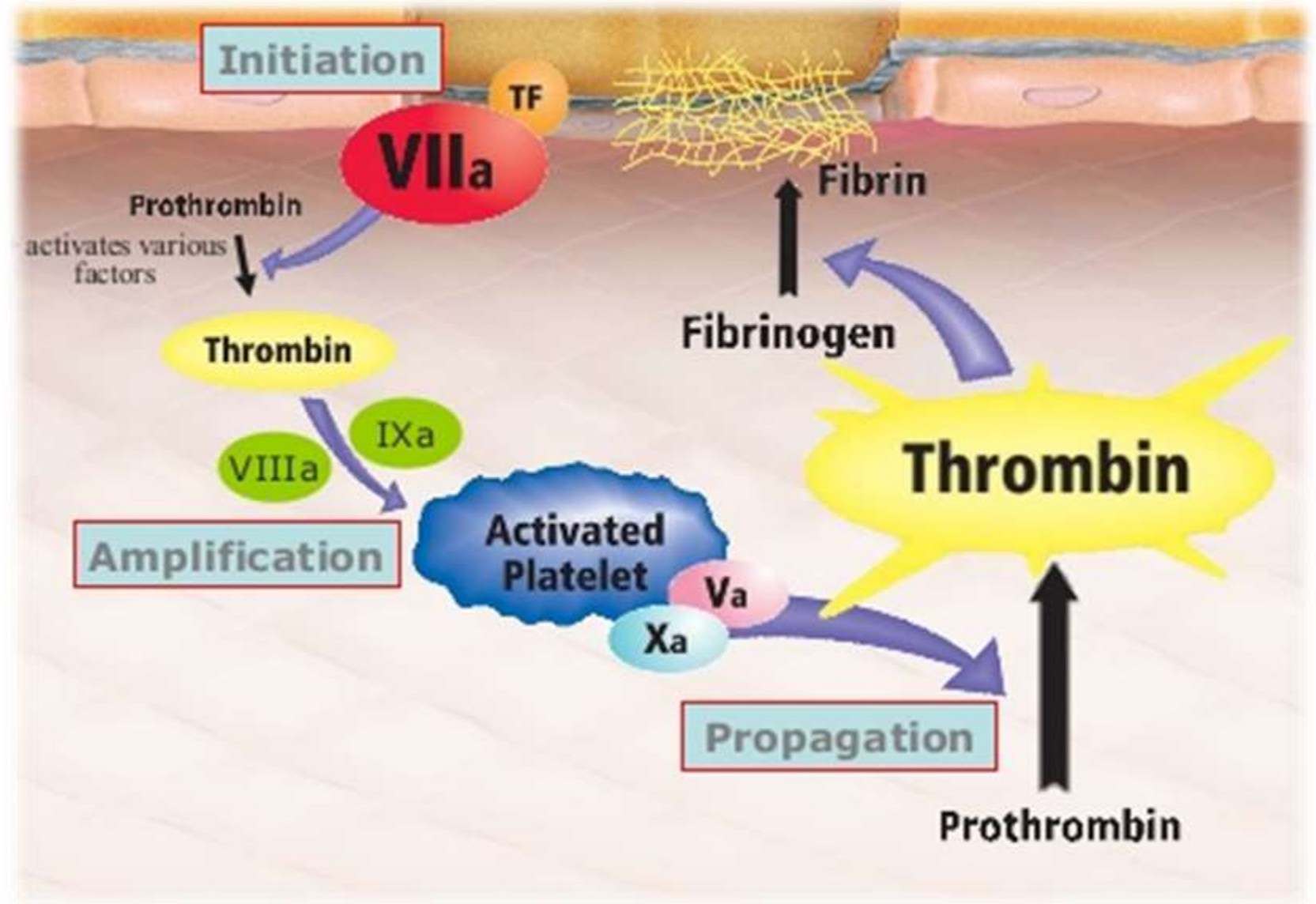
REACTIONARY (INTERMEDIATE)

- Occurs in first 24-hrs after operation
- More severe the operation, more likely it is to occur
- Operations on kidney, thyroid and breasts as well as total hysterectomy are more liable to be followed by reactionary hemorrhage

SECONDARY

- If infection is present, walls of blood vessels may be eroded and may burst, causing what is known as secondary hemorrhage

Cell-based
model of
coagulation



Pathophysiology of blood loss

$$DO_2 = CO * 1,39 * Hb * SaO_2$$

$$CO = SV * HR$$

DO_2 – Oxygen delivery to the tissues

CO – cardiac output

SV – stroke volume

HR – heart rate

Pathophysiology of blood loss

- Vascular compensation (few min after injury)

- Venous spasm
- Tachycardia
- Arterial spasm

- Proportional loss of plasma volume and Hb amount
- Possible hemoconcentration
- No evidence of Hb concentration decrease!

- Hemodilution (24-48 hours)

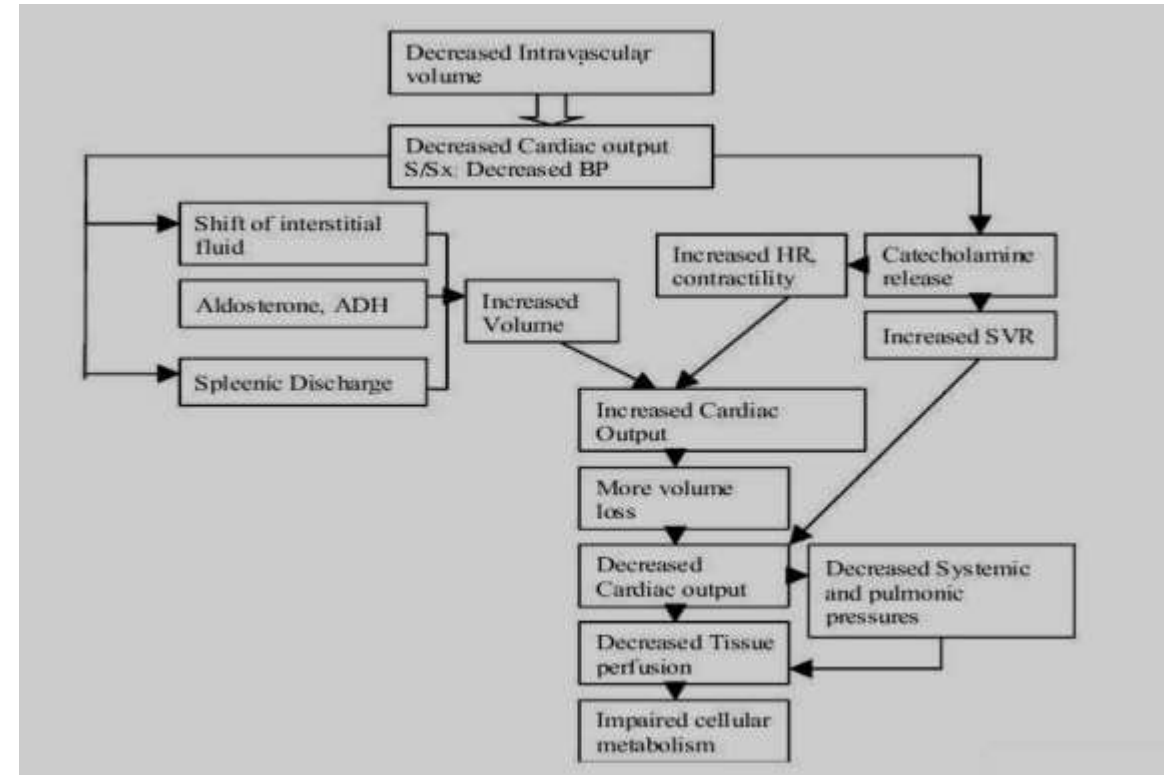
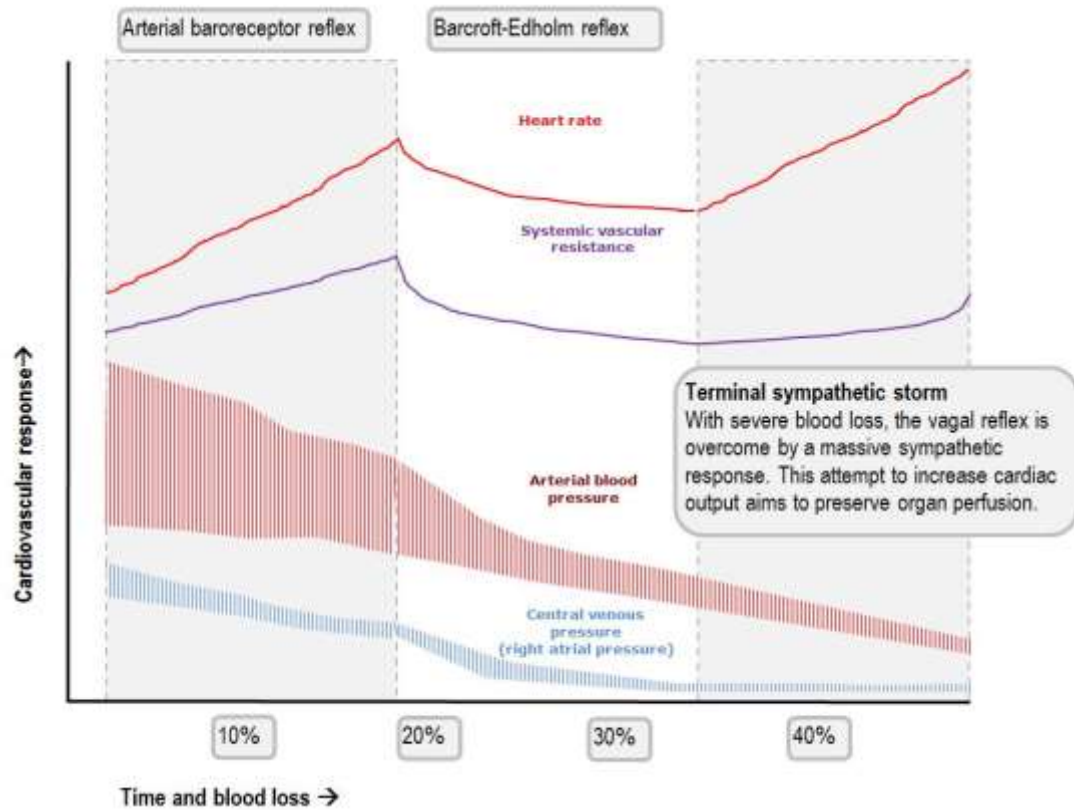
- Shift of the fluid from tissues
- Decrease of urination
- Splenic discharge

- Restoring of plasma volume at the background of the same Hb amount
- Decrease of Hb concentration

- Marrow compensation (>72 hours)

- Restore number of cells

- Production of new RBC and Hb
- Restoring of Hb amount



Pathophysiology of blood loss

Compensation of blood loss

Volume		Time
Blood volume		24-48 h
Plasma volume		24-48 h
Plasma proteins	Maximal dilution	2 h
	Partial restoration	48-72 h
	Full restoration	72-96 h
RBC		20-25 days

Diagnostic of bleeding

Local signs

- Native blood
- Modified blood
- Signs of blood accumulation
 - hemoperitoneum,
 - hemothorax,
 - hemopericardium,
 - hemarthrosis,
 - hemorachis

Systemic signs

- Complaints:
 - weakness
 - dizziness
 - flashing and sweating in the eyes
 - anxiety
 - nausea
 - feeling of lack of air
- Objective signs:
 - pale skin, cold clammy sweat, acrocyanosis
 - impaired consciousness, hypodynamia
 - tachycardia, thready pulse, low ABP
 - dyspnea
 - decreased diuresis

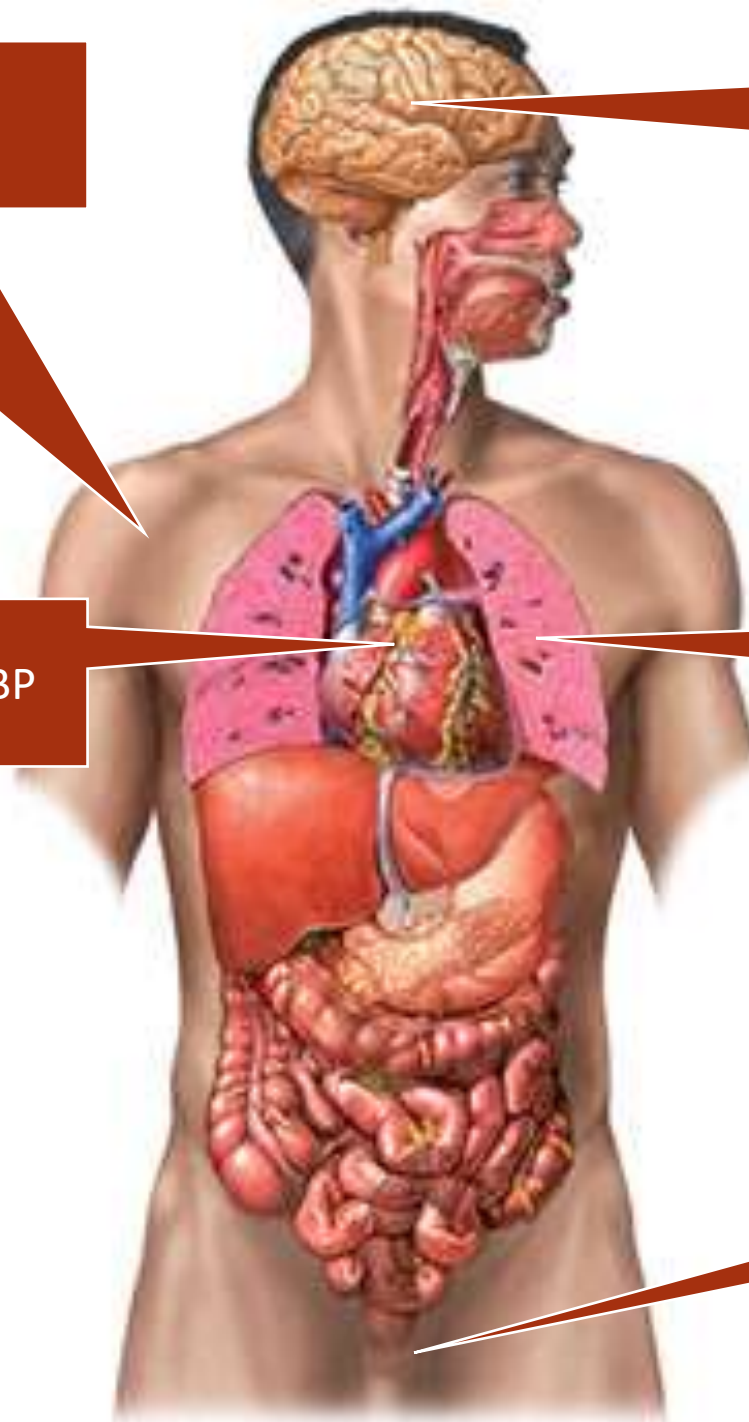
pale skin, cold clammy sweat,
acrocyanosis

weakness, dizziness, flashing and
sweating in the eyes, anxiety,
hypodynamia, impaired consciousness

tachycardia, thready pulse, low ABP

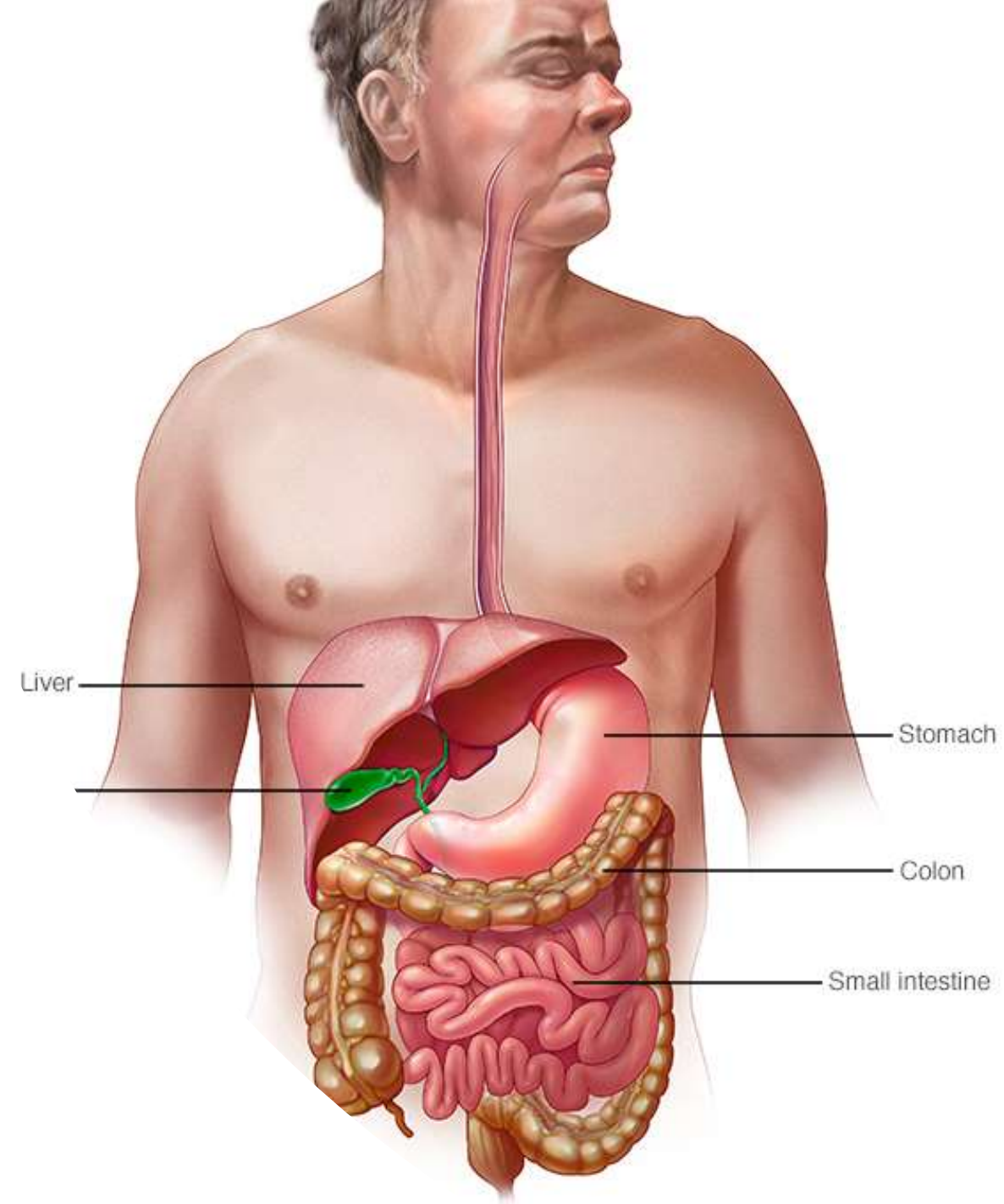
feeling of lack of air, dyspnea

decreased diuresis



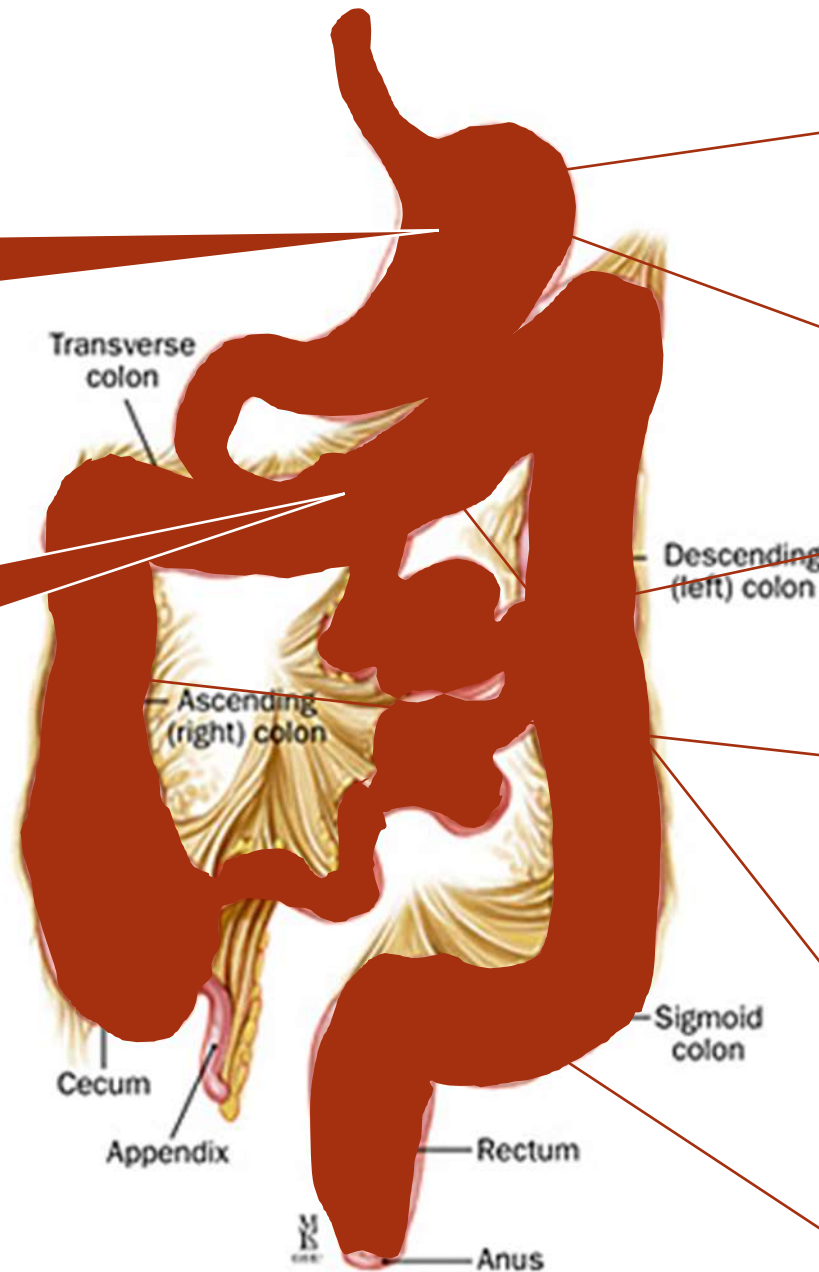
Local symptoms of GI bleeding

- Hematemesis (either red blood or coffee-ground emesis) suggests bleeding proximal to the ligament of Treitz. The presence of frankly bloody emesis suggests moderate to severe bleeding that may be ongoing, whereas coffee-ground emesis suggests more limited bleeding.
- The majority of melena (black, tarry stool) originates proximal to the ligament of Treitz (90%), though it may also originate from the oropharynx, small bowel, or right colon. Melena may be seen with variable degrees of blood loss, being seen with as little as 50 mL of blood.
- Hematochezia (red or maroon blood in the stool) is usually due to lower GI bleeding. However, it can occur with massive upper GI bleeding, which is typically associated with orthostatic hypotension.



Oxidation of Hb from blood by hydrochloric acid from stomach juice

Reduction of Hb from blood by bacterial enzymes



red blood or coffee-ground emesis

melena

melena or native blood

melena or liquid red feces look like raspberry jelly

liquid red feces look like raspberry jelly or native maroon blood

native maroon or brightly red blood

Diagnosis of bleeding

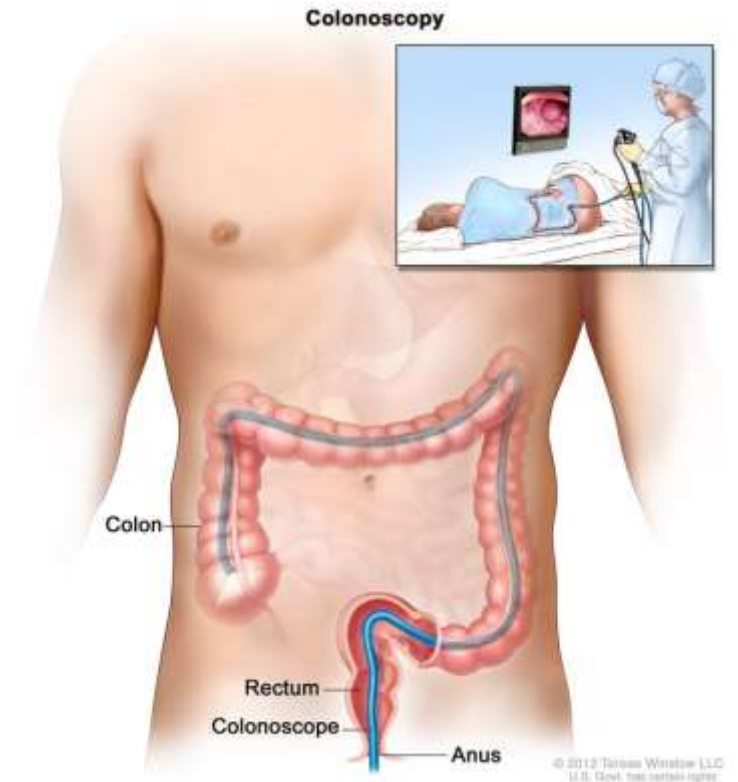
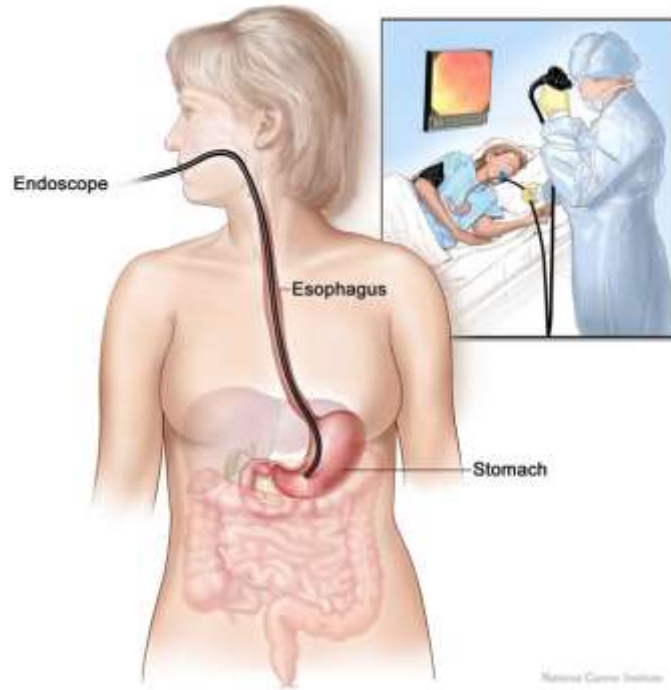
External to the hollow organs

- Esophagogastroduodenoscopy
- Capsule intestinoscopy
- Colonoscopy
- Bronchoscopy
- Cystoscopy

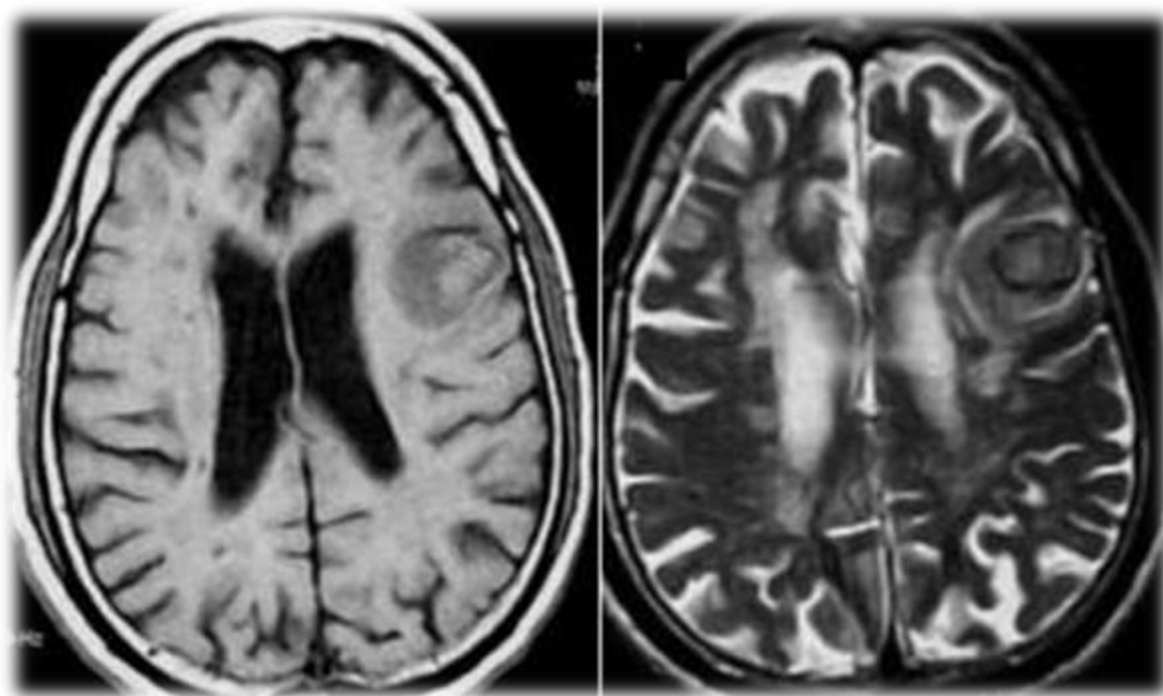
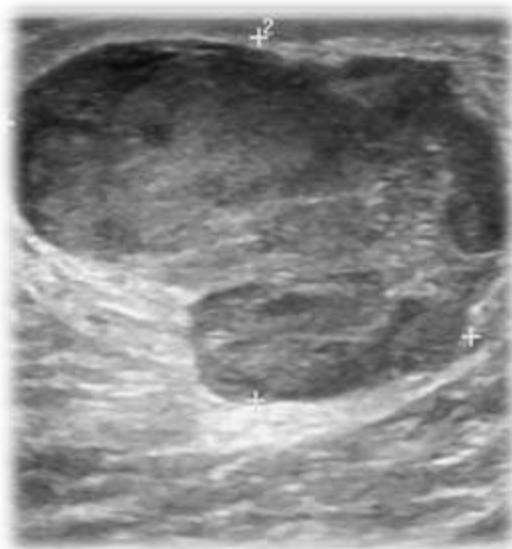
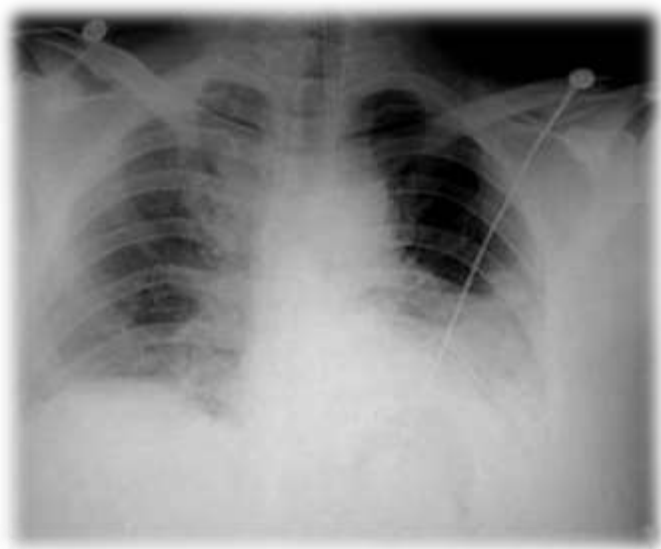
Internal

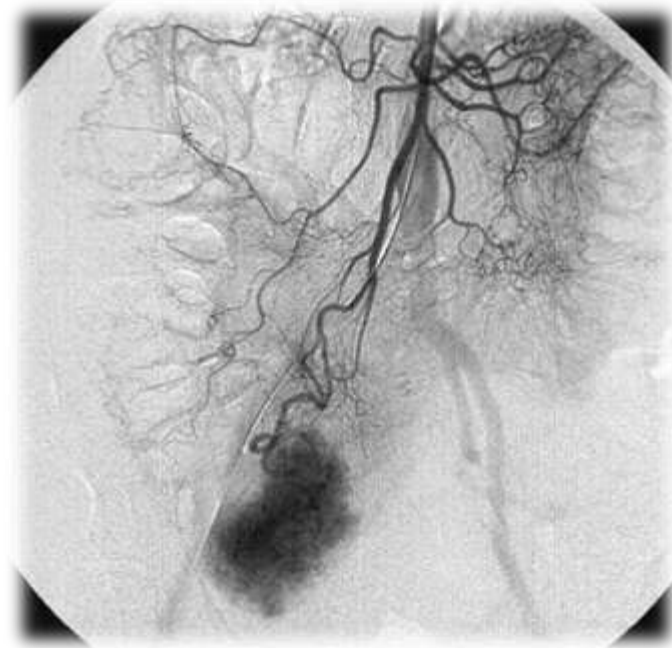
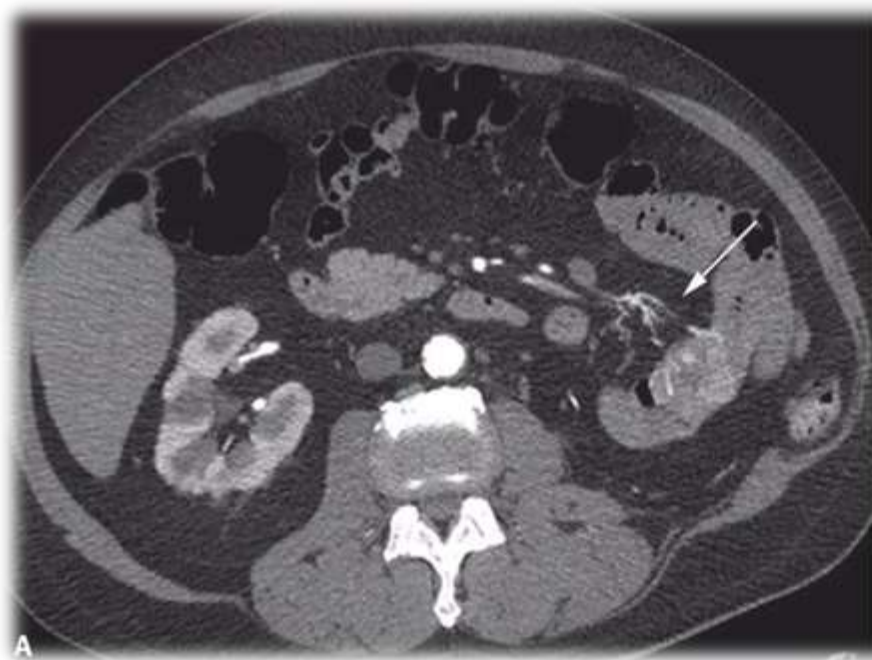
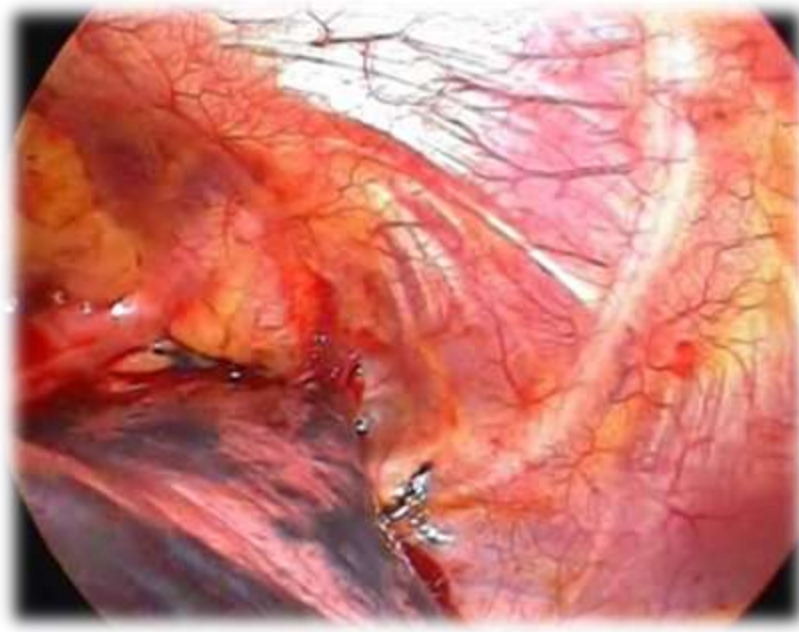
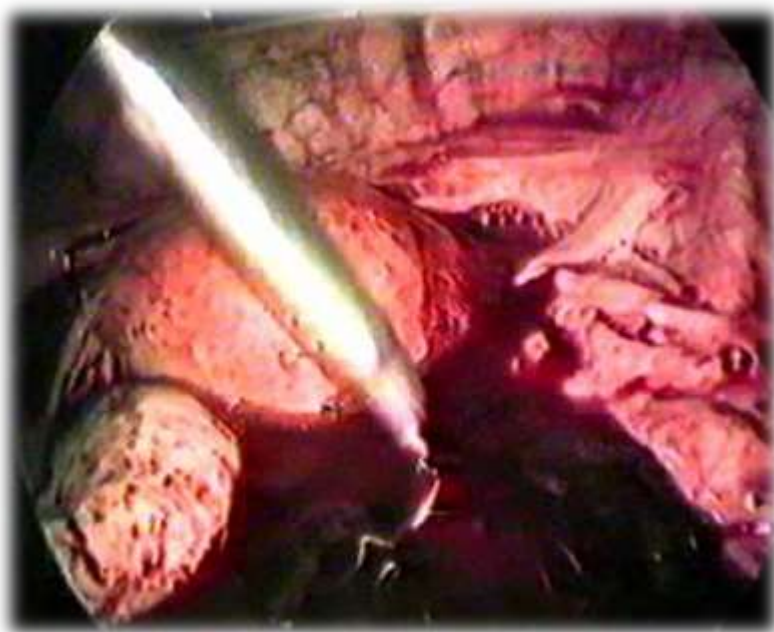
- X-ray
- Ultrasound
- CT
- MRI
- Endoscopy (laparoscopy, thoracoscopy)
- Puncture

Angiography



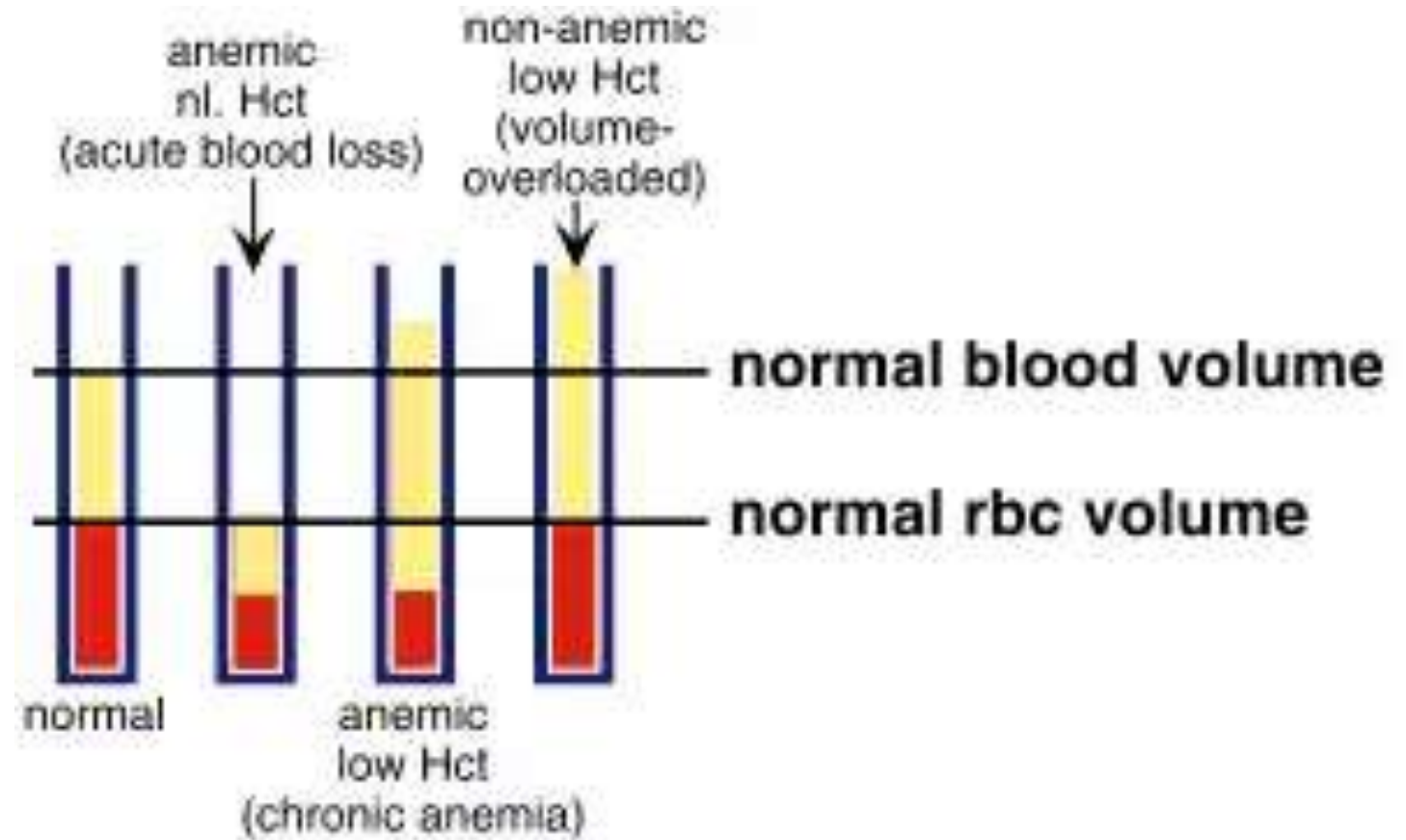
Diagnosis of GI bleeding





Diagnosis of bleeding

- Hb level (12-16 g/dL)
- RBC count ($4.8-5.4 \times 10^{12}$)
- Hct (44-47%)

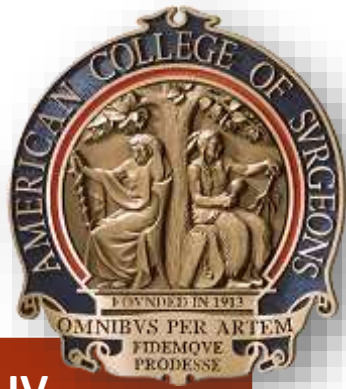


Severity of blood loss

Class	Decrease of EBV	Symptoms
I	15%	Resting tachycardia
II	20-25%	Orthostatic hypotension*
III	30-40%	Supine hypotension, oligonuria
IV	>40%	Impaired consciousness, collapse, shock

*a decrease in the systolic blood pressure of more than 20 mmHg and/or an increase in heart rate of 20 beats per minute when moving from recumbency to standing

Severity of blood loss according to the American College of Surgeons



Factors	I	II	II	IV
Blood loss	<15% (<750 ml)	15-30% (750-1500 ml)	30-40% (1500-2000 ml)	>40% (>2000 ml)
Pulse	<100	>100	>120	>140
ABP	Normal	Normal	↓ (<100)	↓↓ (<60)
Pulse pressure	Normal or ↓	↓	↓↓	↓↓
Capillary refill	<2s	2-3s	3-4s	>5s
Resp. rate	14-20	20-30	30-40	>40
Urine output (ml/h)	≥30	20-30	5-10	Negligible
Mental status	Slightly anxious	Mildly anxious	Anxious & confused	Confused & lethargic

Bleeding arrest



Bleeding arrest

Temporary

Bending,
compression,
tourniquet,
tamponade, bypass

Final

Mechanical

Ligation, suturing,
vascular suture,
tamponade,
embolization

Physical

Coagulation,
hypothermia

Chemical

Local and systemic
hemostatic agents

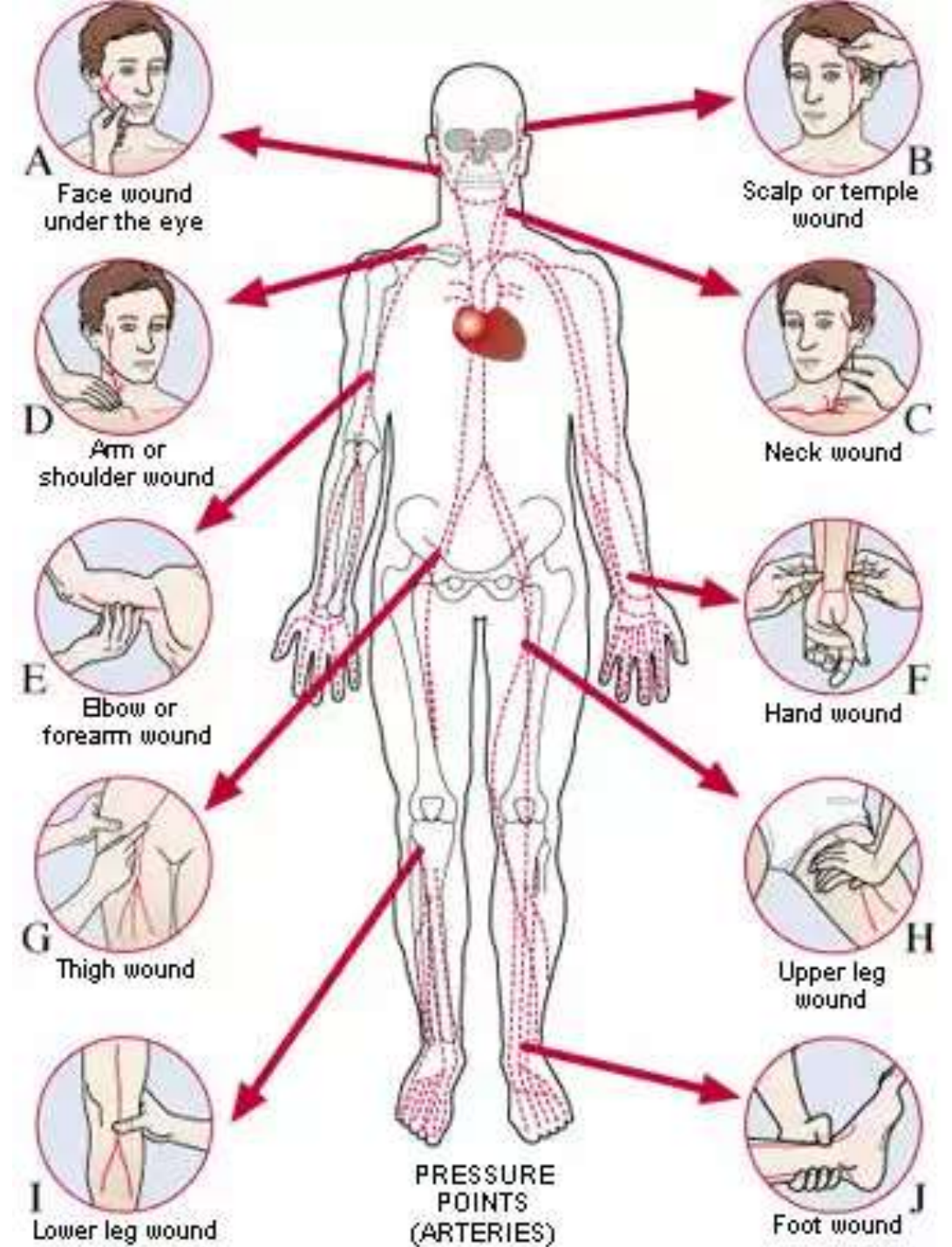
Biological

FFP and it's
derivates

Temporary methods of bleeding arrest

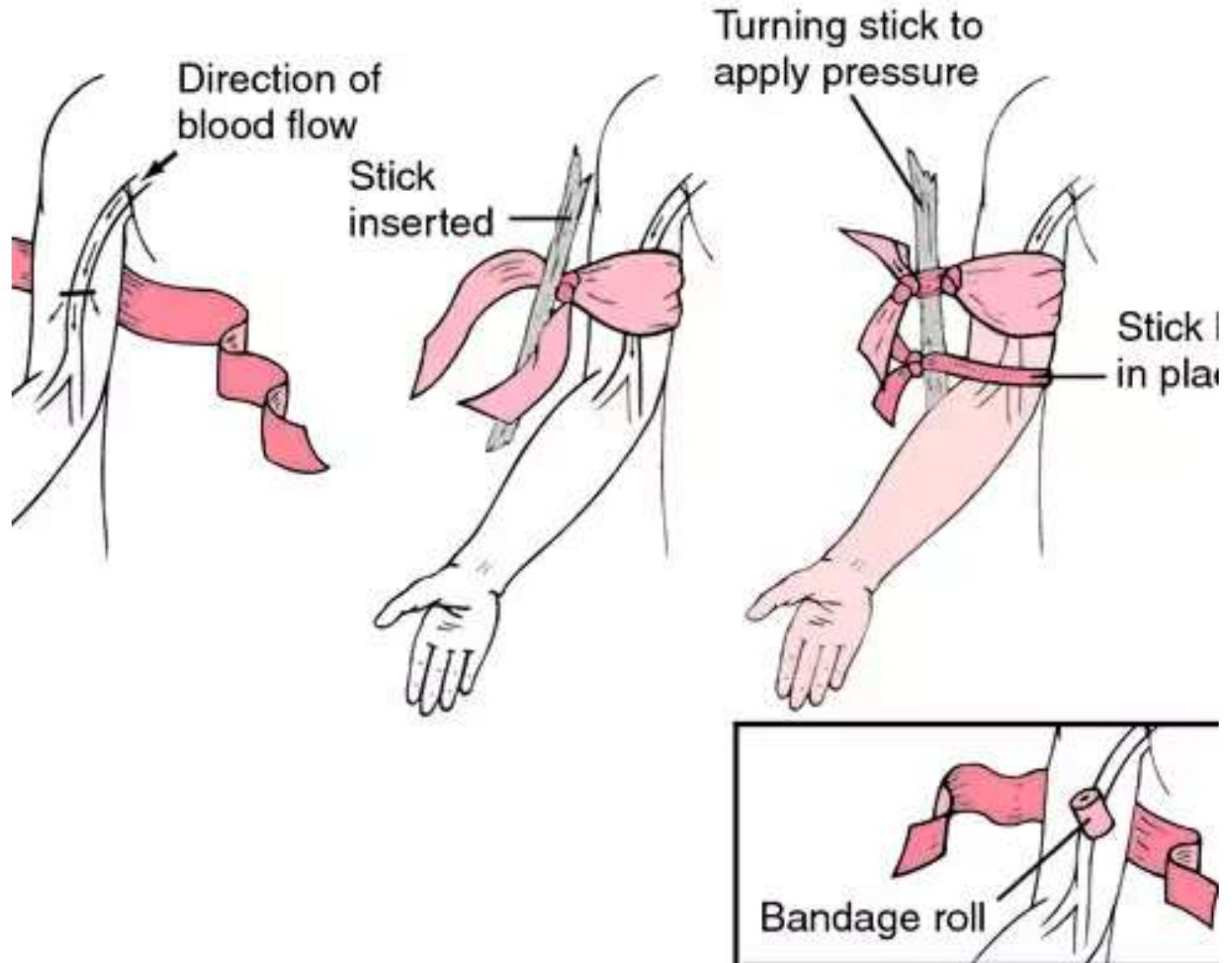
	Arterial	Venous	Capillary	Massive mixed
Maximal bending	+			+
Compression bandage		+	+	
Compression by finger	+			+
Arterial tourniquet	+			+
Tamponade of the wound		+	+	
Surgical clamping	+	+		
Bypass	+			

Compression by finger



Arterial tourniquet

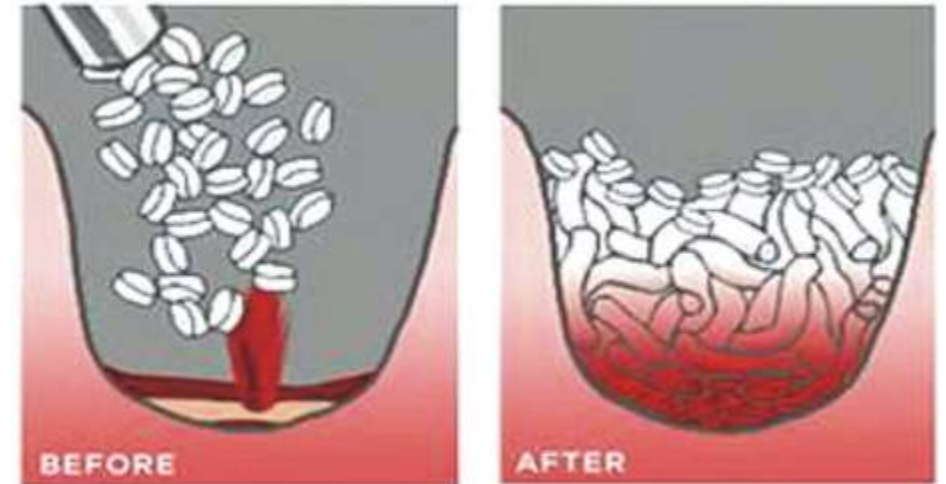
- Localization:
 - Upper third of arm
 - Upper third of thigh
- Main rules:
 - Elevate the limb
 - Do not put the classic tourniquet on the naked skin
 - Make the note with the exact time of application
 - The limb should be available for inspection
 - Patients with tourniquet should be transported firstly
 - The maximal time of tourniquet use is
 - **1,5 h** for the upper limb
 - **2 h** for the lower limb



Arterial tourniquet

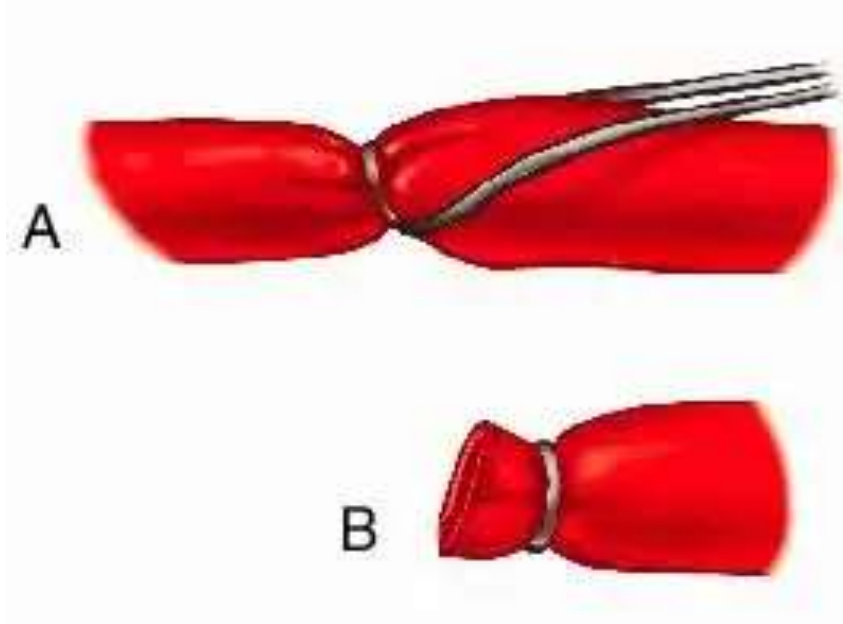


Modern tamponade of the wound

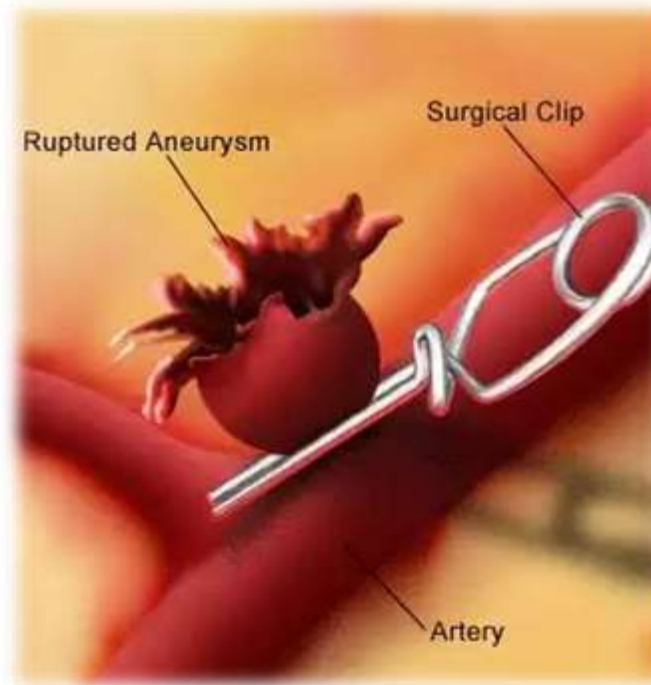


XSTAT® is a first-in-kind hemostatic device for the treatment of gunshot and shrapnel wounds. XSTAT works by injecting a group of small, rapidly-expanding sponges into a wound cavity using a syringe-like applicator. Each sponge contains an x-ray detectable marker. In the wound, the XSTAT sponges expand and swell to fill the wound cavity within 20 seconds of contact with blood. This creates a temporary barrier to blood flow and provides hemostatic pressure.

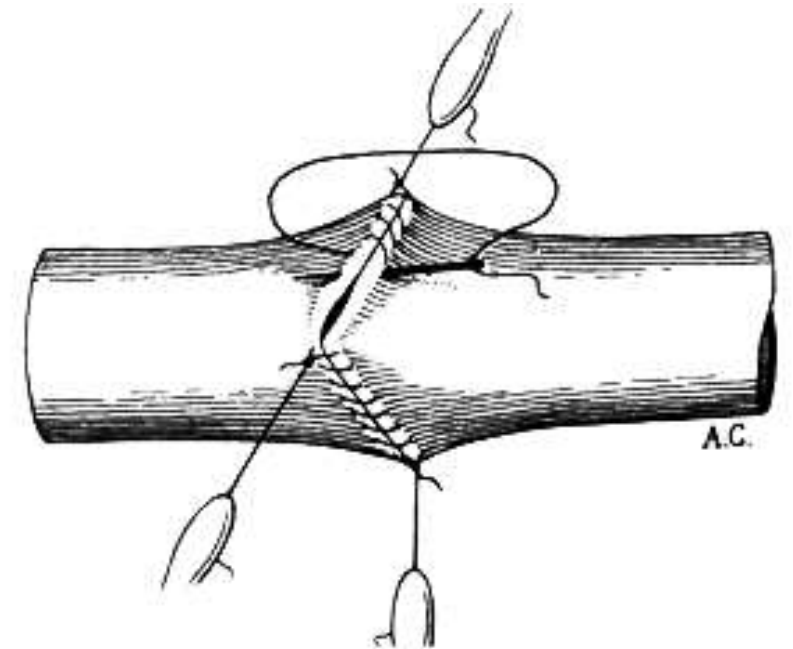
Mechanical bleeding arrest



Surgical ligation

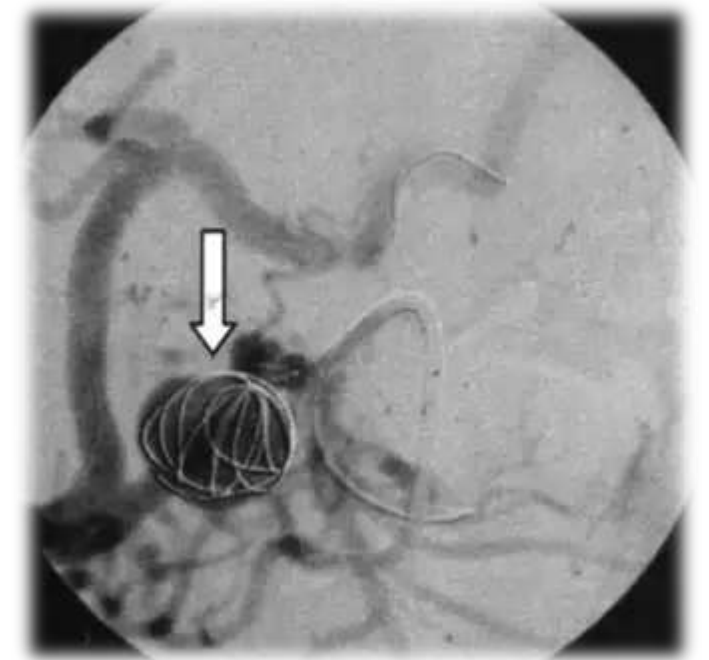
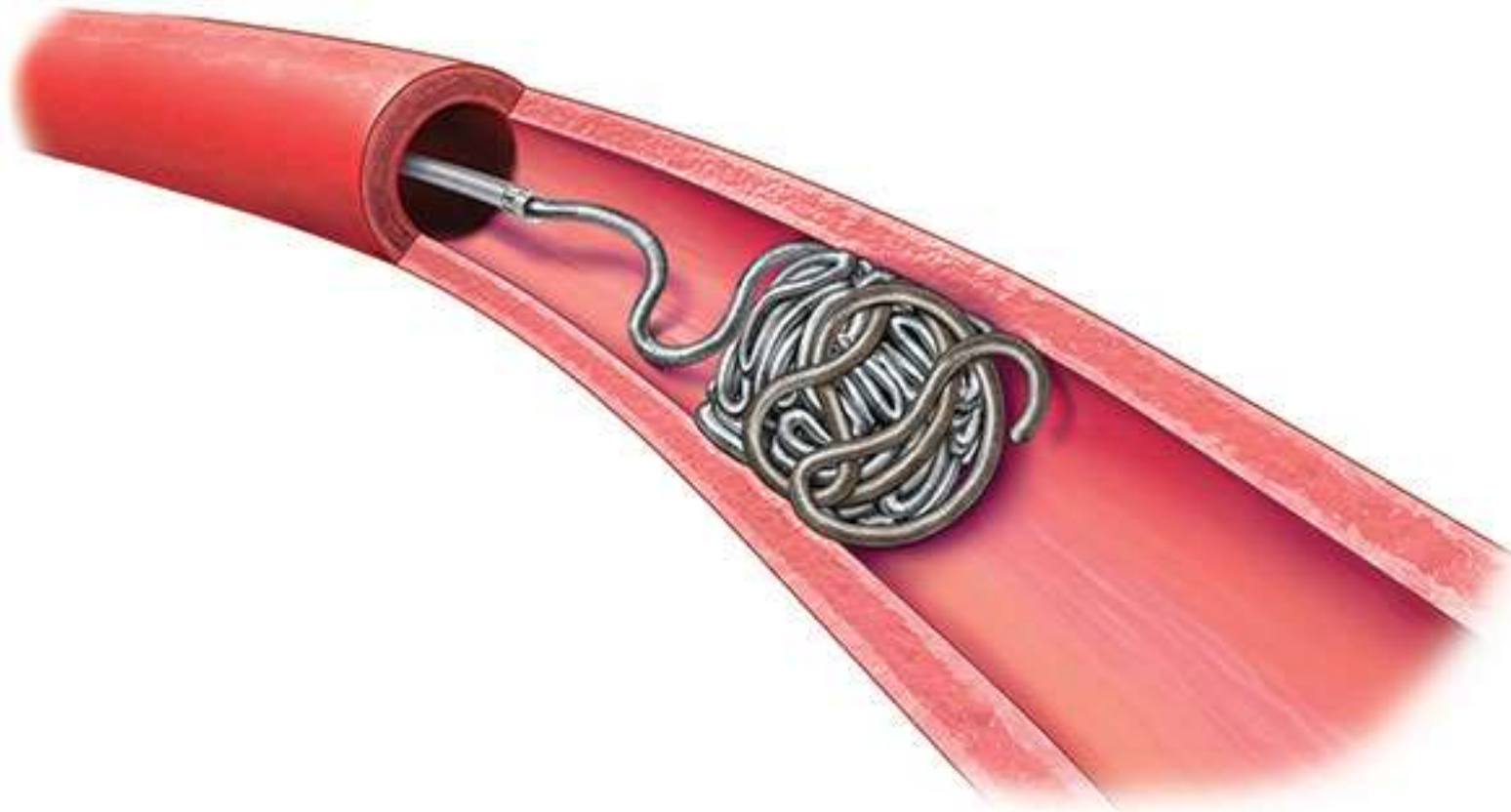


Surgical clipping



Vascular suture

Mechanical bleeding arrest



Arterial embolization

Physical bleeding arrest

Thermal

Hypothermal

Electrical coagulation

Laser coagulation

Radiofrequency coagulation

Ultrasonic coagulation

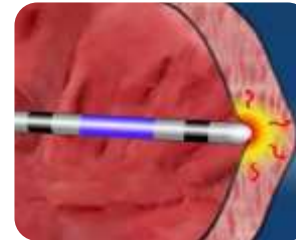
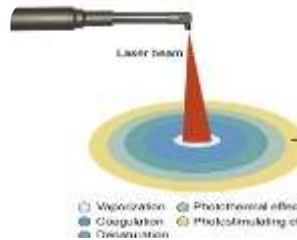
Cryodestruction

Local hypothermia

Monopolar

Bipolar

Plasma



Chemical bleeding arrest

Local

- Oxidatives (hydrogen peroxide)
- Vasoconstrictors (epinephrine)
- Fibrinolysis inhibitors (aprotinin, tranexamic acid, aminocaproic acid)
- Gelatin substances (gelatin sponge)
- Highly acidity cellulose substances
- Surgical vax
- Fe-contains substances (Caproferr)
- Synthetic glues

Systemic

- Fibrinolysis inhibitors (aprotinin, tranexamic acid, aminocaproic acid)
- Calcium chloride
- Sodium ethamzylate
- Vitamin K, synthetic vit.K₁
- Specific drugs (vasopressin, oxytocin)

Biological bleeding arrest

Local

- Collagen sponge
- Fibrine glue
- Combined solutions

Systemic

- Native blood
- Fresh frozen plasma
- Cryoprecipitate
- Prothrombine complex concentrate
- Recombinant VII clotting factor
- Platelet concentrate

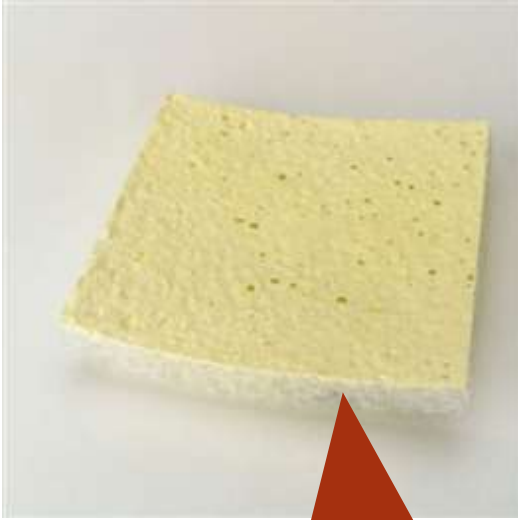
Fibrin glue



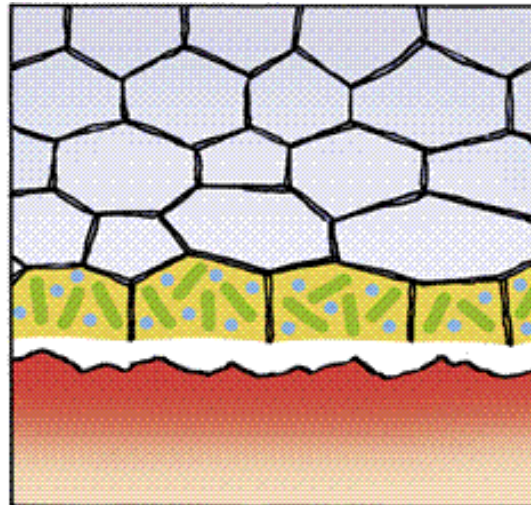
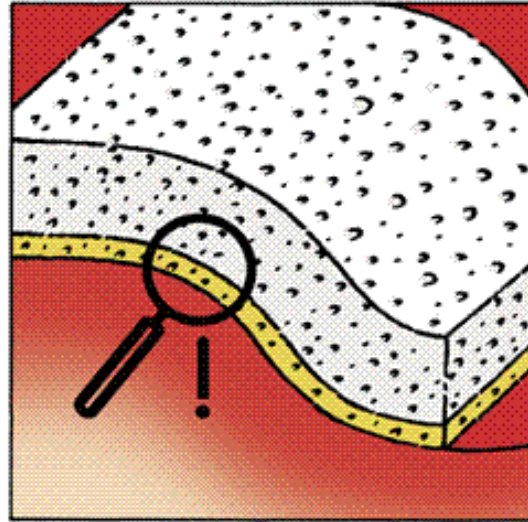
Tissucol: fibrinogen + XIII clotting factor



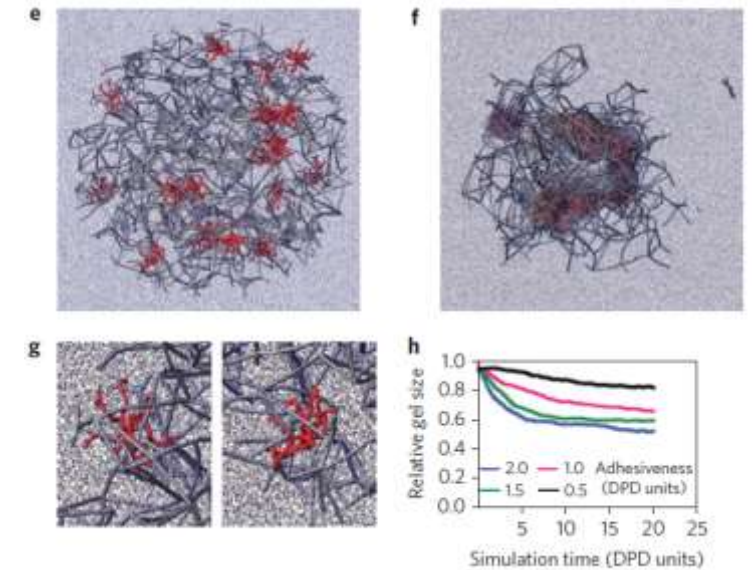
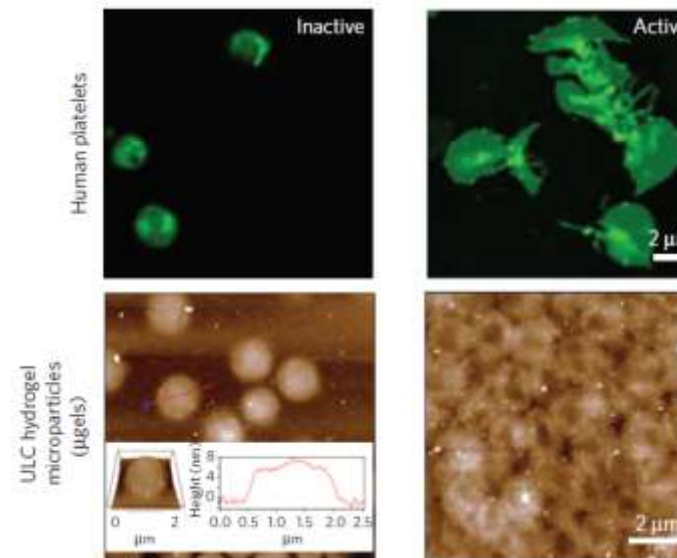
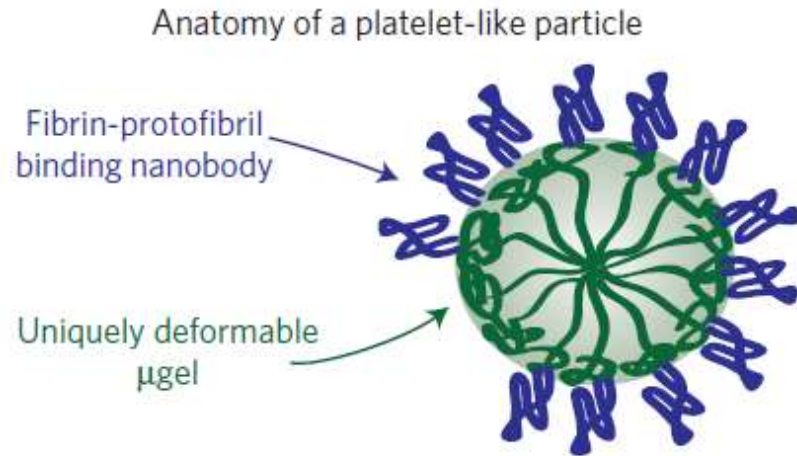
Combined solutions



Collagen sponge +
fibrinogen +
inactivated
lyophilized
thrombine



Modern hemostatic solutions



highly deformable platelet 'body' that enables multivalent display with much greater conformational flexibility, ultra-lowcrosslinked (ULC) poly(N-isopropylacrylamide- co-acrylic acid) (pNIPAm-AAC) microgels (gels) were synthesized via a non-standard, 'crosslinker free', precipitation polymerization method

Modern hemostatic solutions

- Veti-gel is a veterinary product, a plant-derived injectable gel that is claimed to quickly stop traumatic bleeding on external and internal wounds.
- Its name is coined from Medi-Gel, from the video game Mass Effect.
- It uses a plant-based haemophilic polymer made from polysaccharides that forms a mesh which seals the wound





Replenishment of
blood loss

Aims for blood replenishment

$$DO_2 = SV * HR * 1,39 * Hb * SaO_2$$

Volume restoration

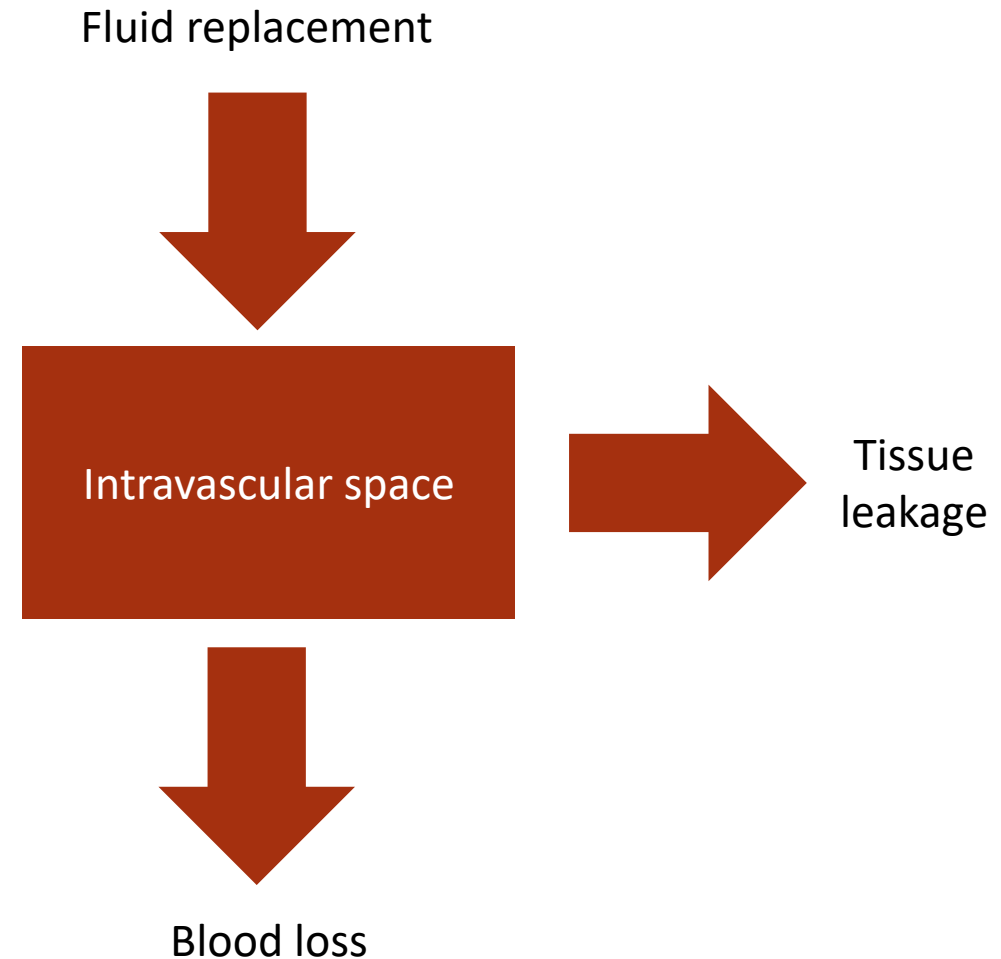
RBC transfusion

Respiratory
support

DO_2 – Oxygen delivery to the tissues; CO – cardiac output; SV – stroke volume; HR – heart rate

Is it enough to restore losing blood with the native blood of the same volume?

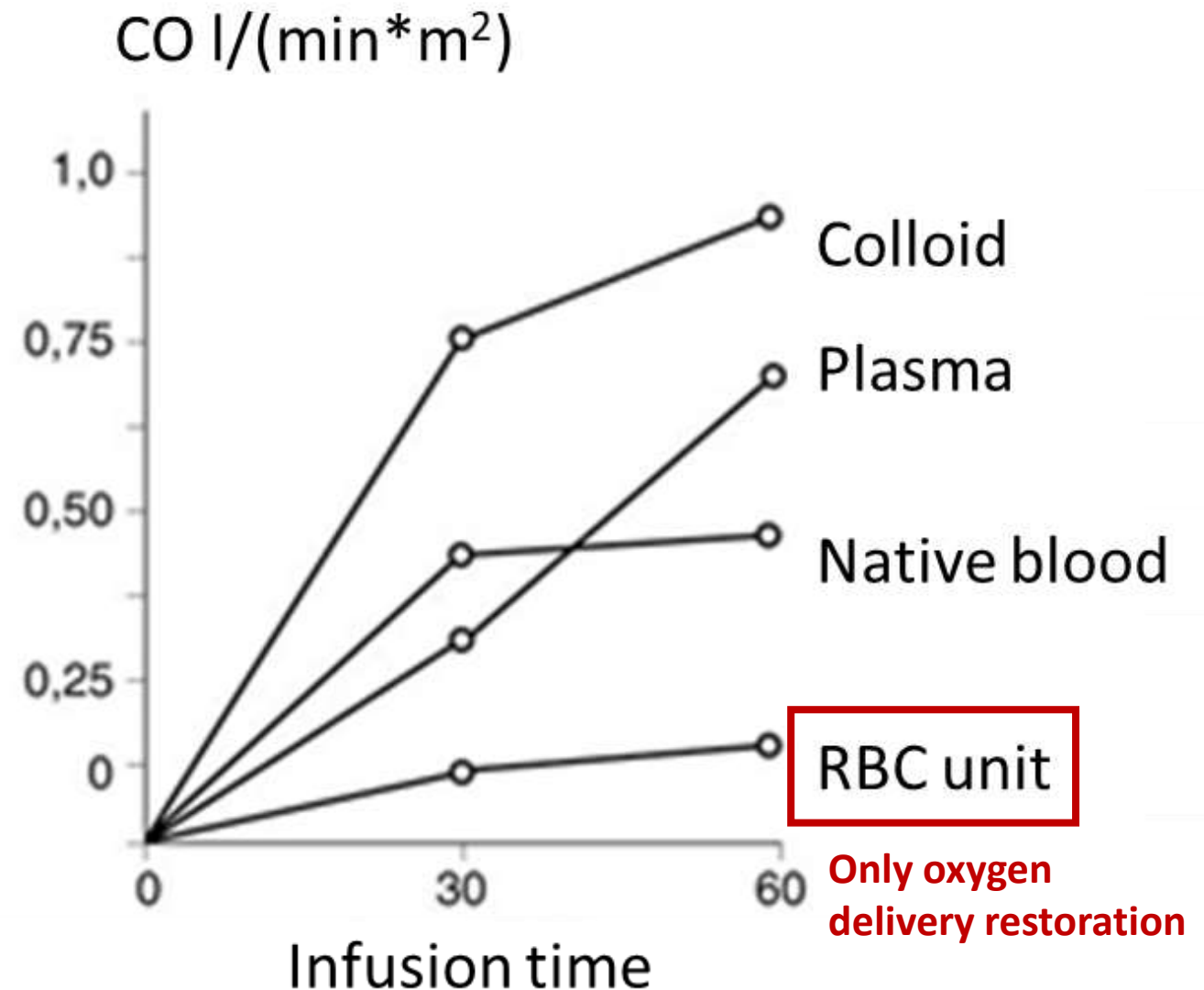
- In 1918 Cannon and coworkers questioned the feasibility of restoring blood pressure back to normal in the face of active hemorrhage.
- Wiggers proposed the concept of 'irreversible shock' after showing that reinfusing blood into a profoundly shocked animal was not sufficient to prevent mortality and morbidity.
- Shires and coworkers demonstrated in experimental preparations that crystalloid fluids were needed in addition to blood to restore perfusion. They were able to demonstrate failure of the sodium–potassium pump, resulting in the ingress of sodium and water into the cells.
- The awareness of 'third space losses' into the interstitium and tissues resulted in the 'three-to-one' rule for resuscitation: that is, 3 ml of crystalloid (Ringers lactate or normal saline) for every 1 ml of blood loss replaced.



Volume restoration

- Native blood
 - Plasma
 - Albumin
 - Colloids
 - Dextran
 - Gelatin
 - HAS
 - Crystalloids
 - Hypertonic saline
 - Isotonic crystalloids (normal saline, Ringer's solution etc.)
- Rapid increase of arterial blood pressure and cardiac output**

Basic volume restoration according to the rule 3 for 1

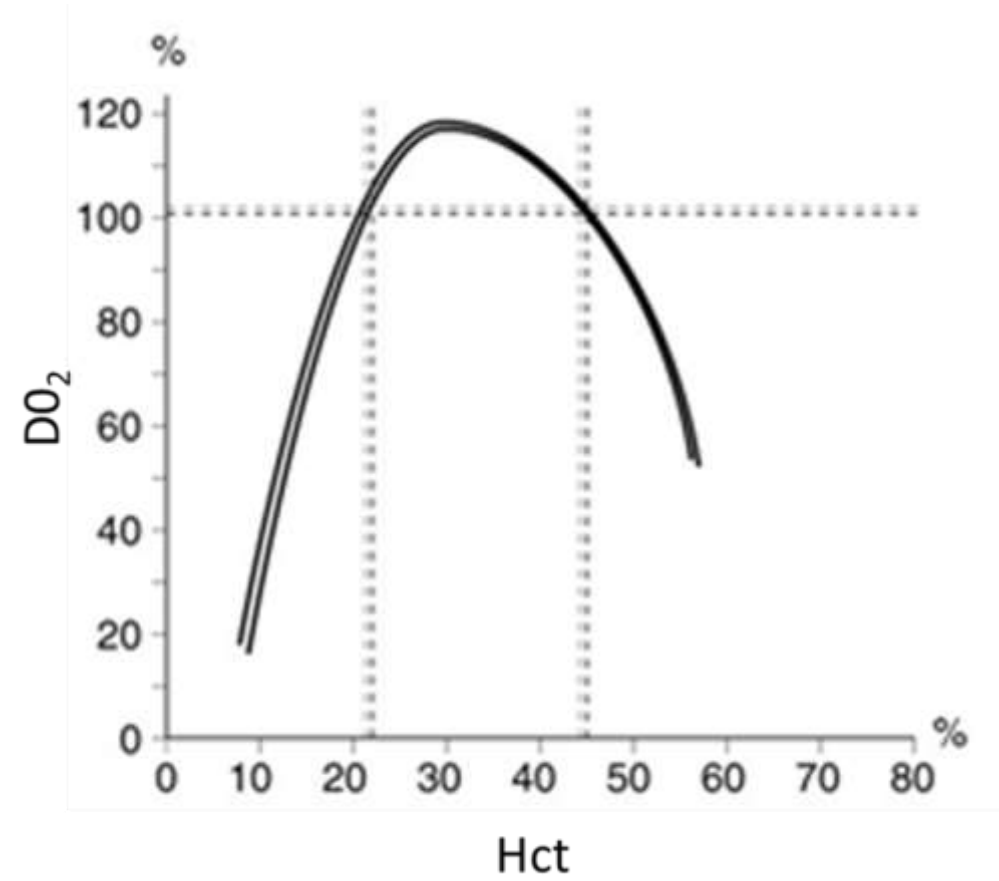


Colloid or crystalloid?

- We identified 78 eligible trials; 70 of these presented mortality data.
- COLLOIDS COMPARED TO CRYSTALLOIDS:
 - **Albumin or plasma protein fraction** - 24 trials reported data on mortality, including a total of 9920 patients. The pooled risk ratio (RR) from these trials was 1.01 (95% confidence interval (CI) 0.93 to 1.10) – **no difference**
 - **Hydroxyethyl starch** - 25 trials compared hydroxyethyl starch with crystalloids and included 9147 patients. The pooled RR was 1.10 (95% CI 1.02 to 1.19) – **increase mortality**
 - **Modified gelatin** - 11 trials compared modified gelatin with crystalloid and included 506 patients. The pooled RR was 0.91 (95% CI 0.49 to 1.72) - **no difference**
 - **Dextran** - nine trials compared dextran with a crystalloid and included 834 patients. The pooled RR was 1.24 (95% CI 0.94 to 1.65) - **no difference**
- COLLOIDS IN HYPERTONIC CRYSTALLOID COMPARED TO ISOTONIC CRYSTALLOID:
 - Nine trials compared **dextran in hypertonic crystalloid** with isotonic crystalloid, including 1985 randomised participants. Pooled RR for mortality was 0.91 (95% CI 0.71 to 1.06) - **no difference**

When transfuse blood?

- Blood characterized with high viscosity
- Increased viscosity decreases the tissue oxygen delivery
- Optimal condition is moderate hemodilution with HCT level of 25-30%
- Blood transfusion is indicated in massive blood loss (>30%) and Hb level less than 70 g/dL



Approach for volume restoration

Factors	I	II	III	IV
Blood loss	<15% (<750 ml)	15-30% (750-1500 ml)	30-40% (1500-2000 ml)	>40% (>2000 ml)
Pulse	<100	>100	>120	>140
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Resp. rate	14-20	20-30	30-40	>40
Urine output (ml/h)	≥30	20-30	5-10	Negligible
Mental status	Slightly anxious	Mildly anxious	Anxious & confused	Confused & lethargic
Fluid replacement	Crystalloid	Crystalloid	Crystalloid & blood	Crystalloid & blood
Blood	-	-	50%	70%
Volume of infusion	300%	300%	300%	300%

Approach for volume restoration

Controlled bleeding

- Early in the course of hemorrhage (during hypovolemic shock) for rapid administration of volume:
 - Isotonic crystalloids
 - Hypertonic saline
 - Colloids
- Later in the course of hemorrhage (after volume has been replaced):
 - Isotonic crystalloids
 - Plasma for correction of clotting factor deficiency
 - Whole blood for correction of anemia or thrombocytopenia
 - Packed RBCs for correction of anemia

Uncontrolled bleeding

- Maintenance of organ perfusion with a minimal mean arterial pressure of approximately 60 mm Hg (or maintenance of urine output) through slow administration of fluids
- Fluid choices
 - Whole blood
 - Packed RBCs plus plasma or isotonic crystalloids
 - Plasma (slow administration, not bolus)
 - Isotonic crystalloids