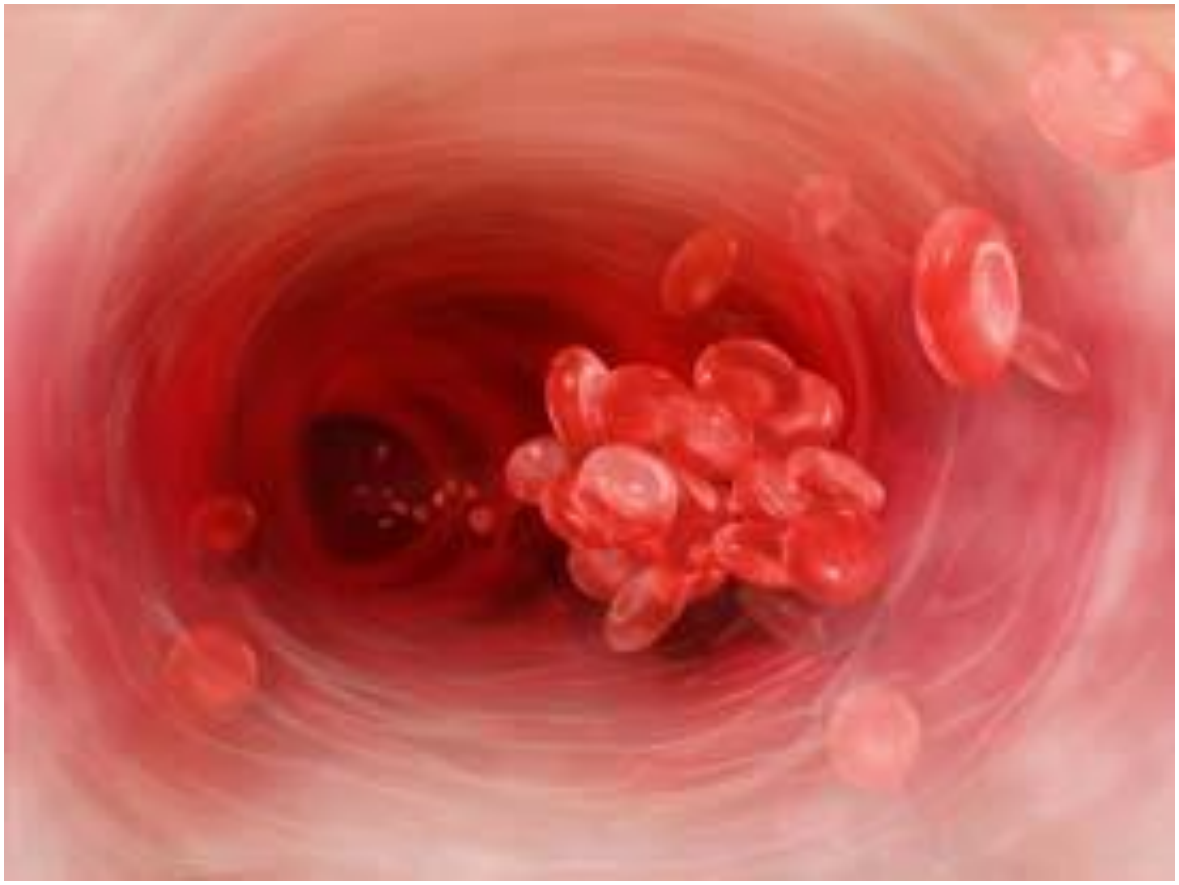
Haemodynamic derangements



Dr Durga Moratuwagam

MD,FRCPath(Haem)

Faculty of Medicine-Ragama

Contents

- Edema
- Hyperaemia and congestion
- Haemorrhage
- Haemostasis & Thrombosis
    - -Normal haemostasis
    - -Thrombosis
    - -DIC
- Embolism
- Infarction
- Shock

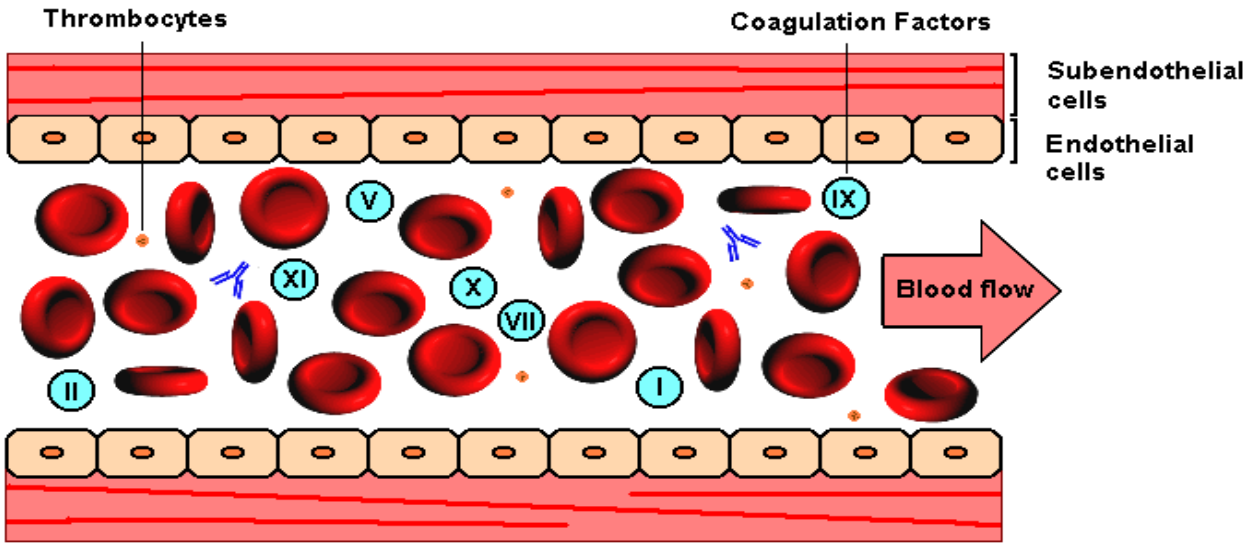
- A 35 year old woman (P_4C_4)became breathless 1 hour after delivery
- She was pale and tachycardic.

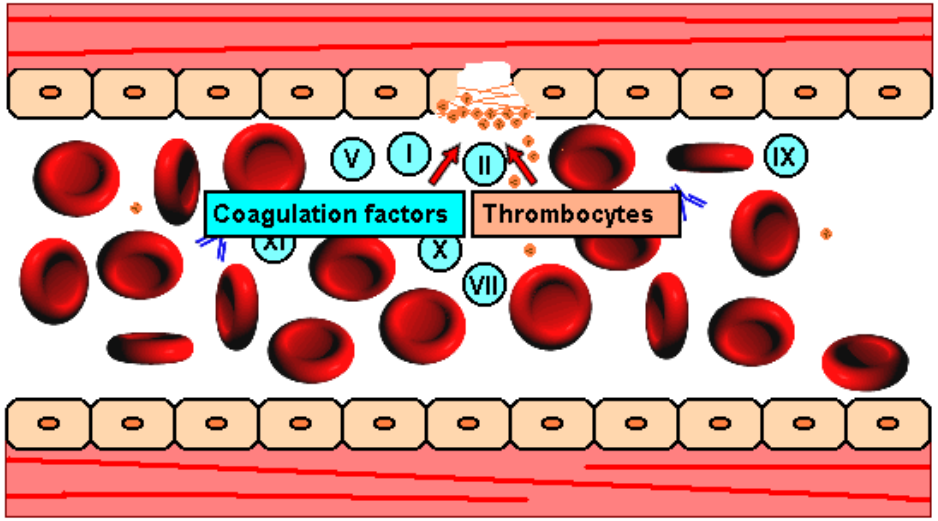
HEMOSTASIS

Definition

- Hemostasis: drives from the Greek meaning "The stoppage of blood flow".
- Components involved in haemostasis
    - *Blood vessel
    - *Platelets
    - *Coagulation factors
    - *Coagulation inhibitors
    - *Fibrinolysis

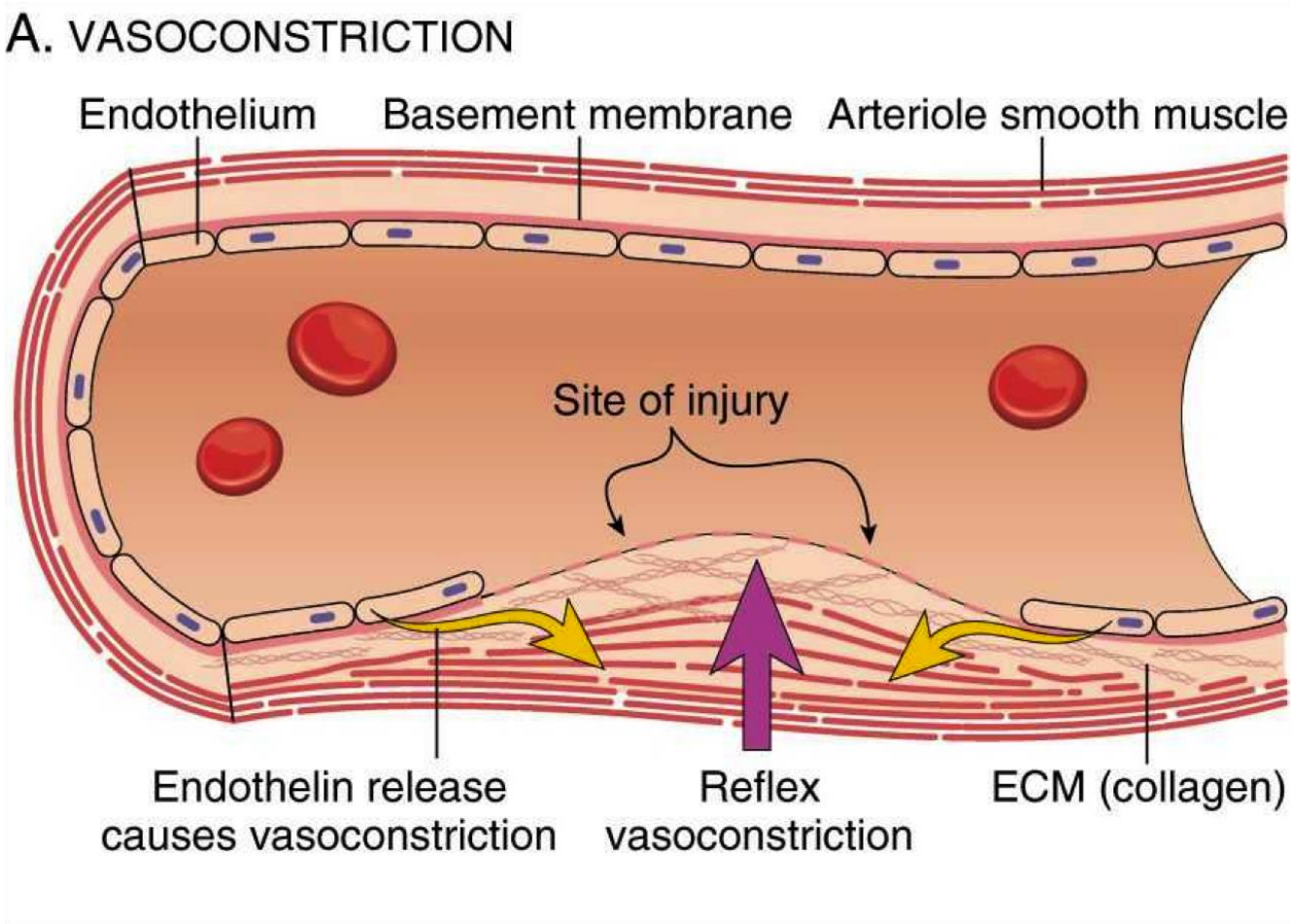
Vessel wall, Blood flow & Coagulation Substances



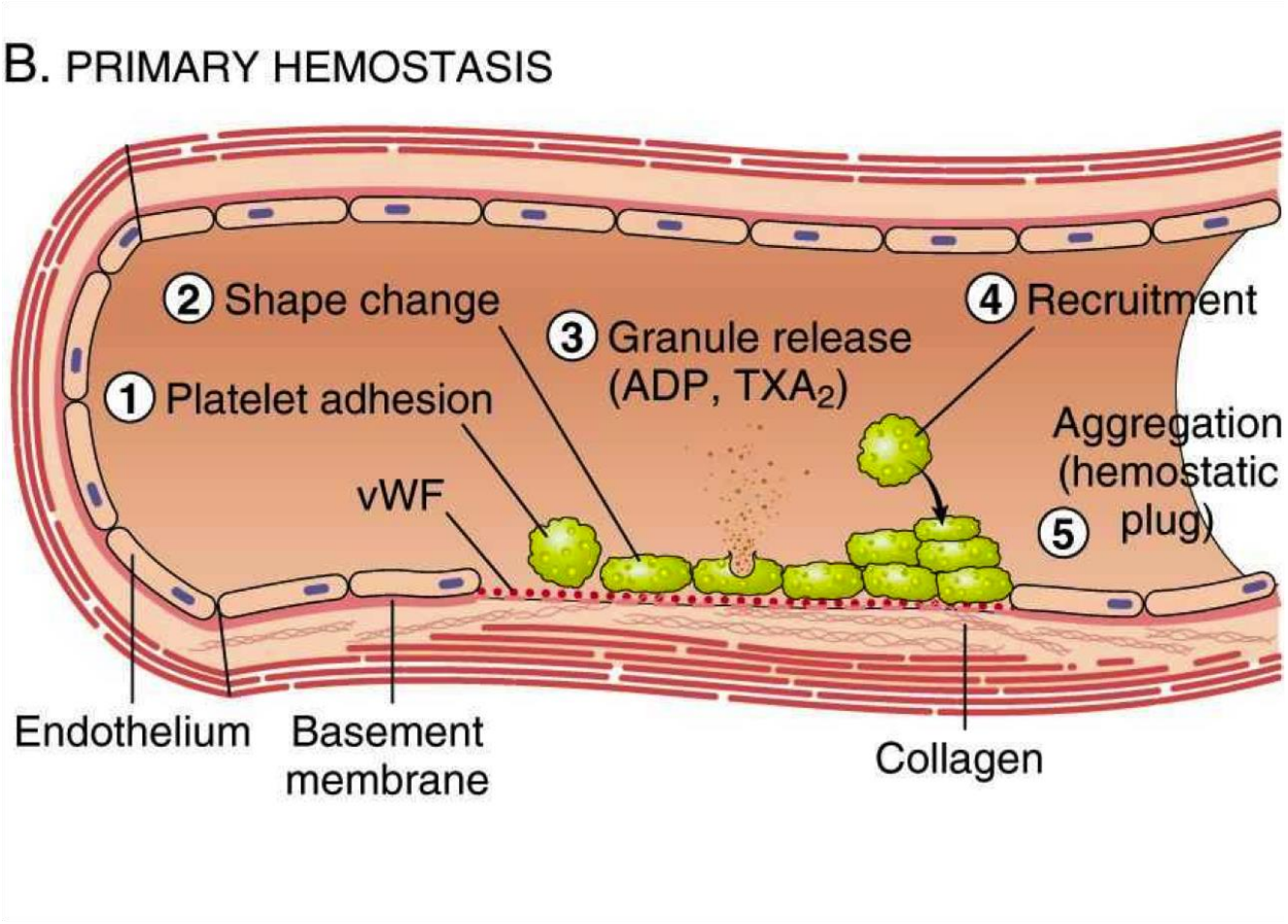


In Case if there is an Endothelial Injury
(Bleeding must be prevented at site of injury)

Normal Haemostasis



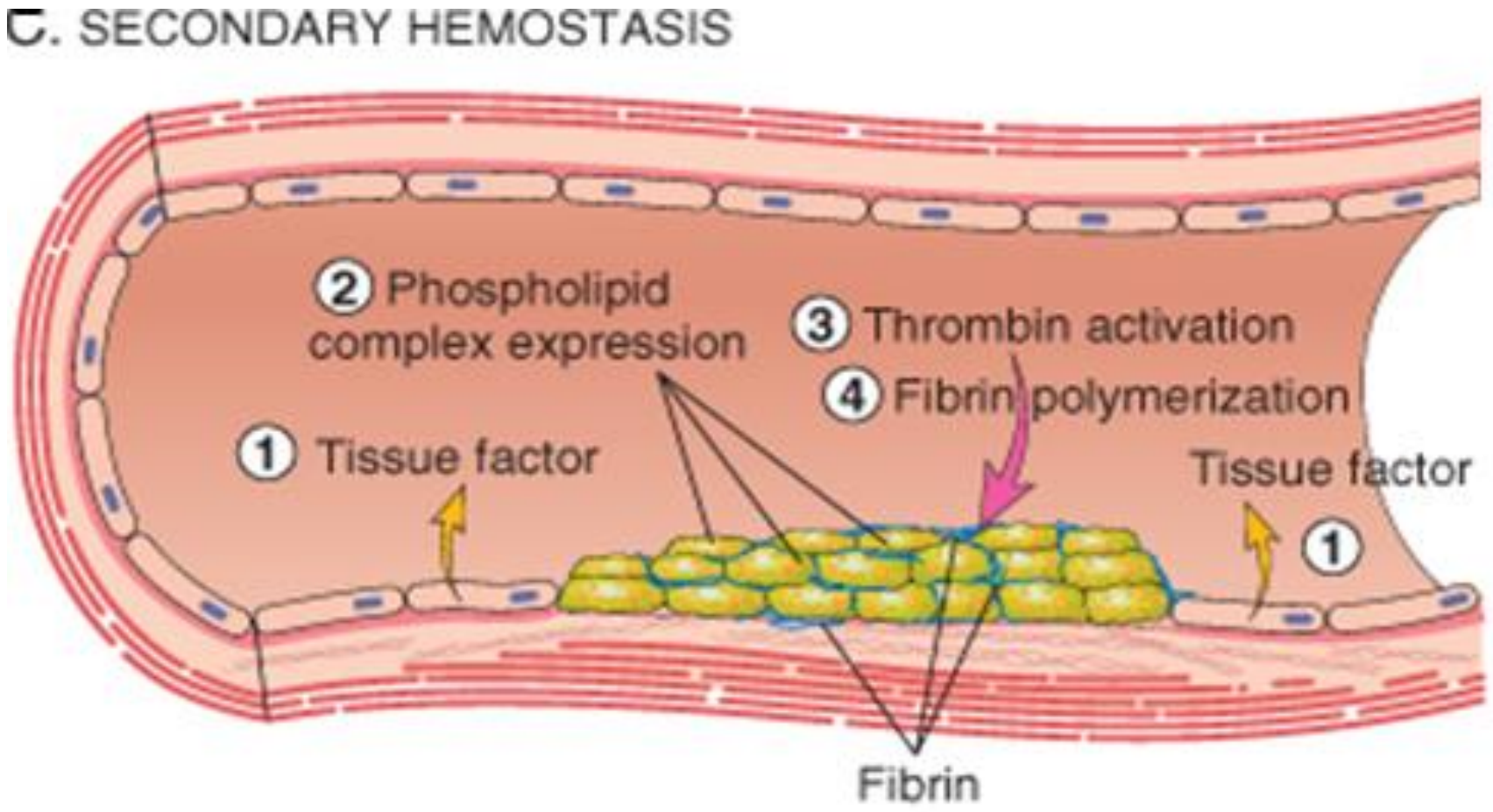
Normal Haemostasis



Normal Haemostasis -Platelets

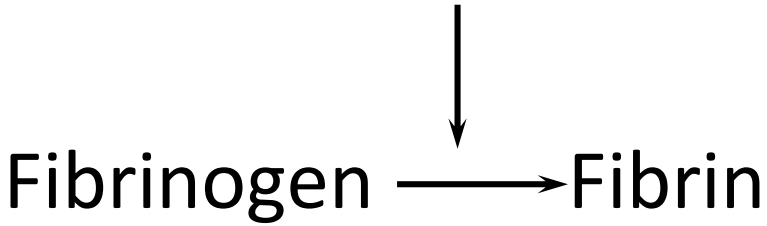
- adhere to damaged vessel wall
- adhere to each other
- form a platelet plug
- platelet release reaction
- Platelet aggregation

Normal Haemostasis

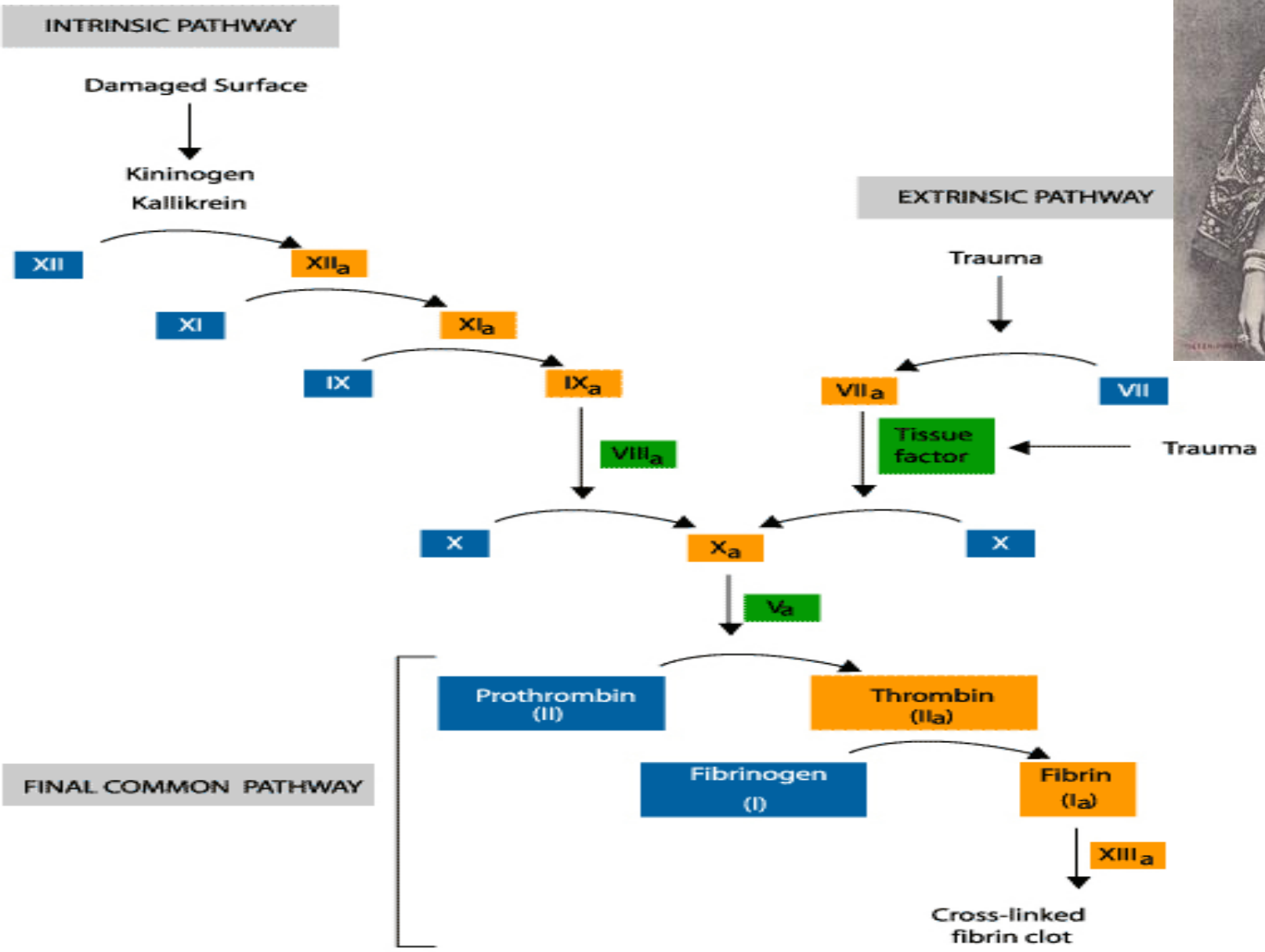


Normal Haemostasis-Coagulation

- Cascade
- Series of inactive components converted to active components
- Prothrombin ⟶ Thrombin



Clotting cascade

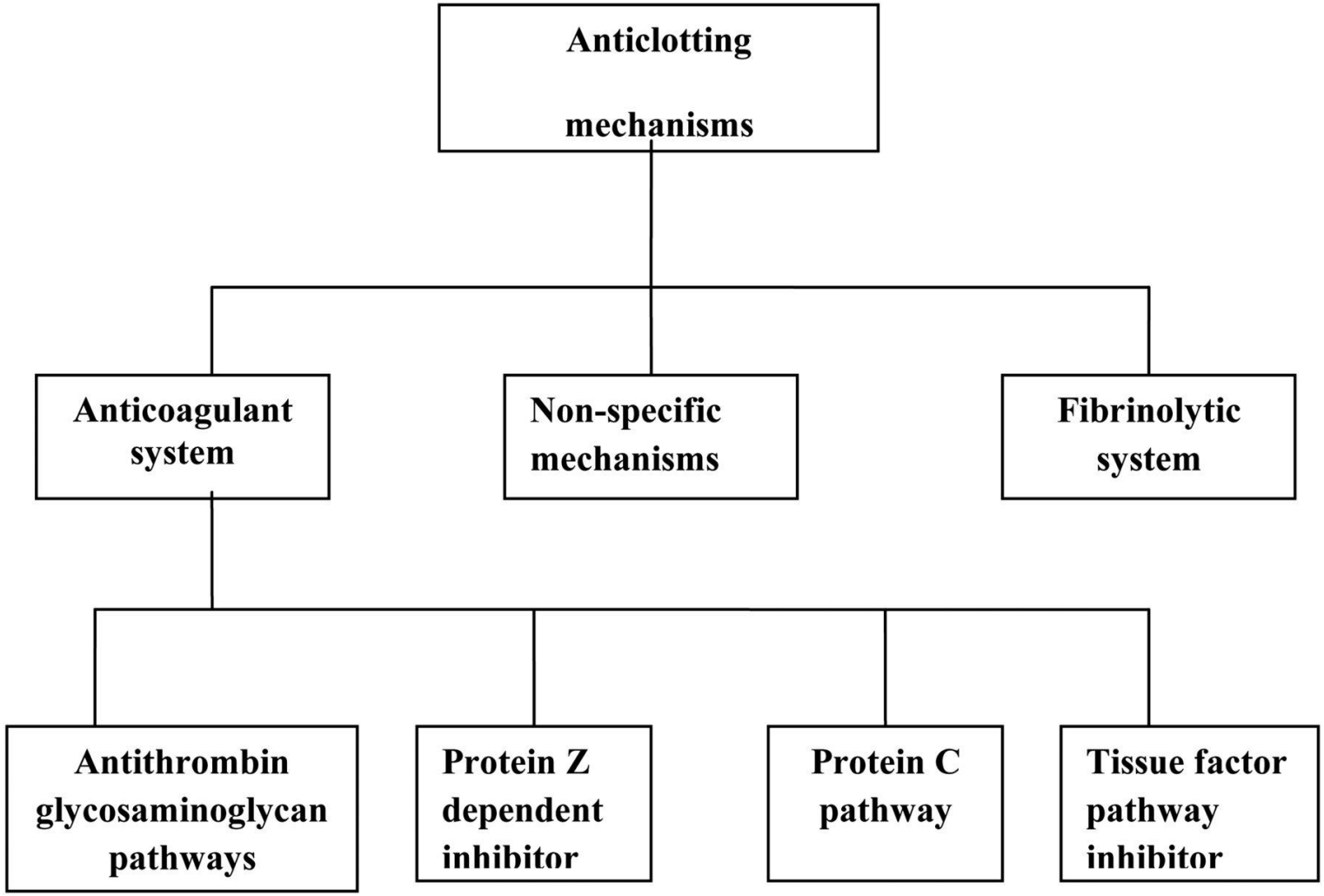



Signature
colors
Cinnamon
PALLADIUM HOTE
INIFD
The Cradle of Designers
BlueSea

Normal Hemostasis Is a Balance

- Coagulation factor inhibitors-TFPI/AT/Pr C/S
- Fibrinolytic pathway-Plasminogen/TPA/TAFI/
- Blood flow

Anticlotting mechanisms.



J. Adanma Ezihe-Ejiofor, and Nevil Hutchinson Contin Educ Anaesth Crit Care Pain 2013;bjaceaccp.mks061

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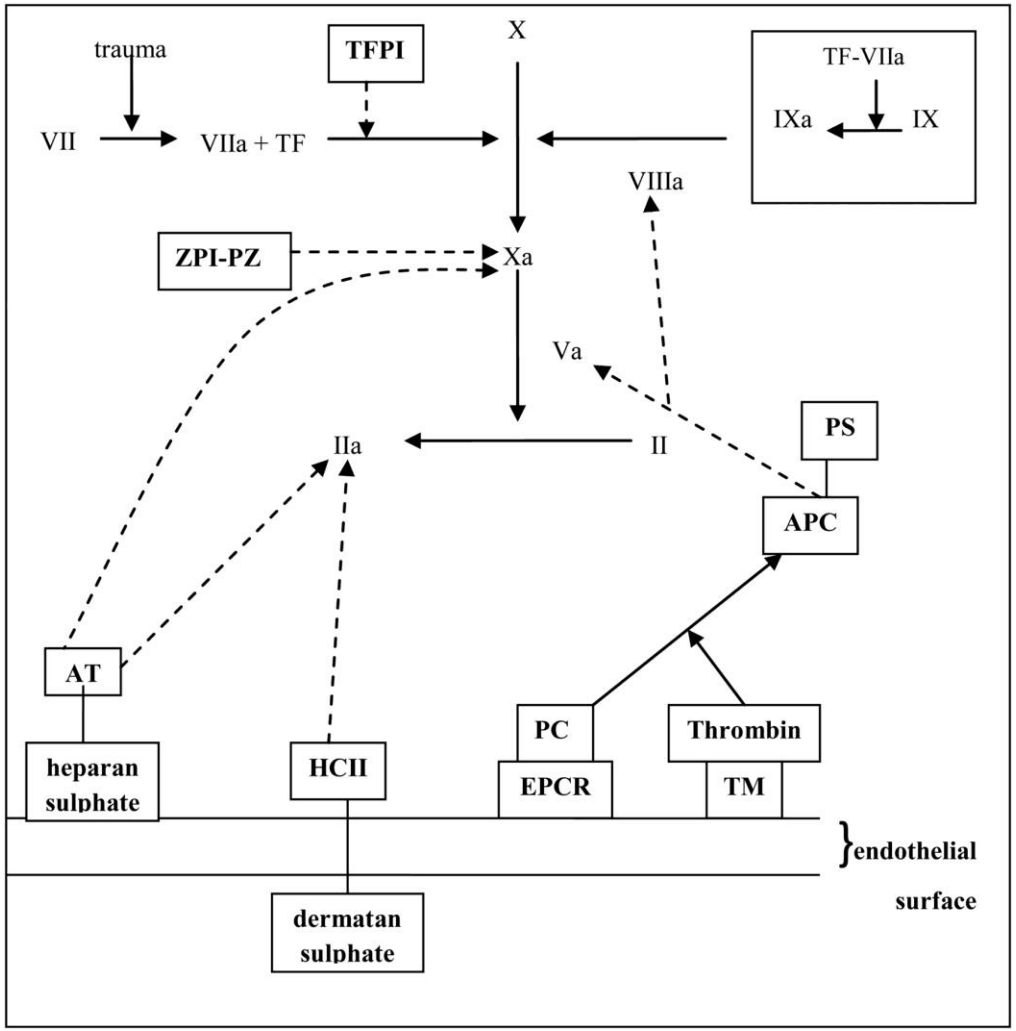
The anticoagulant system.



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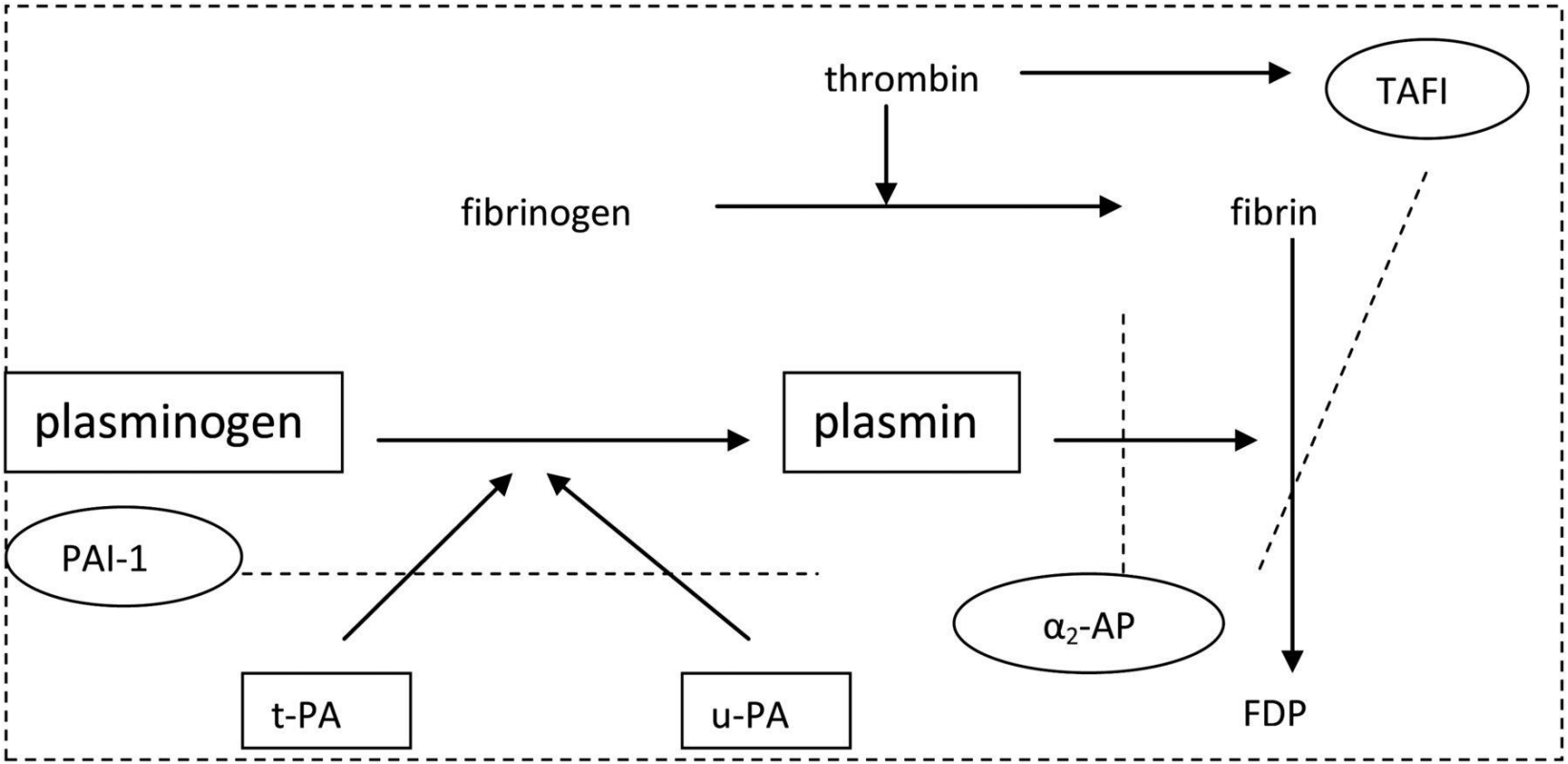
The fibrinolytic system (modified version of diagram by Rijken et al.).6 u-PA, urokinase-type plasminogen activator; t-PA, tissue-type plasminogen activator; PAI-1, plasminogen activator inhibitor 1; FDP, fibrin degradation products; α2-AP, α2 antiplasmin; TAFI, thrombin activatable fibrinolysis inhibitor.



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Which one of the following statements about the platelet phase of hemostasis is TRUE ?

A. Platelets secrete factors that promote primary hemostasis.

B. Most clotting factors circulate as inactive precursors.

C. Platelets can adhere to collagen via the Von Willebrand Factor.

D. ADP, thrombin, and thromboxane A_2 can cause platelets to aggregate.

E. All of the above.

Which ONE of the following does NOT contribute to clot formation?

A Calcium.

.

B Phospholipids.

.

C Thrombin.

.

D Tissue factor.

.

E Heparin.

.

What does von Willebrand factor do?

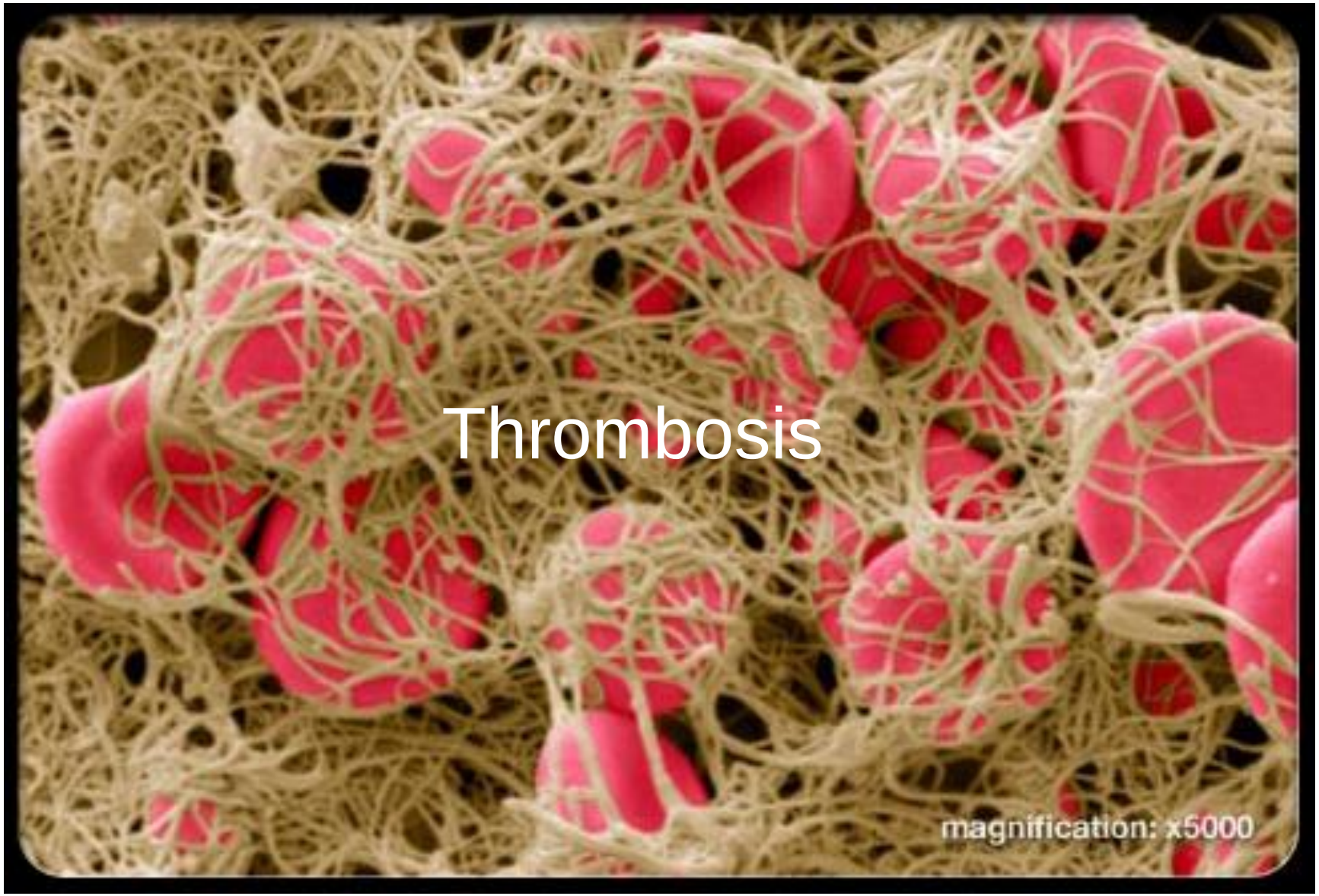
A. Binds platelets to each other
B. Binds platelets to the subendothelium
C. Binds platelets to the phospholipid surface
D. Carries factor VII
E. Cleaves factor V

- Which of the following dissolves clots:

1. Fibrinogen
2. Plasmin
3. Thrombin
4. Tissue Factor
5. vWF

- Deficiency of which of the following is likely to result in thrombosis?

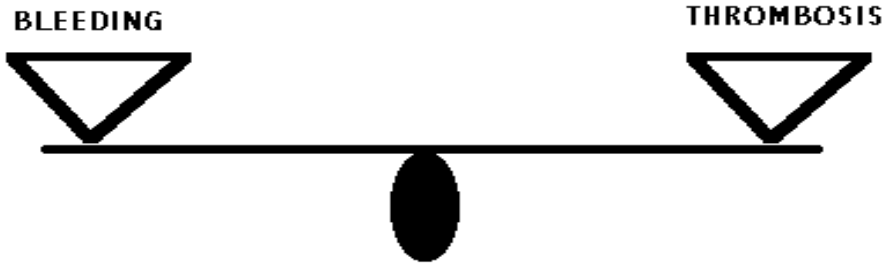
1. Factor IX
2. Fibrinogen
3. Plasmin
4. Protein C
5. Thrombin
6. (1, 3)
7. (3,4)


Thrombosis
magnification: x5000

Objectives

- Describe the pathogenesis of thrombosis.
- Describe the fate of a thrombus.
- Co-relate pathogenesis of thrombosis to clinical conditions
- Ex: pregnancy and thrombosis

  Cancer and thrombosis



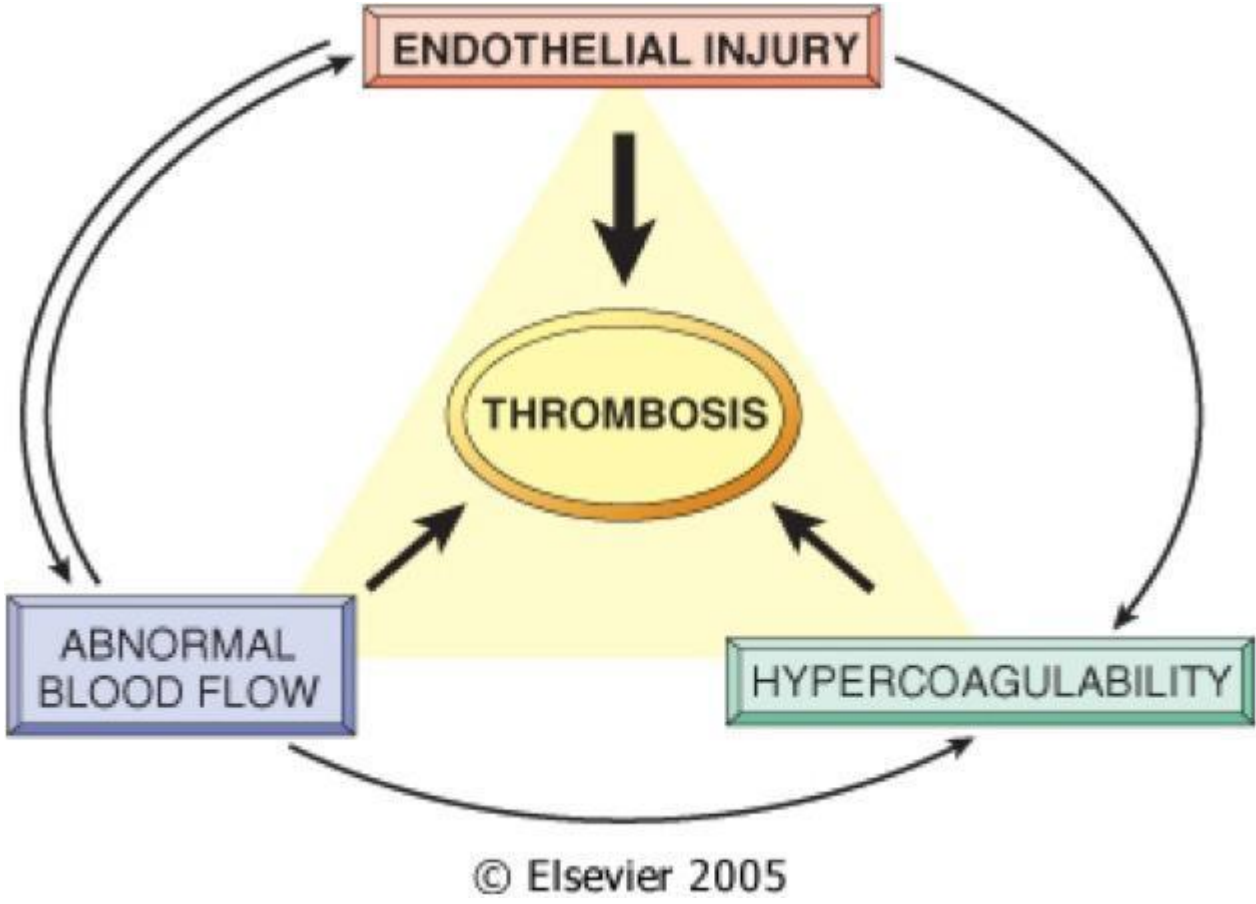
Thrombosis

- **Definition**

  Thrombosis is the formation of a solid mass of blood within the circulatory system in a living being

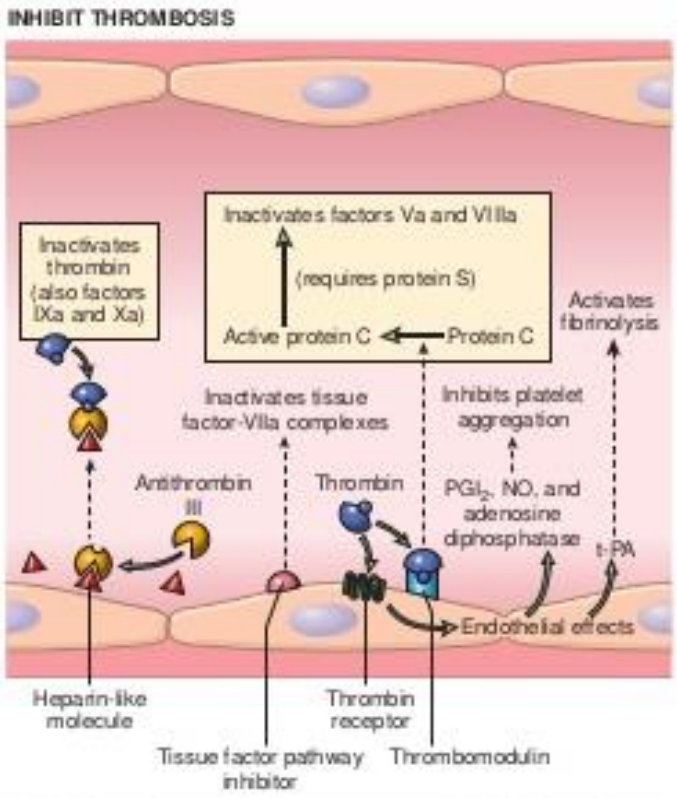
Virchow triad

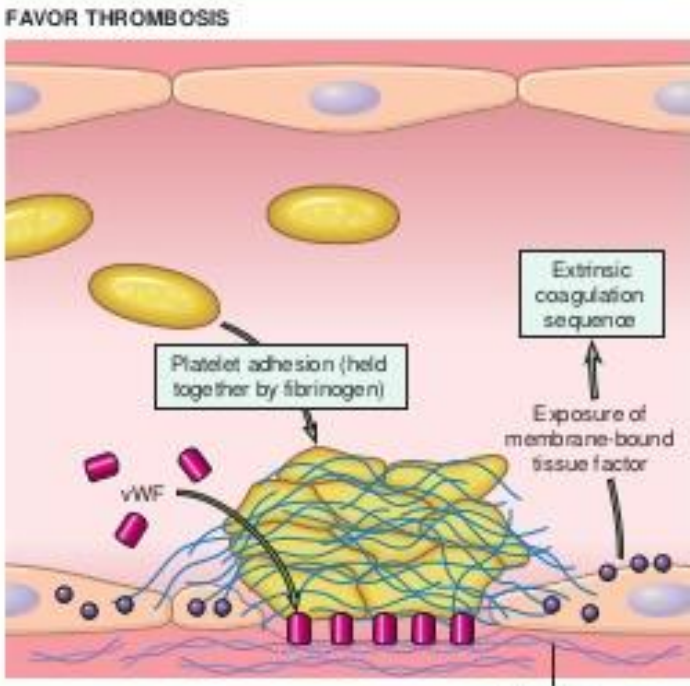
(1821 – 1902)



1.Endothelial injury

- Endothelial injury itself can lead to thrombosis.
- Important in arterial system and in the heart.
- Exposure of subendothelial ECM
- Adhesion of platelets
- Release of TF





2.Alteration in the normal blood flow

- Alteration of blood flow could be

a. Turbulence

b. Stasis

- Normal blood flow is laminar. Platelets flow centrally in the vessel lumen. This is separated from the vessel wall by a zone of clear plasma.
- Turbulence and stasis disrupt this laminar flow .

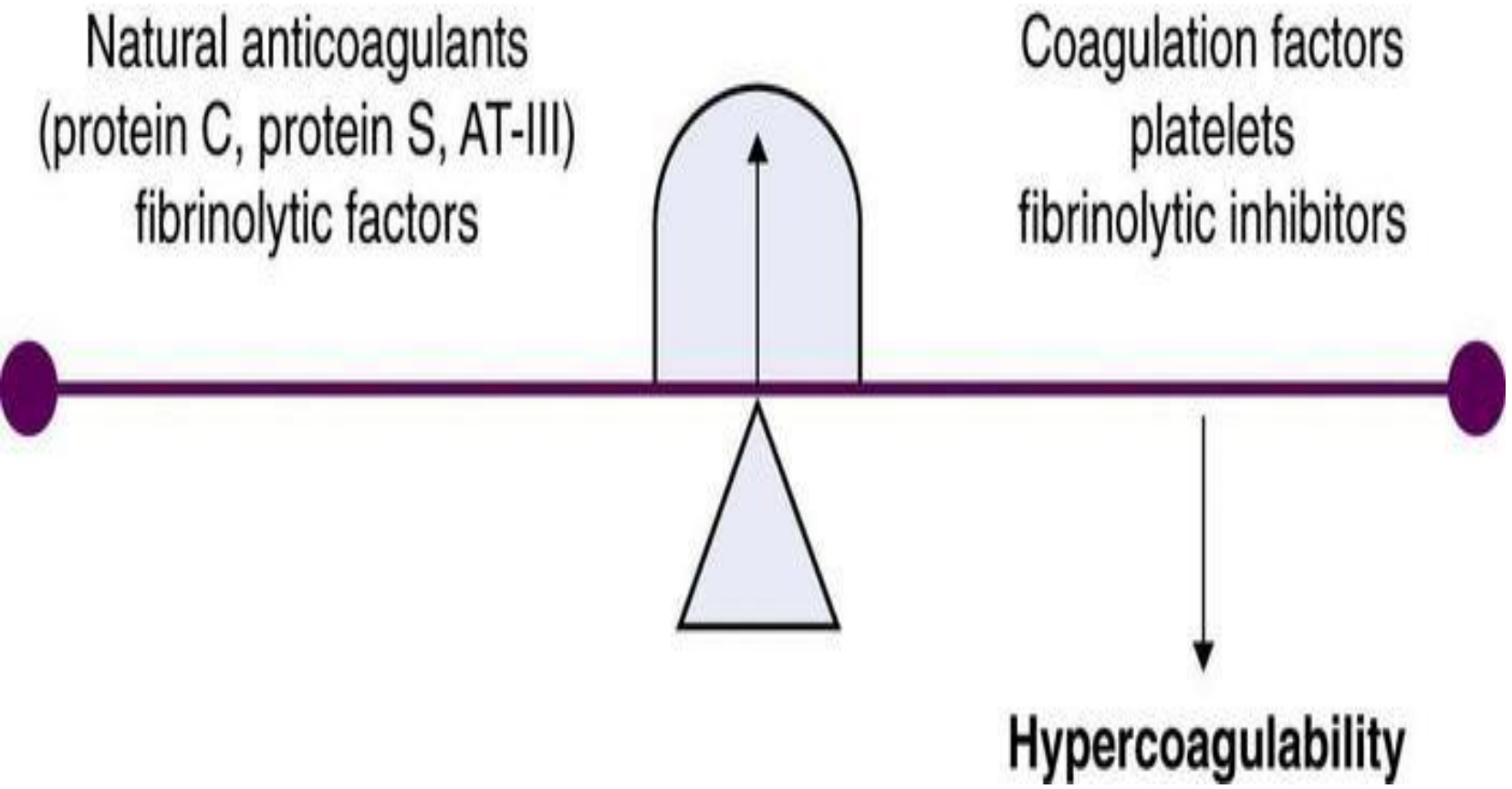
1. brings platelets into contact with the endothelium
2. prevent dilution of the clotting factors from the fresh flowing blood
3. retard inflow of clotting factor inhibitors
4. promote endothelial cell activation

- ***Turbulence is important in arterial thrombosis where as stasis is more important in venous thrombosis***.

3.Hypercoagulability

- Any alteration in the coagulation pathways that predisposes to thrombosis.
- Causes → primary(genetic)
  → secondary(acquired).

Hypercoagulability



Causes-Thrombosis

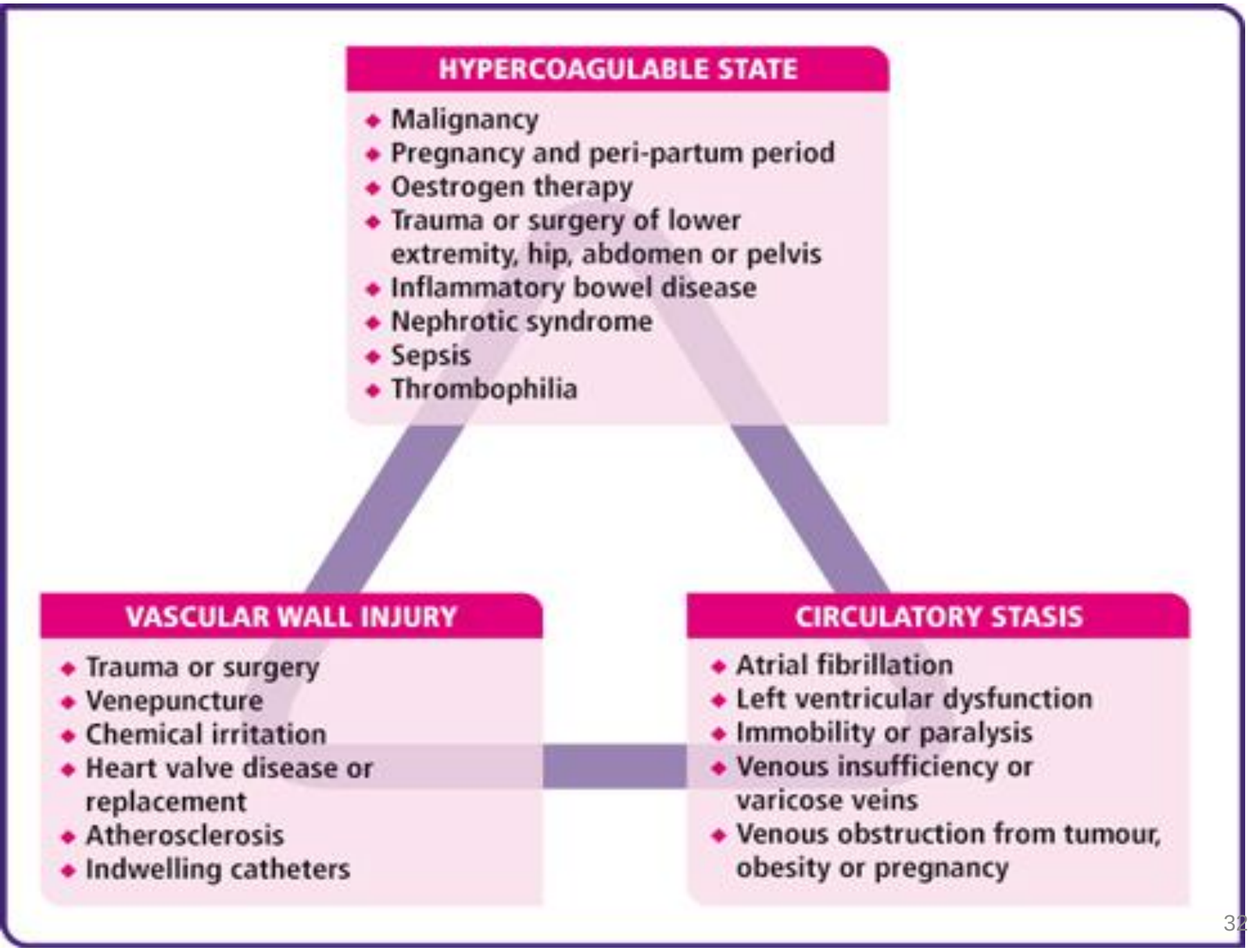
Primary(genetic)

- Factor V gene mutation (factor V leiden)
- Prothrombin gene mutation
- Antithrombin III deficiency
- Protein C deficiency
- Protein S deficiency

Secondary(acquired)

Common

- Prolonged immobilization
- Atrial fibrillation
- Cancer
- Tissue damage; surgery, fractures; burns
- Prosthetic heart valves
- Anti phospholipid syndrome
- Nephrotic syndrome
- Contraceptive pills
- Smoking
- Heparin induced thrombocytopenia


HYPERCOAGULABLE STATE
Malignancy
Pregnancy and peri-partum period
Oestrogen therapy
Trauma or surgery of lower extremity, hip, abdomen or pelvis
Inflammatory bowel disease
Nephrotic syndrome
Sepsis
Thrombophilia
VASCULAR WALL INJURY
Trauma or surgery
Venepuncture
Chemical irritation
Heart valve disease or replacement
Atherosclerosis
Indwelling catheters
CIRCULATORY STASIS
Atrial fibrillation
Left ventricular dysfunction
Immobility or paralysis
Venous insufficiency or varicose veins
Venous obstruction from tumour, obesity or pregnancy

- Arterial thrombi-

occlusive

Common sites-coronary ,cerebral, femoral

Formed on atherosclerotic plaques

Firmly adherent, Grey white ,friable

- Venous thrombi

Occlusive

Common sites-lower extremities

Red

- Heart-Mural thrombi

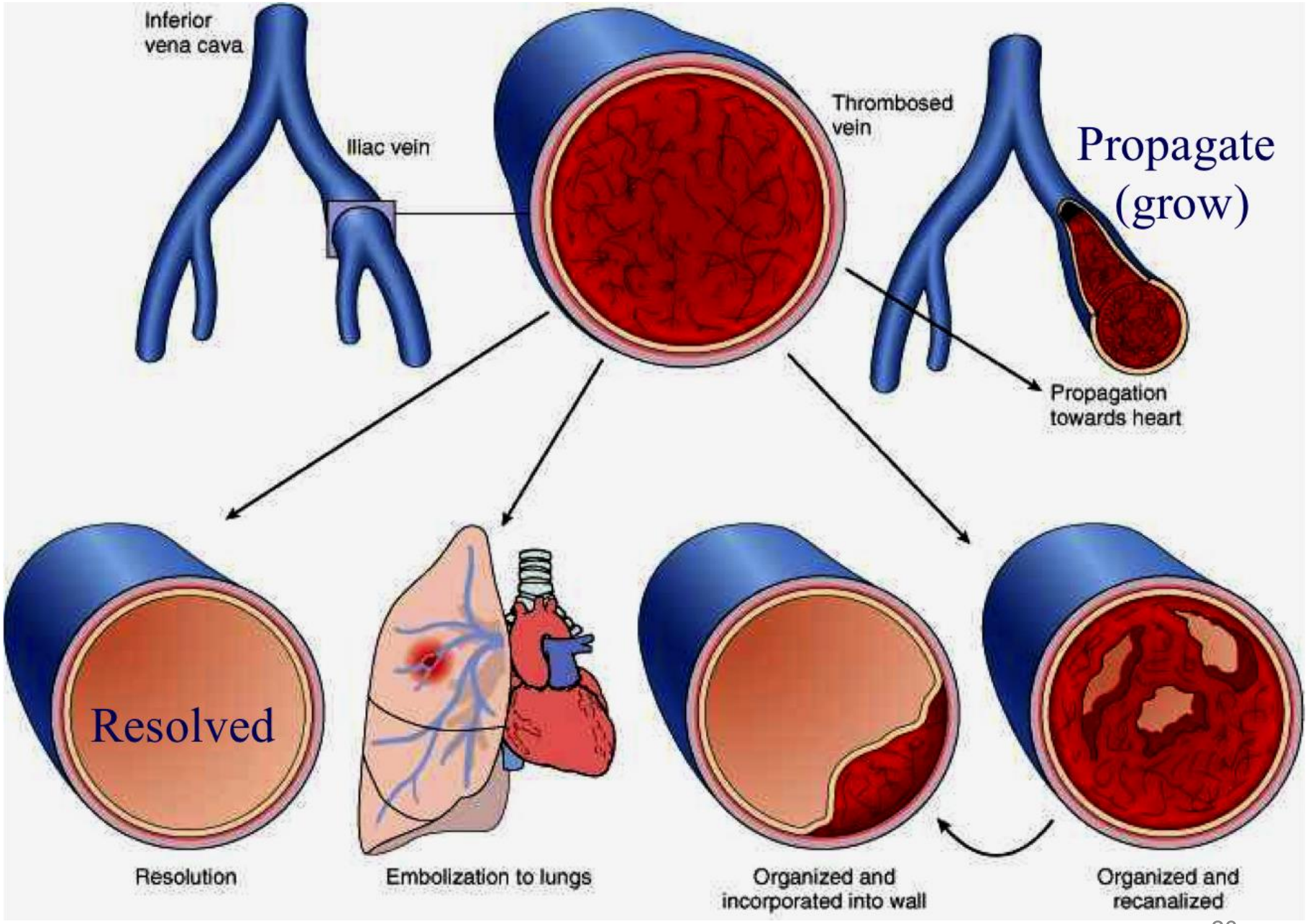
Causes- arrhythmias, Myocardial infarction

Effects of thrombosis

- Arterial
  - ischaemia
  - infarction
  - depends on site and collateral circulation
- Venous
  - congestion
  - oedema
  - ischaemia
  - infarction

Fate of thrombus

1. Propagation (progression)
2. Embolization
3. Dissolution
4. Organization and recanalization (inflammation and fibrosis)


Inferior vena cava
Iliac vein
Thrombosed vein
Propagate (grow)
Propagation towards heart
Resolved
Resolution
Embolization to lungs
Organized and incorporated into wall
Organized and recanalized

- **Question**

1. Describe the pathogenesis of thrombosis.
2. Enumerate the fate of thrombus.

3 . Explain how pregnancy becomes a thrombogenic state ?

Thrombosis and pregnancy

- **Pregnant women are at an increased risk for venous thromboembolic disease (VTE)**
  - 1 in 1000 pregnancies
  - 2-4 fold increase compared to non-pregnant state
  - Cesarian delivery > vaginal delivery
  - 2/3 of DVT occur antepartum (equally distributed among all three trimesters)
  - 43-60% of PE occur 4-6 weeks after delivery
  - Daily risk of PE and DVT highest following delivery than antepartum

- **PE is the major non-obstetric cause of maternal mortality**

Pathogenesis of thrombosis in pregnancy

- Marked by the presence of all three components of Virchow's triad:

➢ venous stasis,

➢ endothelial injury

➢ hypercoagulable state

All features likely contribute to the increased risk of VTE in pregnancy.

Venous **stasis** of the lower extremities

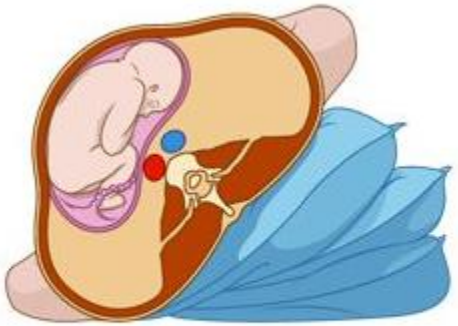
- two factors:

➢ pregnancy-associated changes in venous capacitance.

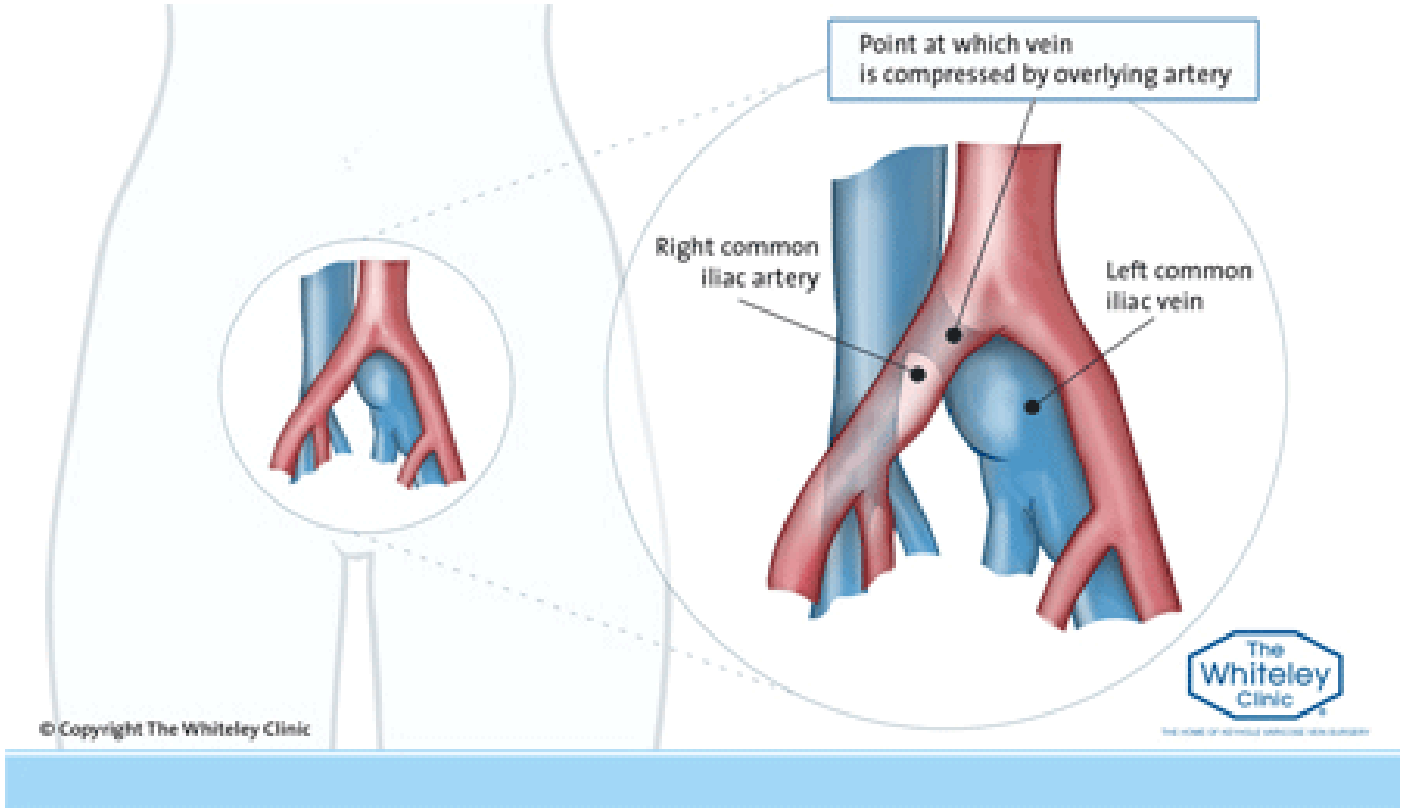
➢ Compression of large veins by the gravid uterus.

- The lower extremity veins appear to be subject to increased stasis even before the uterus has enlarged substantially.
- The linear flow velocity in the lower extremity veins is decreased due **to hormonally induced dilation of capacitance veins, leading to venous pooling and valvular incompetence**
- These changes are amplified by IVC and iliac vein compression by the gravid uterus

Vena cava & aorta compressed by fetus



Compression relieved by tilting patient on left side

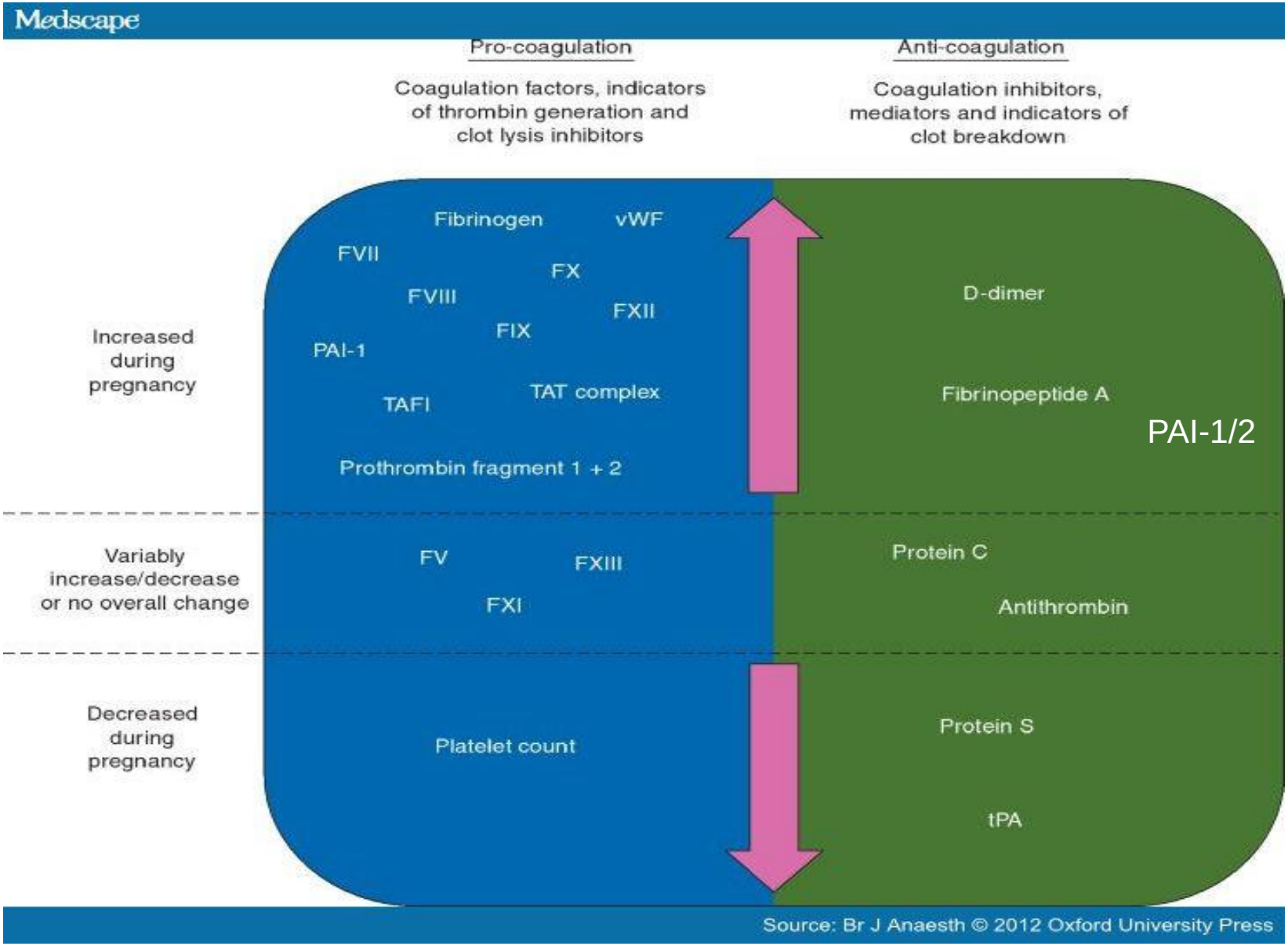


Compression of the left iliac vein by the right iliac artery is thought to contribute to the predilection of left-sided DVT during pregnancy

- **Endothelial injury** —
- Delivery is associated with vascular injury and changes at the uteroplacental surface-contribute to the increased risk of VTE in the immediate postpartum period.

- Forceps, vacuum extraction, or surgical delivery can exaggerate vascular intimal injury

Hypercoagulability



Thrombosis & pregnancy

Hypercoagulability

- ↑ factors VII, VIII, X and von Willebrand factor , fibrinogen.
- Free protein S-decreased during pregnancy.
- Plasminogen activator inhibitor type 1 (PAI-1) levels are increased fivefold. Levels of PAI-2, produced by the placenta, increase dramatically in T3.
- Acquired protein C resistance
- Markers of thrombin generation are also increased.
- Begin with conception
- May not return to baseline until more than 8 weeks postpartum

Thrombosis & pregnancy

- **Physiological changes:**

  *decreased mobility
  Hyperemesis-dehydration

- Which of the following contribute to increased risk of thrombosis in pregnancy?

a) Increased fibrinogen level

b) Decreased protein C level

c) Increased PAI-1

d) Compression of IVC

e) Decreased vascular tone

t,f,t,t,t

Line of Zahn is seen in:

A. Venous thrombi.
B. Pulmonary congestion.
C. Postmortum clot.
D. Arterial Thrombi.
E. Amniotic fluid embolism.

- D

- Endothelial cell injury is the principal mechanism for production of thrombosis in case of:

A. Thrombosis occurring in post-partum women.
B. Thrombosis associated with pancreatic cancer.
C. Thrombosis of atherosclerotic coronary arteries.
D. Protein C deficiency.
E. Left atrial dilatation

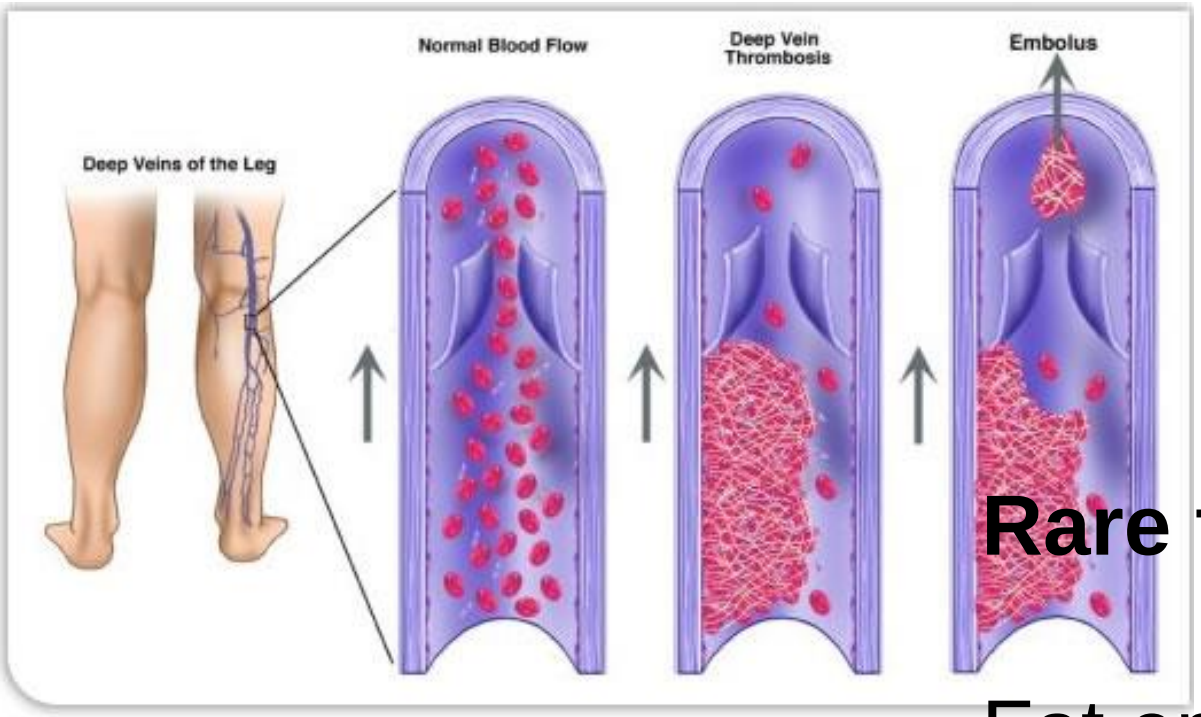

search by pwants2
© Original Artist

Embolism

- Definition

  Detached intravascular solid, liquid or gaseous mass that is carried by the blood to a site distant from its point of origin.

  >90% of emboli are thrombo-emboli



Rare forms of emboli

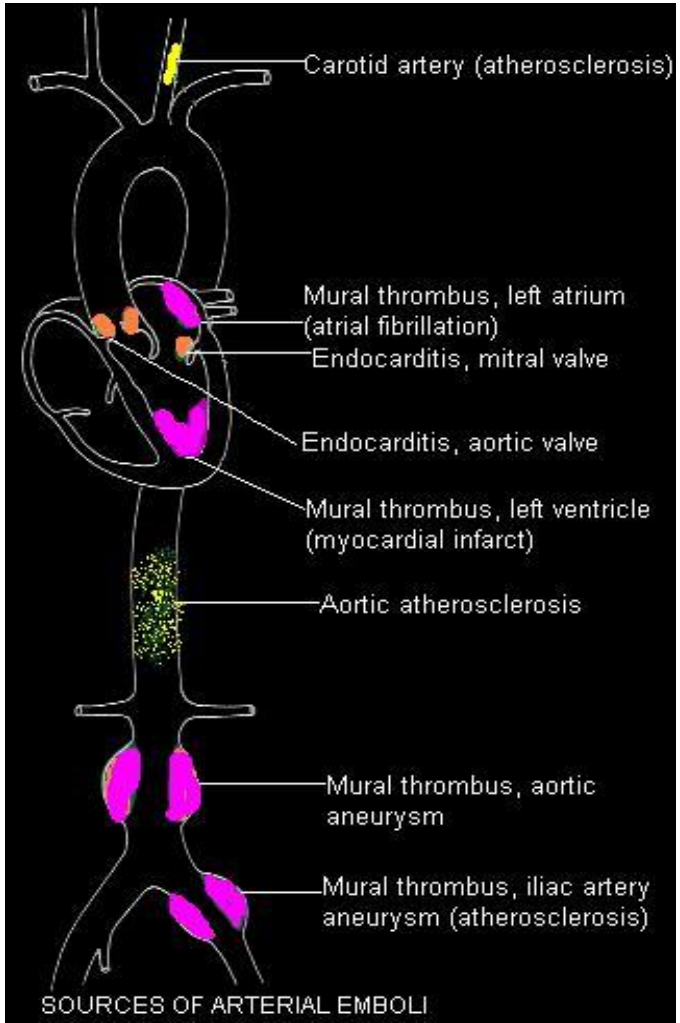
Fat embolism
Air embolism
Amniotic fluid embolism
Tumor emboli
Cholesterol
Bone marrow
Foreign bodies

Effect of emboli

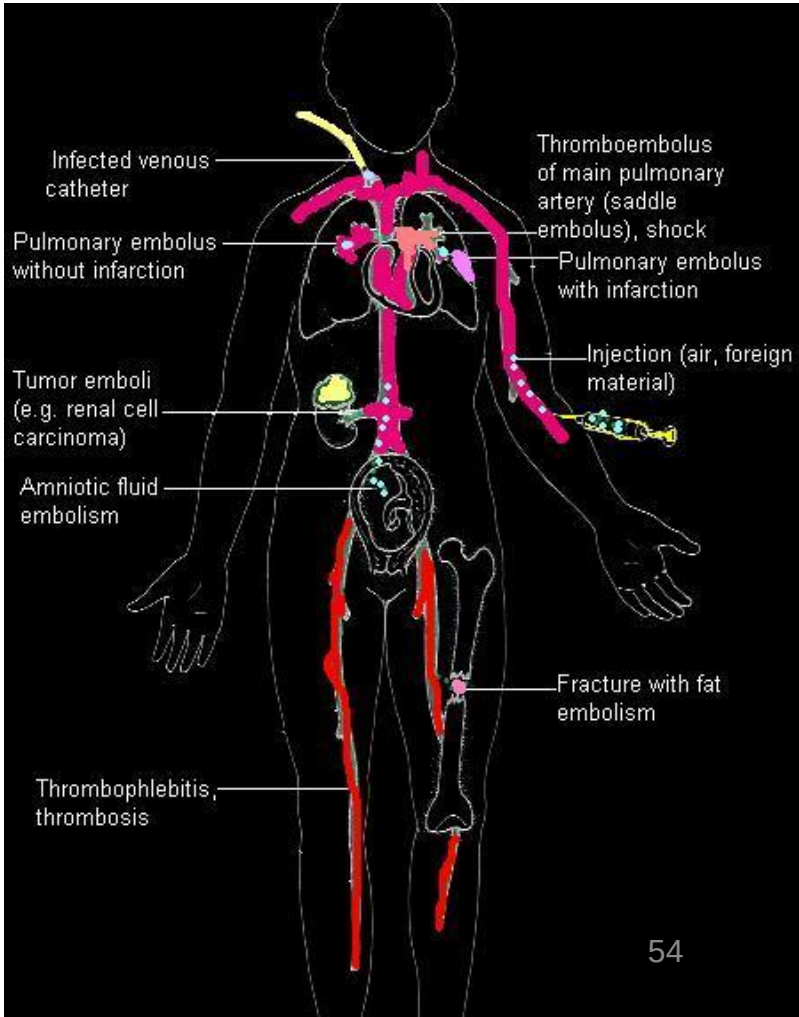
- Occlusion of vessels
- Ischaemic necrosis of the tissue supplied by the vessel

Embolism

Arterial



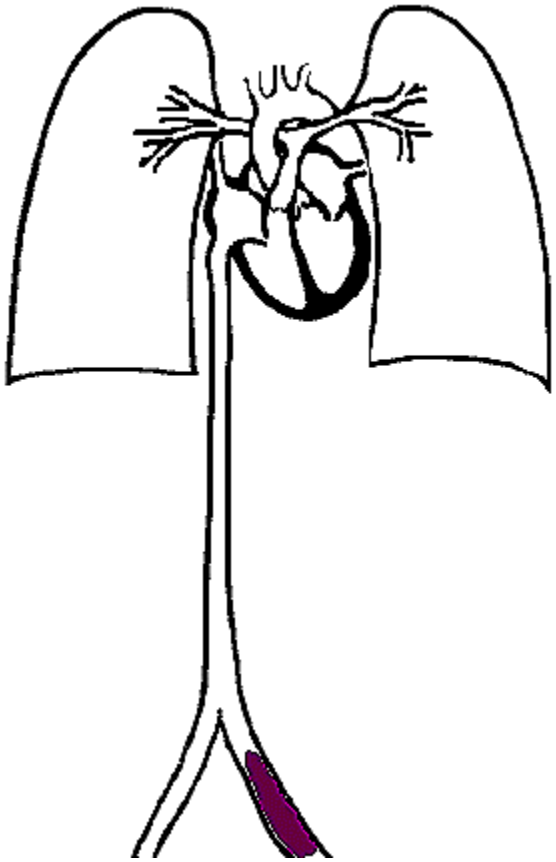
Venous



Thrombo-emboli

- from systemic veins pass to the lungs = pulmonary emboli
- from the heart pass via the aorta to renal, mesenteric, and other femoral arteries
- from atheromatous carotid arteries pass to the brain
- from atheromatous abdominal aorta pass to arteries of the legs

Pulmonary embolism



A pulmonary thromboembolus travels from a large vein in the leg up the inferior vena cava, through the right side of the heart, and to the main pulmonary arteries as they branch. Such thrombi embolize most often from large veins in the legs and pelvis where thrombi may form with stasis and/or inflammation

Pulmonary Thromboembolism

- 95% coming from DVT (above knee)
- may occlude main pulmonary artery (Saddle embolus)
- or in small branches of vessels (multiple)

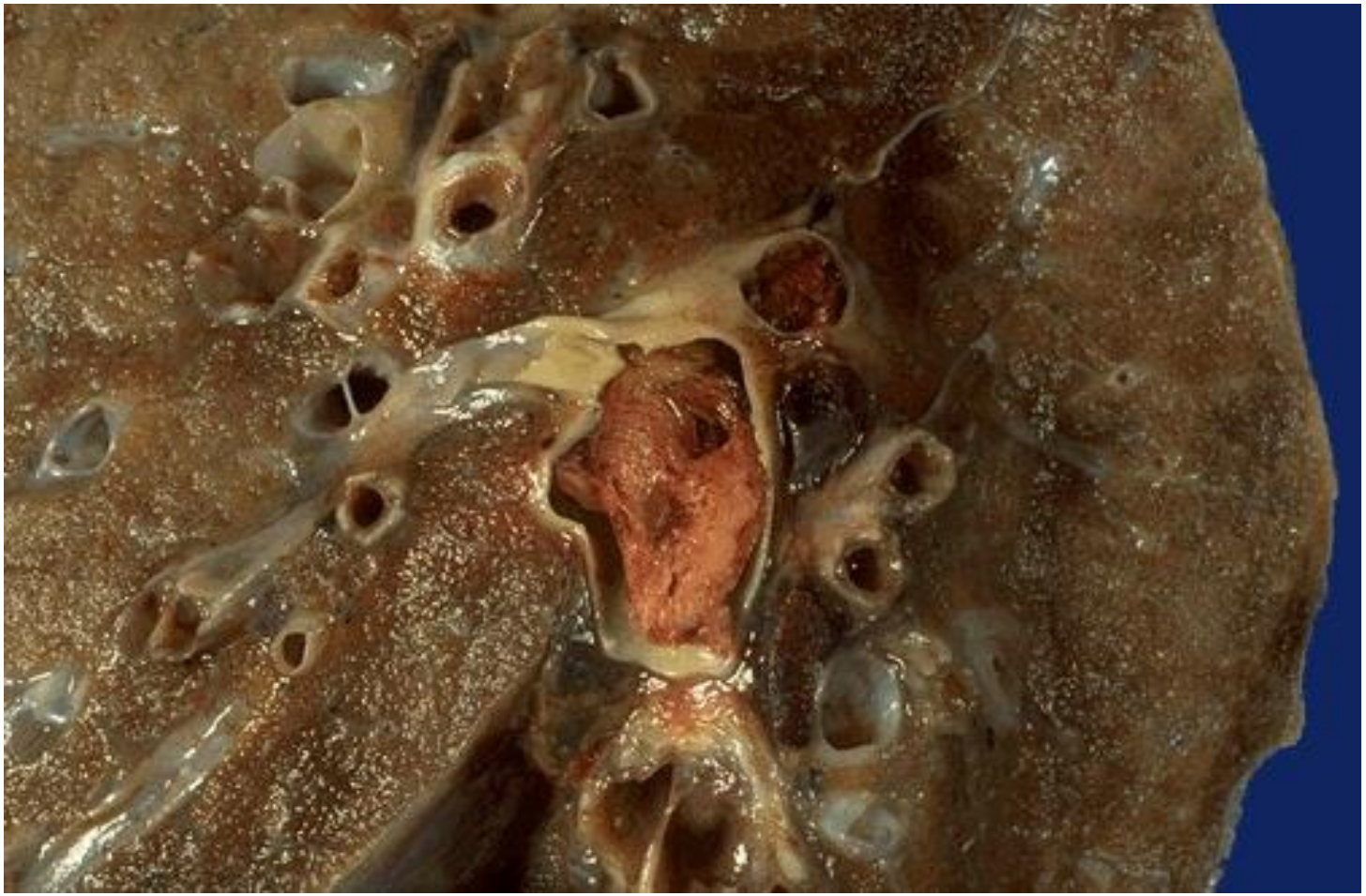
Pulmonary Thromboembolism

- 60-80% are asymptomatic

- sudden death
- Right hear failure
- Cardiovascular collapse

>60% reduction in BF

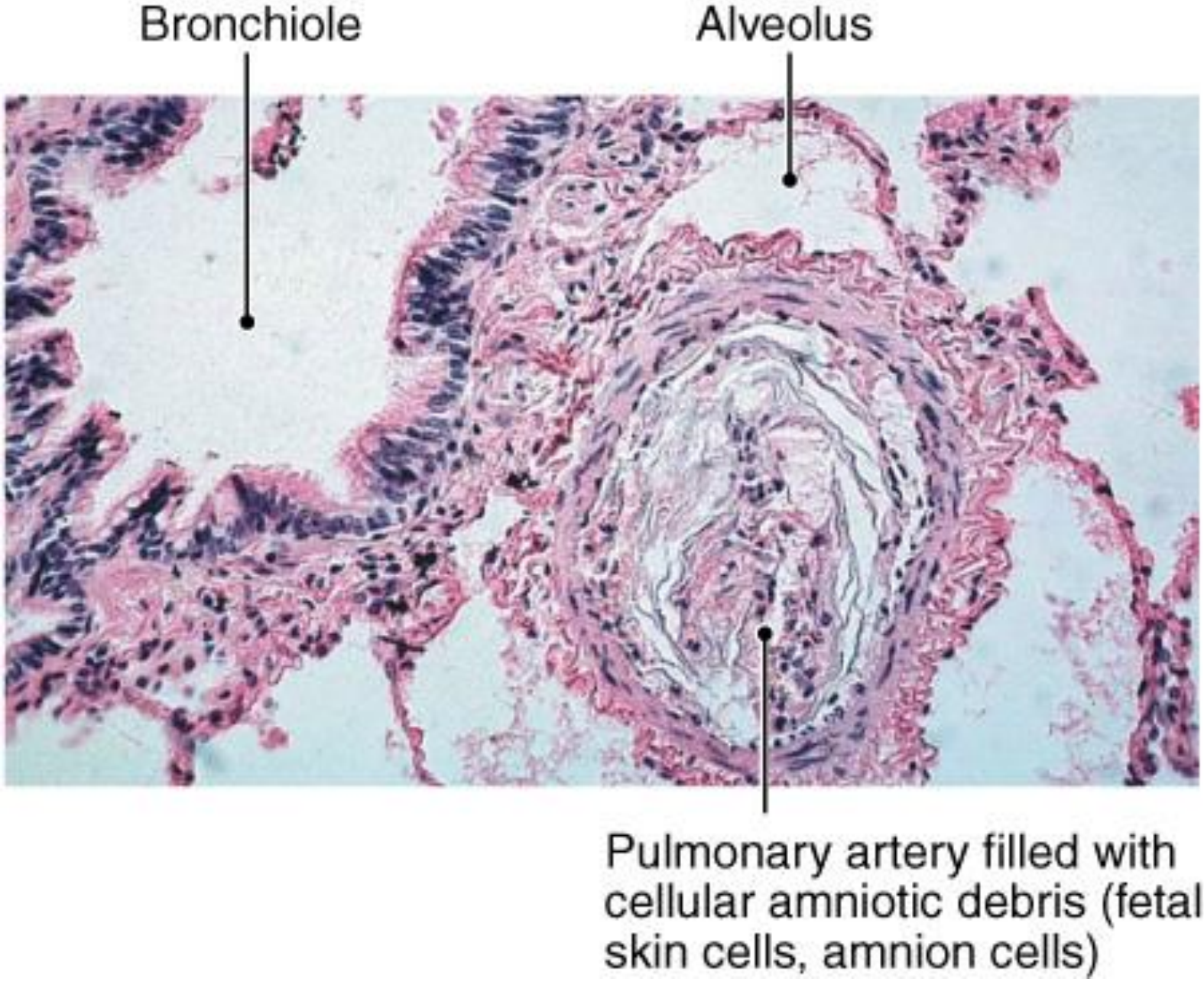
- Pulmonary hemorrhage
- Pulmonary infarct
- Multiple emboli may lead to pulmonary hypertension

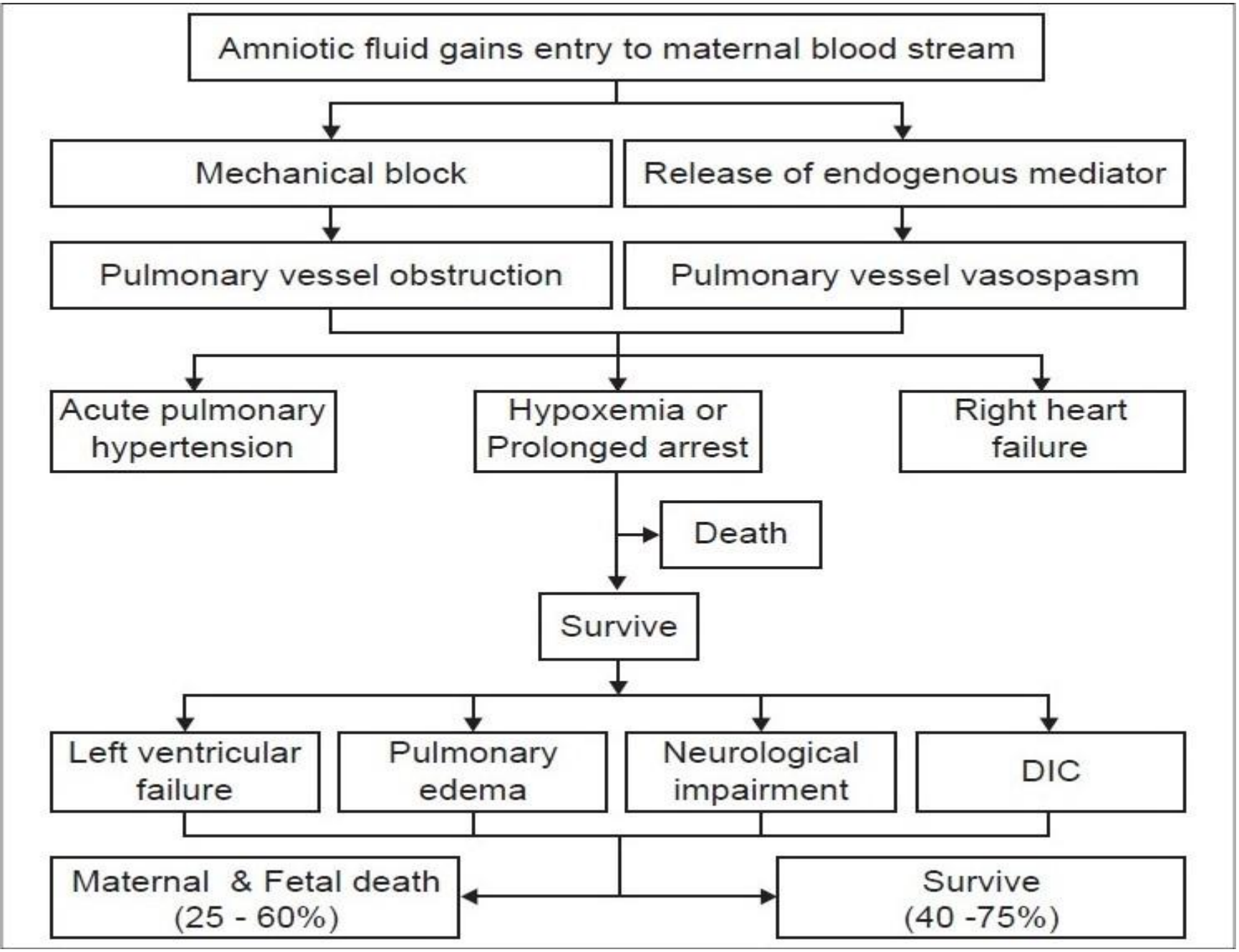


This pulmonary **thromboembolus** is occluding the main pulmonary artery. The patient can experience sudden onset of shortness of breath. Death may occur within minutes.

Amniotic fluid embolism

- Sudden SOB,cyanosis,hypotensive shock,seizures,comma
- Pulmonary oedema,DIC
- Infusion of AF or fetal tissue in to the maternal circulation
- Fetal Squamous cells ,lanugo hair,fat –vernix caseosa,mucin-RT/GIT
- *Diffuse alveolar damage,Fibrin thrombi*


Bronchiole
Alveolus
Pulmonary artery filled with cellular amniotic debris (fetal skin cells, amnion cells)


Amniotic fluid gains entry to maternal blood stream
Mechanical block
Release of endogenous mediator
Pulmonary vessel obstruction
Pulmonary vessel vasospasm
Acute pulmonary hypertension
Hypoxemia or Prolonged arrest
Right heart failure
Death
Survive
Left ventricular failure
Pulmonary edema
Neurological impairment
DIC
Maternal & Fetal death (25 - 60%)
Survive (40 -75%)

Differential diagnosis of amniotic fluid embolism

Pulmonary thromboembolism

Air embolism

Anesthetic complications (total spinal or high epidural block)

Drug-induced allergic anaphylaxis

Myocardial infarction

Cardiac arrhythmia

Peripartum cardiomyopathy

Aortic dissection

Aspiration of gastric contents

Reaction to local anesthetic drugs

Blood transfusion reaction

Sepsis

Postpartum hemorrhage

Uterine rupture

Placental abruption

Eclampsia

Fat Embolism Syndrome may present with:

(a) Hypotension.

(b) Hypoxaemia.

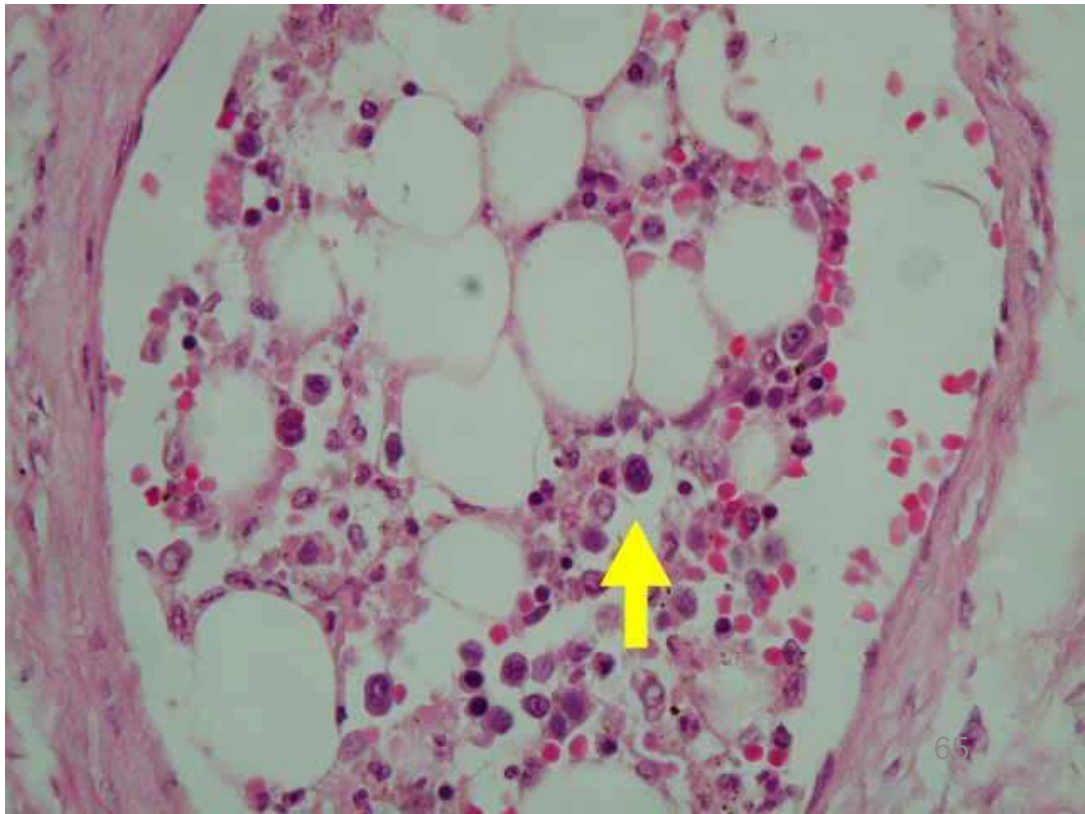
(c) Confusion.

(d) Petechial rash.

(e) Hypoventilation

Fat embolism

- Pulmonary insufficiency
- Neurologic symptoms
- Anaemia
- Thrombocytopenia

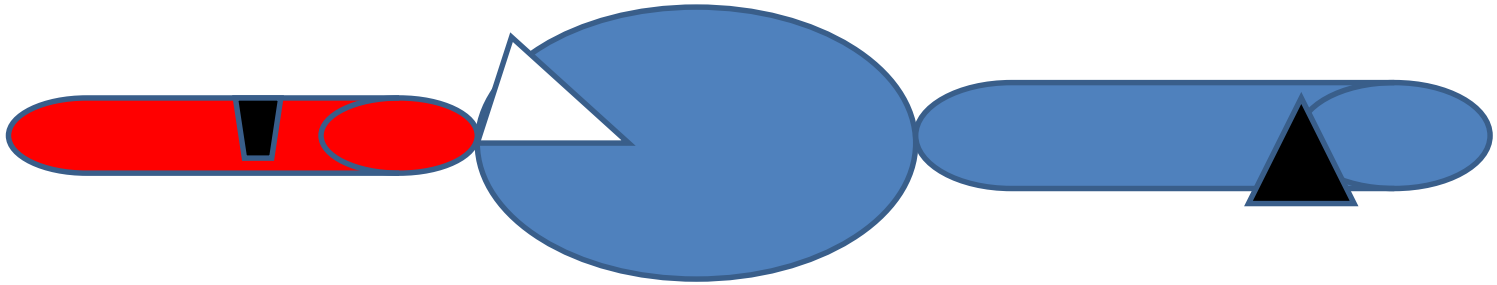


Infarction-Objectives

- Define an infarct.
- List the causes of infarction.
- Describe macroscopy and microscopy of an infarct
- Describe the factors that determine the development of an infarct.

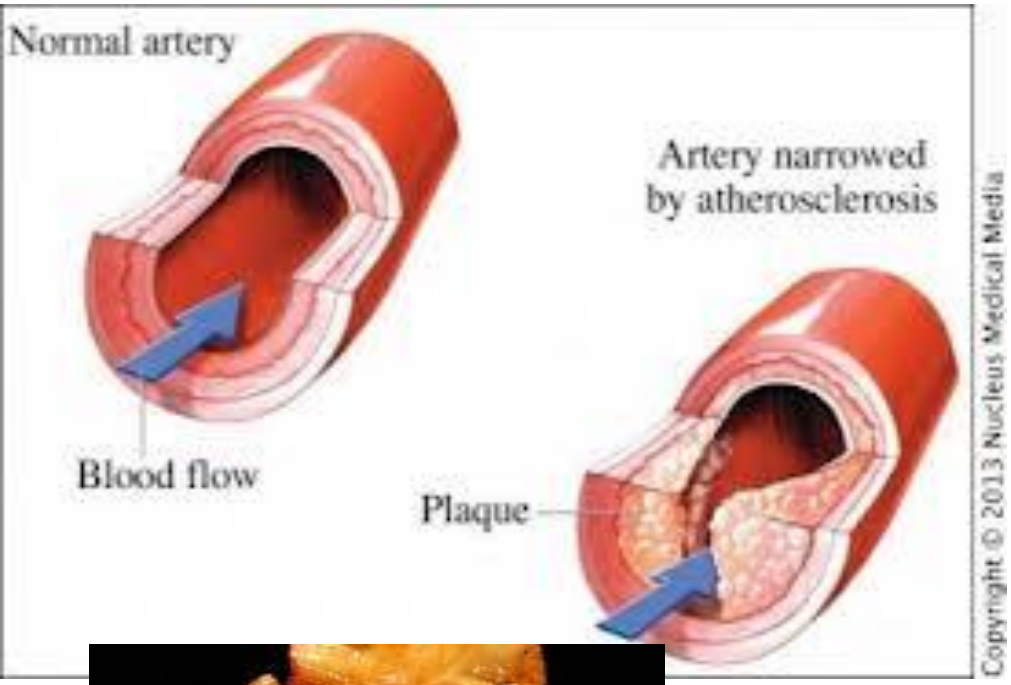
Infarction

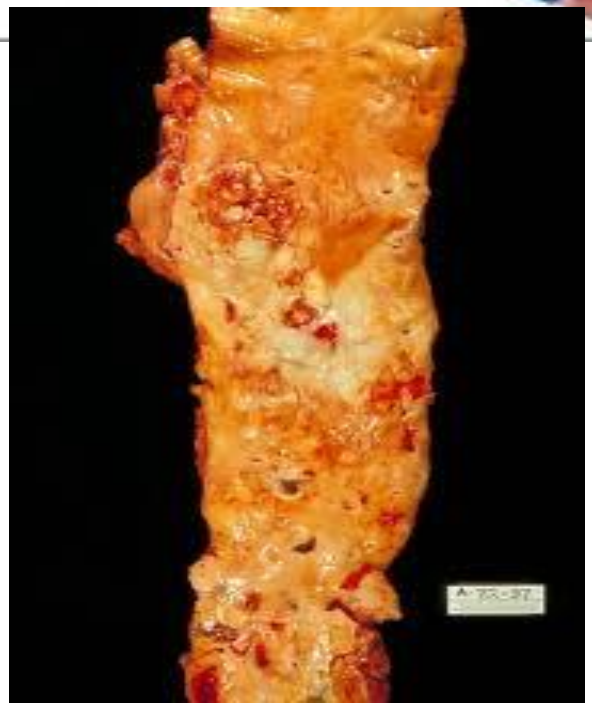
- Area of ischemic necrosis caused by occlusion of arterial supply or venous drainage
- Example: MI, cerebral infarction, pulmonary infarct, bowel infract



Causes

- 99%-thrombotic or embolic events
- Others-vasospasm
    - extrinsic compression
    - twisting
    - compression-oedema
    - Hyperviscosity
    - Spasm





Classification

- Red vs Pale
- Solid vs liquid
- Septic vs bland

Infarction

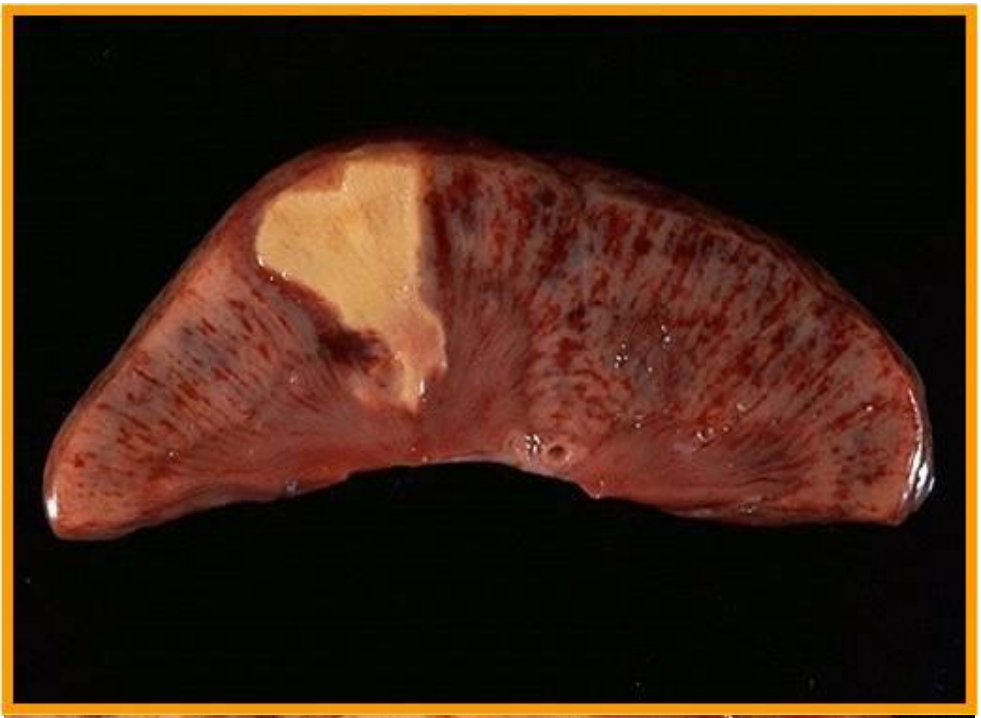
- Red infarct:
  - Due to venous occlusion ex:Ovarian torsion
  - In loose tissue ex. Lung
  - Organs with dual circulation
  - In tissues that have been previously congested
  - Reestablishment of flow
  - Venous infarct occurs in organs with single venous outflow. Ex: Testis, ovary

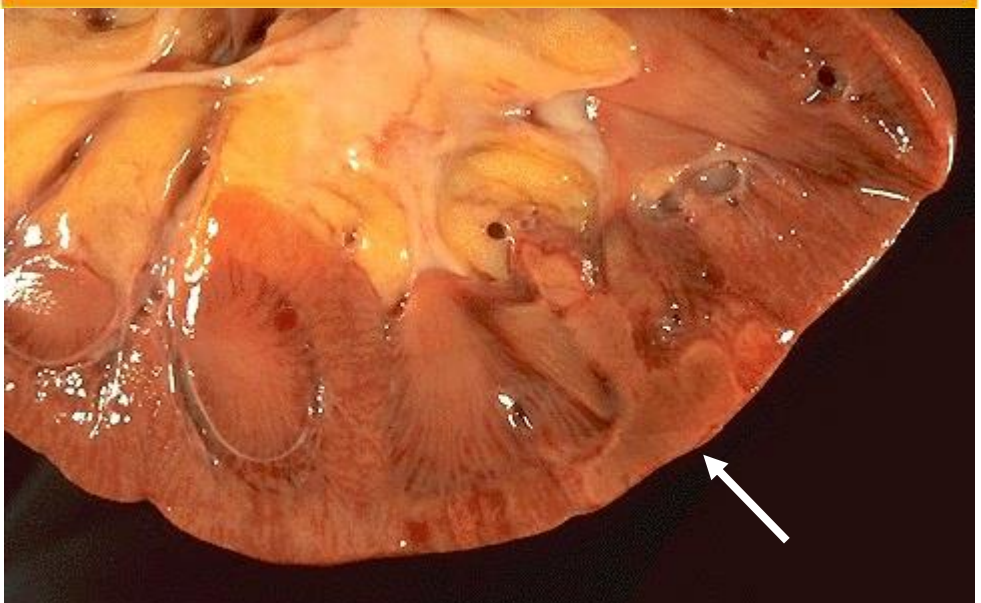
- White infarct
  - Arterial occlusion of solid organs, ex: Heart, kidneys, spleen

Infarction

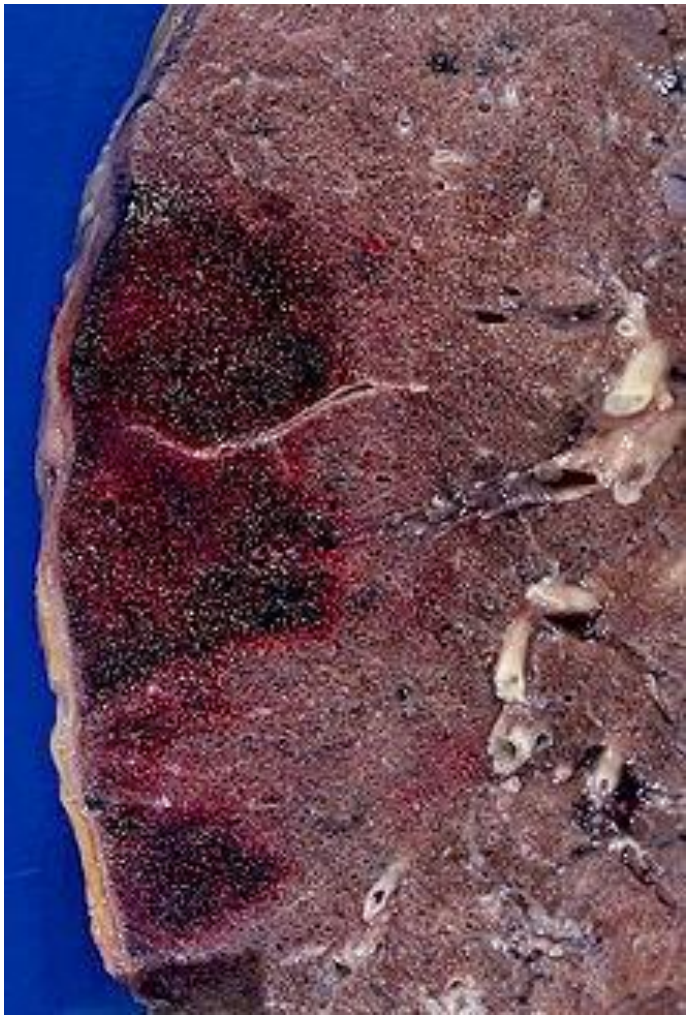
- Infarction is usually wedge shape surrounded by rim of hyperemia
- Necrosis is of coagulative type (except brain: liquifactive)
- Inflammation within few hours
- Repair process

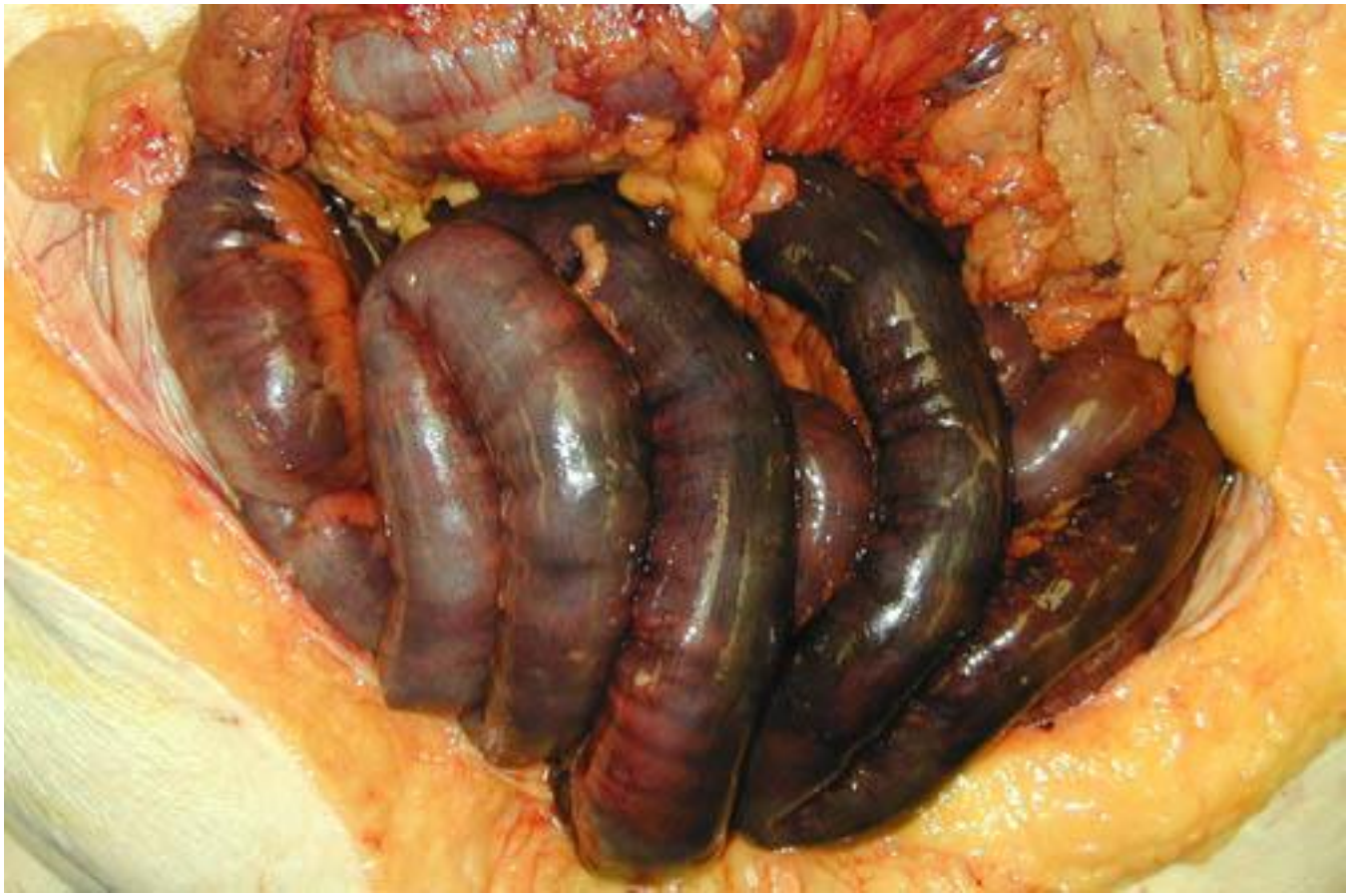
White infarct





Red infarct





Hemorrhagic infarction may be seen in places where some collateral flow can occur, as in the bowel, shown here at autopsy with marked dark red ischemic small bowel. Ordinarily, it is difficult to infarct the small or large bowel, because of an extensive anastomosing blood supply. Typically, severe compromise of at least 2 of the 3 major arterial supplies (celiac trunk, superior mesenteric, inferior mesenteric) is required for infarction to occur. Such arterial compromise is most likely to occur with severe atherosclerosis (often with diabetes mellitus) and with vasculitis (as with classic polyarteritis nodosa).Cardiac failure with severe hypotension can produce a similar result.

Factors influencing the development of an infarct

- Nature of the vascular supply
- Rate of development of the occlusion
- Vulnerability of the organ to hypoxia
- Blood oxygen content

- Question 3 2013

3.1. Define an infarct. (10 marks)

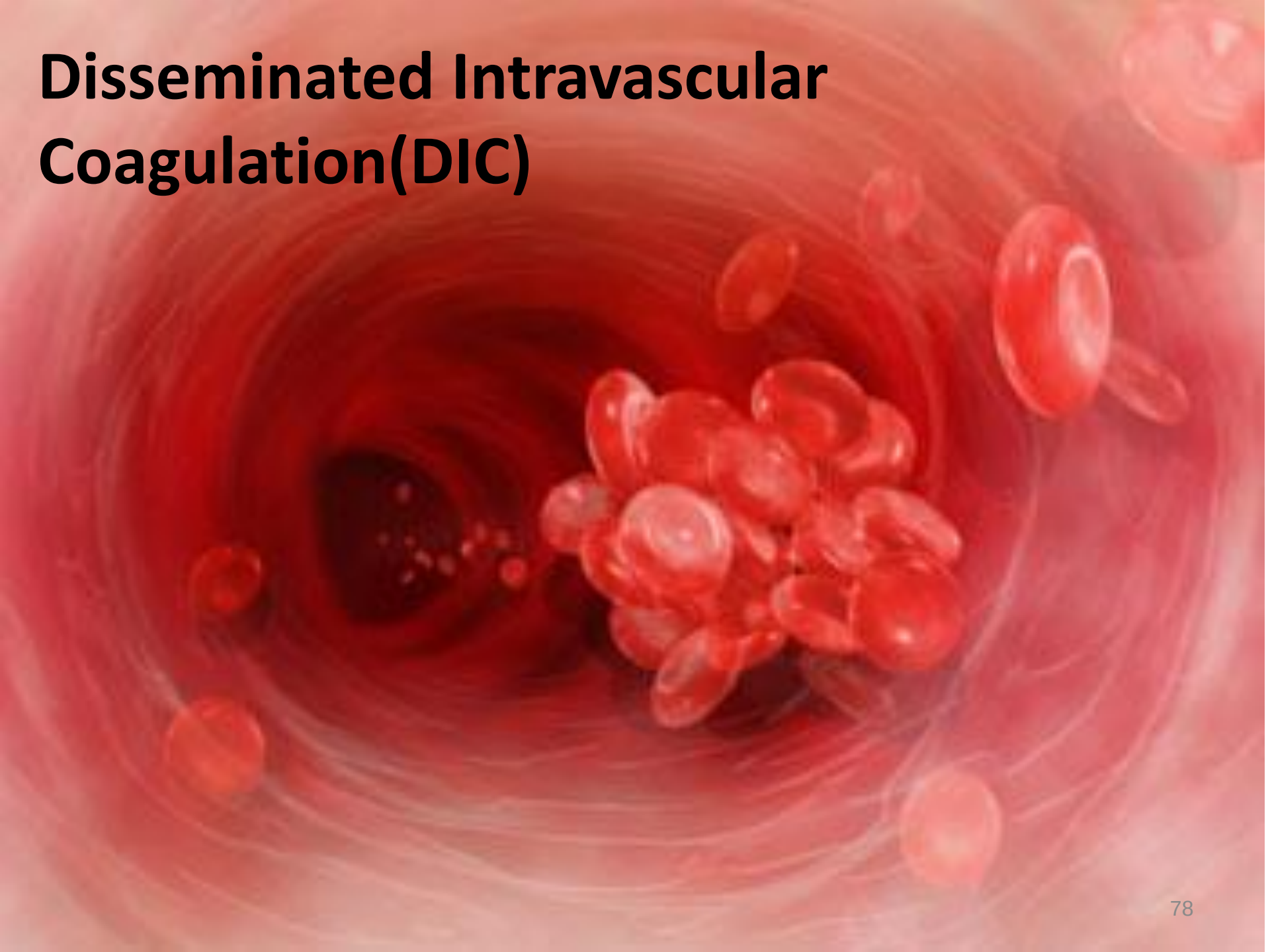
3.2. List five causes of infarction. (20 marks)

3.3 Describe the factors that determine the development of an infarct.(40 marks)

3.4. Outline with examples, the different mechanisms through which healing occurs in tissue following infraction. (30 marks)

- Where are Red infarcts not typically seen:
- A. Intestines
- B. Testes
- C. Liver
- D. Lungs
- E. Kidneys

Disseminated Intravascular Coagulation(DIC)



DIC-Objectives

- Define DIC
- List the causes of DIC
- Describe the pathogenesis of DIC

(DIC & obstetrical and gynaecological conditions)

- List the investigations to confirm DIC
- Describe the principles of management of DIC

- Discuss disseminated intra-vascular coagulation (D.I.C) with special reference to different -"obstetrical and gynaecological conditions’’.

DIC

- Acquired bleeding disorder
- Widespread inappropriate intravascular deposition of fibrin
- Due to

➢ Increased procoagulant material

➢ Widespread endothelial damage

➢ Platelet aggregation

DIC -Etiology

- Severe sepsis
- Disseminated malignancy
- Obstetric complications- ***amniotic fluid embolism / septic abortions/eclampsia/HELP/placental abruption/IUD/PPH/AFLP***
- Widespread tissue damage-Surgery /trauma / burns
- Incompatible blood transfusions
- Massive blood loss
- ……

- **A case of fatal hemorrhagic diathesis** with **premature detachment** of the **placenta**. Am J Obstet Gynecol ... (**Am**. **J**. **Obstet**. 44; 785, 1901).

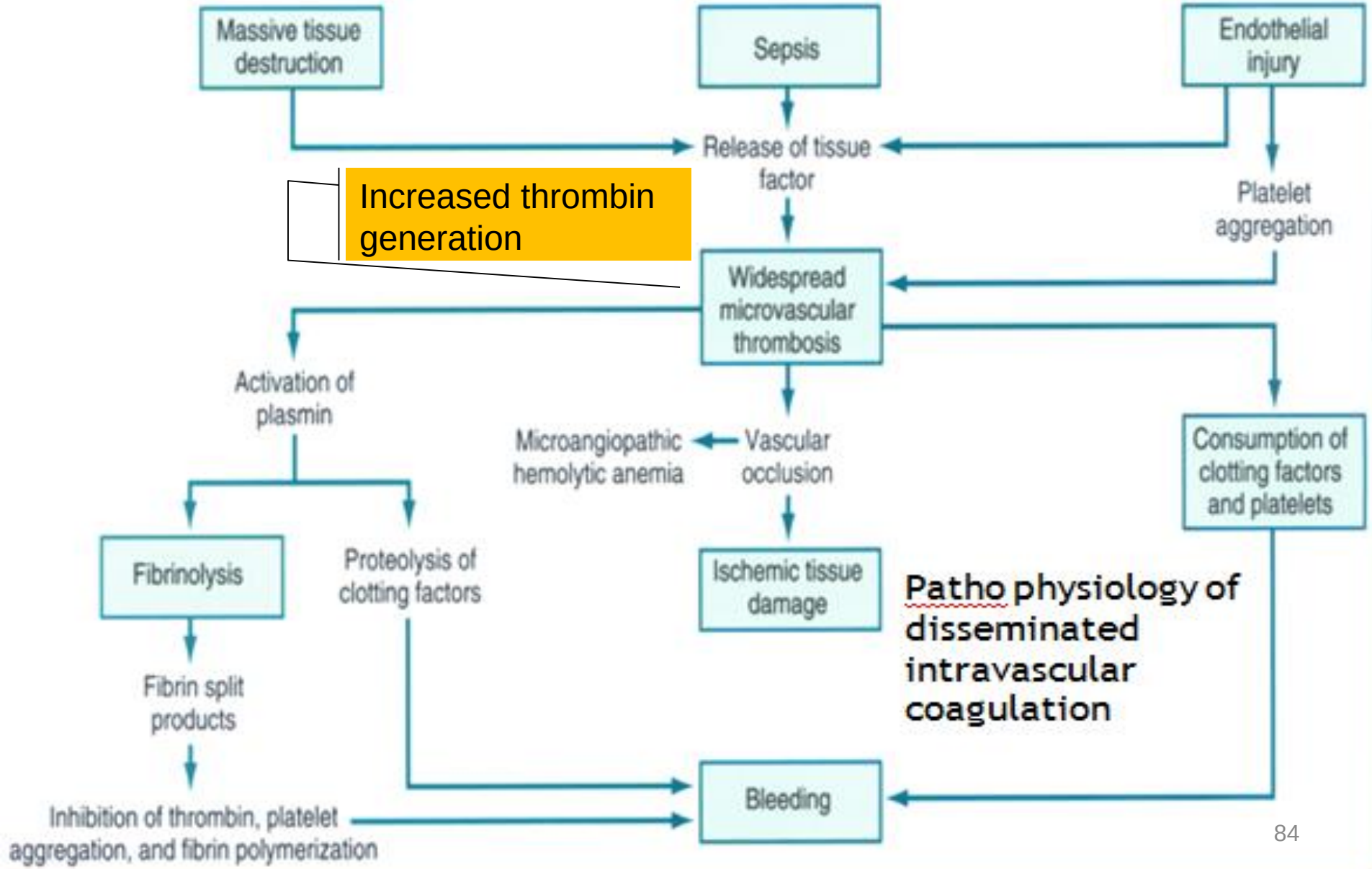
A CASE OF FATAL HEMORRHAGIC DIATHESIS, WITH PREMATURE DETACHMENT OF THE PLACENTA.[1]

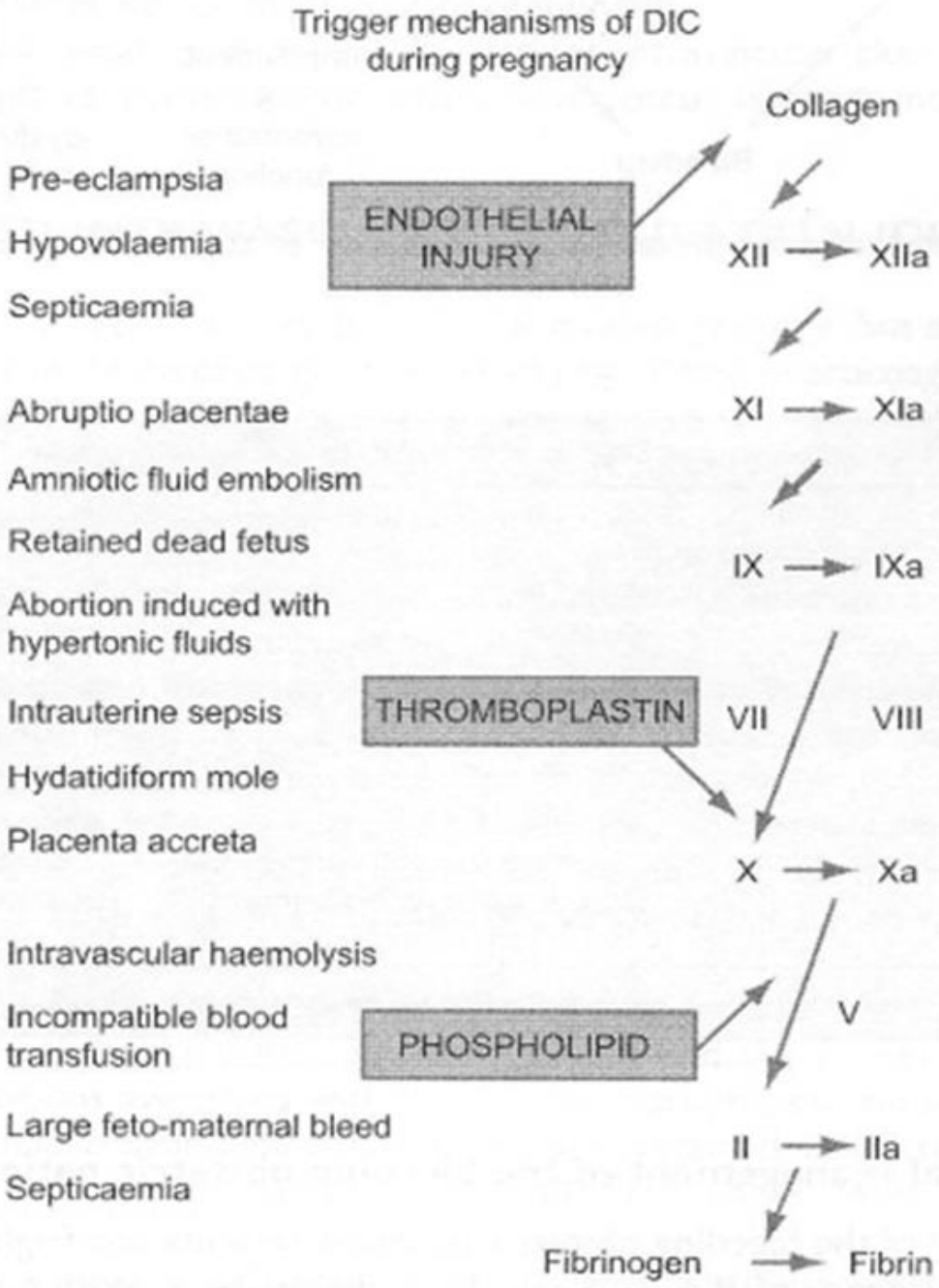
BY

JOSEPH B. DE LEE, M.D.,

Chicago, Ill.

- **Two major mechanisms may trigger DIC:**
  (1) release of tissue factor or thromboplastic substances into the circulation
  (2) widespread injury to endothelial cells





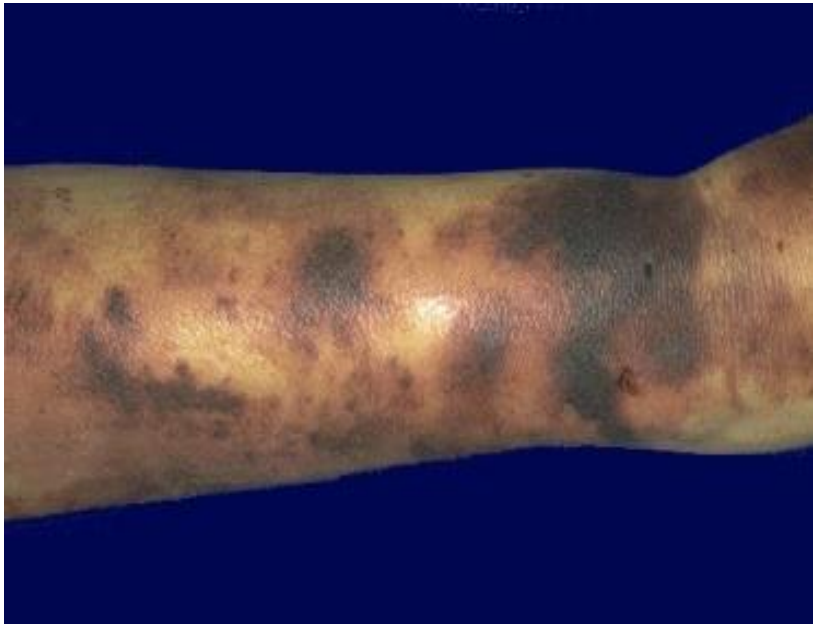
Three main triggers

- Endothelial injury
- Thromboplastin release
- Phospholipid exposure

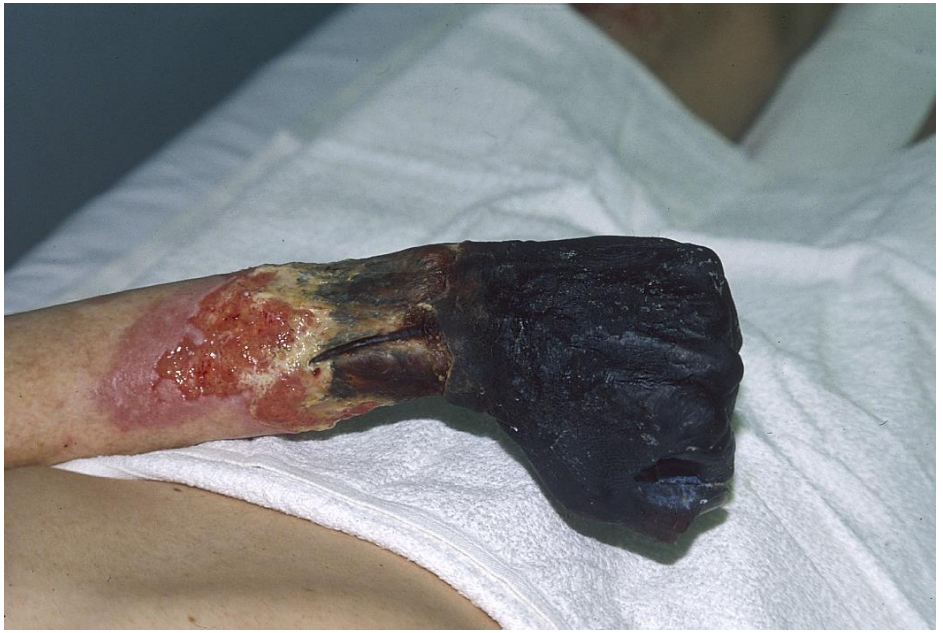
End result = generation of thrombin with ↑fibrin deposition

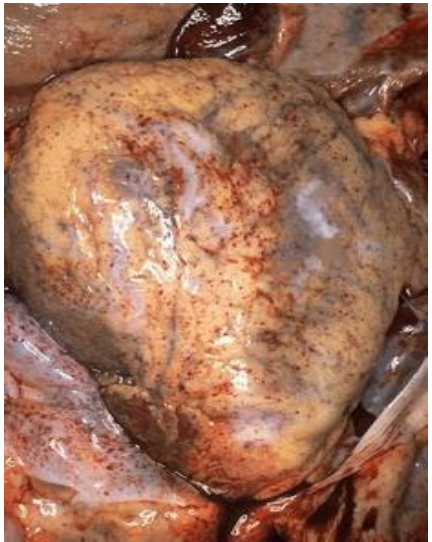
Many pathologies overlap…

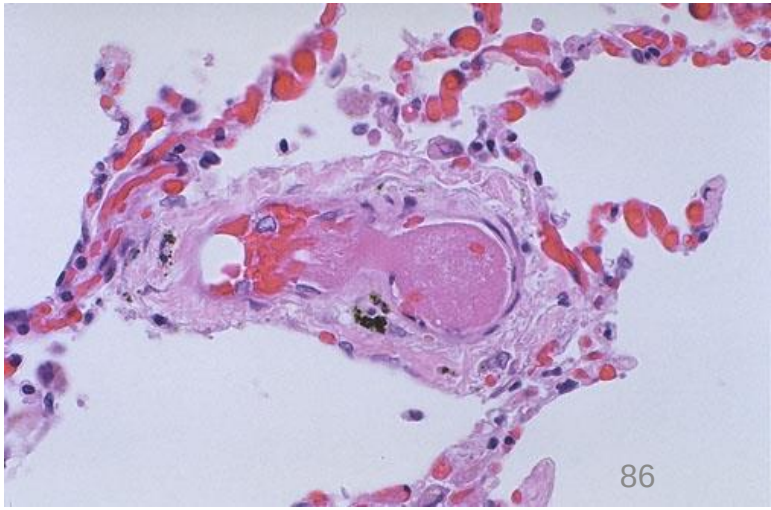
DIC-Bleeding



DIC-Thrombosis







Laboratory findings

- FBC+BP+retic count
- Coagulation tests-PT/APTT/TT
- Fibrinogen
- FDP/D-dimers

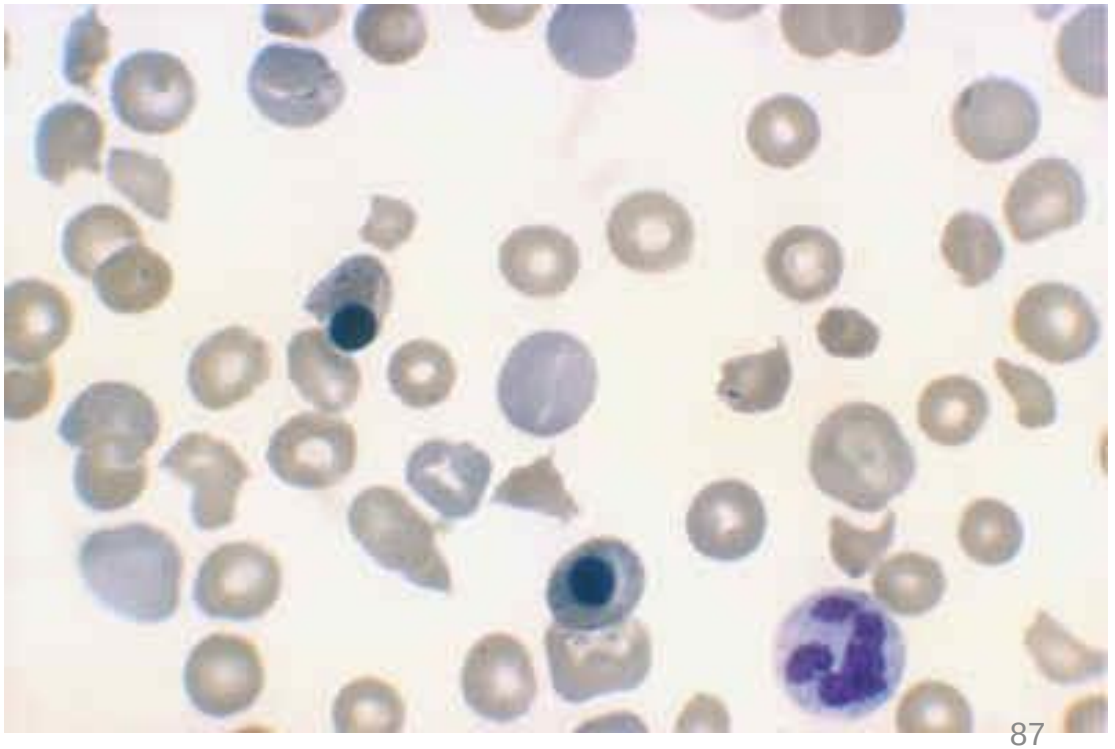


Table II. ISTH Diagnostic Scoring System for DIC.

Scoring system for overt DIC

Risk assessment: Does the patient have an underlying disorder known to be associated with overt DIC?

If yes: proceed

If no: do not use this algorithm

Order global coagulation tests (PT, platelet count, fibrinogen, fibrin related marker)

Score the test results

- Platelet count (>100 × 10^9/l = 0, <100 × 10^9/l = 1, <50 × 10^9/l = 2)
- Elevated fibrin marker (e.g. D-dimer, fibrin degradation products) (no increase = 0, moderate increase = 2, strong increase = 3)
- Prolonged PT (<3 s = 0, >3 but <6 s = 1, >6 s = 2)
- Fibrinogen level (>1 g/l = 0, <1 g/l = 1)

Calculate score:

≥5 compatible with overt DIC: repeat score daily

<5 suggestive for non-overt DIC: repeat next 1–2 d

Management

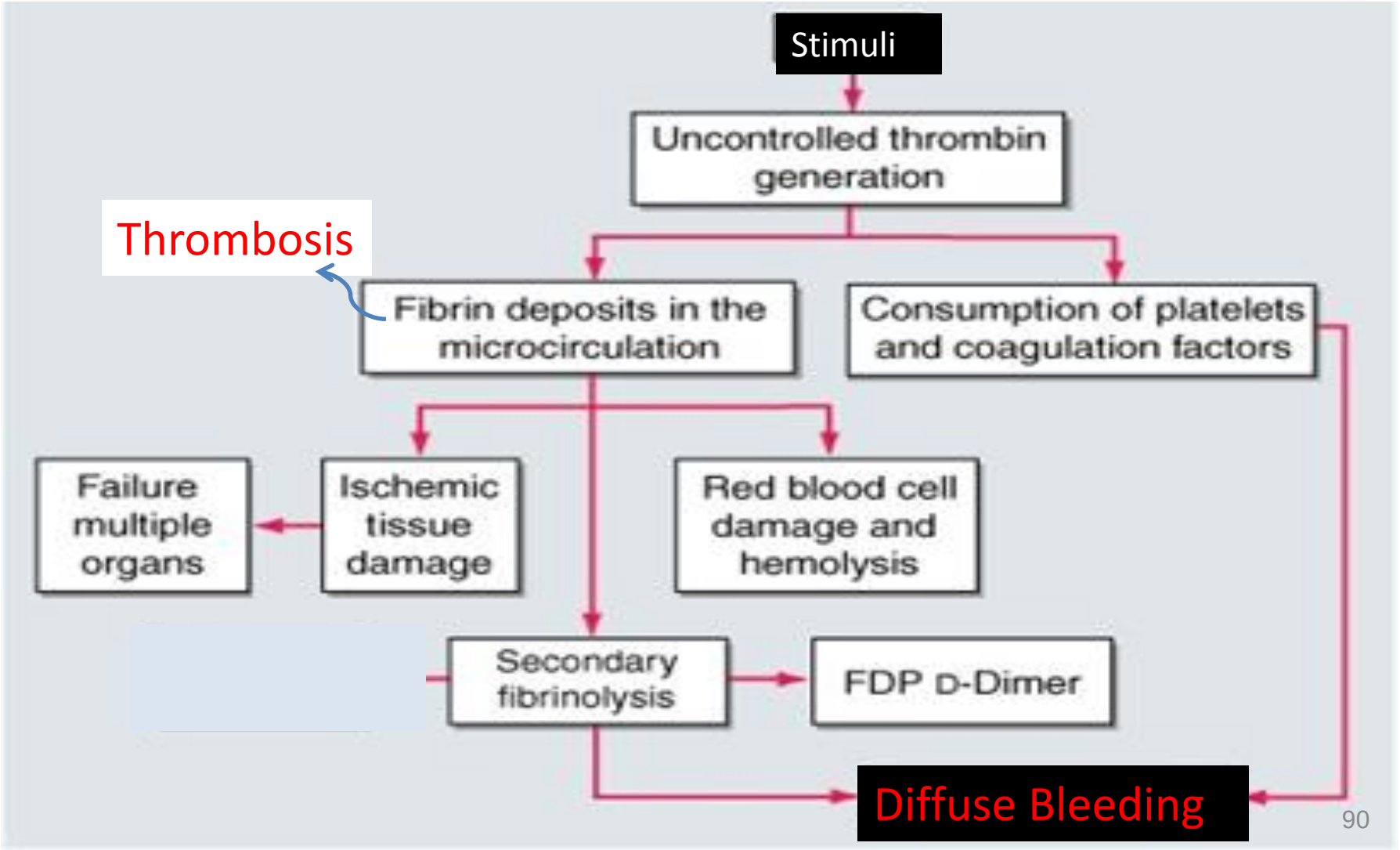
- **Treat the underlying condition**

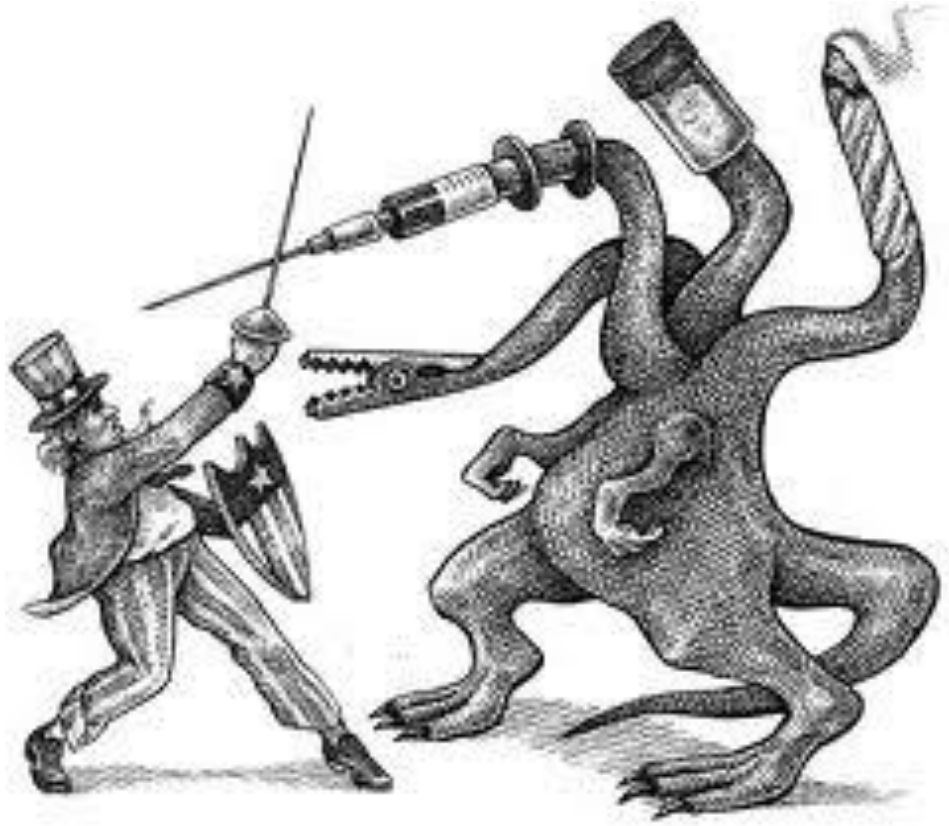
- Blood and blood product support

  Don't treat the lab reports

- Thrombosis-?anticoagulation

Summary-DIC


Stimuli
Uncontrolled thrombin generation
Thrombosis
Fibrin deposits in the microcirculation
Consumption of platelets and coagulation factors
Failure multiple organs
Ischemic tissue damage
Red blood cell damage and hemolysis
Secondary fibrinolysis
FDP D-Dimer
Diffuse Bleeding



Shock-Objectives

- Definition of shock
- Classification of shock
- Pathophysiology of shock
- Macroscopy and Microscopy of affected organs

Definition of shock

Systemic hypo perfusion caused by reduction either in CO or in the effective circulating blood volume.

Physiologic Determinants

- Global tissue perfusion is determined by:

- Cardiac output (CO)
  - CO = **Heart rate** (**HR**) times **Stroke Volume** (**SV**)
  - SV = function of **Preload, Afterload, Contractility**

- Systemic vascular resistance (SVR)

Pathophysiology of shock

Inadequate tissue perfusion

↓

Decreased oxygen supply

↓

Anaerobic metabolism

↓

Accumulation metabolic waste

↓

Cellular failure

Types of Shock

- Cardiogenic
- Hypovolemic
- Distributive
  - Sepsis
  - neurogenic (spinal shock)
  - anaphylaxis

Cardiogenic Shock

- Intracardiac
  - Arrhythmias
  - Valvular lesions
  - AMI
  - Severe CHF
  - Hypertrophic Cardiomyopathy

pump failure or ↓SV

- Extracardiac

Pulmonary Embolism

Cardiac Tamponade

pump failure or ↓SV

Hypovolemic Shock

- Reduced circulating blood volume with secondary decreased cardiac output
  - Acute hemorrhage-ex-PPH
  - Vomiting/Diarrhea
  - Dehydration
  - Burns

  from ↓preload

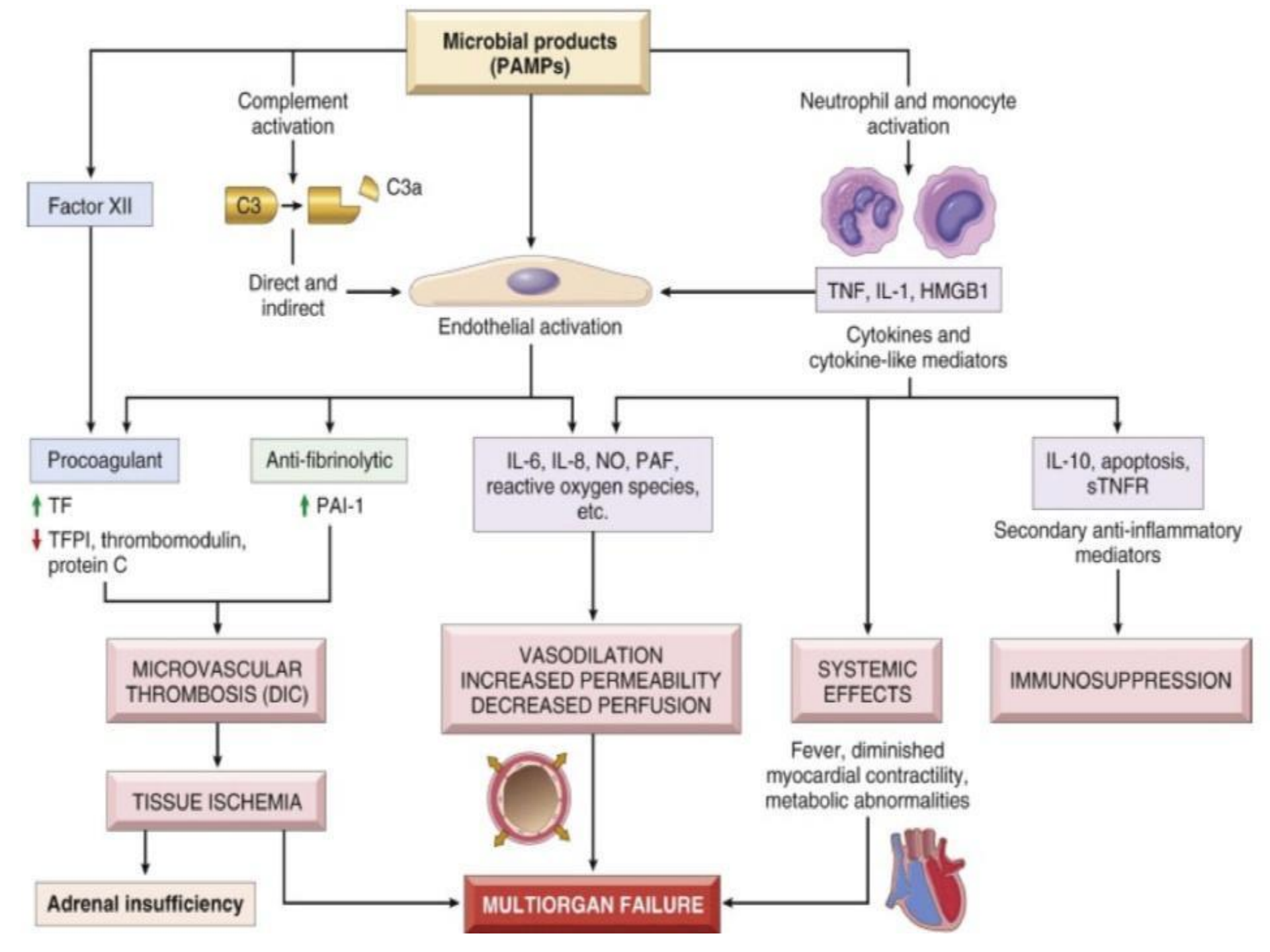
Distributive Shock

- Peripheral Vasodilatation secondary to disruption of cellular metabolism by the effects of inflammatory mediators.
- Gram negative or other overwhelming infection.

Results in decreased Peripheral Vascular Resistance.

Pathogenesis of Septic shock

- Inflammatory mediators
- Endothelial cell activation-thrombosis / increased vascular permiability/vasodilatation
- Metabolic abnormalities
- Immunosuppression
- Organ dysfunction


Microbial products (PAMPs)
Complement activation
Neutrophil and monocyte activation
Factor XII
C3
C3a
Direct and indirect
Endothelial activation
TNF, IL-1, HMGB1
Cytokines and cytokine-like mediators
Procoagulant
Anti-fibrinolytic
IL-6, IL-8, NO, PAF, reactive oxygen species, etc.
IL-10, apoptosis, sTNFR
TF
TFPI, thrombomodulin, protein C
PAI-1
Secondary anti-inflammatory mediators
MICROVASCULAR THROMBOSIS (DIC)
VASODILATION INCREASED PERMEABILITY DECREASED PERFUSION
SYSTEMIC EFFECTS
IMMUNOSUPPRESSION
TISSUE ISCHEMIA
Fever, diminished myocardial contractility, metabolic abnormalities
Adrenal insufficiency
MULTIORGAN FAILURE

Stages of shock

- Non progressive
- Progressive
- Irreversible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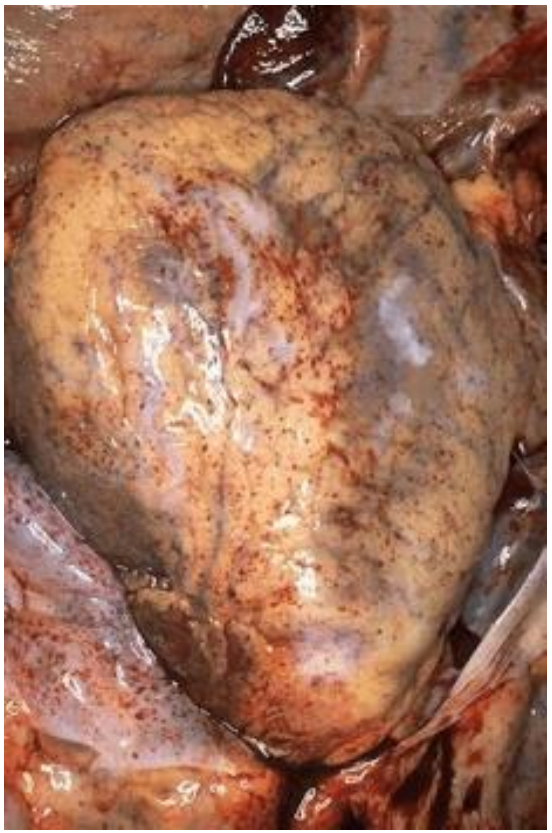
Morphology of organs

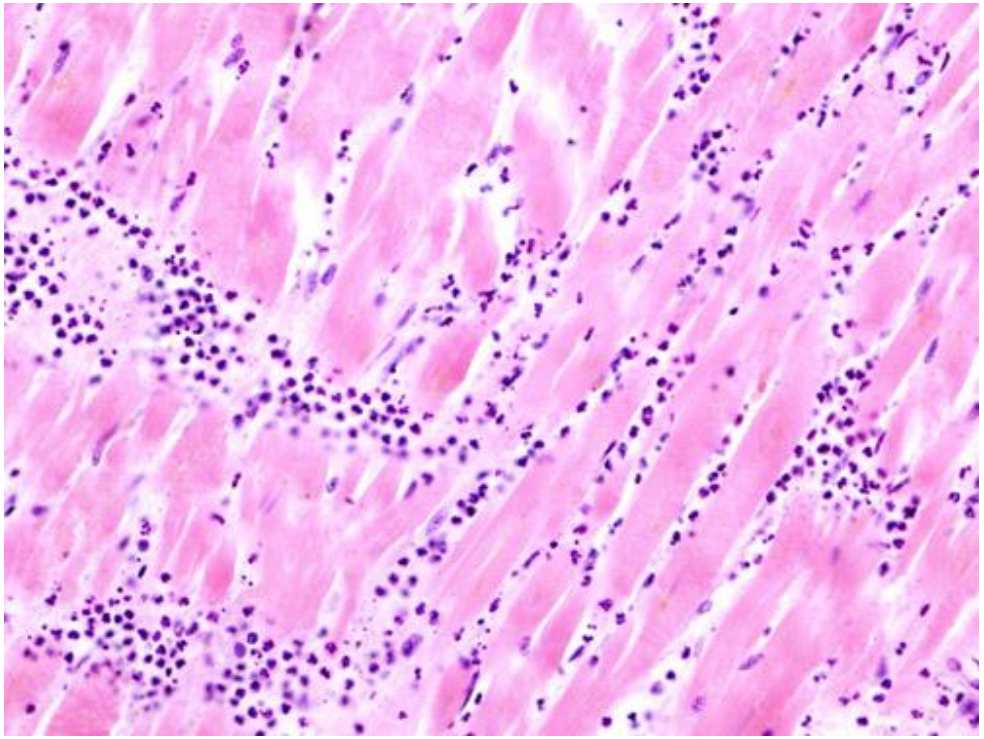
- Those of hypoxic injury
- Any organ
- Specially in Brain,Heart,Lungs,Kidneys,adrenals,GIT

Heart

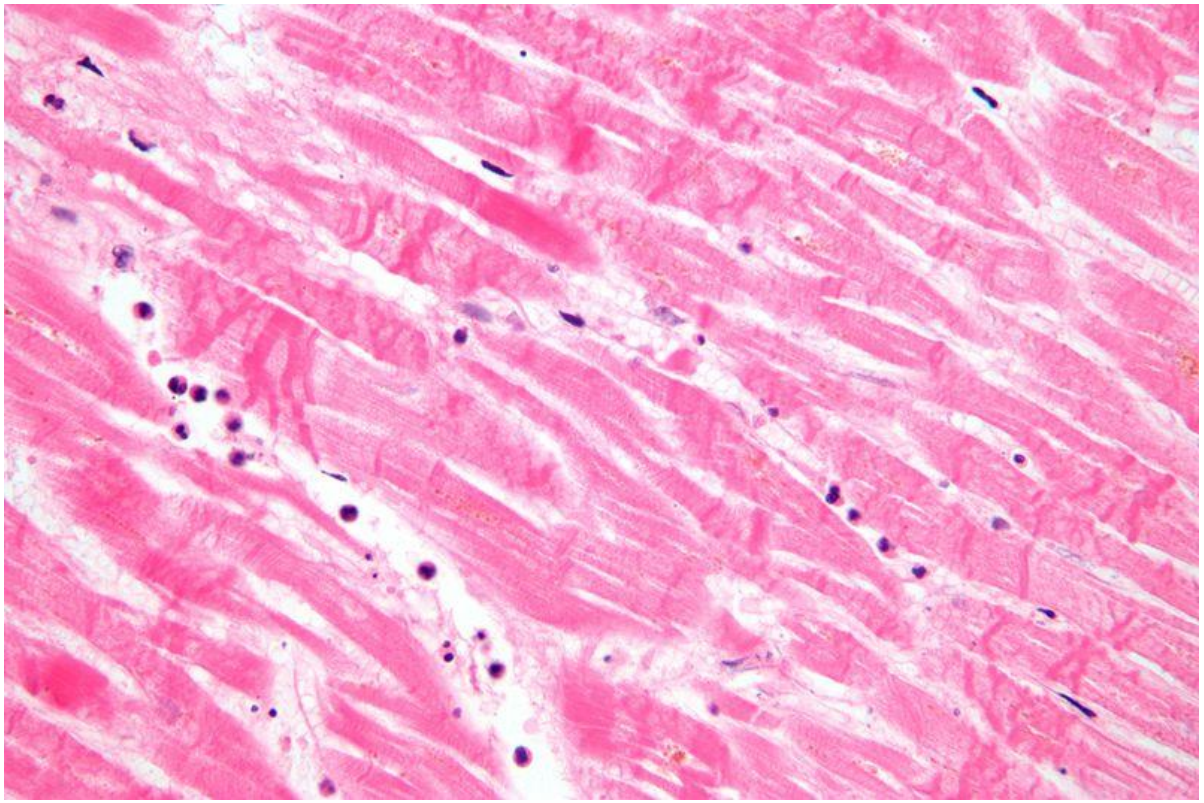
- Macroscopy: petechial hemorrhages of the epicardiumn, the endocardium, especially the left outflow tract.



- Microscopically: necrotic foci in the myocardium, (loss of single fibres to large areas of necrosis.)
- The affected fibres stain a deep red with eosin and the nuclei become pyknotic.
- Prominent contraction bands-better seen by EM

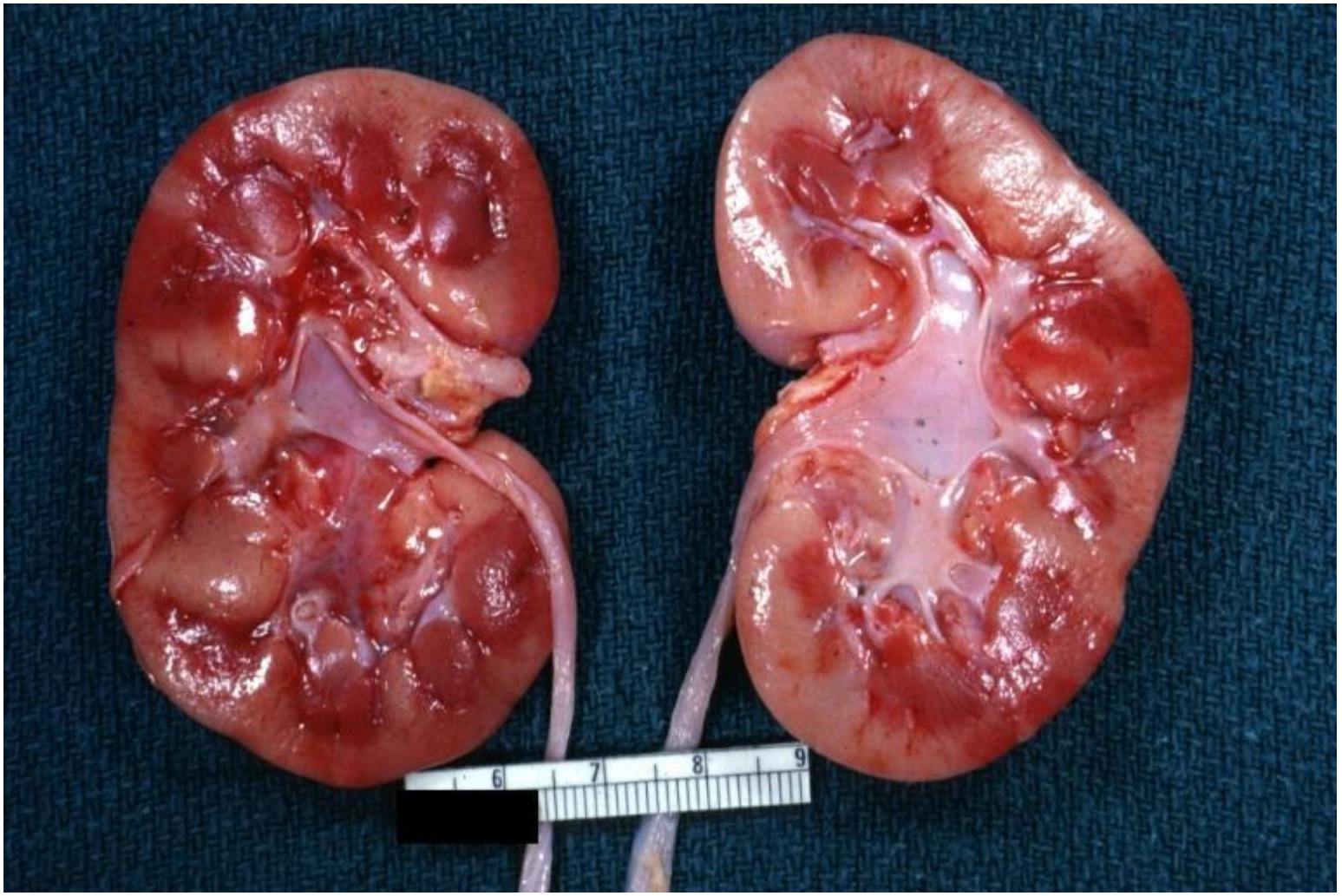


- contraction bands are thick intensely eosinophilic staining bands (typically 4-5 micrometres wide) that span the short axis of the myocyte.



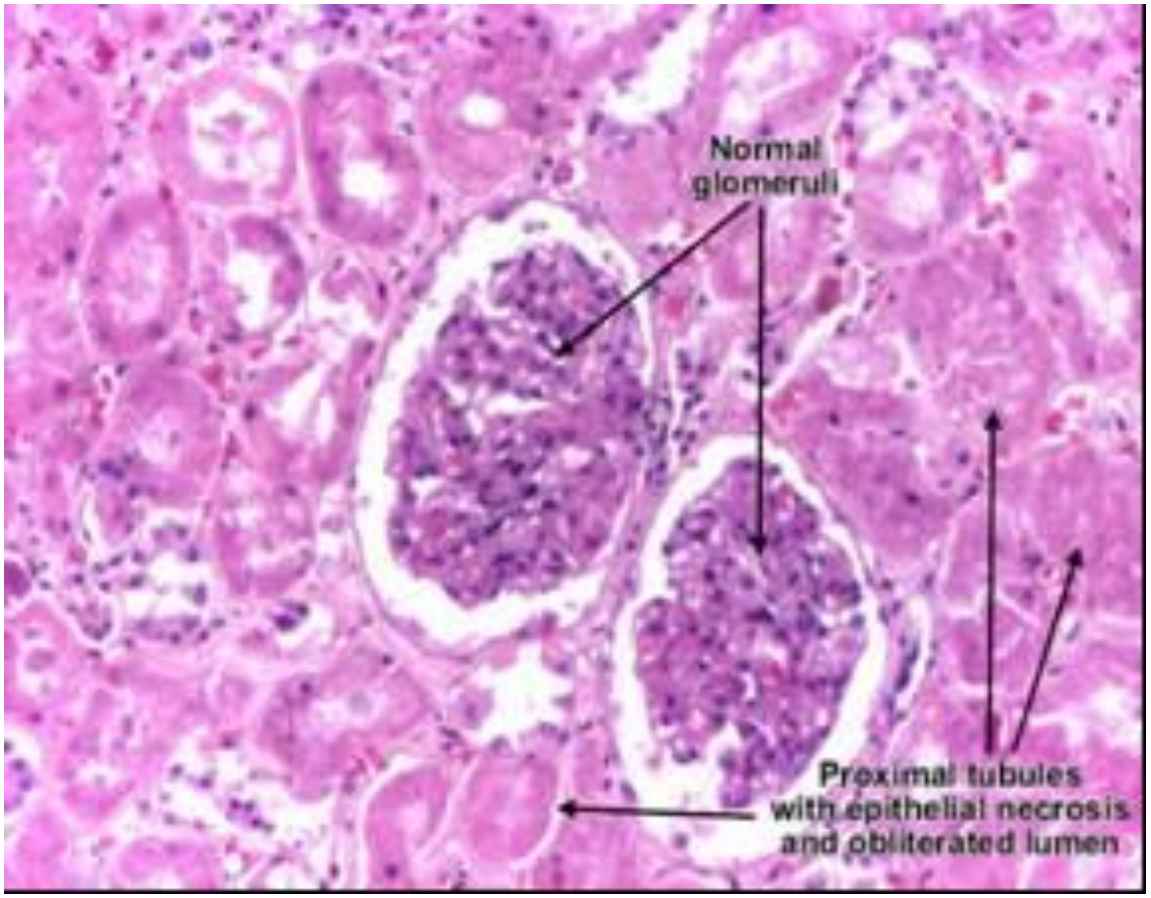
Kidney

- Acute renal failure- kidney is large, swollen,congested,cortex may be pale.
- Cross section-blood pooling in the outer strip of the medulla.



Acute Tubular Necrosis: Gross ; swollen cortex secondary to body burn

- Microscopically: acute tubular necrosis; dilatation of the proximal tubules and focal necrosis of cells.



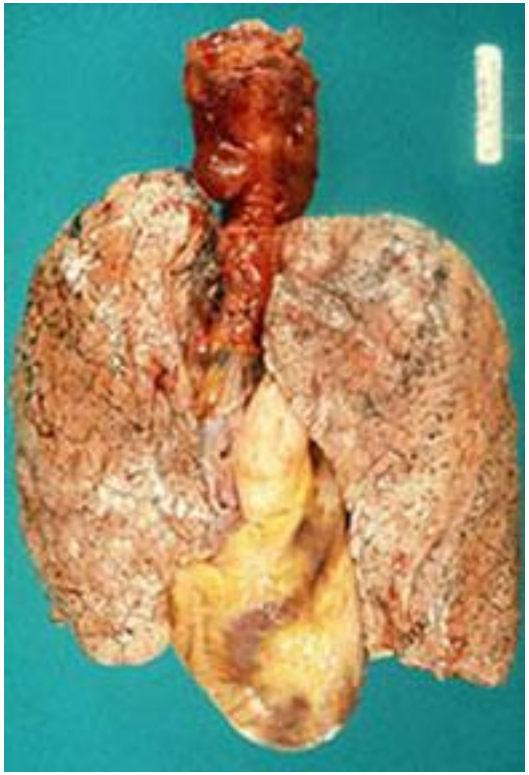
Acute tubular necrosis

Lung

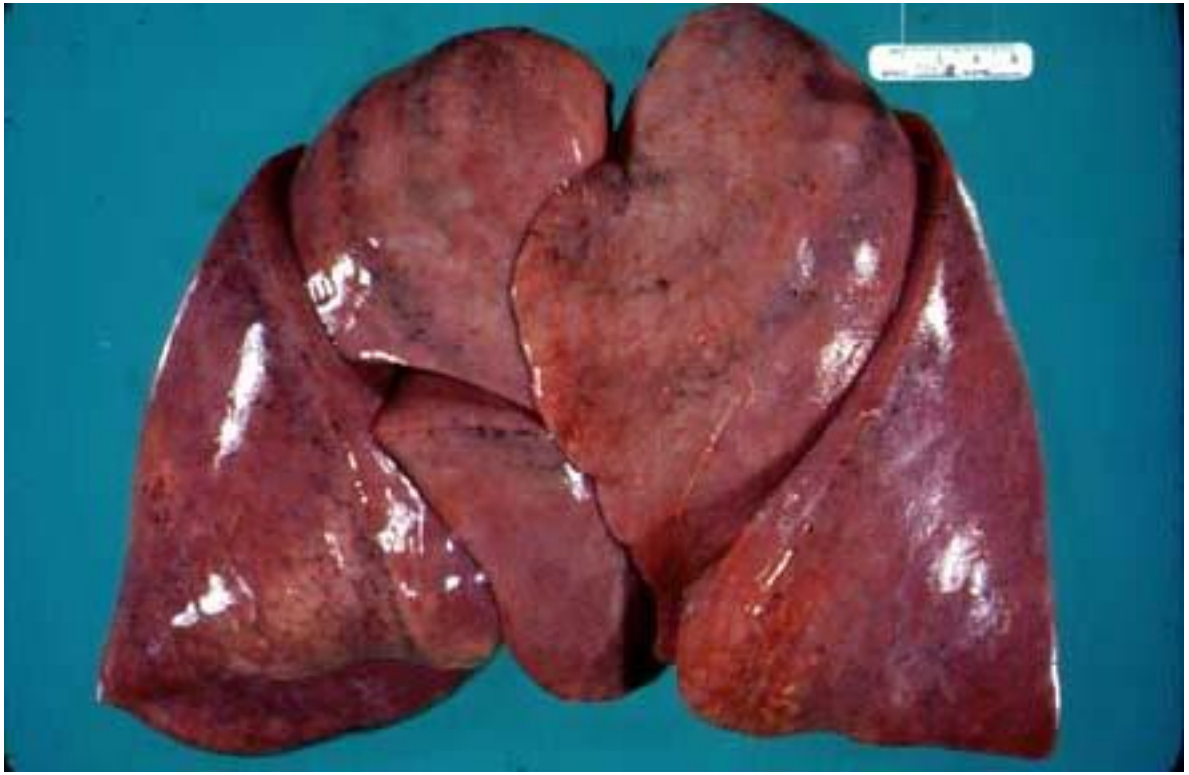
- Following the onset of severe and prolonged shock, injury to the alveolar wall results in focal or generalized interstitial pneumonitis (shock lung).
- The sequence of changes is mediated by acute inflammatory cells and includes interstitial edema, necrosis of endothelial cells, microthrombi, and necrosis of the alveolar epithelium.

Lung cont.

- Grossly: lung is firm and congested. Frothy fluid exudes from the cut surface.

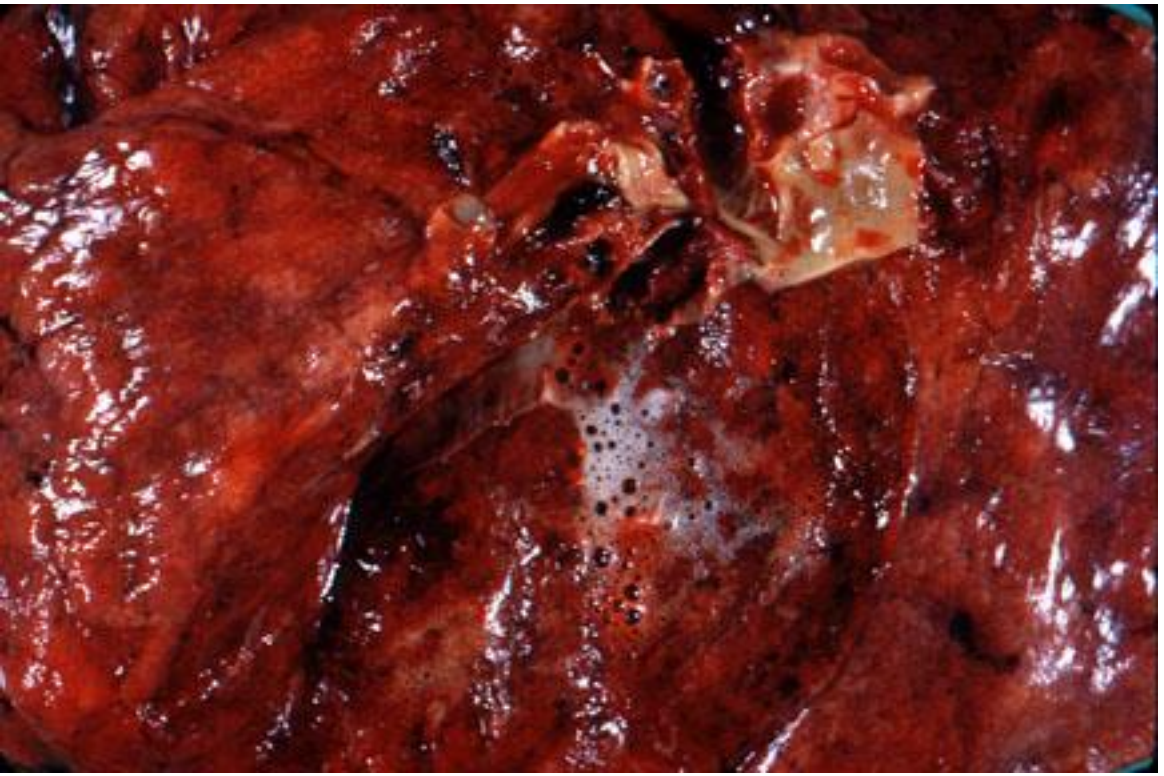


Normal lung



The lungs are large and dusky red. Firm and airless by palpation.

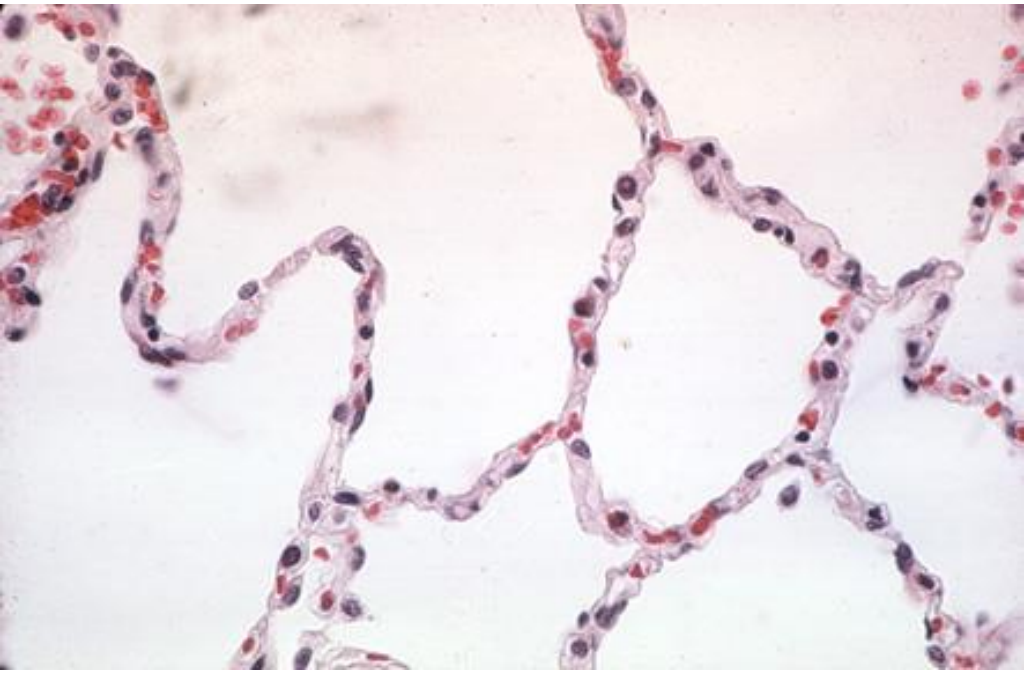
Lung cont.

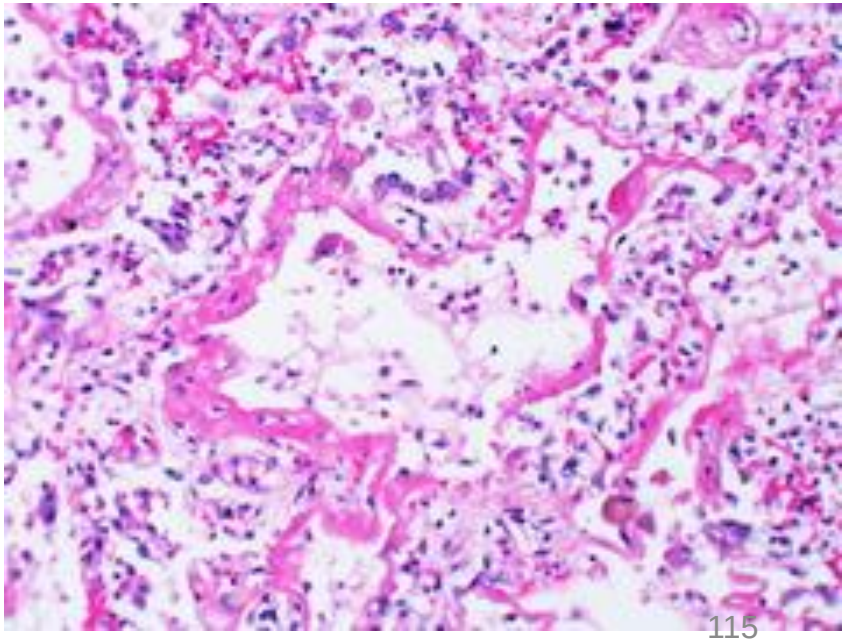


The frothy liquid oozing from the cut surface of the lung is caused by air moving through water in the respiratory tract.

Lung cont

Shock-induced lung injury leads to the appearance of hyaline membranes in the alveoli, which are frequently expelled into the alveolar ducts and terminal bronchioles.
These lung changes may heal entirely, but in half of the patients the repair processes progress and cause a thickening of the alveolar wall.

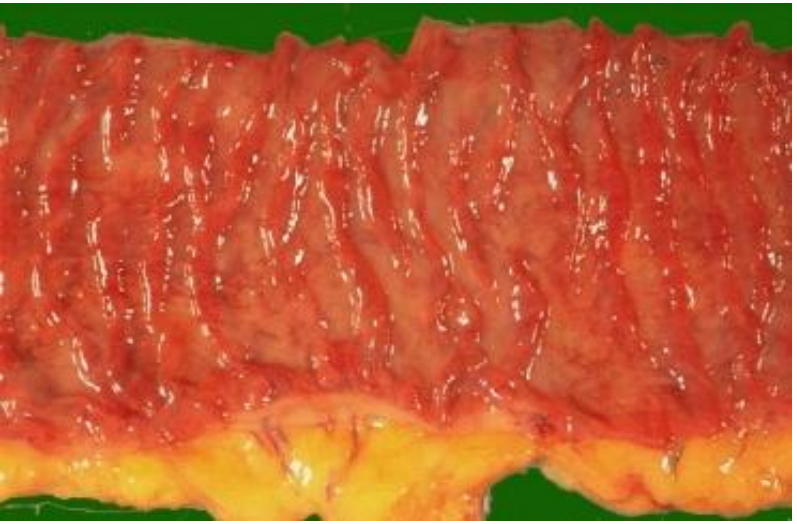




Intestine

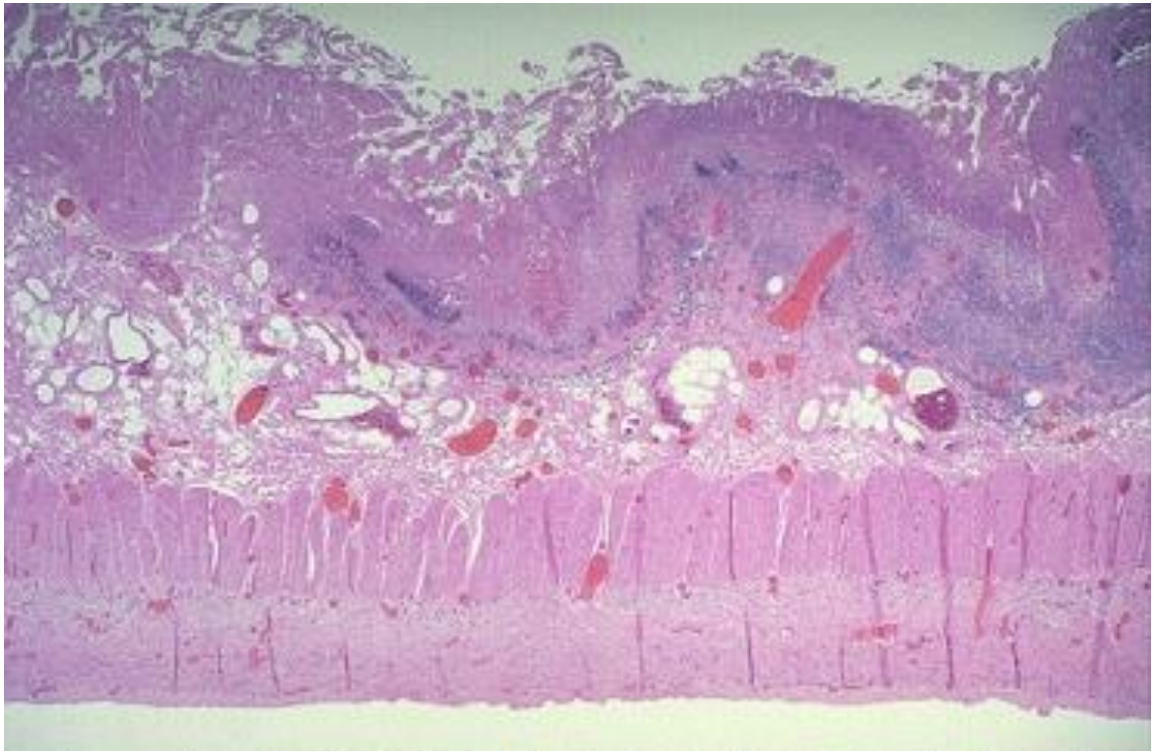
The small intestinal mucosa demonstrates marked hyperemia as a result of ischemic enteritis. Such ischemia most often results from hypotension (shock) from cardiac failure, from marked blood loss, or from loss of blood supply from mechanical obstruction (as with the bowel incarcerated in a hernia or with volvulus or intussusception). If the blood supply is not quickly restored, the bowel will infarct.

Intestine cont.



Early ischemic enteritis involves the tips of the villi. A colonoscopic view of ischemic colitis with minimal overlying exudate is shown above. Bowel is hard to infarct from atherosclerotic vascular narrowing or thromboembolization because of the widely anastomosing blood supply. Thus, most cases of bowel ischemia and infarction result from generalized hypotension and decreased cardiac output.

Intestine cont.



Mucosal surface of the bowel- early necrosis with hyperemia extending all the way from mucosa to submucosal and muscular wall vessels. The submucosa and muscularis, however, are still intact.

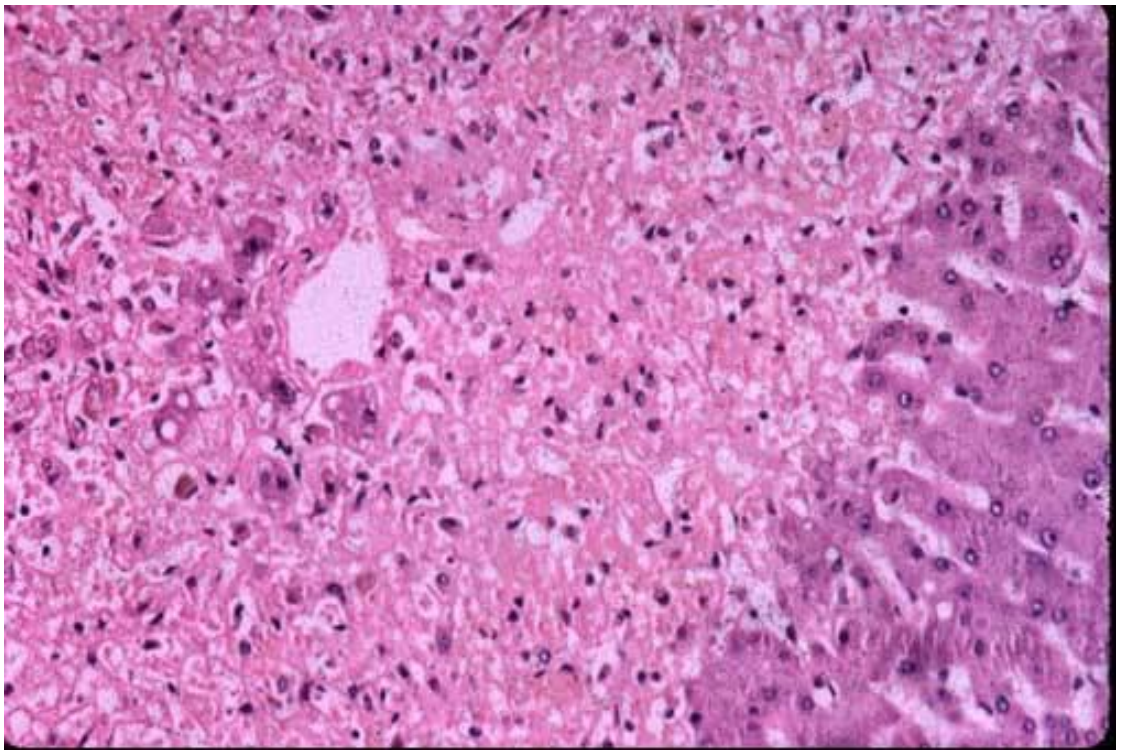
Liver

- Macroscopy: liver is heavy and enlarged and has a mottled cut surface that reflects marked centrilobular pooling of blood.

Liver cont.

- Microscopy: centrilobular zonal necrosis

  The cells in the centre of the lobule are the most distant from the blood supply that comes from the portal tracts and are, therefore, presumably more vulnerable to circulatory disturbances.



Centri-lobular hepatic necrosis

Brain

- Brain lesions are rare.
- Occasionally, microscopic hemorrhages are seen
- In severe cases, hemorrhage and necrosis may appear in the overlapping region between the terminal distributions of major arteries; watershed zone.

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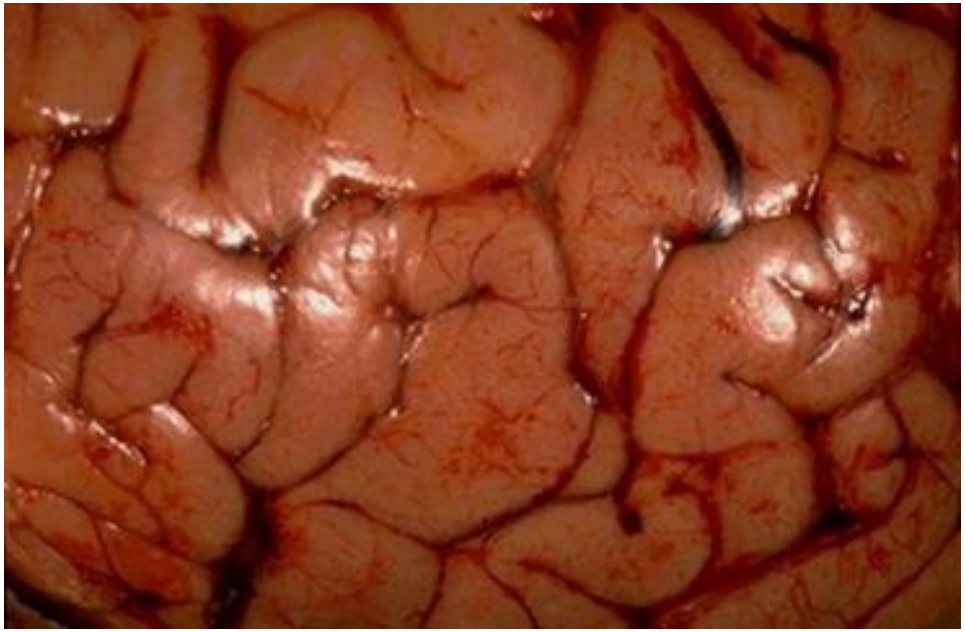
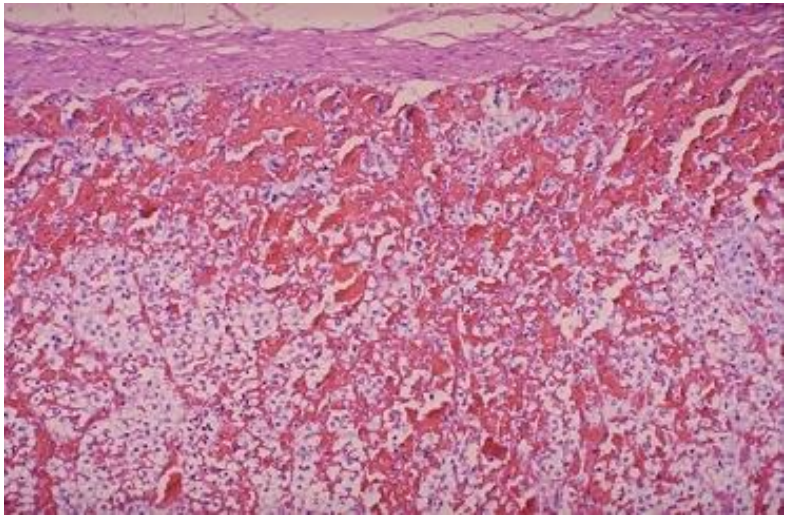


Adrenals

- In severe shock the adrenal glands may exhibit conspicuous hemorrhage in the inner cortex. Frequently, this hemorrhage is only focal, but it can be massive and accompanied by hemorrhagic necrosis of the entire gland, as seen in the Waterhouse-Friderichsen syndrome.

Adrenal



1.1 Describe the pathogenesis of septic shock including its systemic effects.

(50 marks)

THANK YOU