Hemodynamic Disorders, Thromboembolic Disease and Shock (Part 1)

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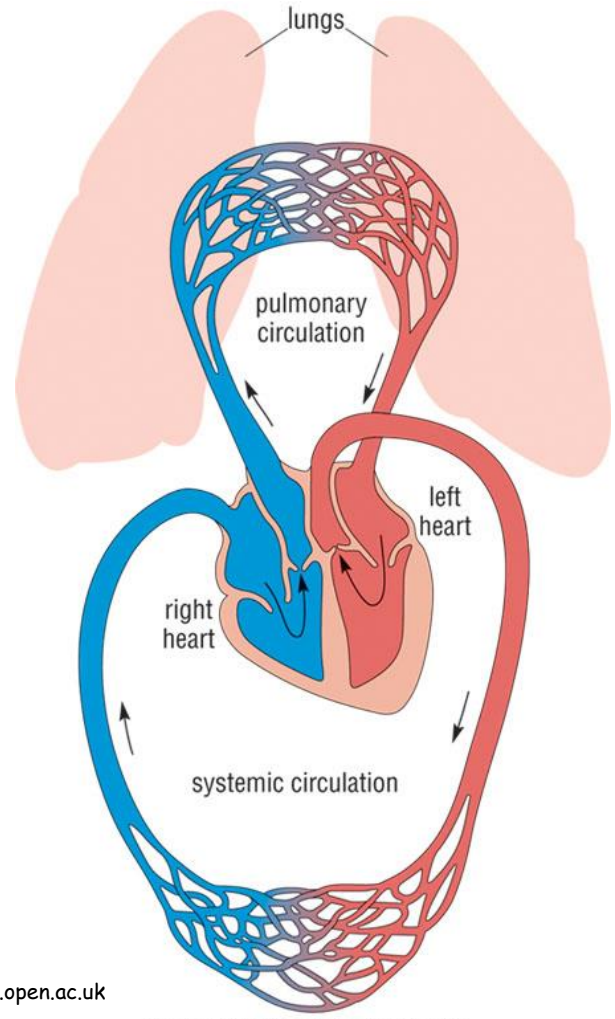
Normal fluid homeostasis

- Vessel wall integrity
- Intravascular pressure and osmolarity in physiologic ranges
- Maintaining blood as a liquid

Protagonists

- Heart
- Blood vessels and lymphatic vessels
- Blood



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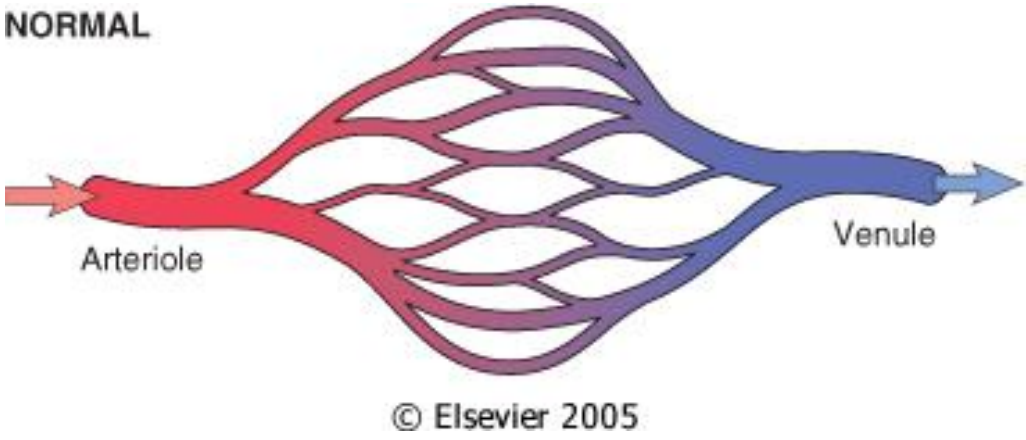
Hemodynamic disorders

- Hyperemia (active and passive)
- Edema
- Hemorrhage
- Thrombosis
- Embolism
- Infarction
- Shock

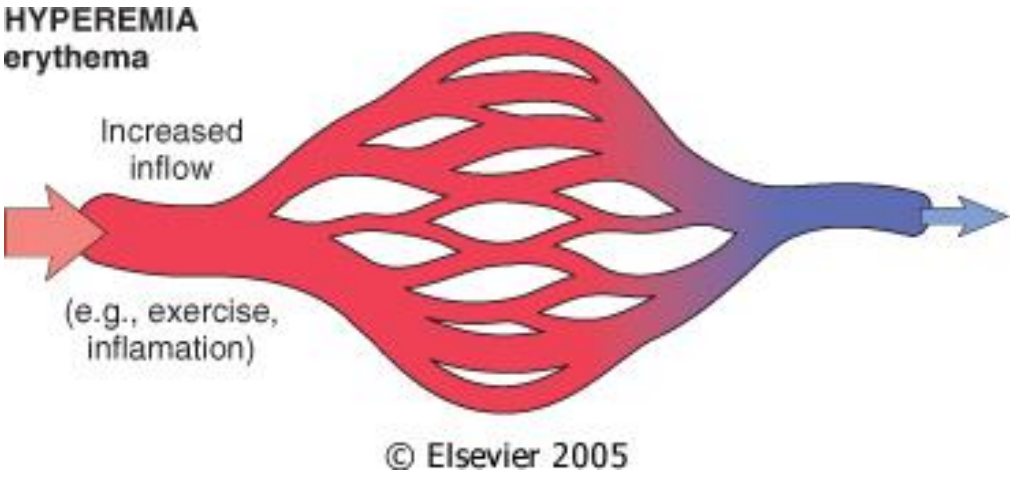
HYPERAEMIA

HYPEREMIA I.

- **Definition:** locally increased blood volume
- **Forms**:
  - active,
  - passive/congestion

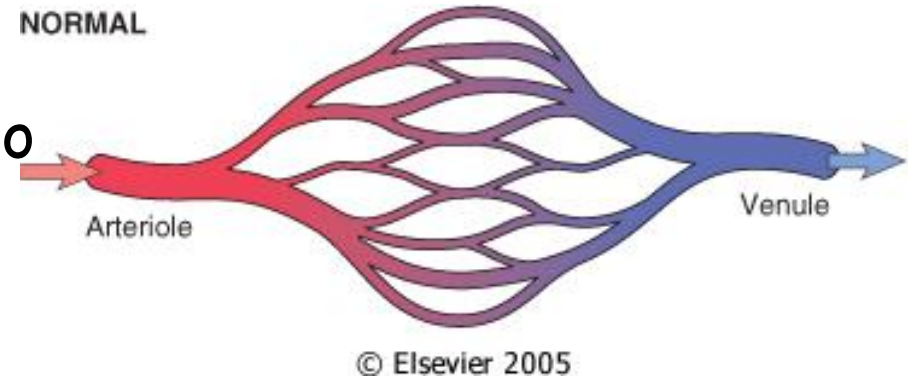


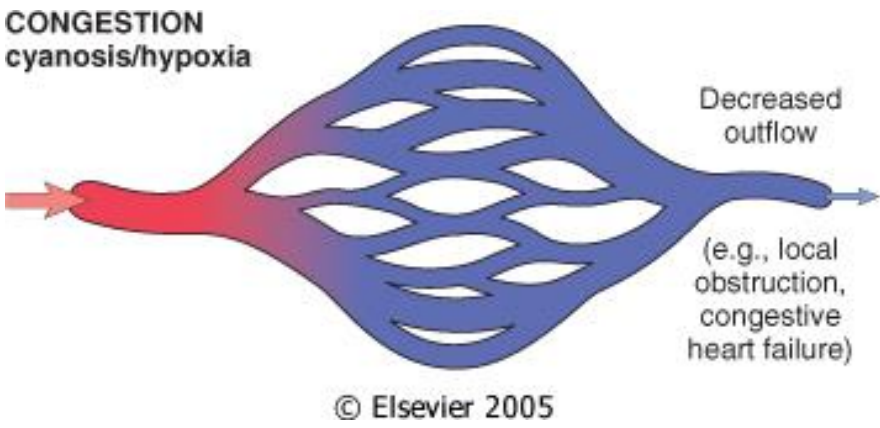
- **ACTIVE HYPEREMIA**
  - Active dilation of arteriae, arterioles, capillaries
  - erythema
  - Forms: physiological, pathologic (inflammation, fever, chemical and physical injury)



HYPEREMIA II.

- **PASSIVE HYPEREMIA** (congestion)
  - dilation of venous side due to decreased outflow
  - cyanosis, hypoxia
  - **Causes**:
    - **Local**: thrombosis, obstruction
      - Deep venous thrombosis-legs
      - Pylethrombosis- portal congestion
      - V.cava sup. syndrome
    - **Systemic**: congestive heart failure



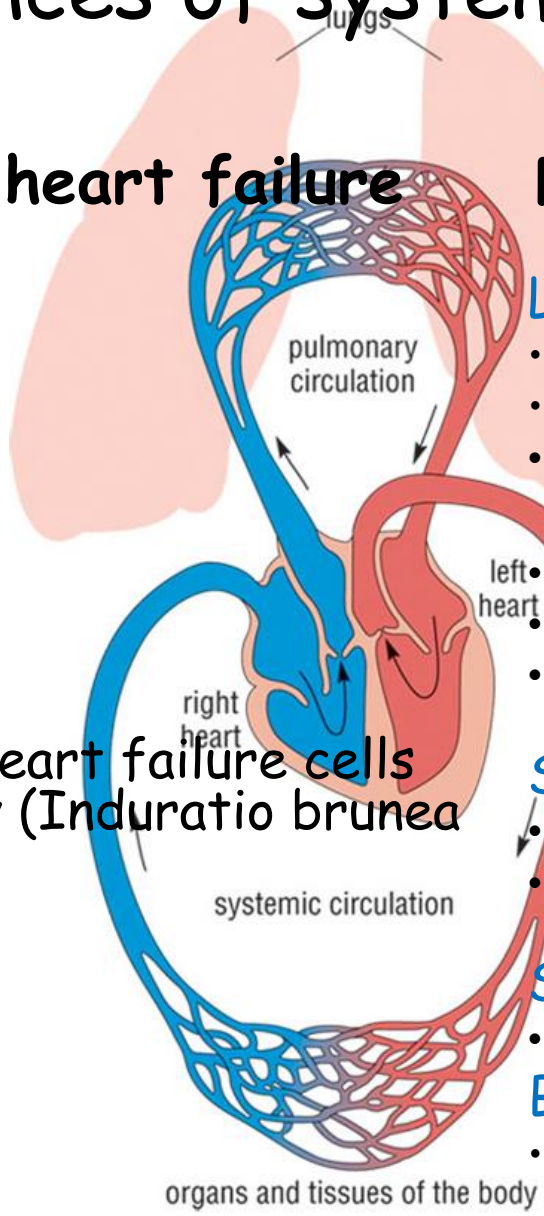


Consequences of systemic chronic congestion

Left sided heart failure

Lungs

heavy, firm, heart failure cells on microscopy (Induratio brunea pulmonum)



Right sided heart failure

Liver

- nutmeg liver (hepar moschatum)
- centrilobular necrosis
- cardiac fibrosis (cirrhosis-misnomer!)

Kidneys

- stellate veins accentuated
- cortex widened
- sharp separation of medulla and cortex

Spleen

- enlarged, livid
- fibrosis with time (Induratio cyanotica lienis)

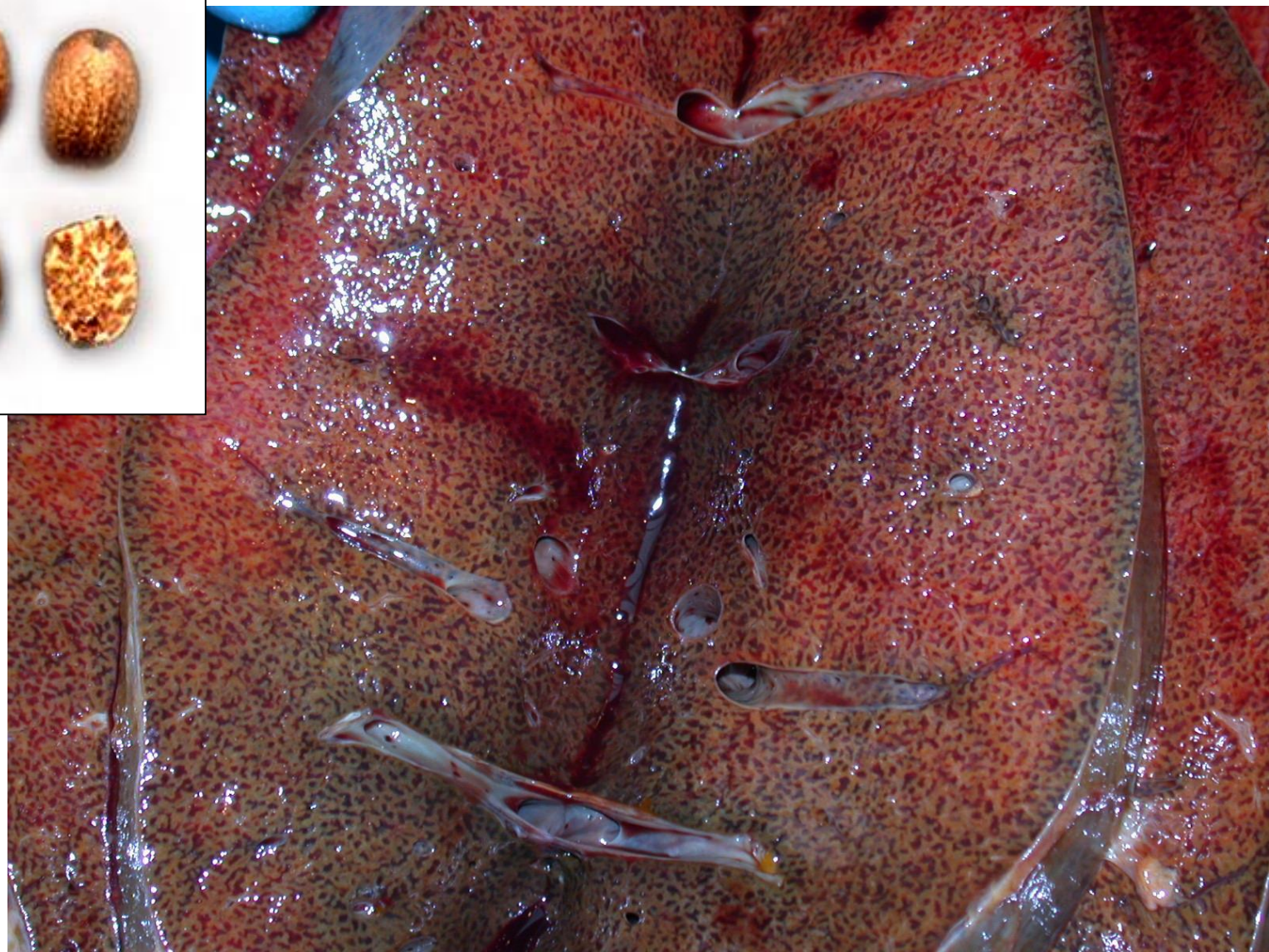
Skin

- cyanosis, anasarca

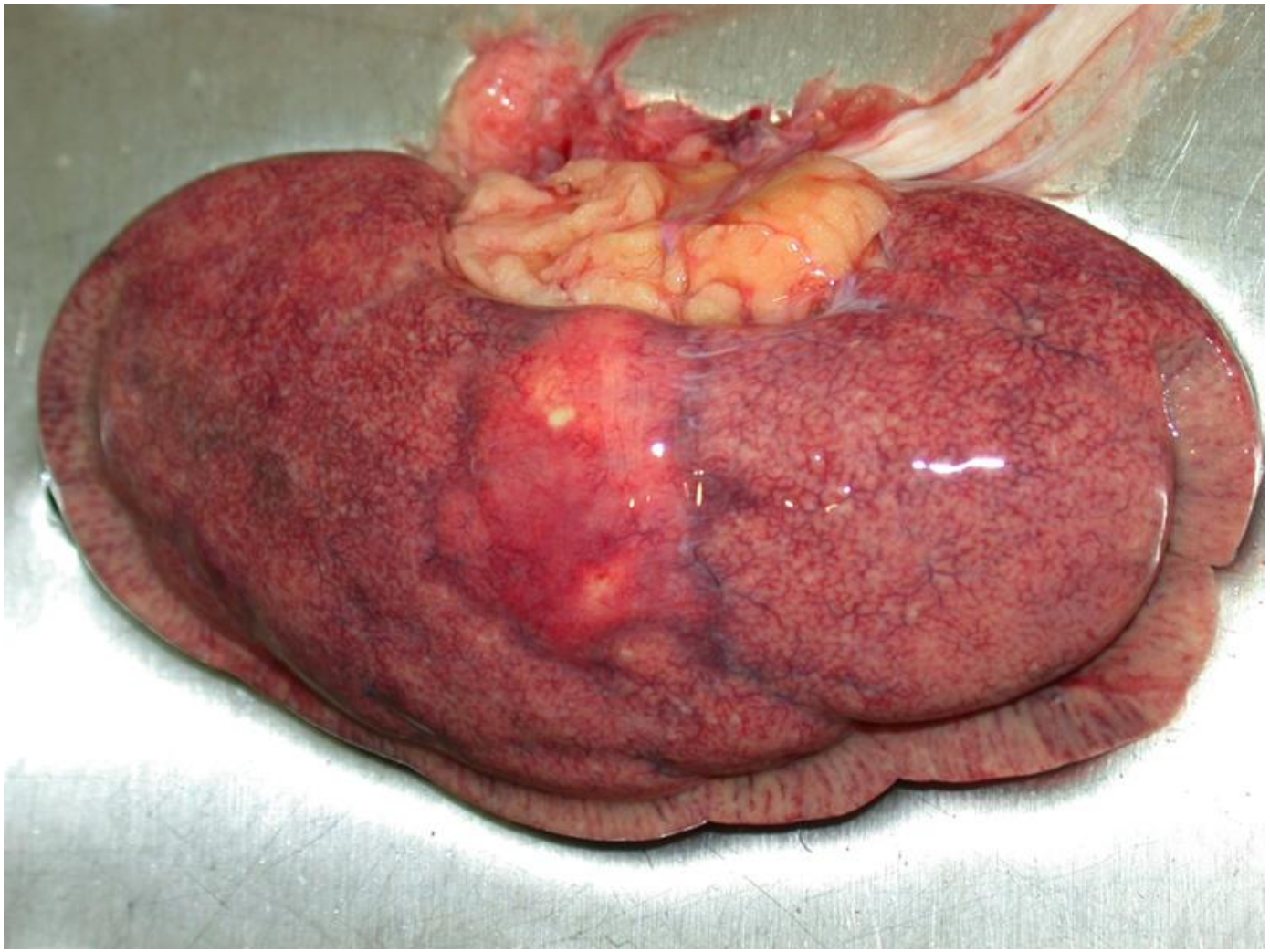
Body cavities

- Ascites, hydrothorax

Systemic congestion-Nutmeg liver

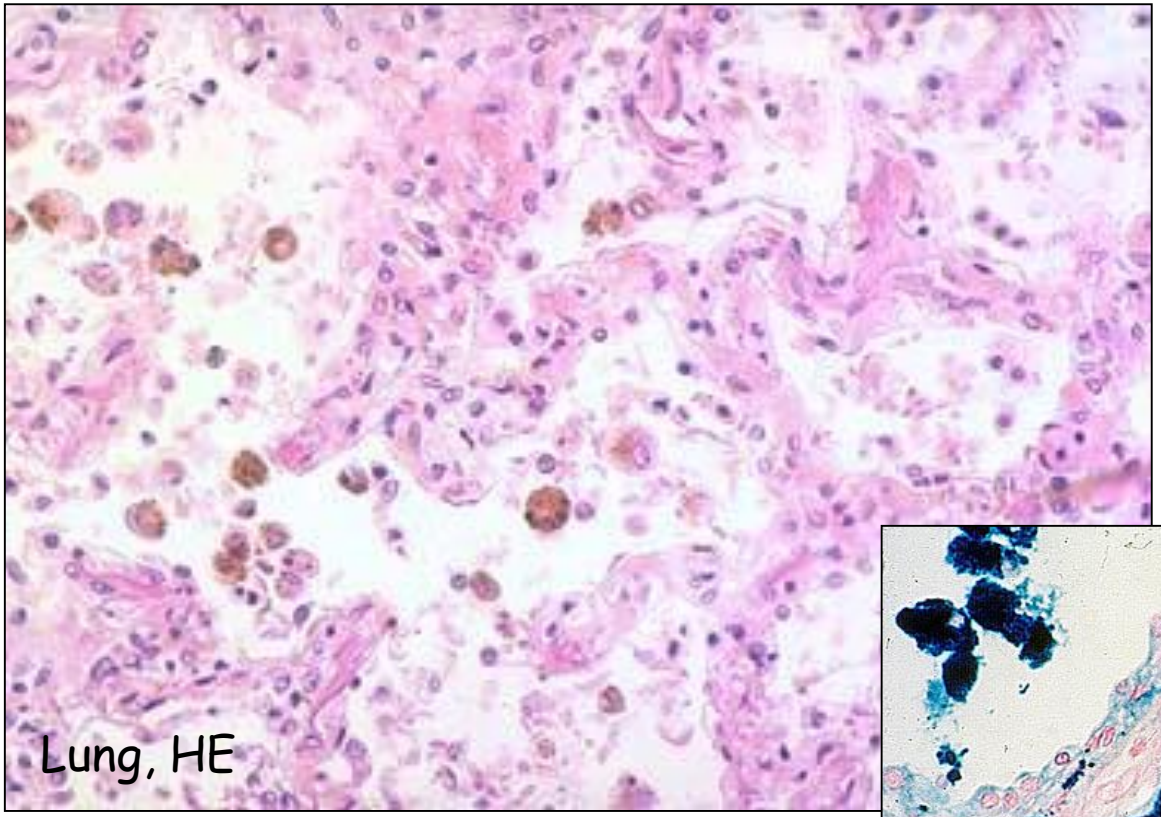


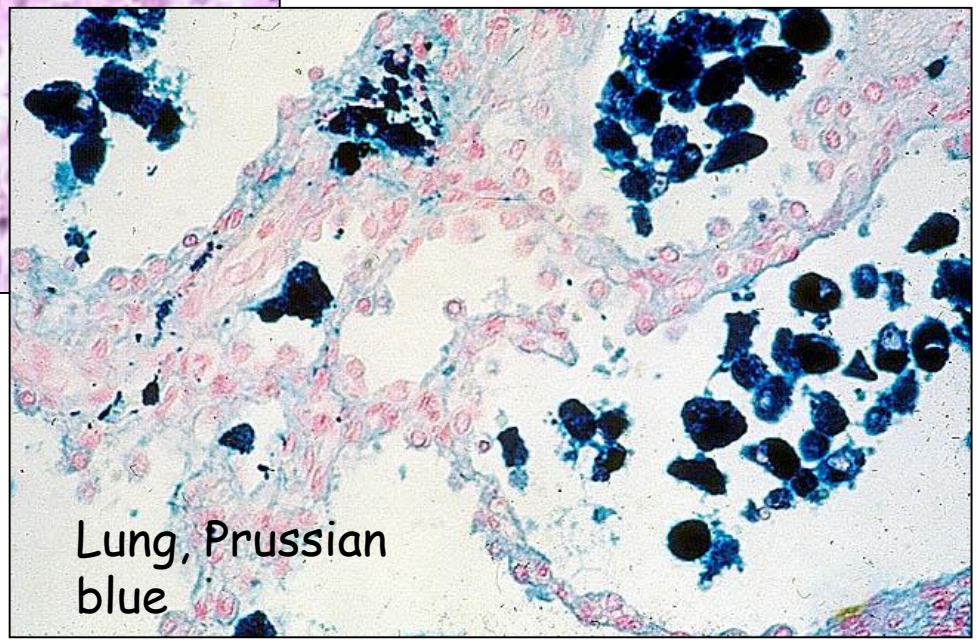
Systemic congestion (+?) - kidney



Lung, chronic passive hyperemia/ congestion

Hemosiderin in heart failure cells

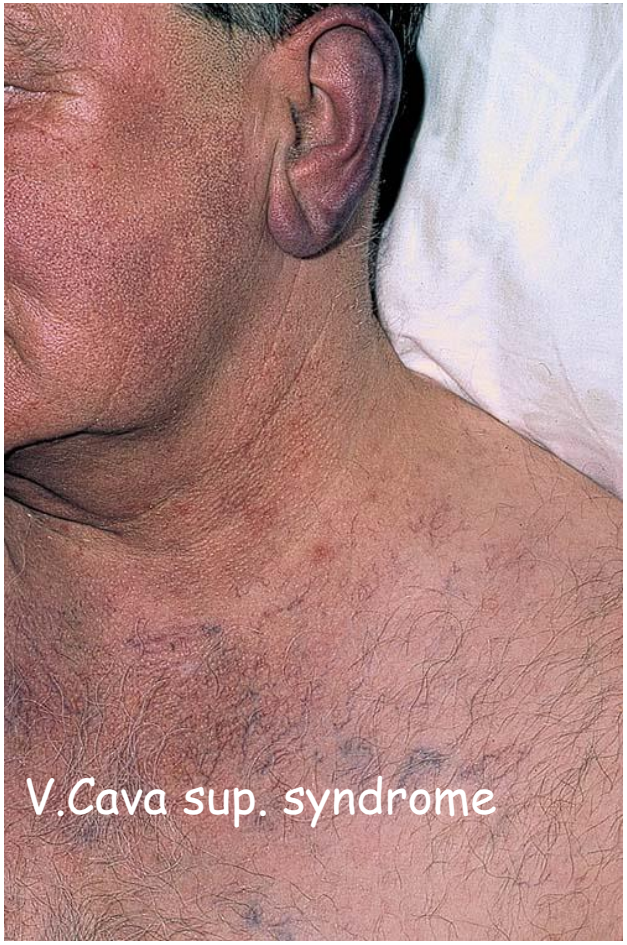


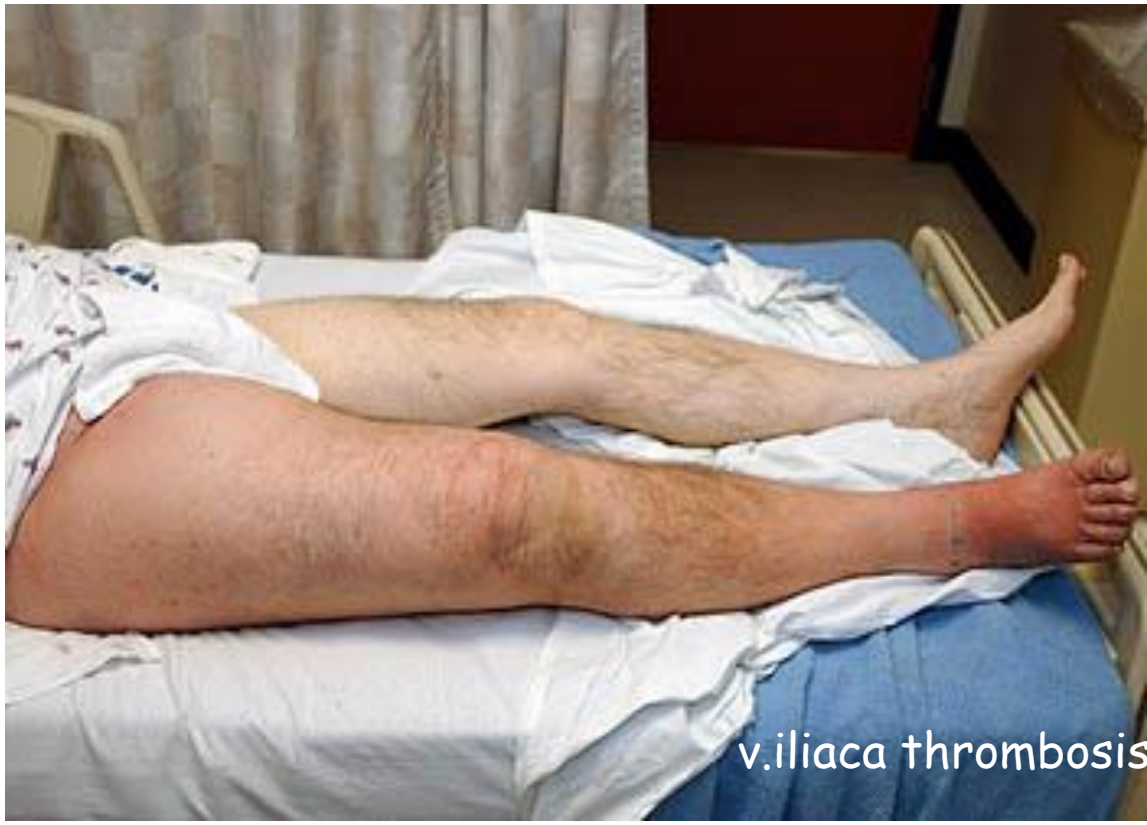


Local chronic congestion

- May occur in every organ
  - E.g. Vena cava superior syndrome, Budd-Chiari sy (hepatic vein thrombosis), extremities etc.

Local congestion





EDEMA

EDEMA

- Definition: increased fluid content in the interstitium

(transudate or exudate)

- Causes:
  - **Increased intravascular hydrostatic pressure**

    (arteriolar dilation or impaired venous return)

    (local- eg. Deep venous thrombosis of the legs,

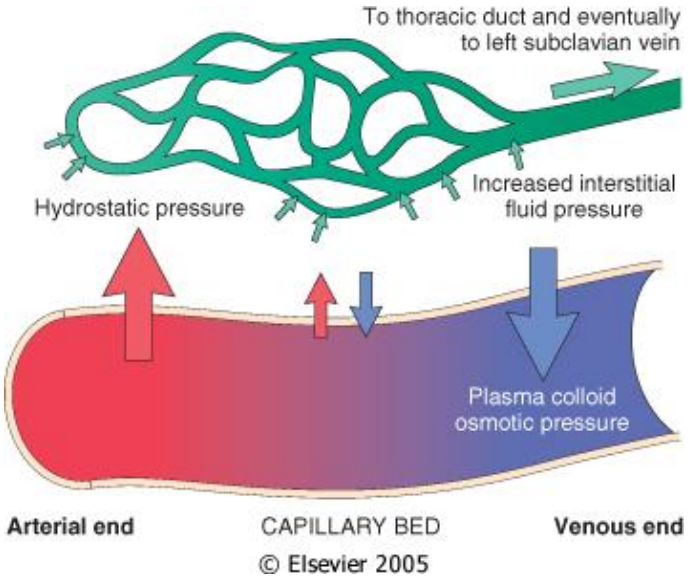
    systemic- eg. Congestive heart failure)
  - **Decreased plasma colloid osmotic pressure**

    (eg. nephrosis sy, cirrhosis, protein malnutrition)
  - **Lymphatic obstruction** (lymphedema, elephantiasis)
  - **Salt and water retention** (GN, Acute renal failure)
  - **Inflammation** (exudate)

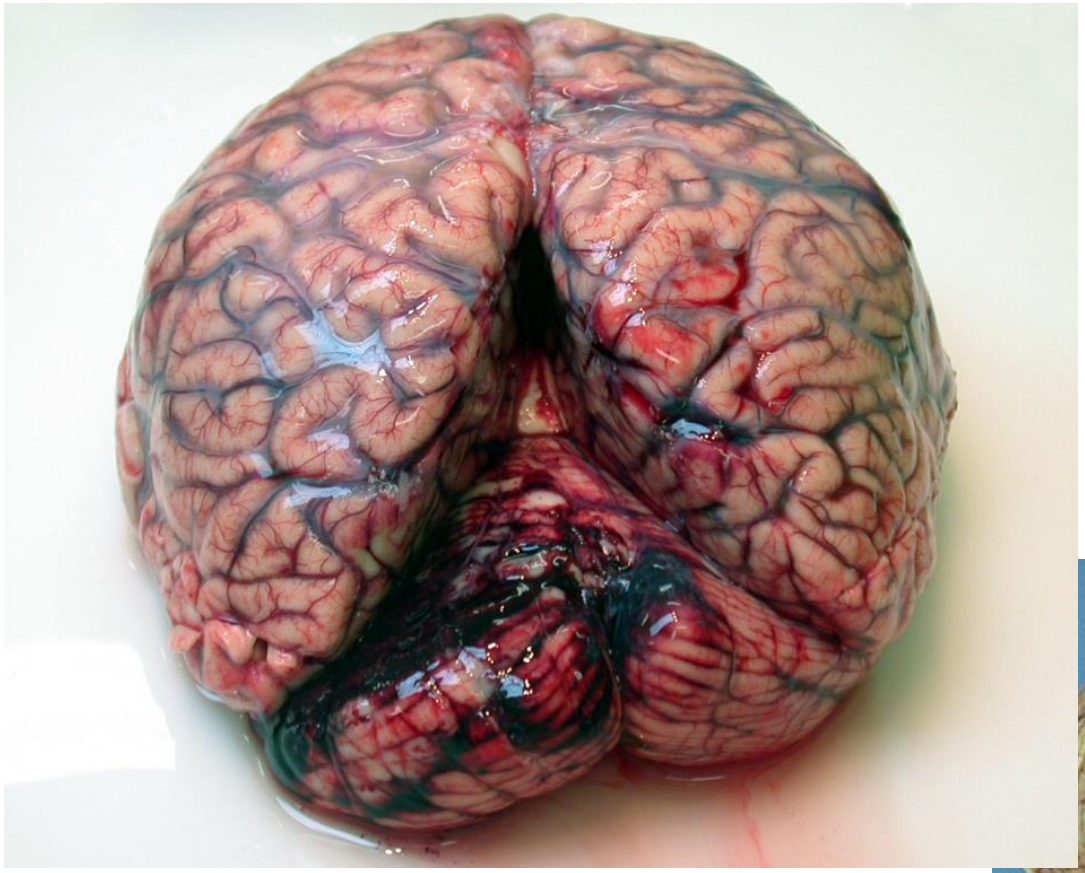
Normal fluid homeostasis:

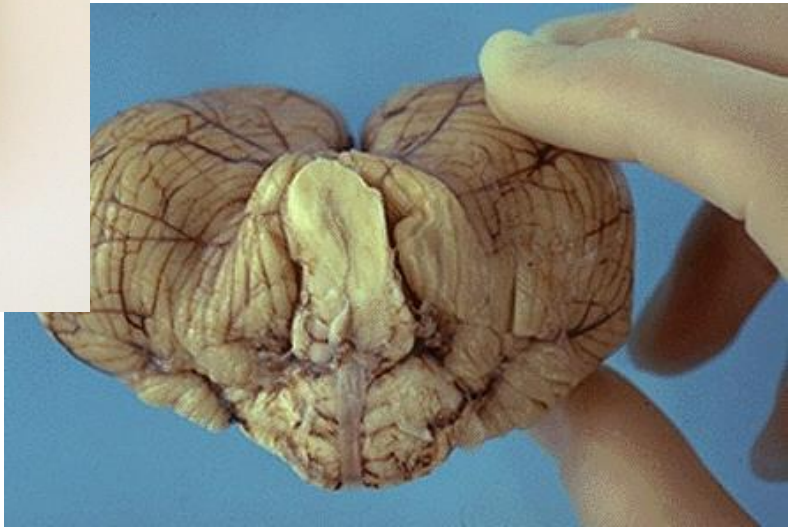
60% of body weight is water

2/3 intracellular, 5% blood, remainder within interstitium

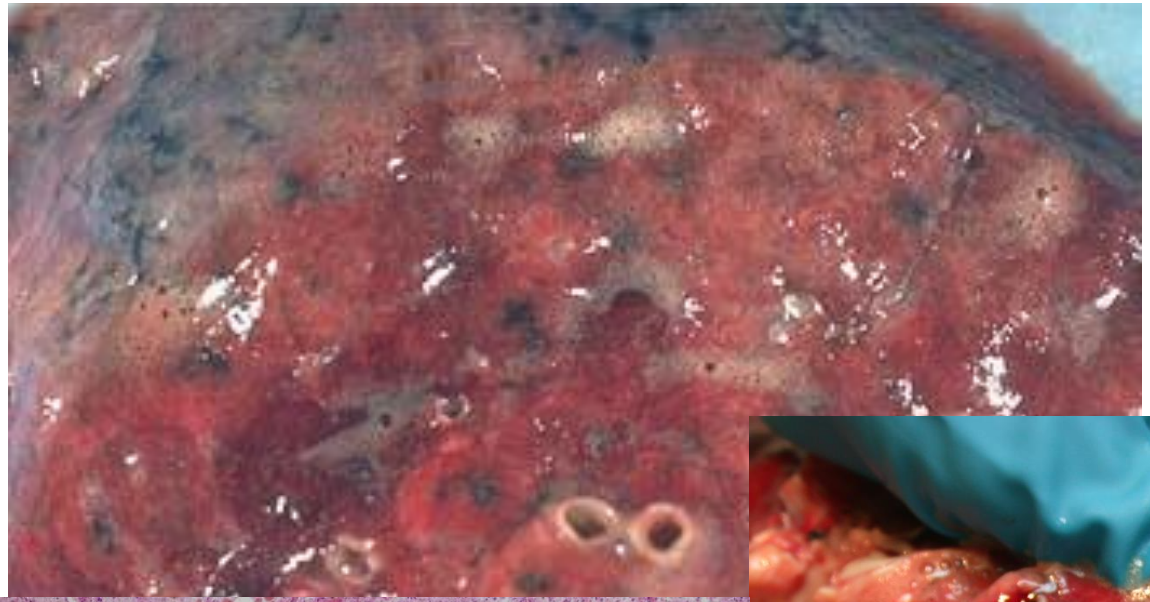


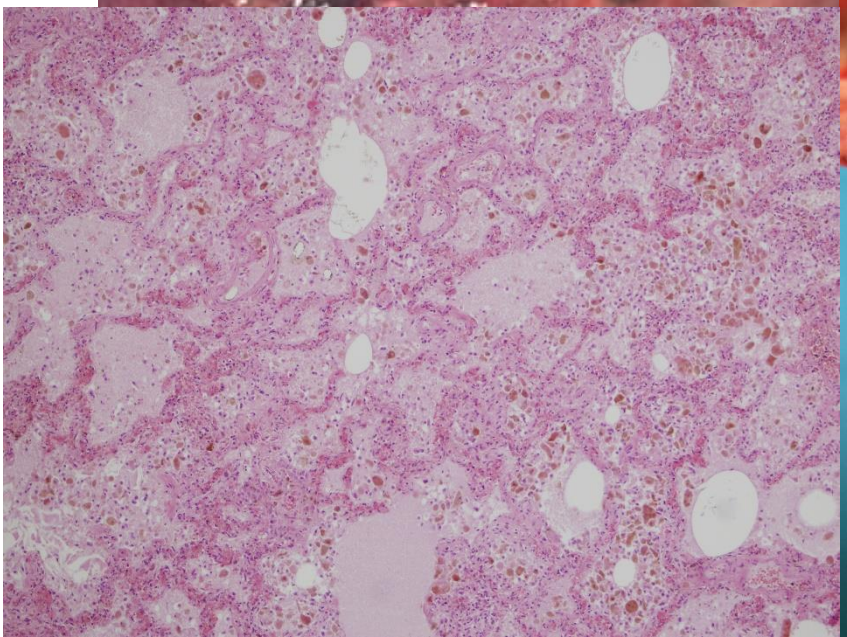
Cerebral edema- tonsillar herniation

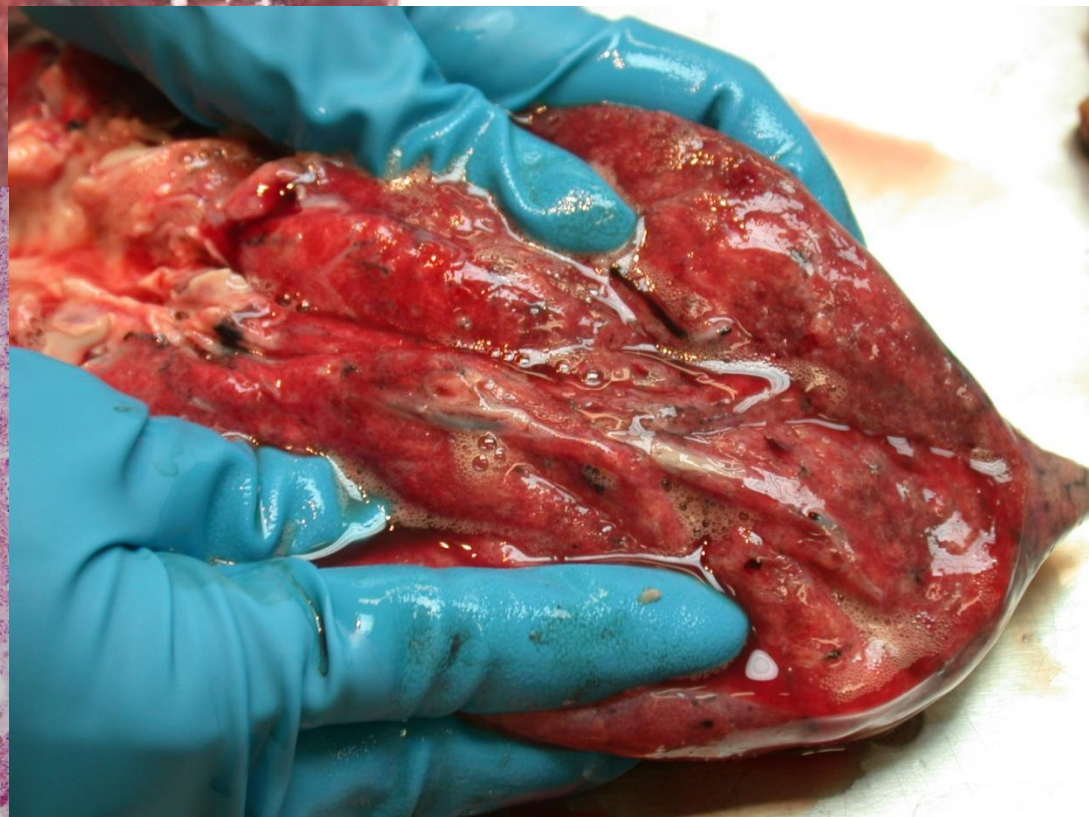


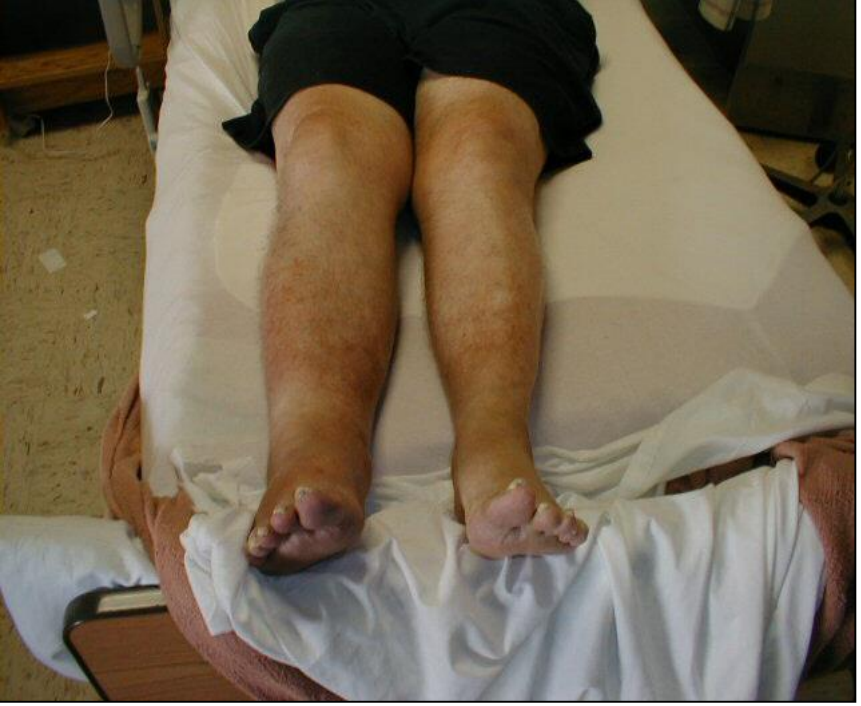


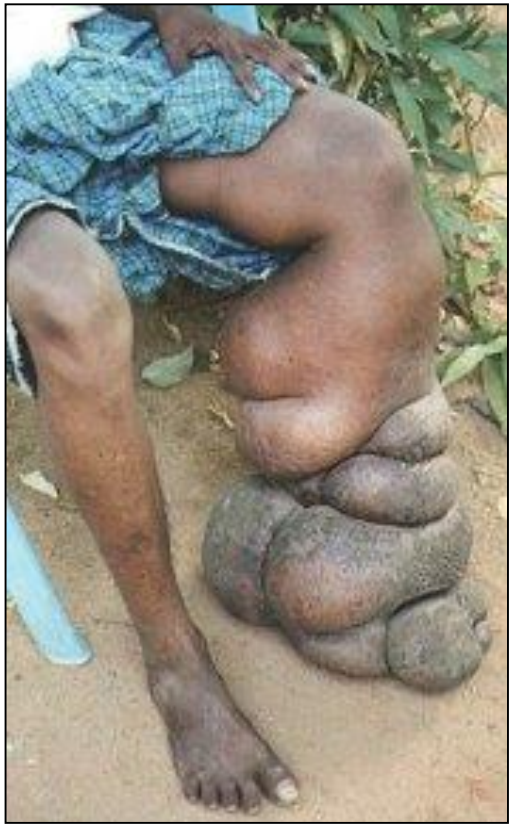
Pulmonary edema

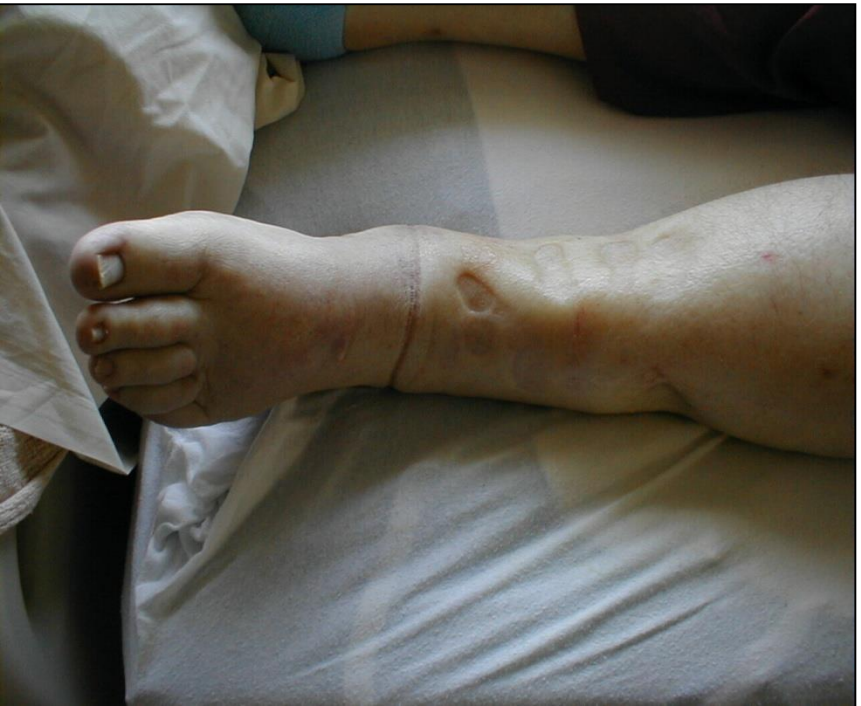


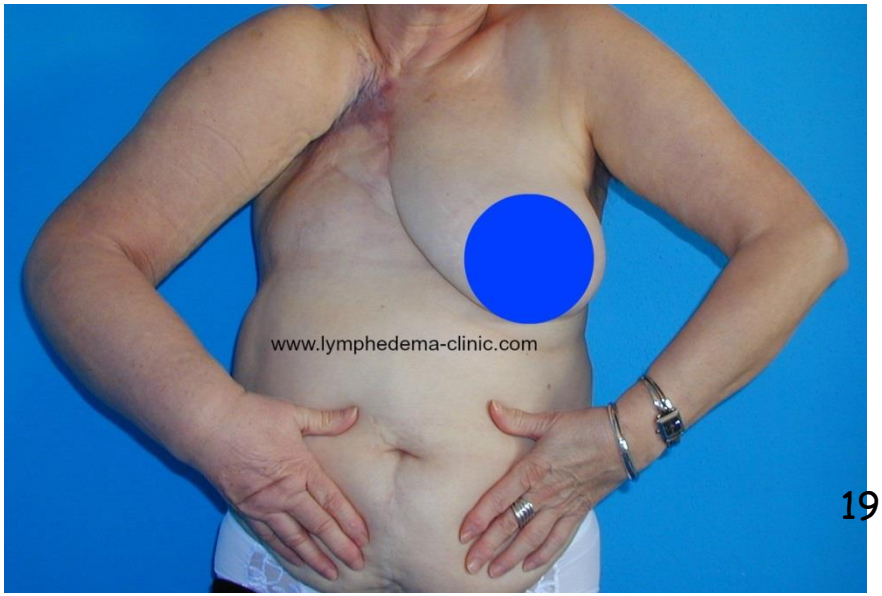








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HEMORRHAGE

Hemostasis-protagonists

- Vascular wall (endothelium)
- Platelets
- Coagulation cascade

Normal hemostasis–sequence of events

- **Arteriolar vasoconstriction** (major regulator: endothelin)
- Platelet adherence, activation and aggregation ⟹ **Primary hemostasis** (major regulator: ECM)
- Fibrin meshwork creation, additional platelet recruitment ⟹ **Secondary hemostasis** (major regulator:Tissue factor)

Hemorrhage

- **Definition:** Extravasation of blood
- **Pathogenesis:**
  - Rupture of vessel wall **(haemorrhagia per rhexim)**
  - Erosion of vessel wall **(haemorrhagia per arrosionem)**
  - Vascular wall disturbances and other hemorrhagic diatheses **(haemorrhagia per diapedesim)**
    - **Vessel wall abnormalities**: due to – hypoxia, infections, drugs, impaired collagen synthesis, Henoch-Schönlein purpura, Hereditary hemorrhagic teleangiectasia etc.
    - **Other hemorrhagic diatheses**

-Thrombocytopenia (low platelet count)

Decreased platelet production

Bone marrow diseases, bone marrow infiltration, drug induced (Heparin-induced thrombocytopenia), infections (HIV associated!) etc.

Decreased platelet survival

- Immune thrombocytopenic purpura (ITP, autoimmune)
- Thrombotic microangiopathies (TTP: thrombotic thrombocytopenic purpura, HUS: Hemolytic- uremic syndrome)

-Thrombasthenia (defective platelet function): primary, secondary (aspirin!!!)

-Abnormalities in clotting factors

- Primary, or Secondary (acquired – eg. In hepatic diseases!)
- Von Willebrand disease
- Hemophilia A (factor VIII deficiency)
- Hemophilia B (Factor IX deficiency- Christmas disease)
- Hemophilia C (Factor XI deficiency)

Disseminated intravascular coagulation (DIC, consumption coagulopathy)

» Causes: obstetric complications, infections, neoplasms, excessive tissue injury

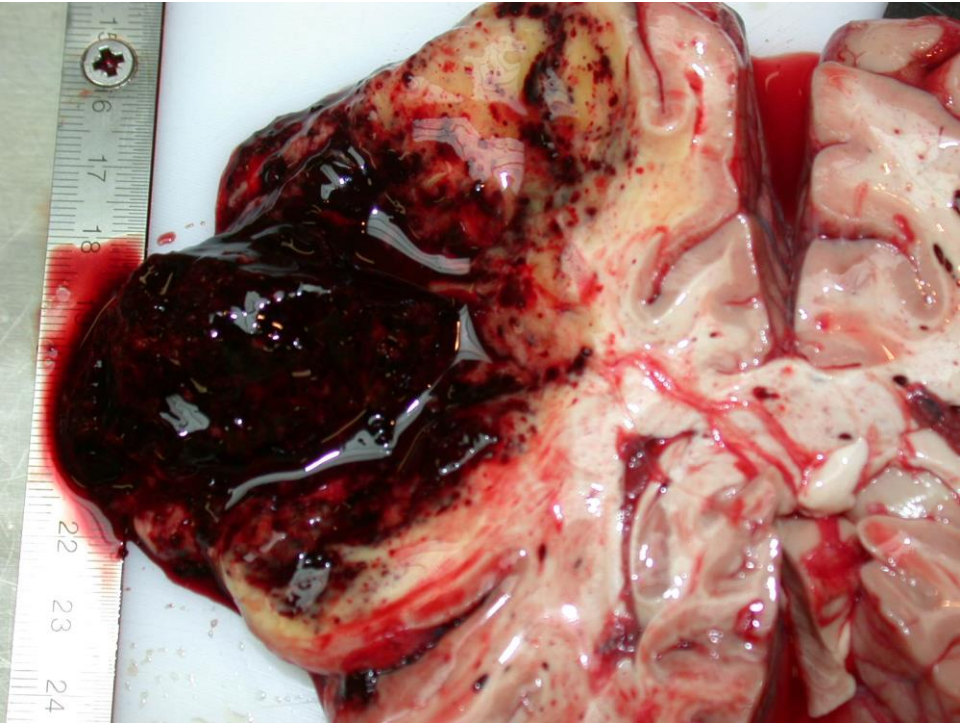
» Hemorrhage and thrombosis

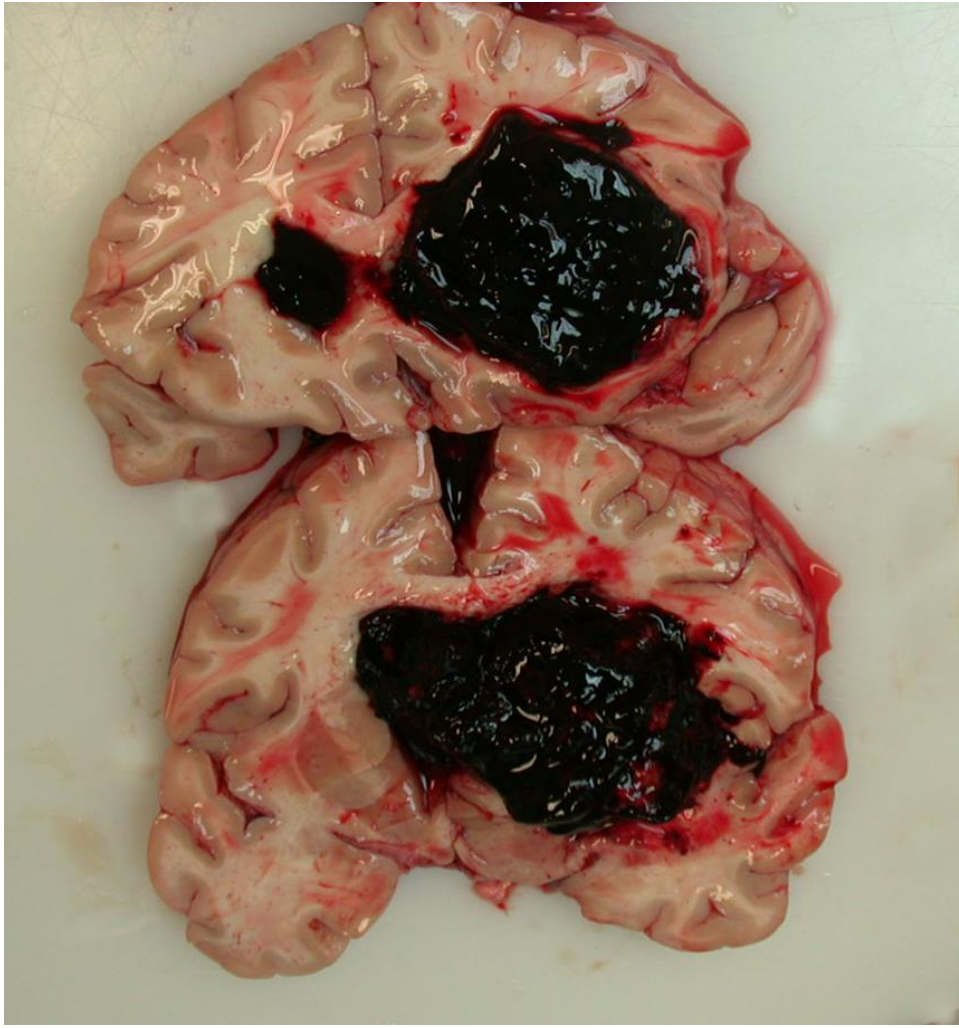
Categories

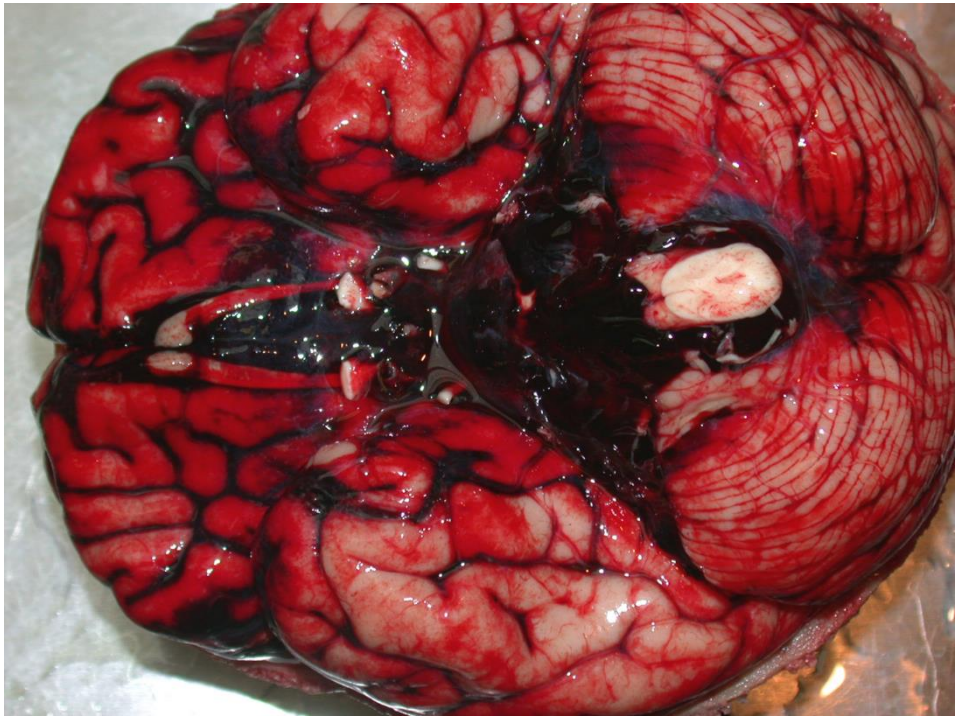
- By extent
  - Exsanguination, hematoma, suffusion, ecchymosis, petechia, purpura
- By localization

  eg: hemothorax, hemopericardium, hemascos, hemarthrosis, epistaxis, hematemesis, melena, hematochesia…

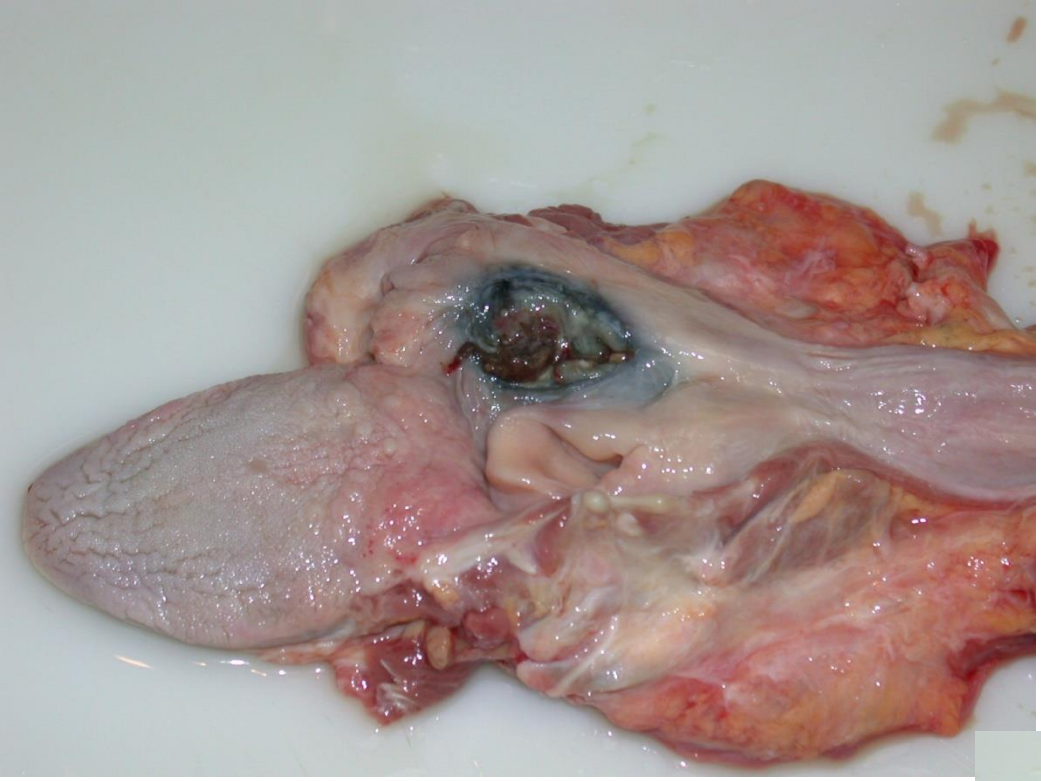
By pathomechanism…

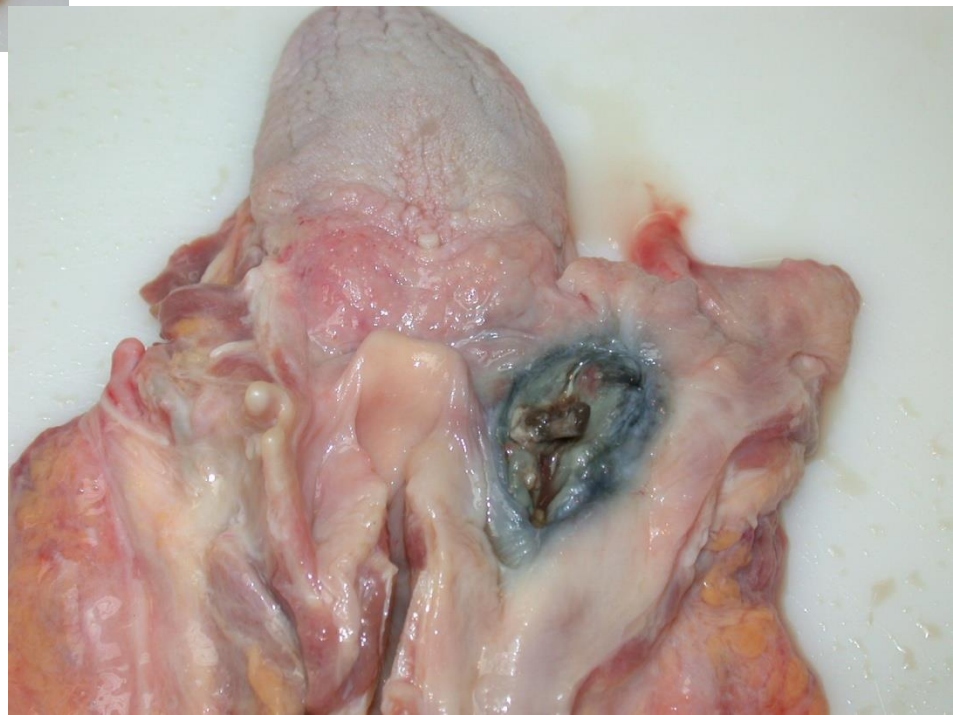






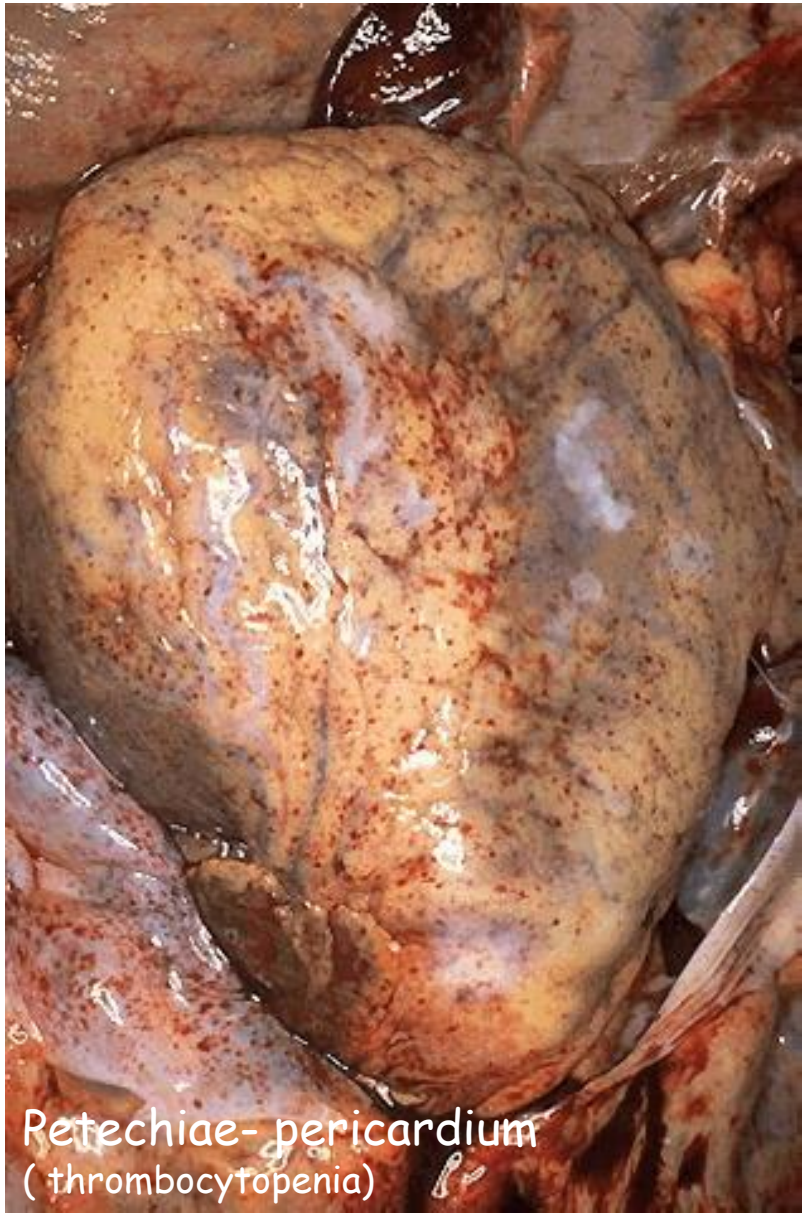
Haemorrhagia per rhexim (by rupture)- cerebral



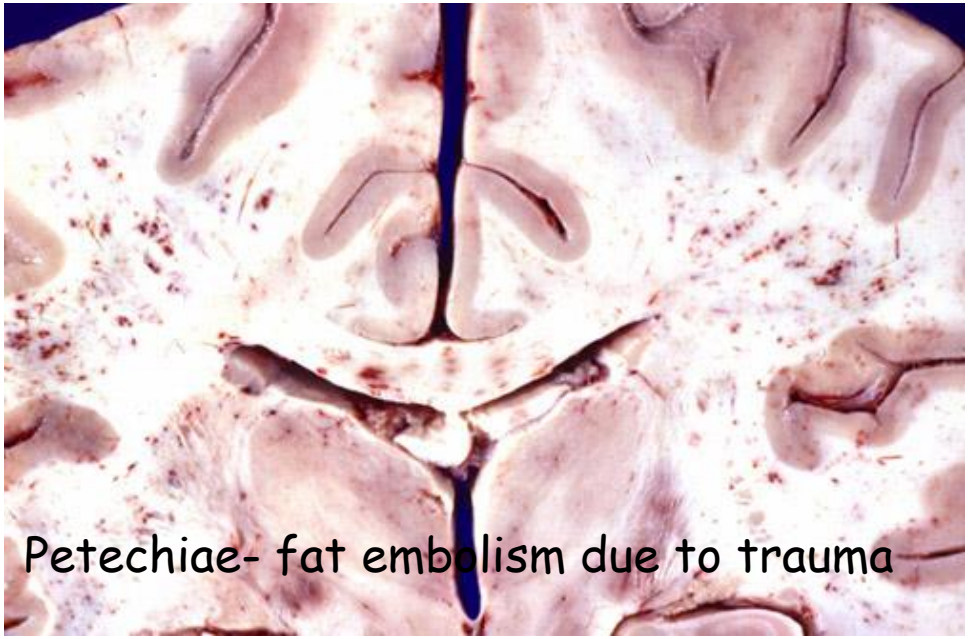


Haemorrhagia per arrosionem
(by erosion)

(hypopharynx tumor)



Petechiae- pericardium
(thrombocytopenia)

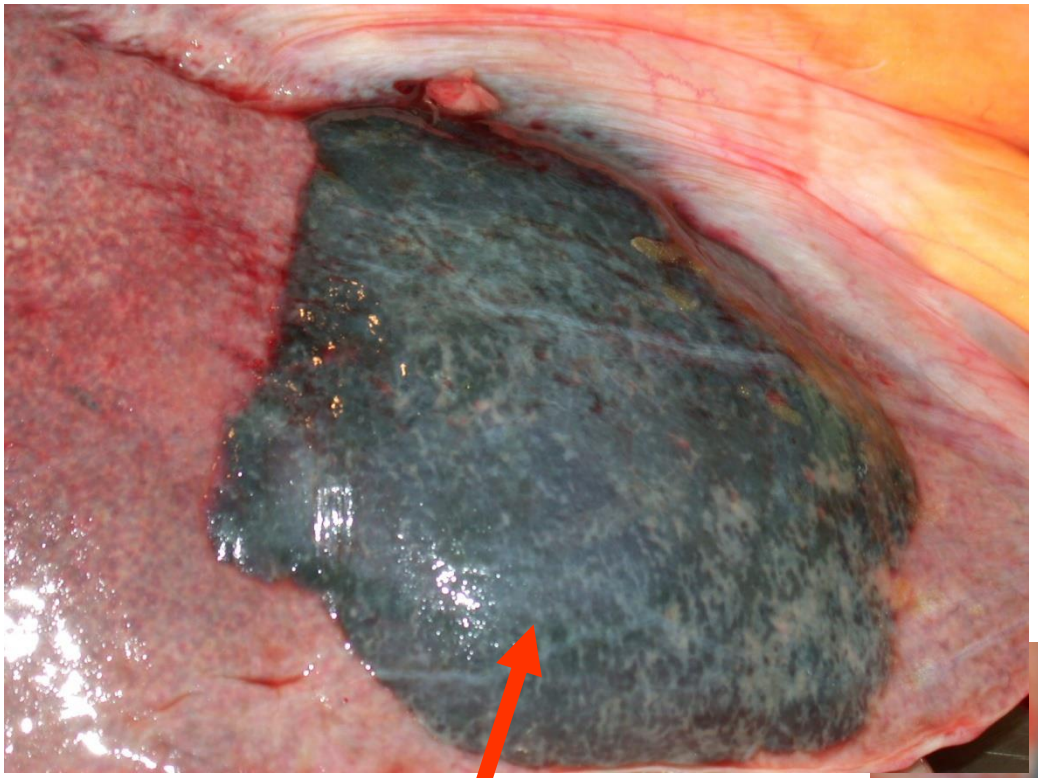


Petechiae- fat embolism due to trauma

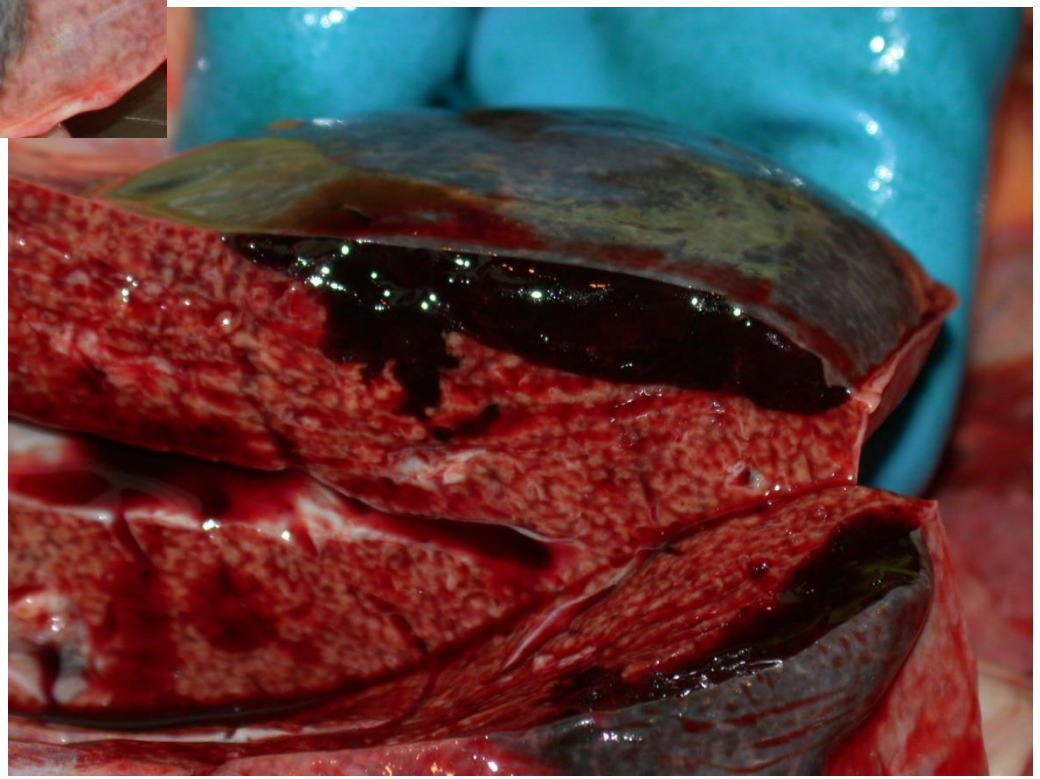
Haemorrhagia per diapedesim (by diffusion)

Categories by extent…

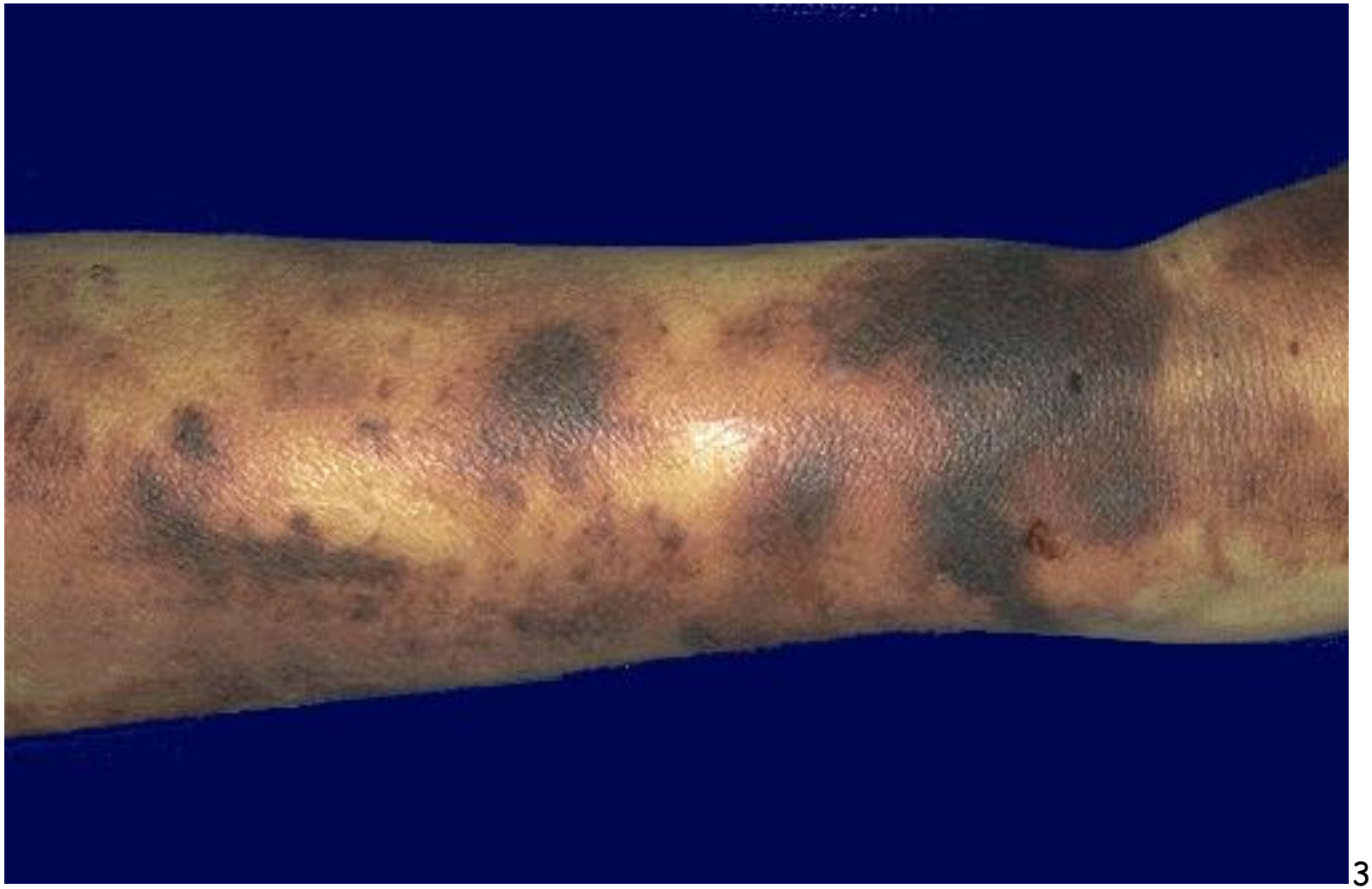
Subcapsular hematoma - liver

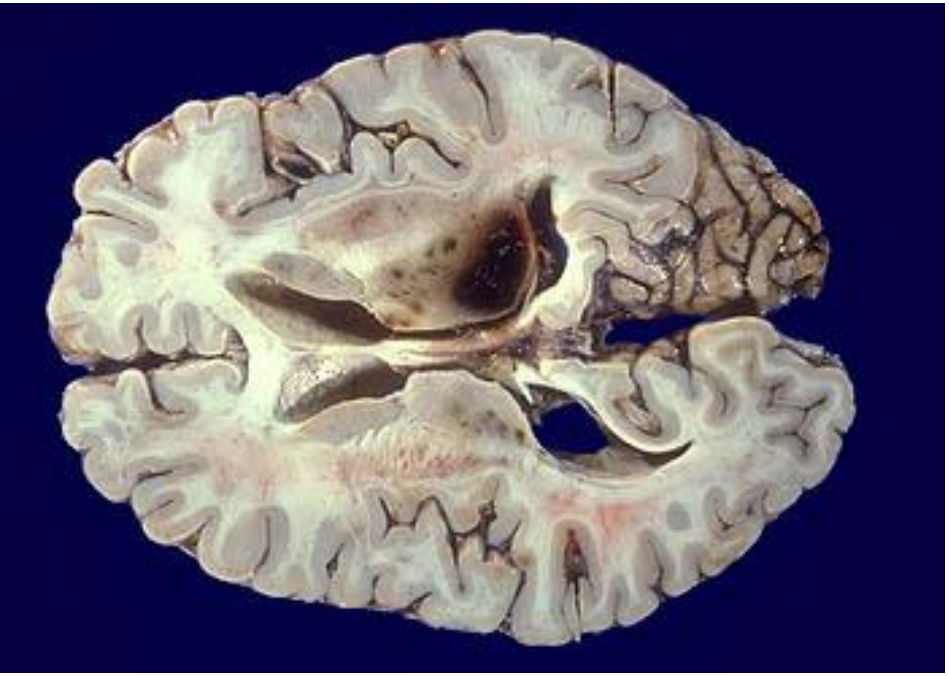


hematoma

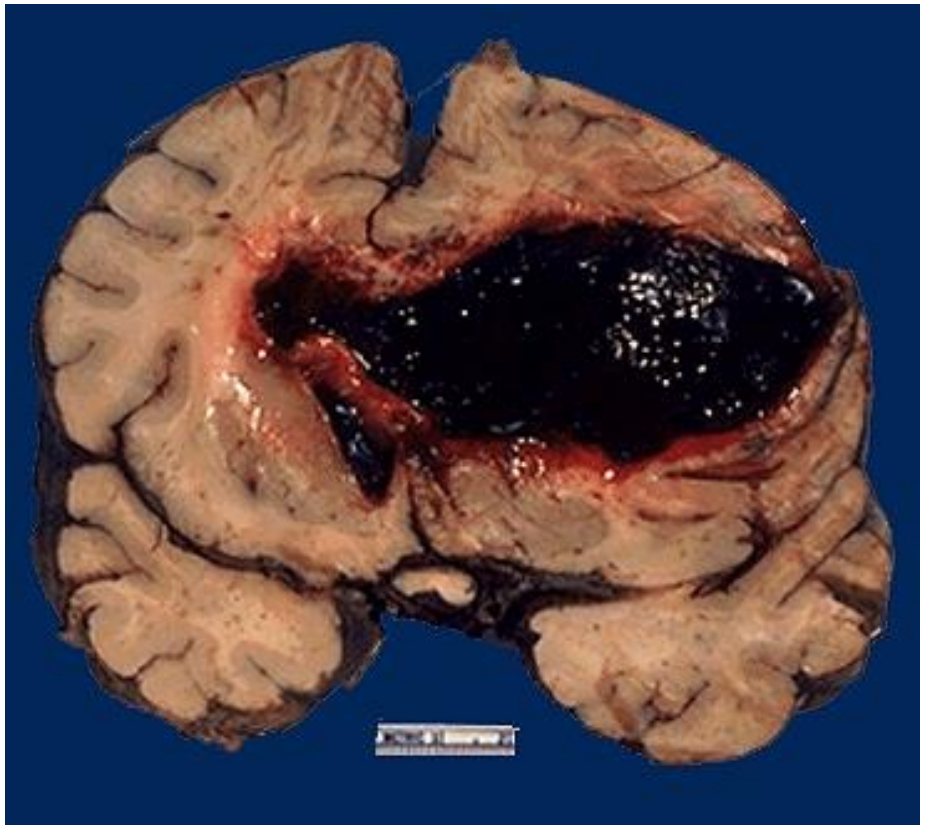


Suffusion, hematoma

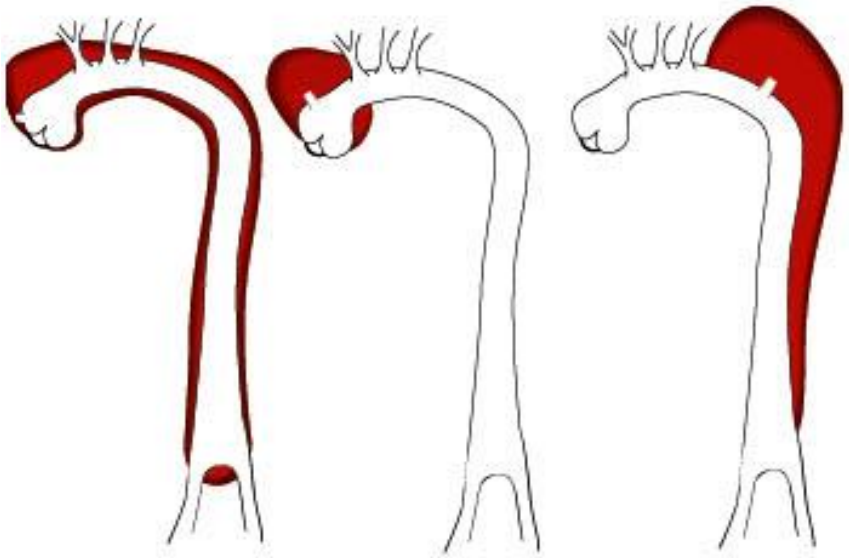


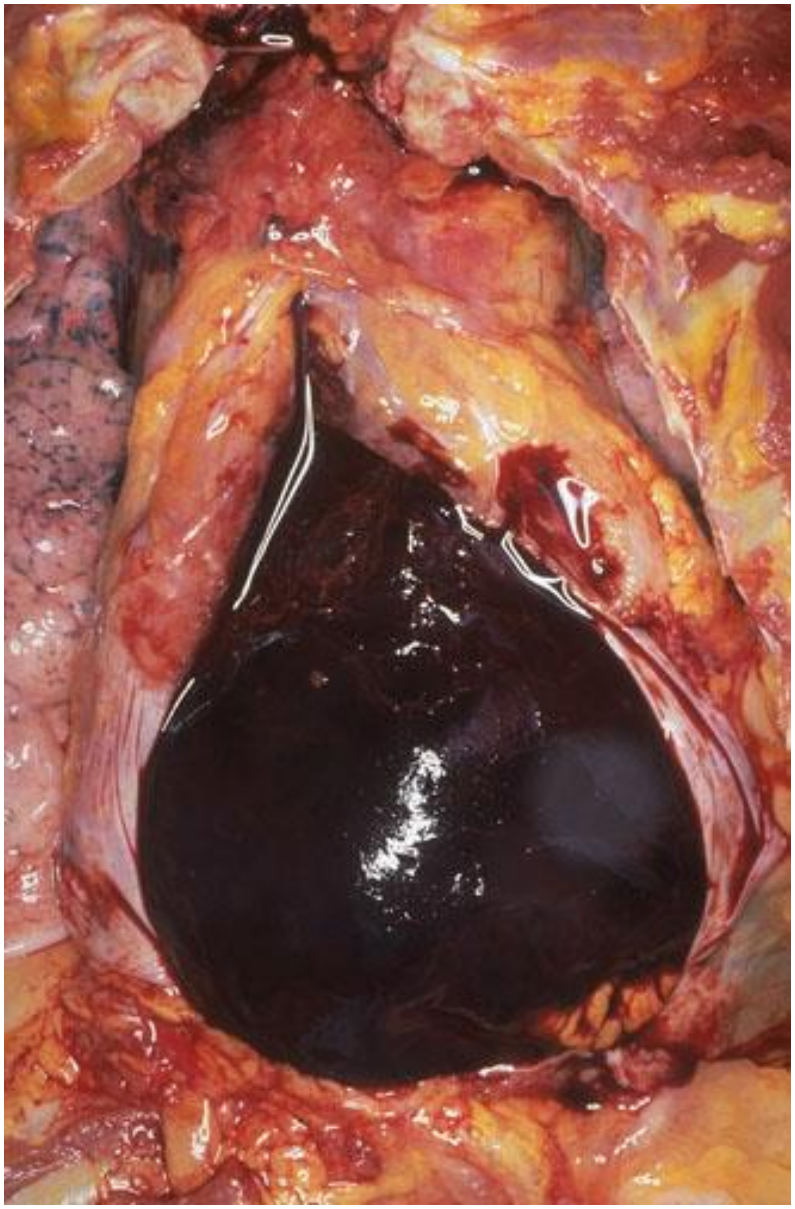


Thalamus -
hemorrhage-
hypertension



Apoplexia cerebri-
hypertension





Hemopericardium- due to aortic dissection

THROMBOSIS

THROMBOSIS

- **Definition**: coagulation of blood within vessels or heart chambers

- **Pathogenesis** (Virchow's triad)
  1. **Endothelial injury** (inflammation, hypertension, atherosclerosis etc.)
  2. **Stasis or turbulence** of blood flow
  3. **Hypercoagulability**
     - **Primary** (Genetic predisposition) (e.g. Leyden-mutation in factor V. (resistant to cleavage by protein C)
     - **Secondary (Acquired):** smoking, obesity, drugs, pregnancy, malignant tumors (e.g. pancreas cc- Trousseau phenomenon), antiphospholipid antibody syndrome

Classification by localization I.

Arterial thrombosis

Pathogenesis: endothelial injury, turbulent blood flow (due to atherosclerosis, vasculitis)

Complications:

- **Ischemia** (non occlusive thrombus)
- **Infarction** (occlusive thrombus)

a.coron.-AMI, angina pectoris
Cerebral arteries- TIA, stroke, status lacunaris
a. mesenterica sup. or inf.- bowel infarction

Classification by localization II.

Venous thrombosis (phlebothrombosis)

Pathogenesis: stasis (varicositas, immobilization), thrombophlebitis

Localization: 90% legs

Periprostatic, parametrial plexus, dura sinuses, v. portae, vv.hepaticae, Trousseau phenomenon: migratory thrombophlebitis

Complications: Ulcus cruris

Postthrombotic sy

Vena cava superior sy

Vena cava inferior sy- congestion in lower extremities, pelvis

Classification by localization III.

Thrombosis in heart chambers (like arterial thrombosis)

Pathogenesis: endothelial injury (eg. AMI), turbulent blood flow (dilatation, AMI)

Complications: atrial, ventricular, valvular (endocarditis maranthica) thrombi may be the source of **embolism**

Fibrin (Hyalin) thrombi

- In arterioles, capillaries, venules (disordered microcirculation)
- Composed of platelets, fibrin
- DIC

Secondary hypercoagulable states

High risk for thrombosis

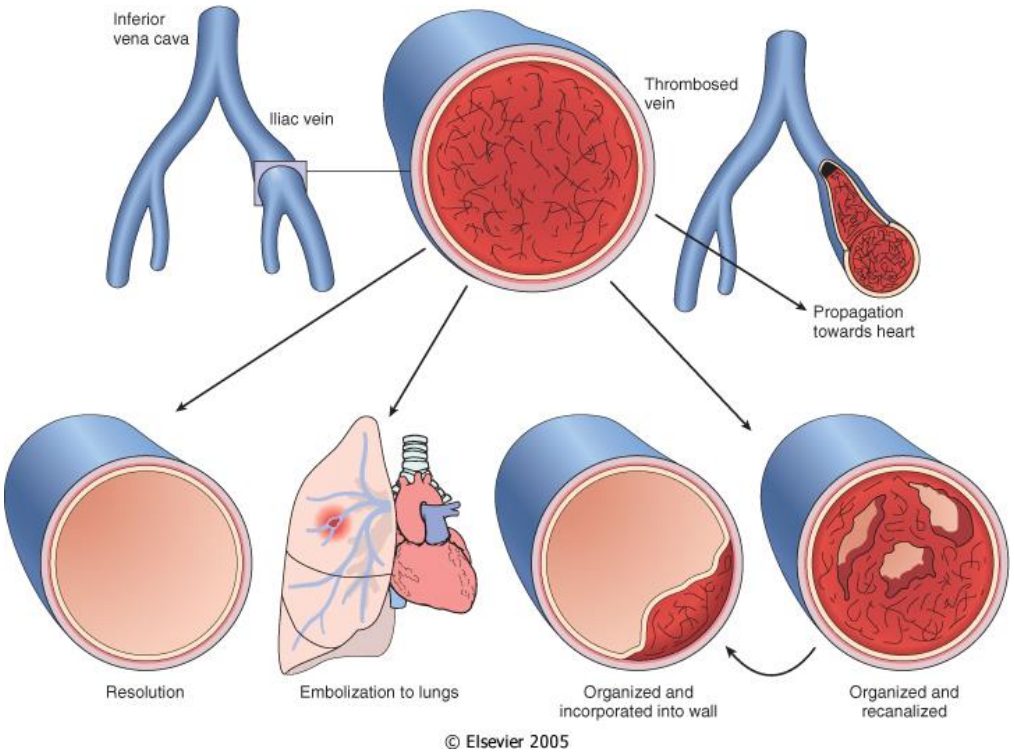
- Prolonged bed rest or immobilization
- Myocardial infarction
- Atrial fibrillation
- Tissue damage
  - (including surgery fractures, burns etc)
- Prosthetic cardiac valves
- Disseminated intravascular coagulation
- Heparin-induced thrombocytopenia
  - HIT (unfractionated heparin)
- Cancer
- Antiphospholipid antibody syndrome
  - („lupus anticoag.sy")

Secondary hypercoagulable states

Lower risk for thrombosis

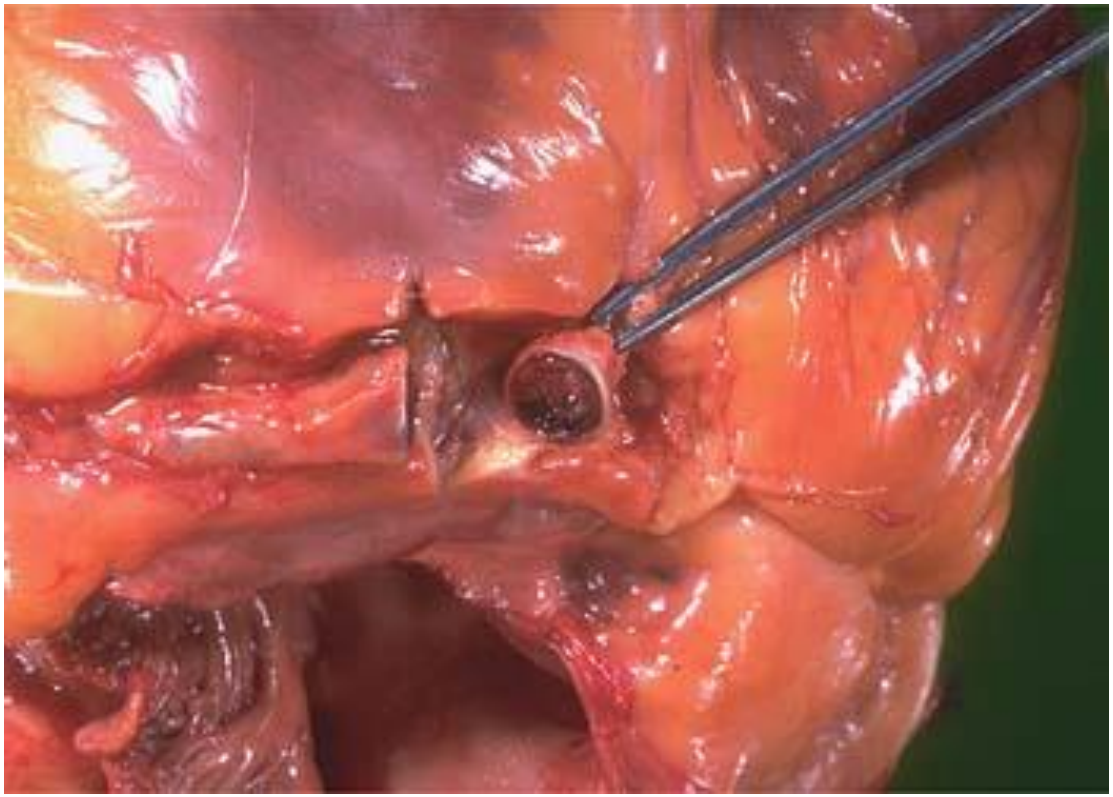
- Cardiomyopathy
- Nephrotic syndrome
- Hyperestrogenic states
  (Pregnancy,postpartum)
- Oral contraceptives
- Hyperlipidaemia
- Sickle cell anaemia
- Smoking

FATE OF THROMBI



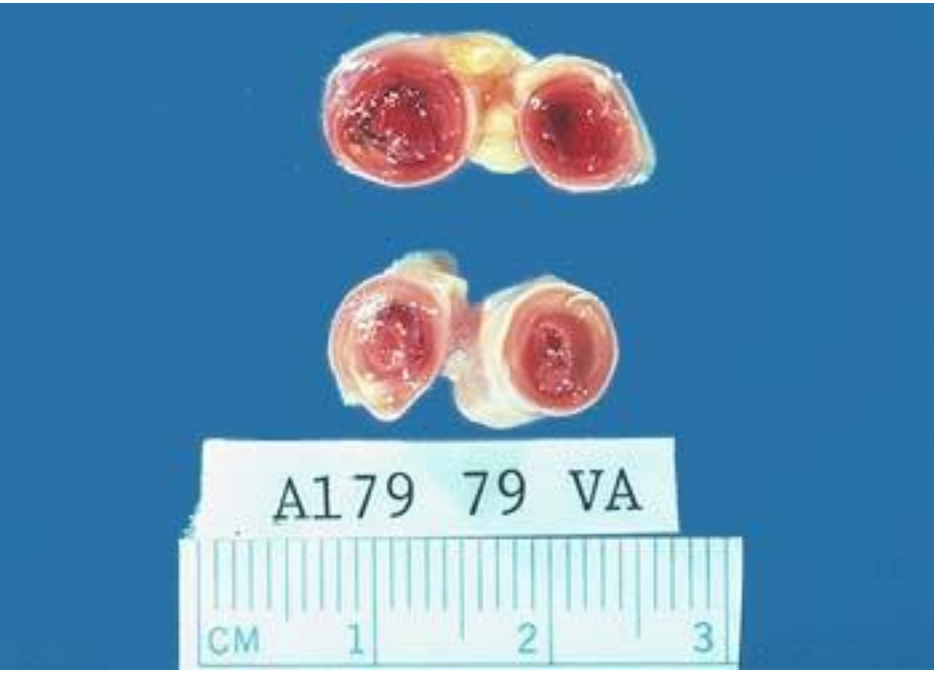
- Resolution
- Propagation
- Embolization
- Organization, recanalization

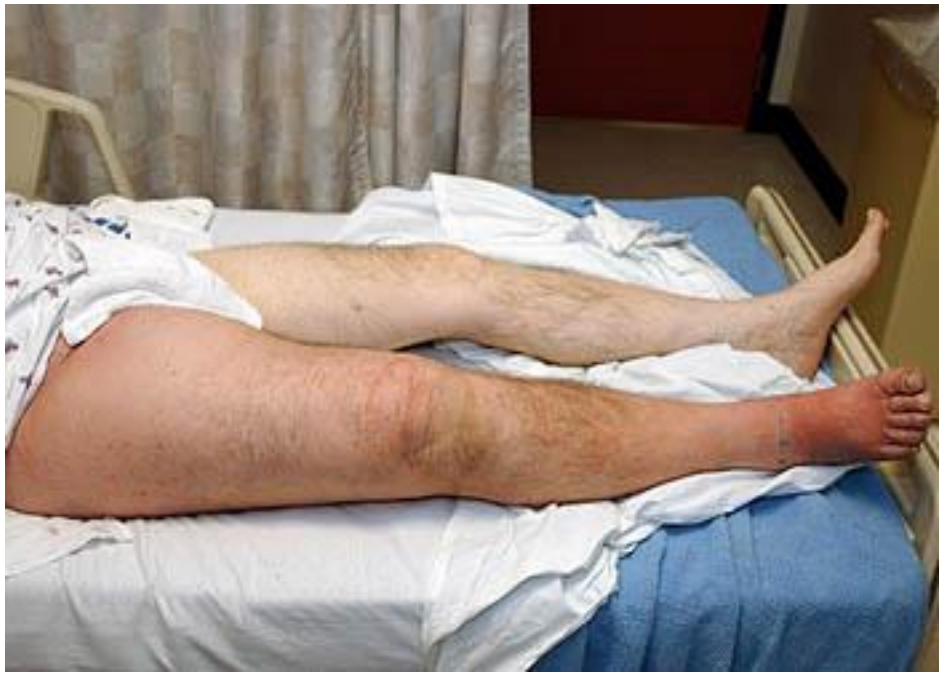
Arterial thrombus



Coronary artery thrombosis

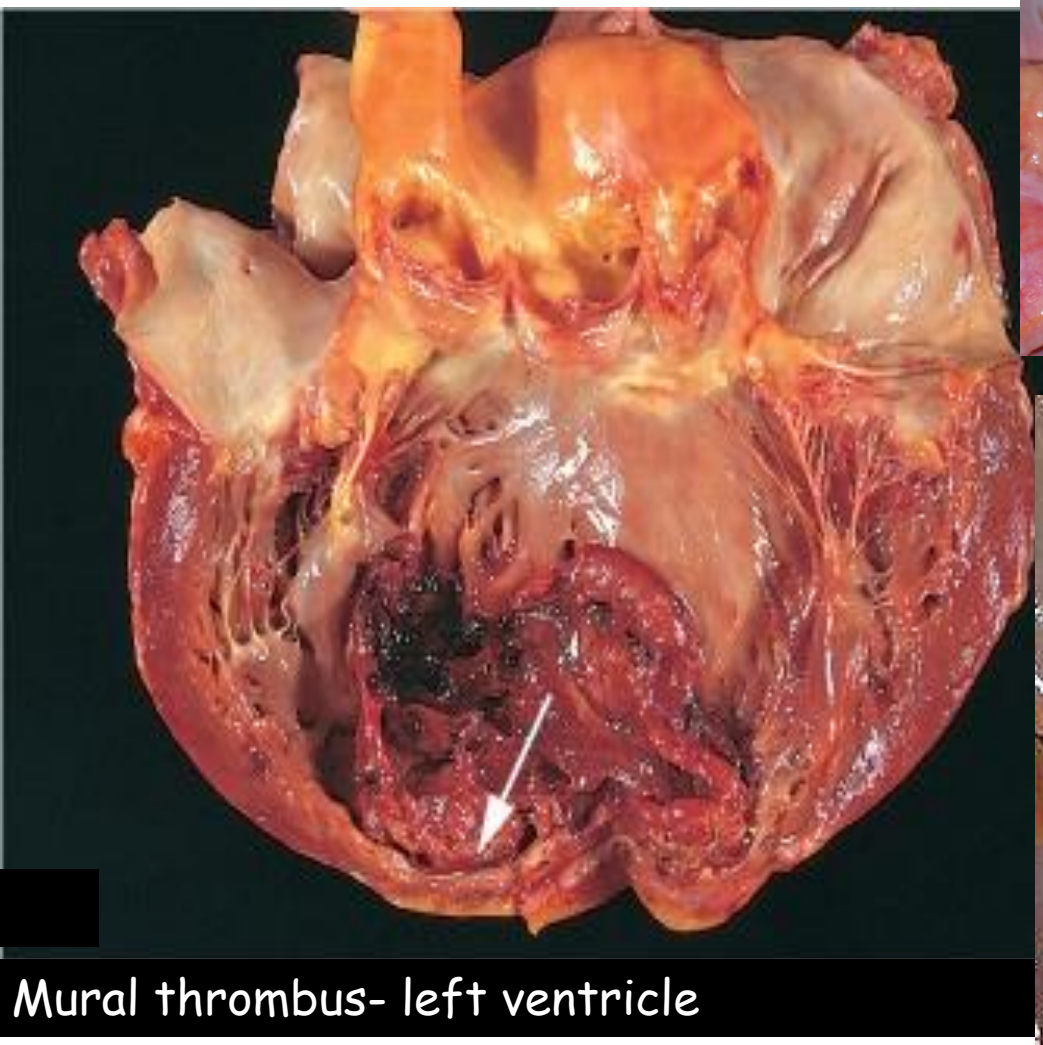
Venous thrombosis



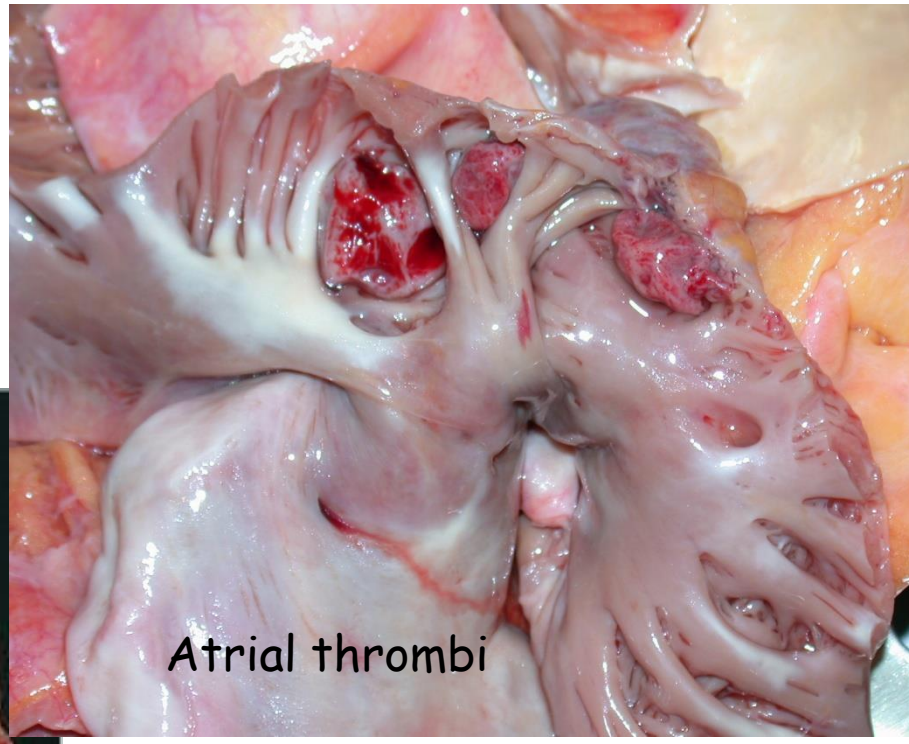


Thrombus in iliac vein

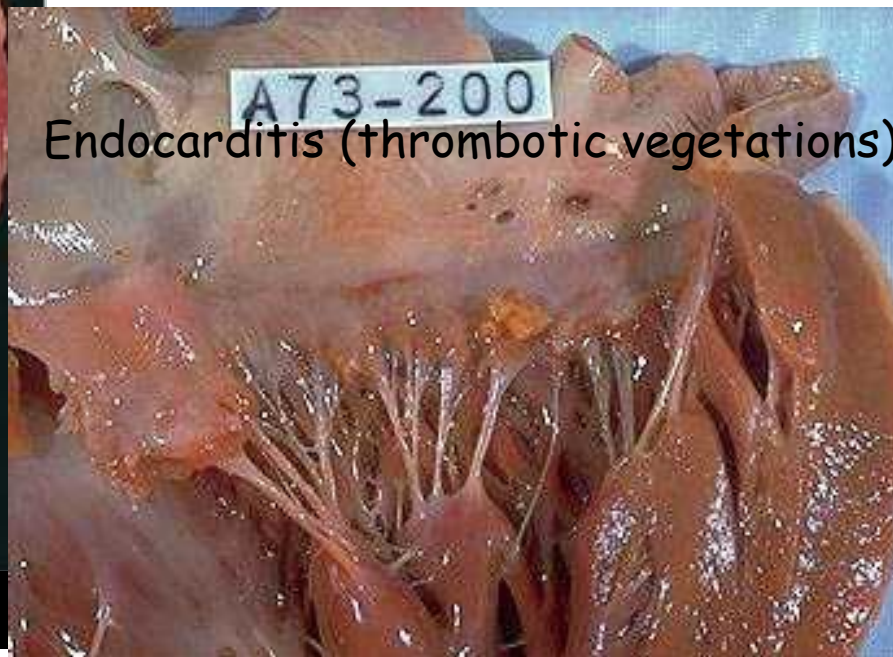
Cardiac thrombi



Mural thrombus- left ventricle



Atrial thrombi



Endocarditis (thrombotic vegetations)

EMBOLISM

- **Embolus**: detached intravascular gaseous, liquid or solid mass carried by the bloodstream from its site of origin to another site where it causes vascular obstruction and subsequent tissue damage (necrosis)
- **Forms**:
  - **Thromboembolism**
  - **Fat embolism**
  - **Air embolism**
  - **Amniotic fluid embolism-**pulmonary edema, ARDS, DIC
  - Cholesterol embolism- kidney
  - Bacterial embolism- e.g. infective endocarditis
  - Foreign body embolism- i.v. drug abusers

Thromboembolism I.

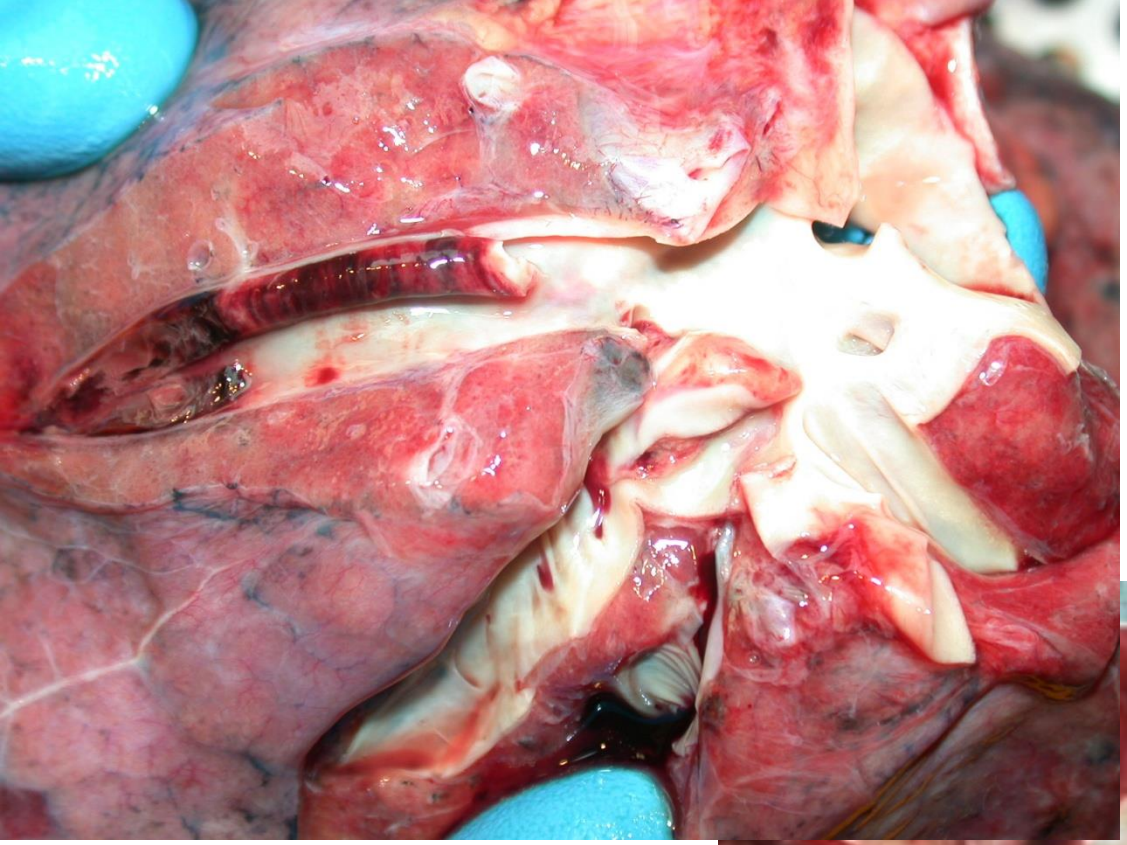
Pulmonary thromboembolism

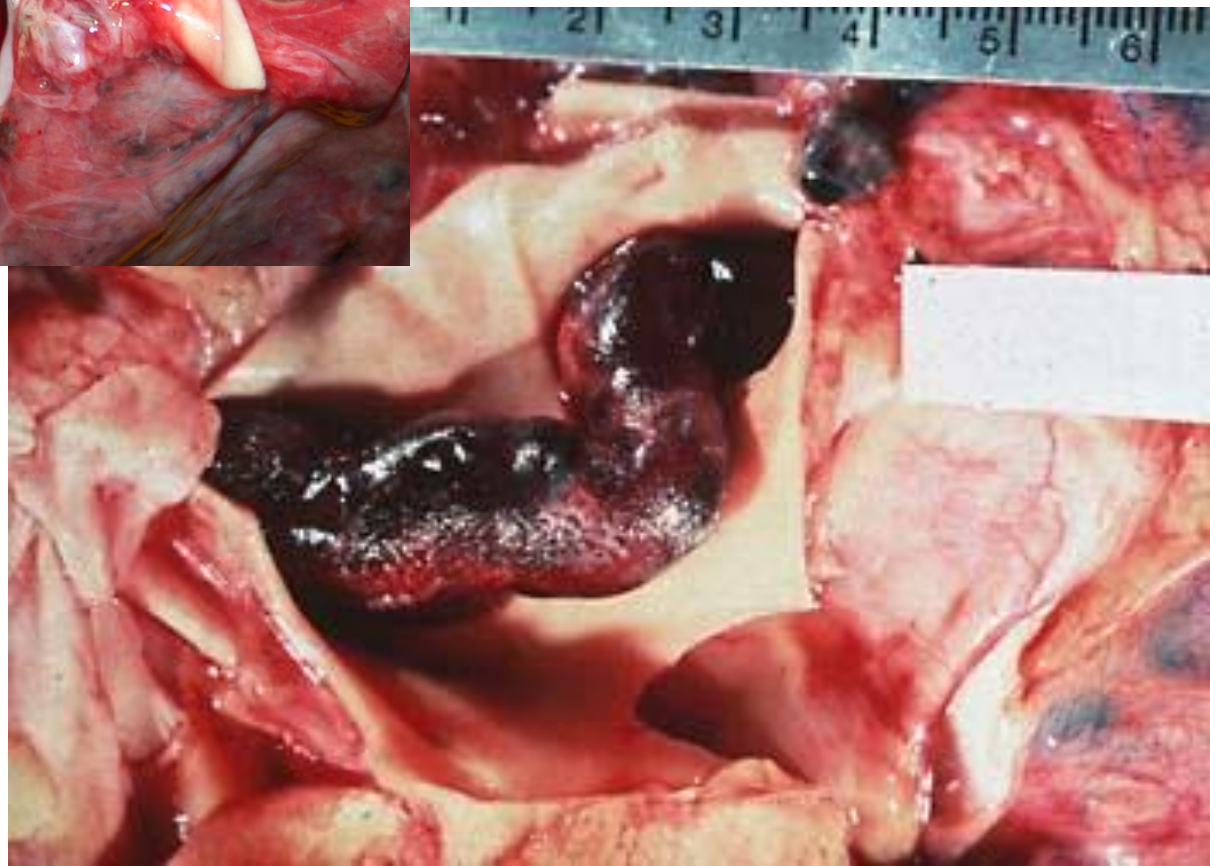
Source: deep venous thrombosis of lower extremities

Possible complications: - sudden death (saddle embolus)

- pulmonary hypertension, cor pulmonale
- hemorrhage, hemorrhagic infarction

Pulmonary embolism





Thromboembolism II.

Systemic thromboembolism

Source: -80% mural thrombi within heart chambers (AMI, left atrial thrombi)

-others: aortic atherosclerosis, aortic aneurysm, vegetations (in endocarditis), unknown origin

Paradoxical embolism!

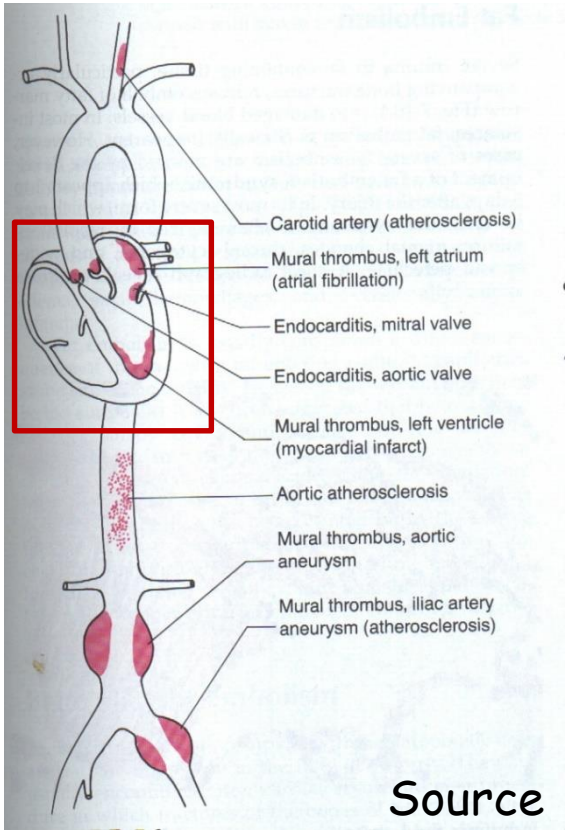
Complications: arterial embolization

-in lower extremities (75%)

-in the brain (10%),

-in arteries of bowel, kidney, spleen, upper extremities

→INFARCTION



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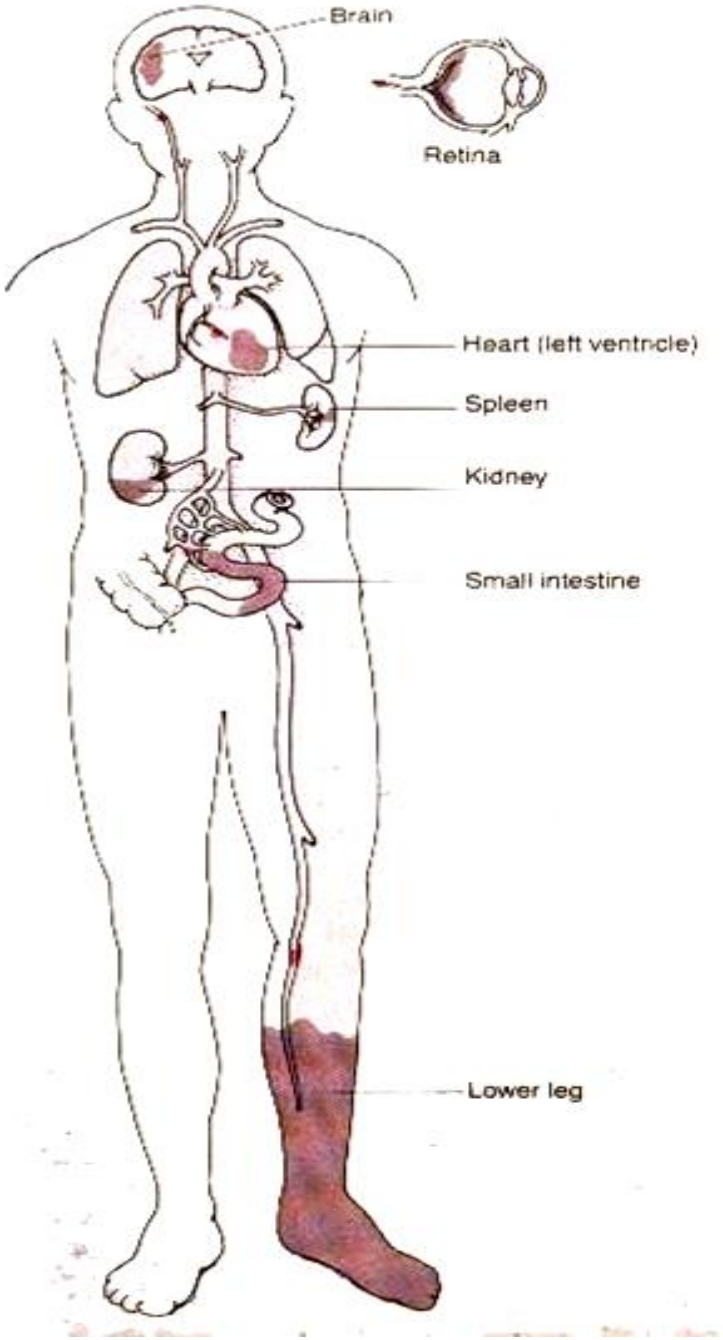

Systemic arterial embolization

lower extremities
brain
retina
heart
spleen
kidney
small bowel

Fat embolism

- After fractures of long bones
- **Clinical signs**: respiratory distress, neurologic symptoms (restlessness, irritability, delirium, coma), anemia, thrombocytopenia
- Mechanic and toxic injury

Air embolism

Causes:-Trauma (chest wall injury)

-obstetric complications

-decompression disease (eg. scuba divers)

-caisson's disease

Complications: neurological symptoms, pulmonary hemorrhage and edema, atelectasis, epiphyseal necrosis of long bones