

# Hemodynamic Disorders, Thromboembolic Disease and Shock (part 1)



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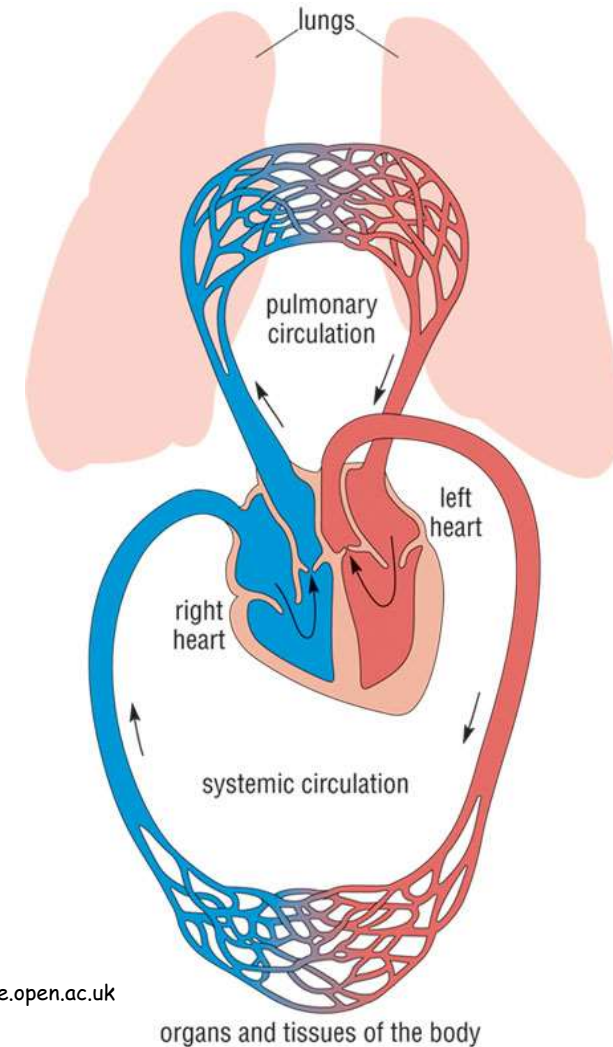
18<sup>th</sup> September 2017

# 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



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- **ACTIVE HYPEREMIA**

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



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# HYPEREMIA II.

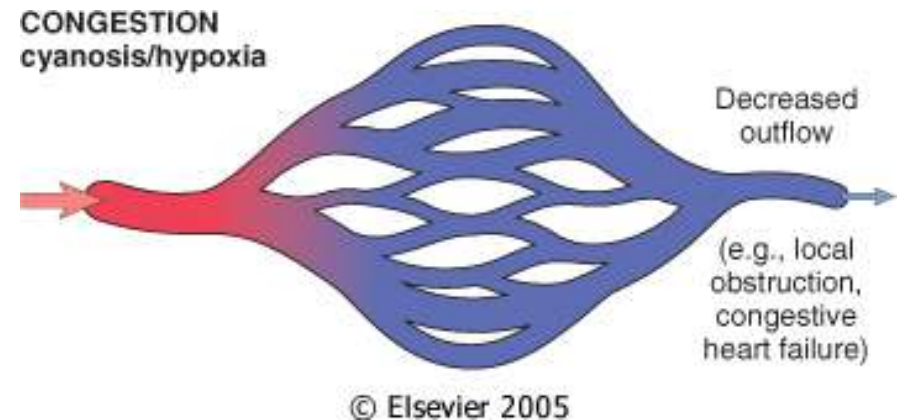
- **PASSIVE HYPEREMIA**

(congestion)

- dilation of venous side due to decreased outflow
- cyanosis, hypoxia

- **Causes:**

- **Systemic:** congestive heart failure
- **Local:** thrombosis, obstruction
  - Deep venous thrombosis-legs
  - Pylethrombosis- portal congestion
  - V.cava sup. syndrome

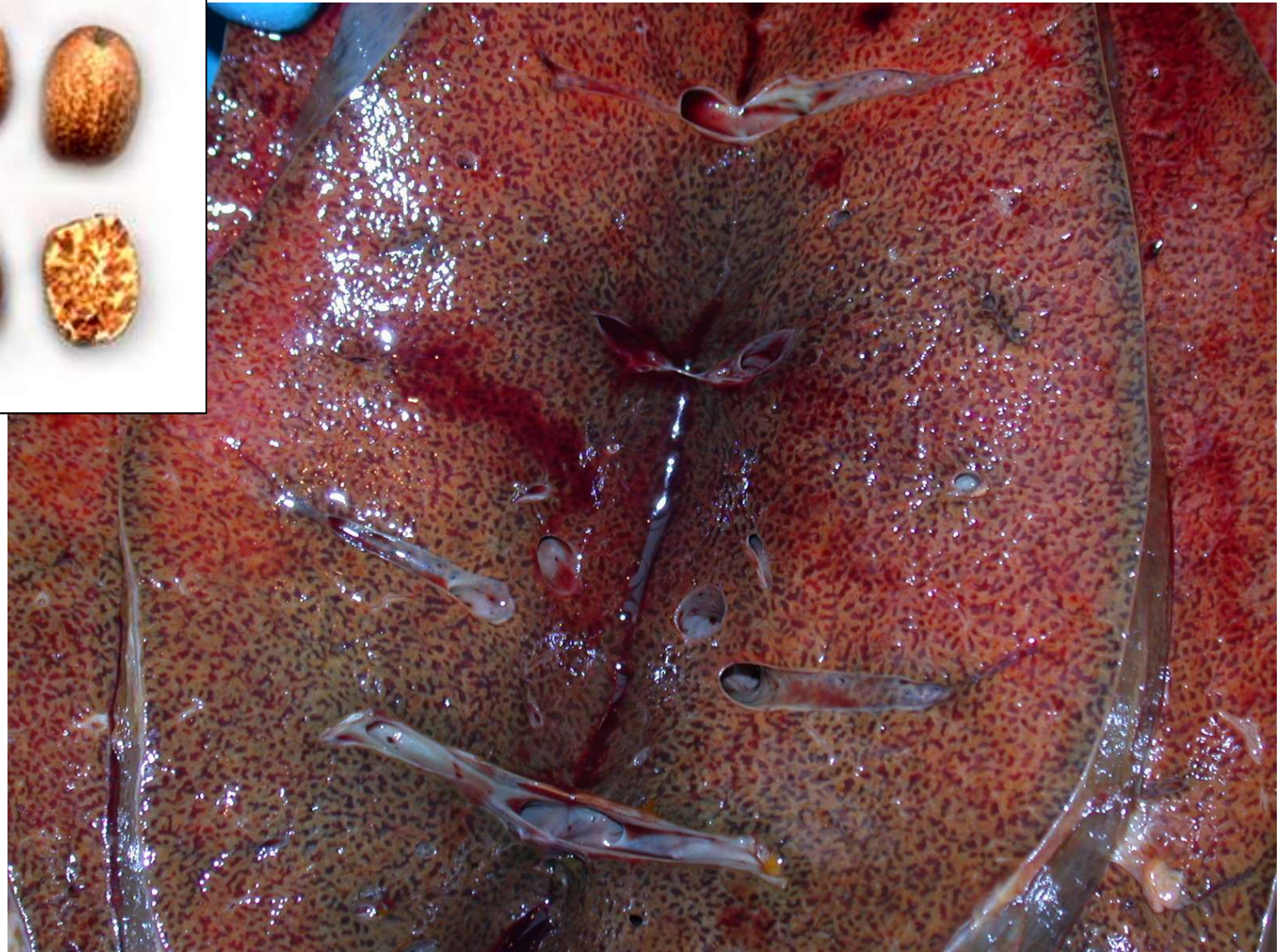


# Consequences of chronic congestion

- Systemic
  - 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
  
  - Lungs: heavy, firm, heart failure cells on microscopy, (Induratio brunea pulmonum)
- Local
  - May occur in every organ
  - E.g. Budd-Chiari sy (hepatic vein thrombosis), extremities etc.
- Stasis
  - Arterial supply maintained, venous outflow stopped
  - Consequence: necrosis ( role of collaterals!)
  - Eg. Volvulus, incarcerated hernia

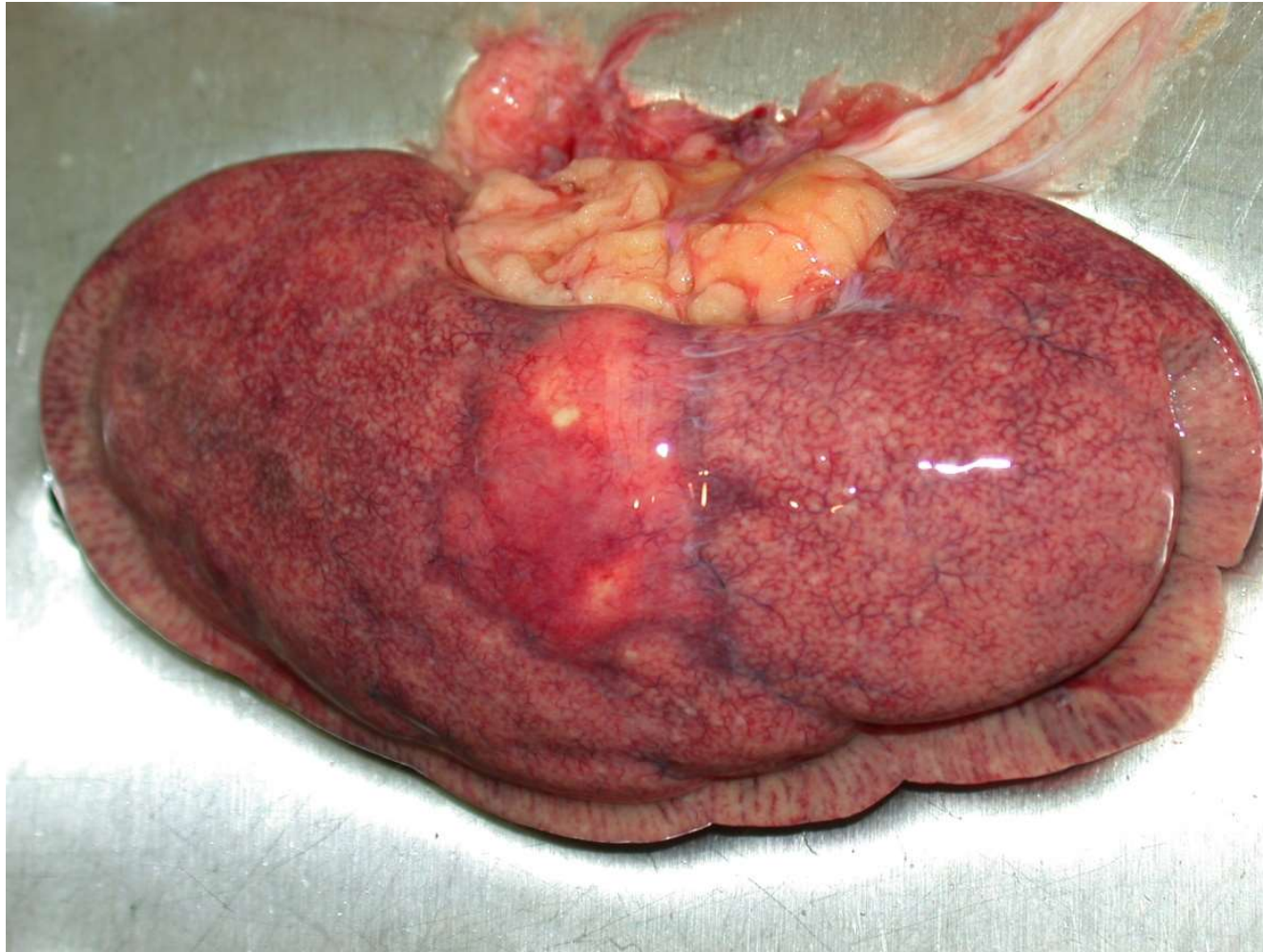


# Nutmeg liver





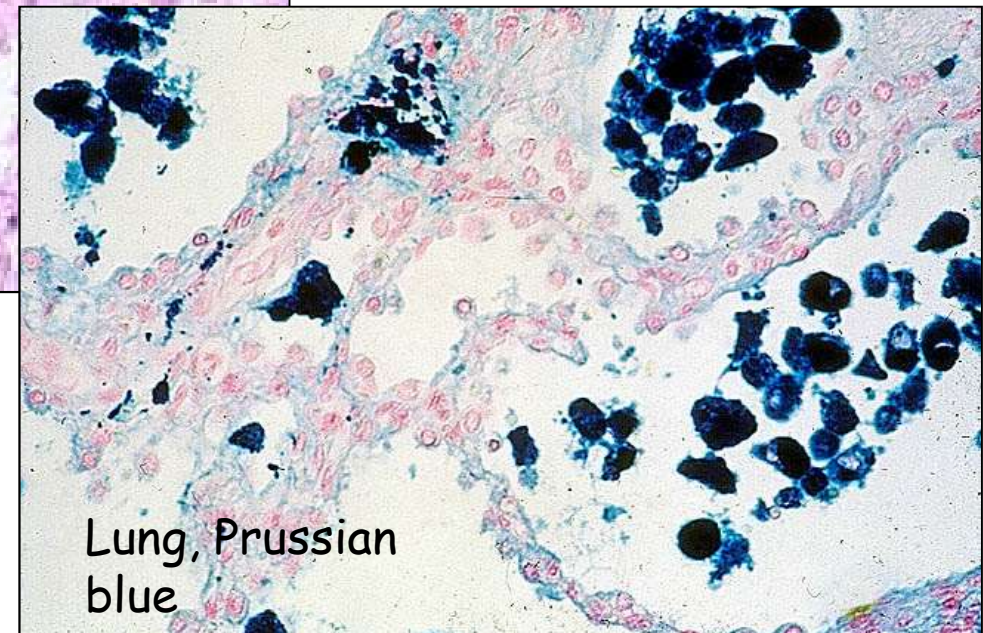
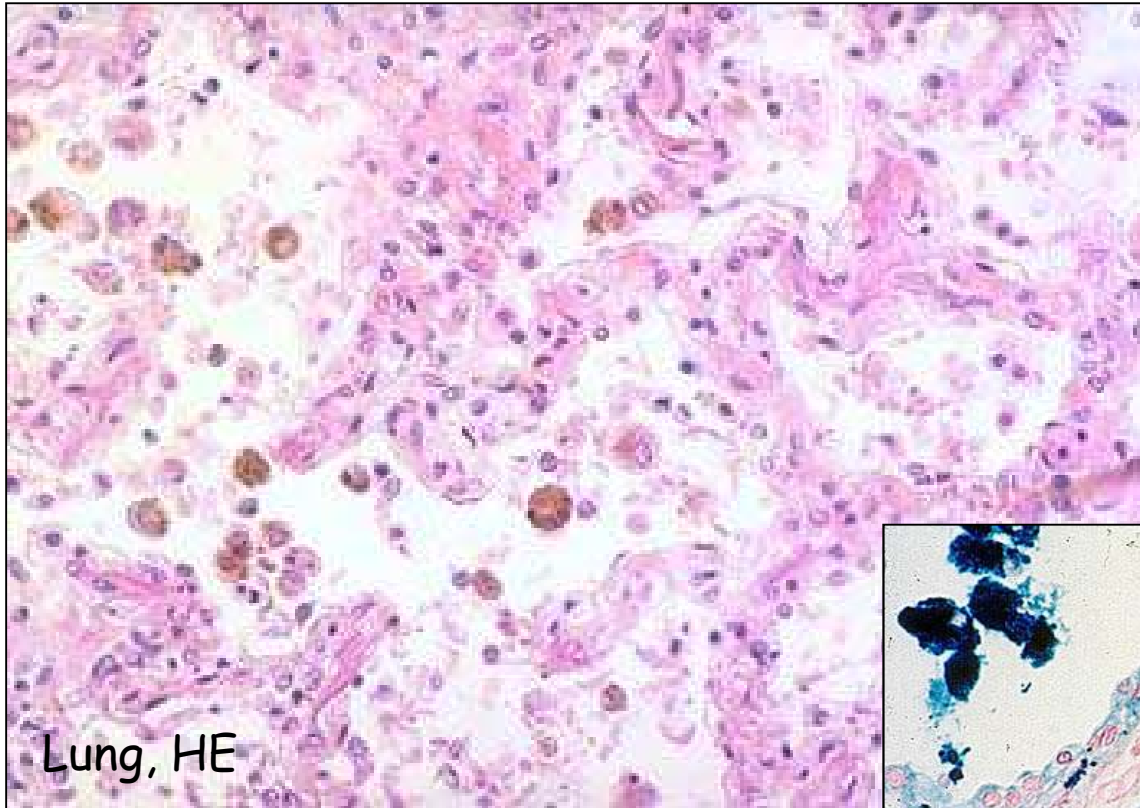
# Kidney-congestion (+?)



# Lung, chronic passive hyperemia/ congestion



# Hemosiderin in heart failure cells







EDEMA

# EDEMA

## Normal fluid homeostasis:

60% of body weight is water

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

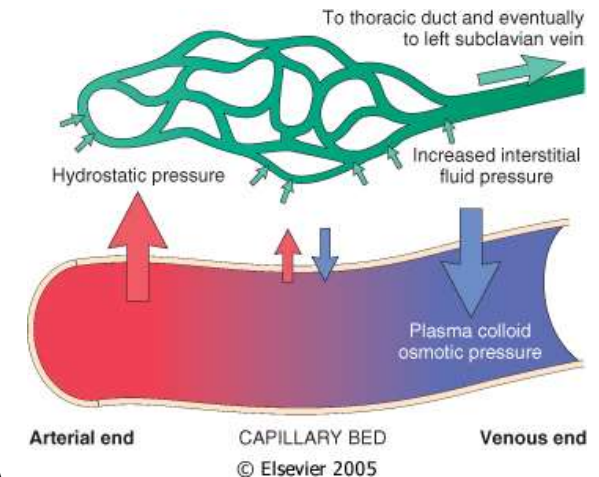
- Definition: increased fluid content in the interstitium (transudate or exudate)

- Causes:

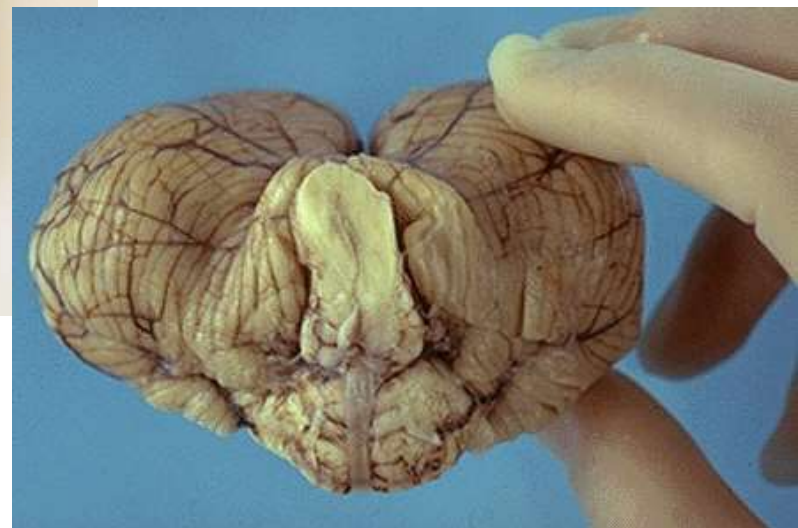
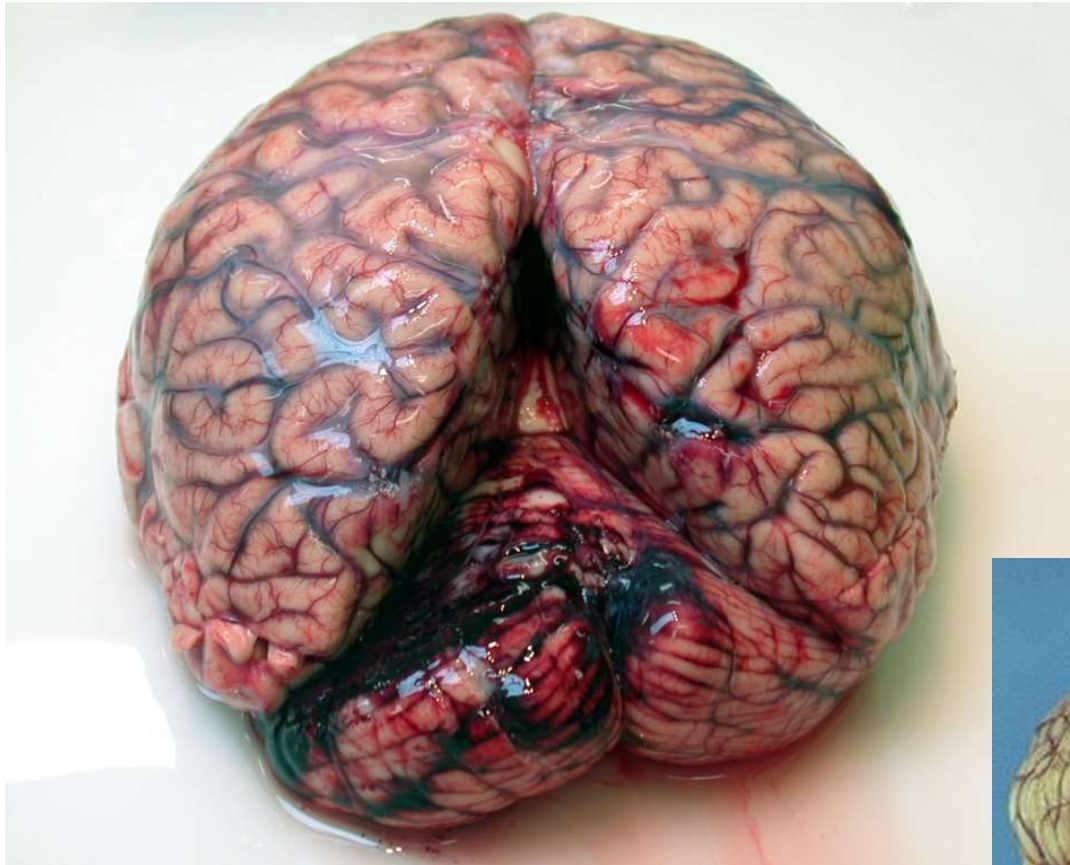
- Increased intravascular hydrostatic pressure (arteriolar dilation or impaired venous return) (local- eg. Deep venous thrombosis of the legs, systemic- eg. Congestive heart failure)
- Decreased plasma colloid osmotic pressure (eg. nephrosis sy, cirrhosis, protein malnutrition)
- Lymphatic obstruction (lymphedema, elephantiasis)
- Salt and water retention (GN, Acute renal failure)
- Inflammation (exudate)

- Morphology

- Cerebral edema (causes, morphology)
- Pulmonary edema (causes, morphology)
- Laryngeal edema (causes, Quincke-edema, morphology)
- Anasarca
- Edema in body cavities :hydrothorax, hydropericardium, ascites  
Renal origin (periorbital)— Congestive heart failure

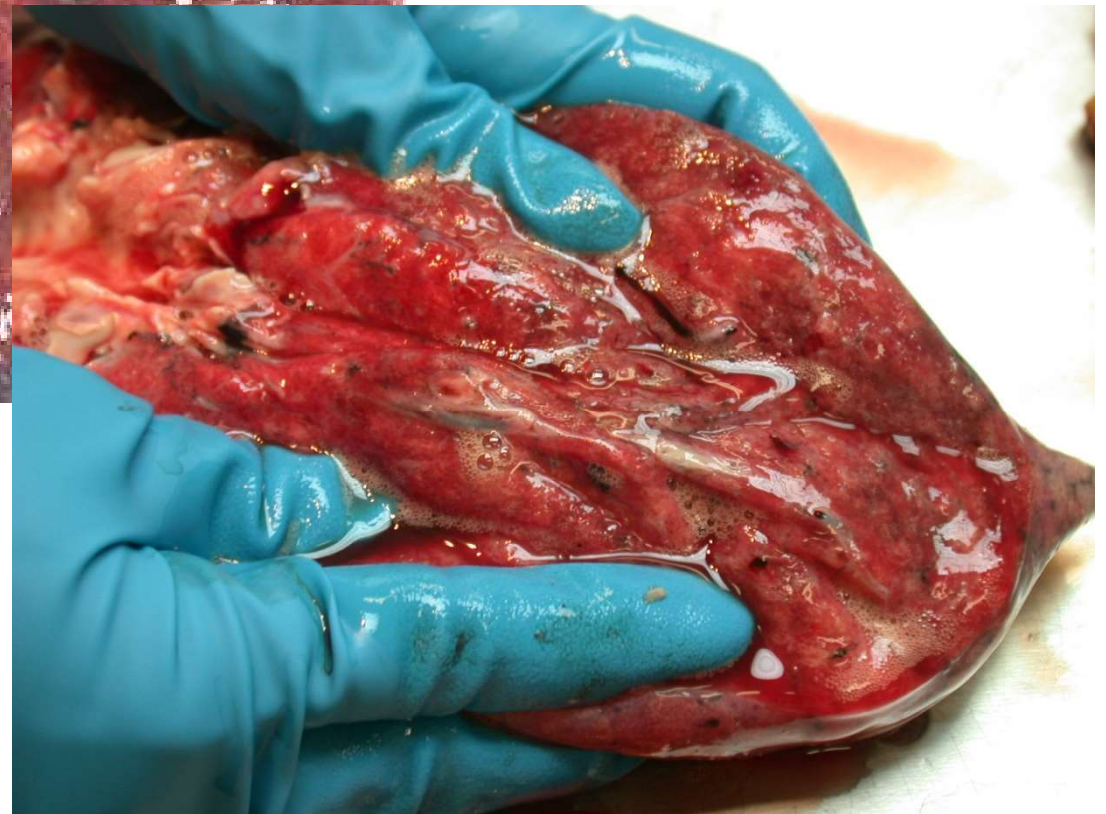
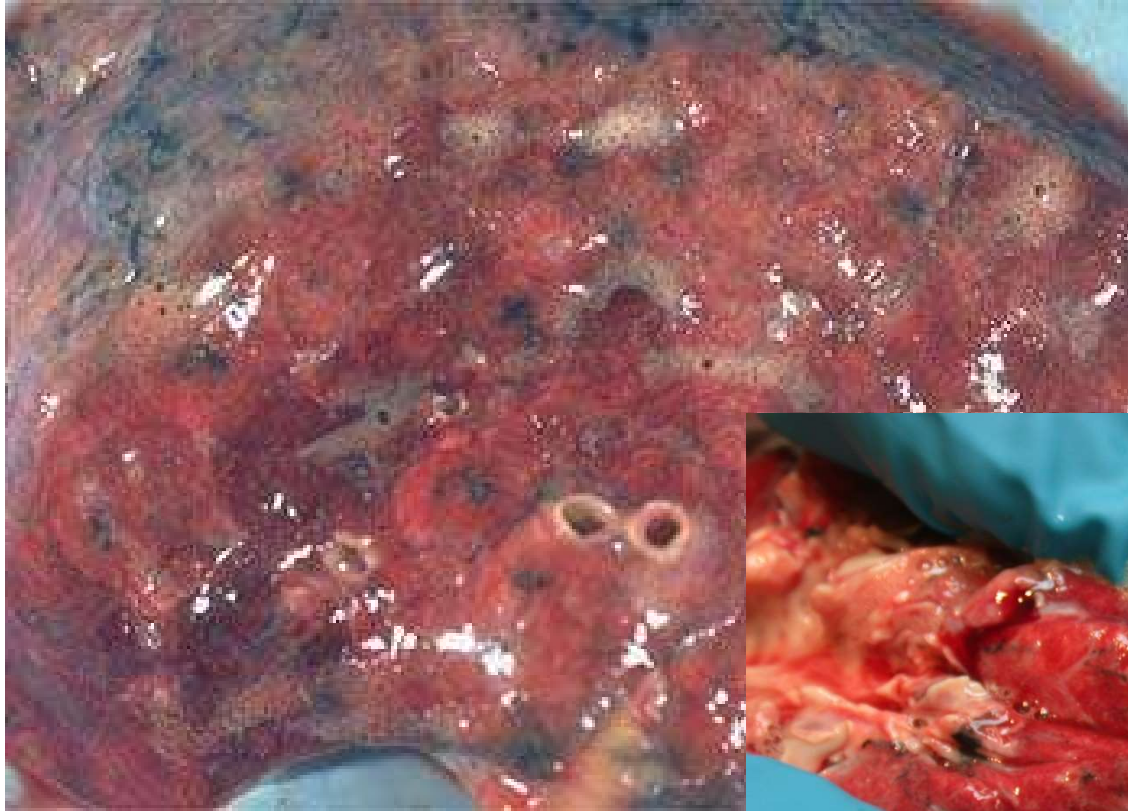


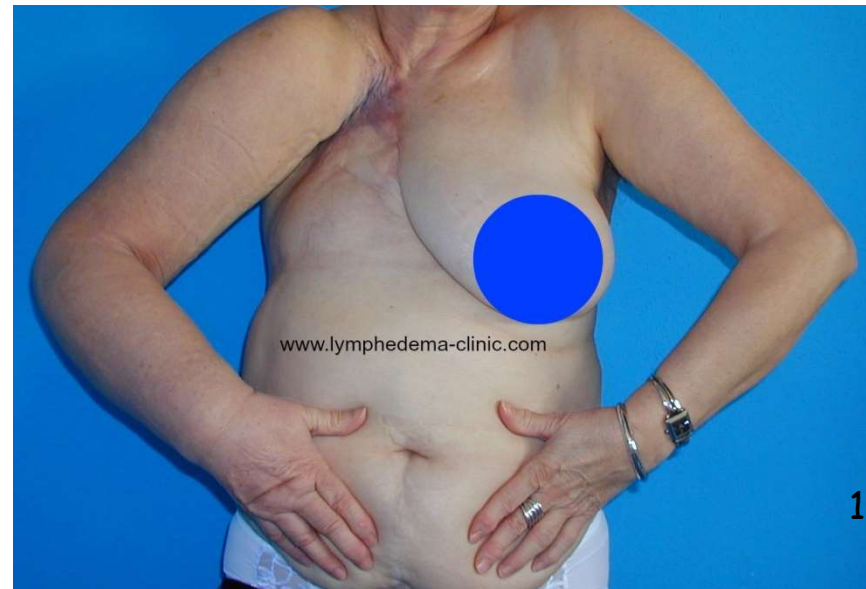
# Cerebral edema





# Pulmonary edema





# HEMORRHAGE

# Hemostasis-protagonists

- Vascular wall ( endothelium)
- Platelets
- Coagulation cascade

# Normal hemostasis - sequence of events

- Arteriolar vasoconstriction (major regulator: endothelin)
- Platelet adherence, activation and aggregation  $\longrightarrow$  Primary hemostasis (major regulator: ECM)
- Fibrin meshwork creation, additional platelet recruitment  $\longrightarrow$  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)**

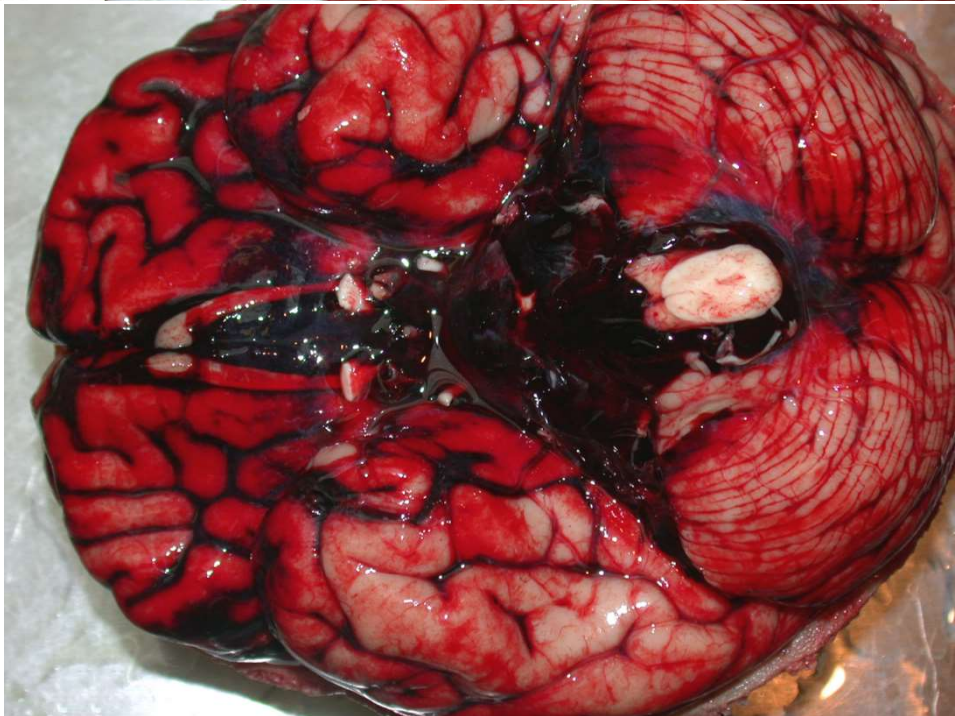
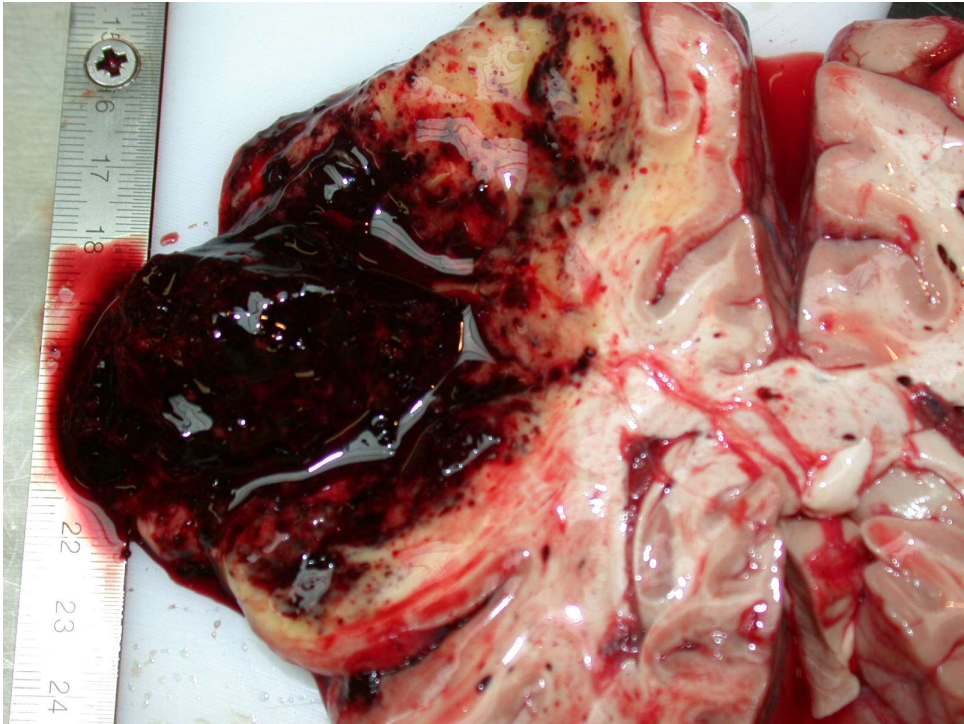
- » Causes: obstetric complications, infections, neoplasms, excessive tissue injury
- » Hemorrhage and thrombosis

# Categories

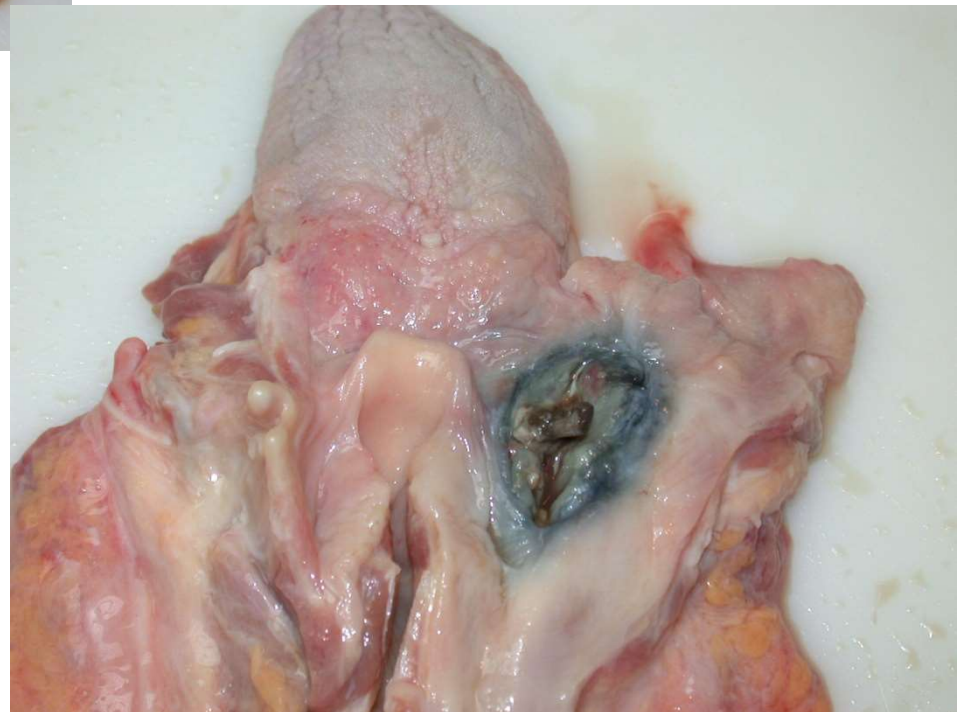
- By extent
  - Exsanguination, hematoma, suffusion, ecchymosis, petechia, purpura
- By localization
  - eg: hemothorax, hemopericardium, hemascos, hemarthrosis, epistaxis, hematemesis, melena, hematochesia...

By pathomechanism...





Haemorrhagia per rhexim-  
cerebral

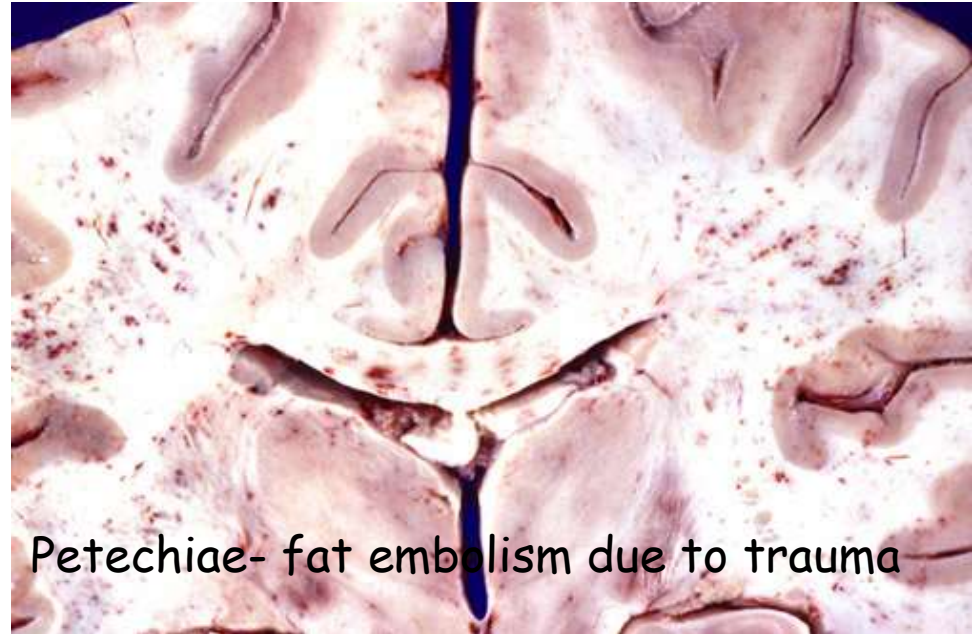


Haemorrhagia per arrosionem  
(hypopharynx tumor)





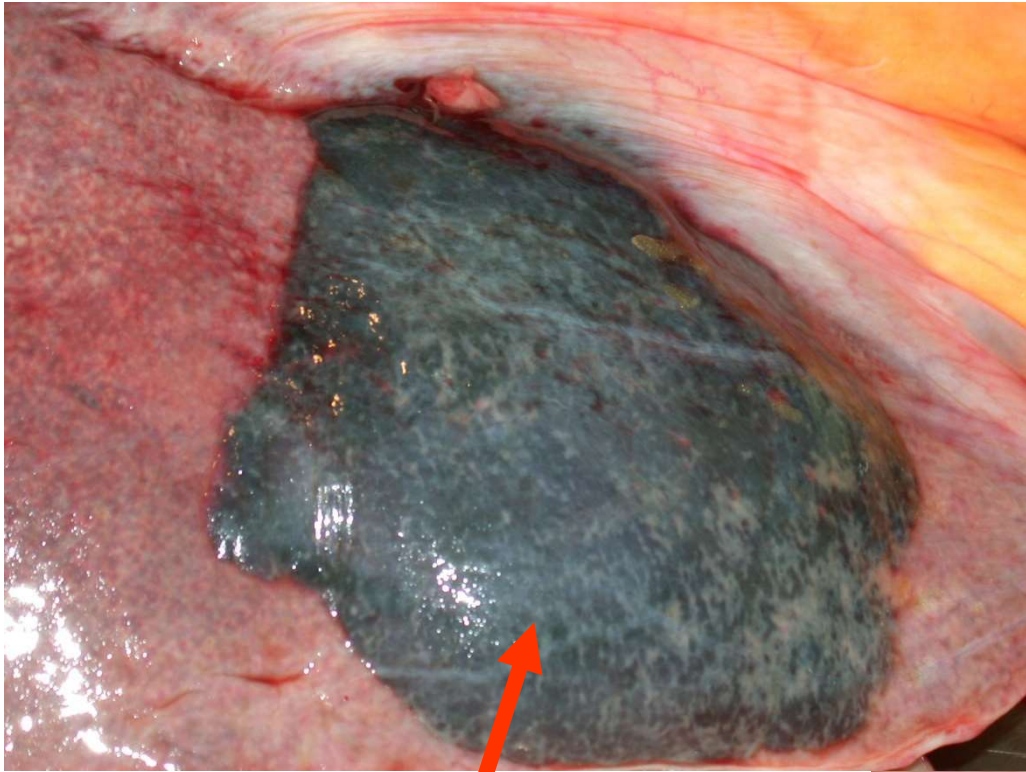
Petechiae- pericardium  
( thrombocytopenia)



Petechiae- fat embolism due to trauma

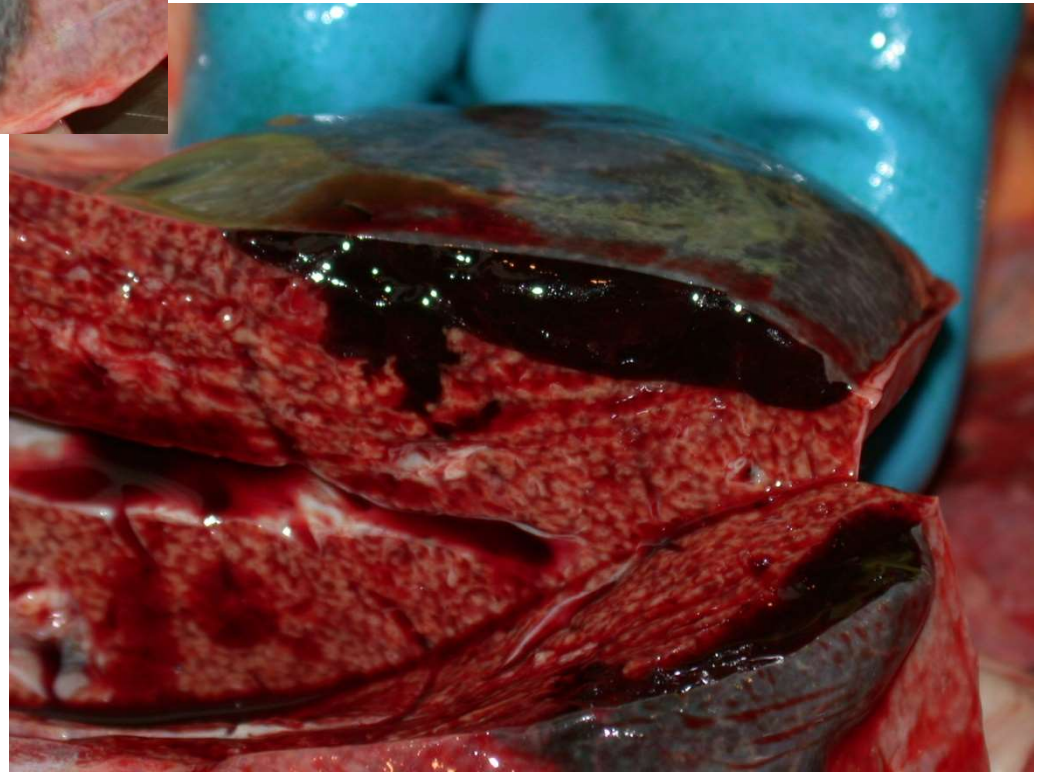
**Haemorrhagia per diapedesim**

Categories by extent...



**Subcapsular  
hematoma -  
liver**

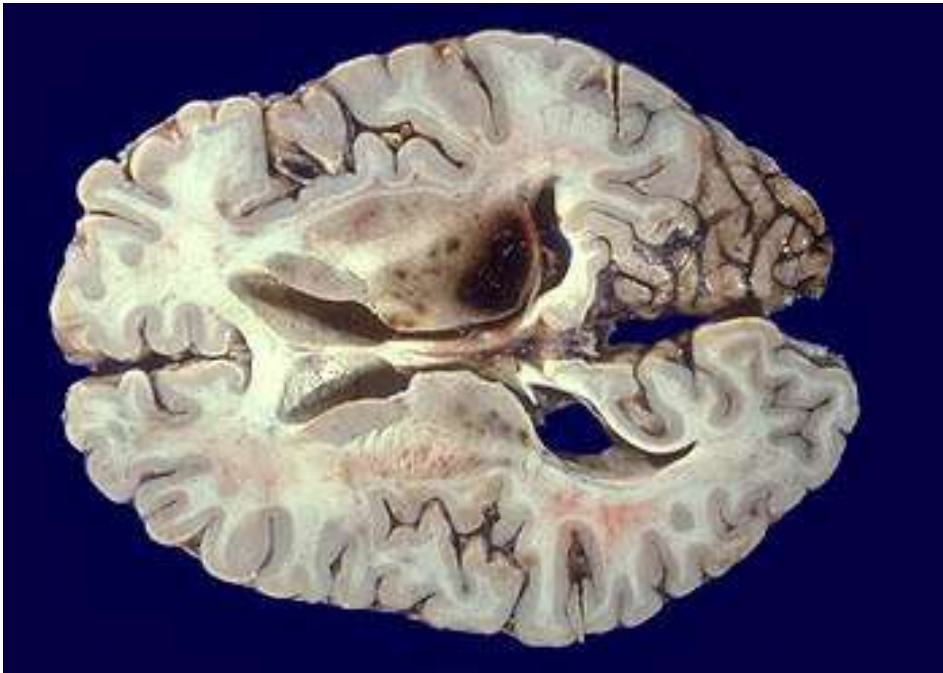
**hematoma**



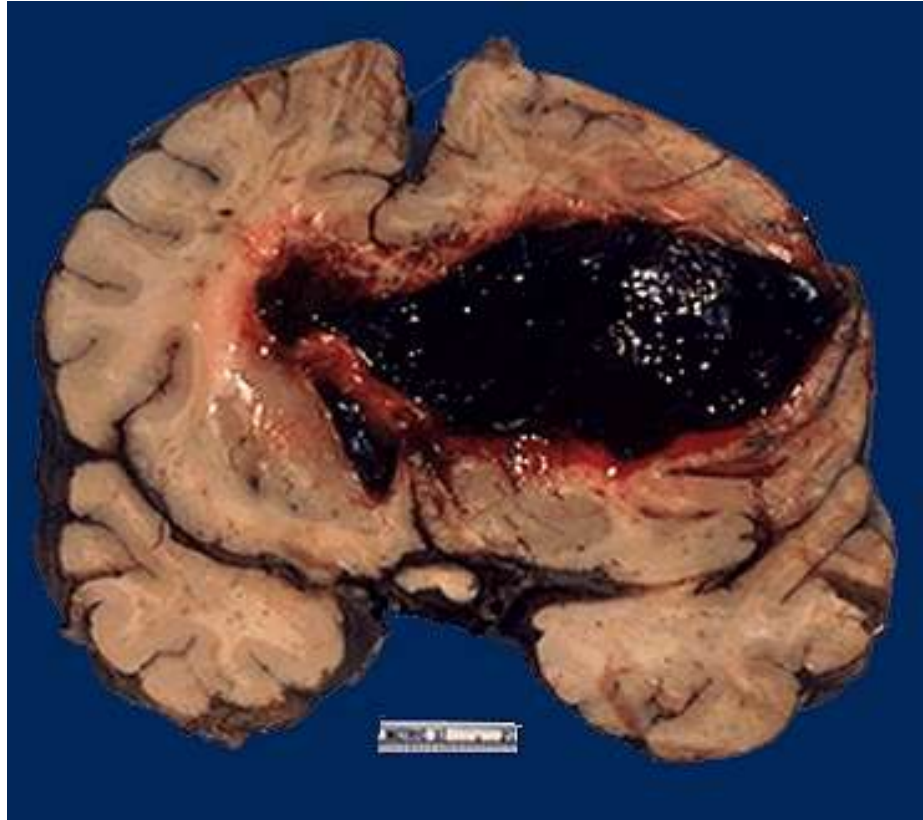


# Suffusion, hematoma

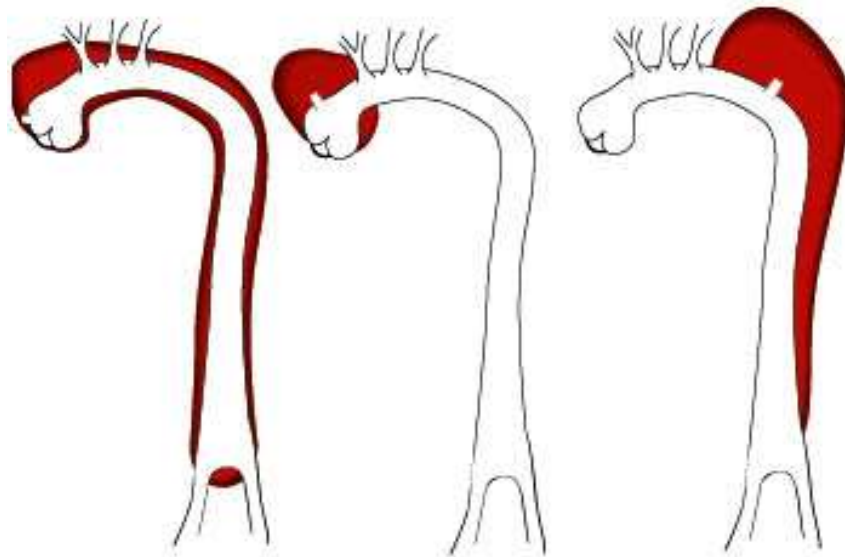




Thalamus -  
hemorrhage-  
hypertension



Apoplexia cerebri-  
hypertension



Hemopericardium- due to aortic dissection 32



# 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- Trousseau phenomenon), antiphospholipid antibody syndrome

# Classification by localization 1.

## 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 2.

## Venous thrombosis ( phlebothrombosis)

**Pathogenesis:** stasis (varicosity, immobilization)  
thrombophlebitis

**Localization:** 90% legs

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

**Complications:** Ulcus cruris

Postthrombotic sy

Vena cava superior sy

Vena cava inferior sy- congestion in lower extremities, pelvis

# Classification by localization 3.

## Thrombosis in heart chambers ( like arterial thrombosis)

**Causes:** 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

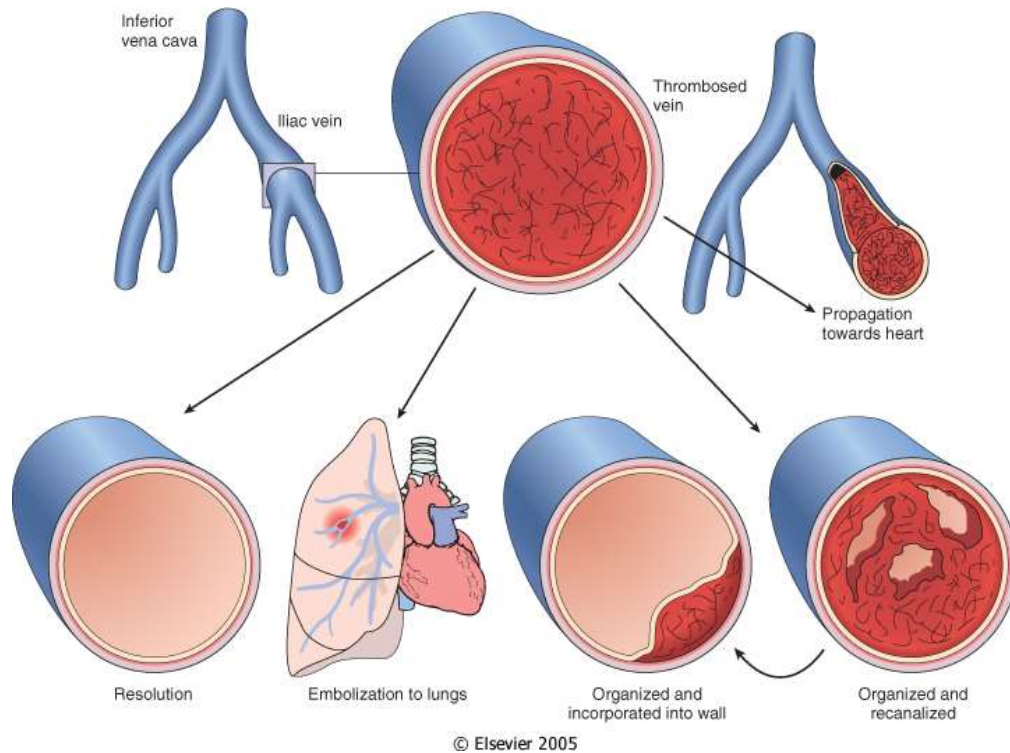
- Prolonged bed rest or immobilization
- Myocardial infarction
- Atrial fibrillation
- Tissue damage
  - (including surgery fractures, burns etc)
- Prosthetic cardiac valves
- Disseminated intravascular coagulation
- Heparin-induced thrombocytopenia
  - HIT (unfractionated heparin)
- Cancer
- Antiphospholipid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

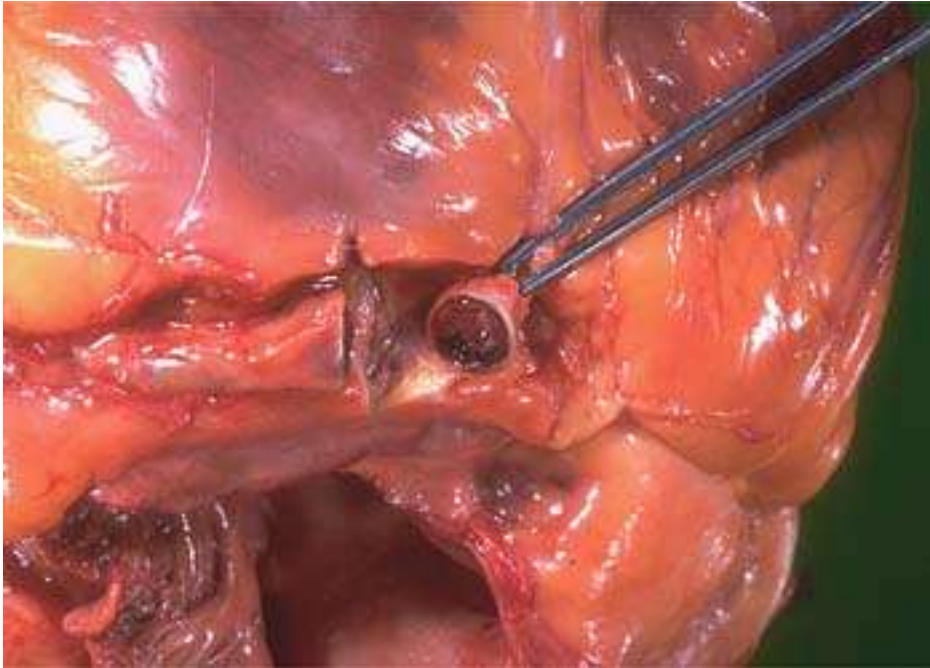
# FATE OF THROMBI



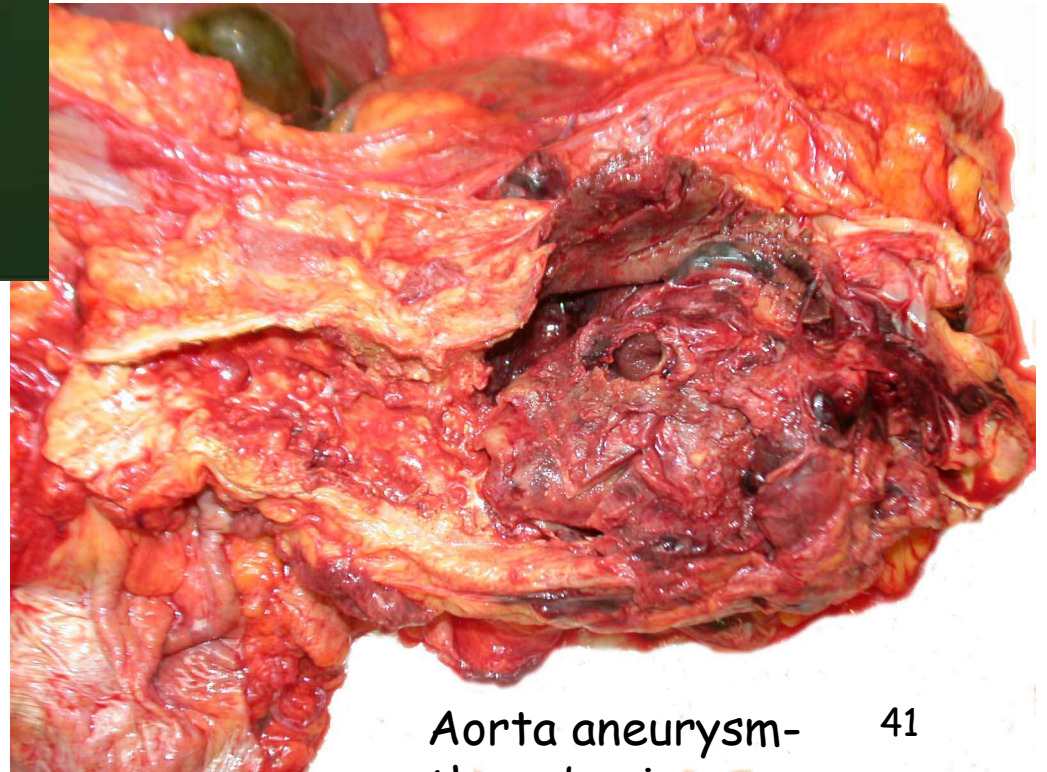
- Resolution
- Propagation
- Embolization
- Organization, recanalization



# Arterial thrombus

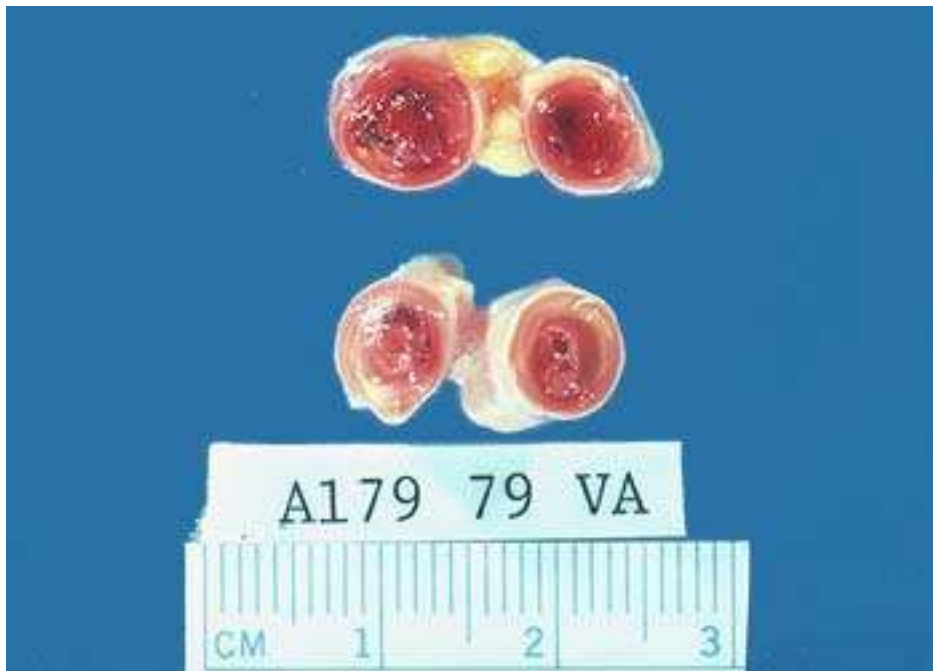


a. coronaria thrombosis



Aorta aneurysm-  
thrombosis

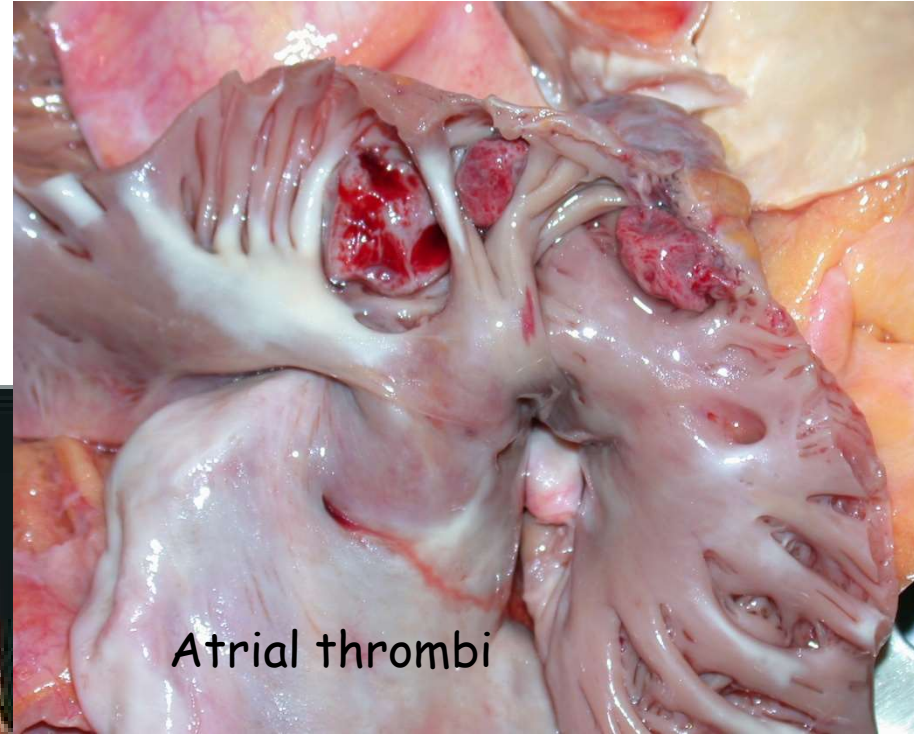
# Venous thrombosis



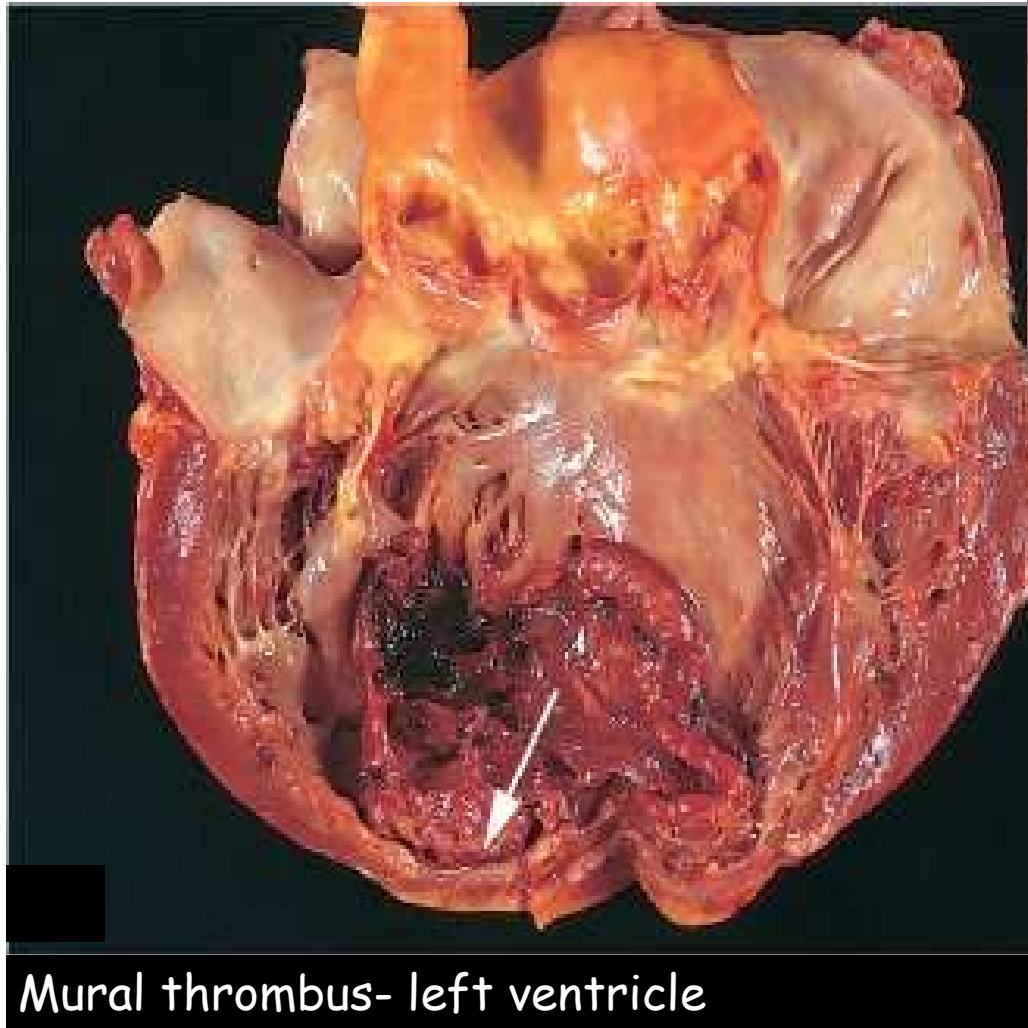
Thrombus in iliac vein



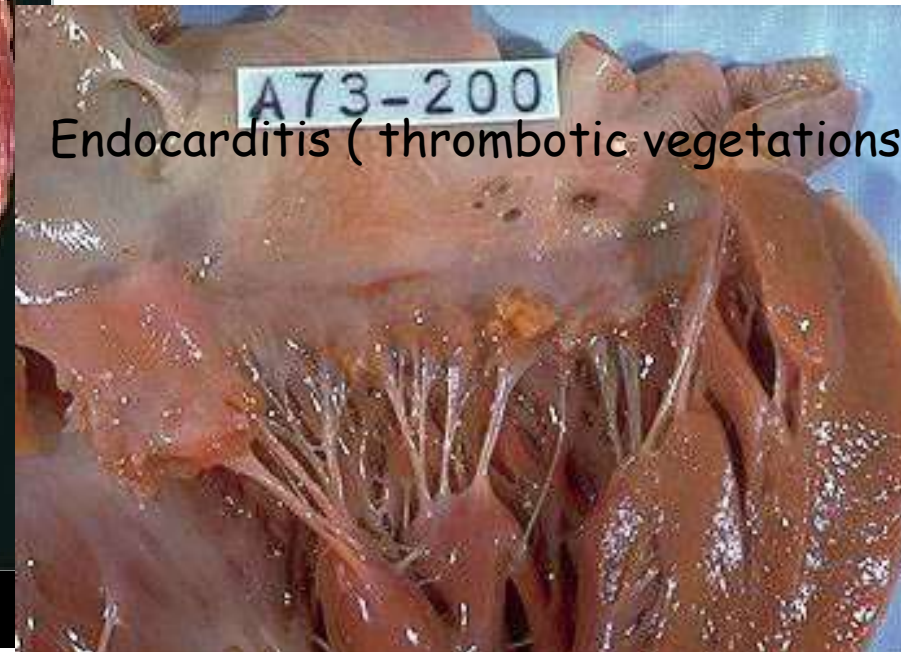
# Cardiac thrombi



Atrial thrombi



Mural thrombus- left ventricle



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 1.

## 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!

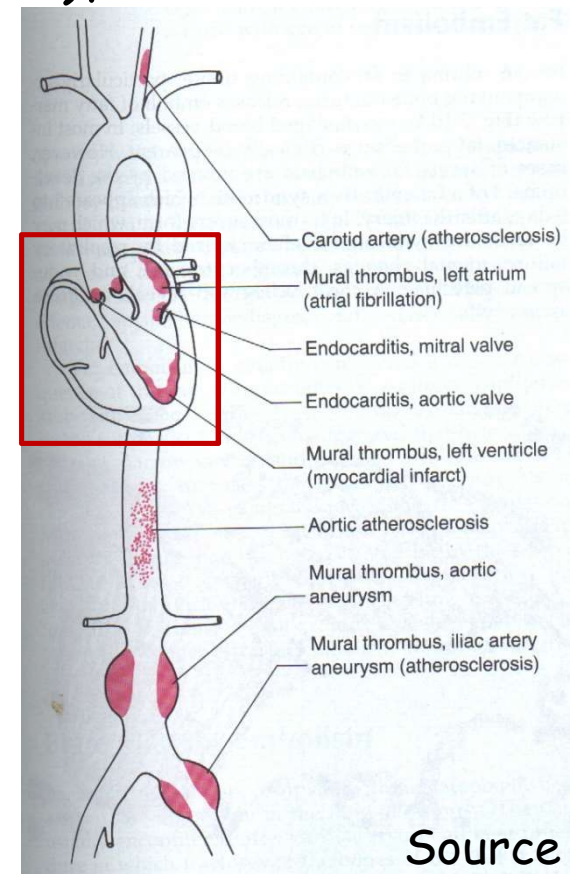
**Complications:** arterial embolization

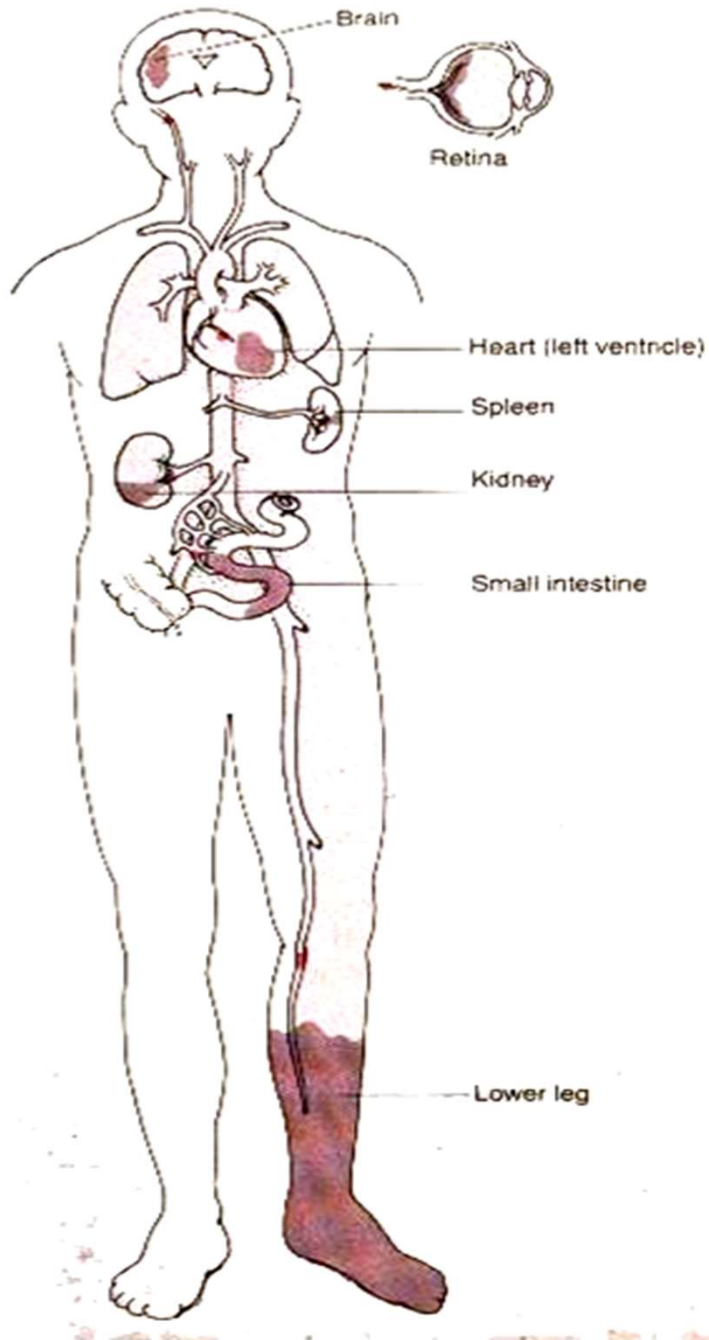
-in lower extremities (75%)

-in the brain (10%),

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

→ INFARCTION





## Systemic arterial embolization

lower extremities  
brain  
retina  
heart  
spleen  
kidney  
small bowel

# Thromboembolism 2.

## Pulmonary thromboembolism

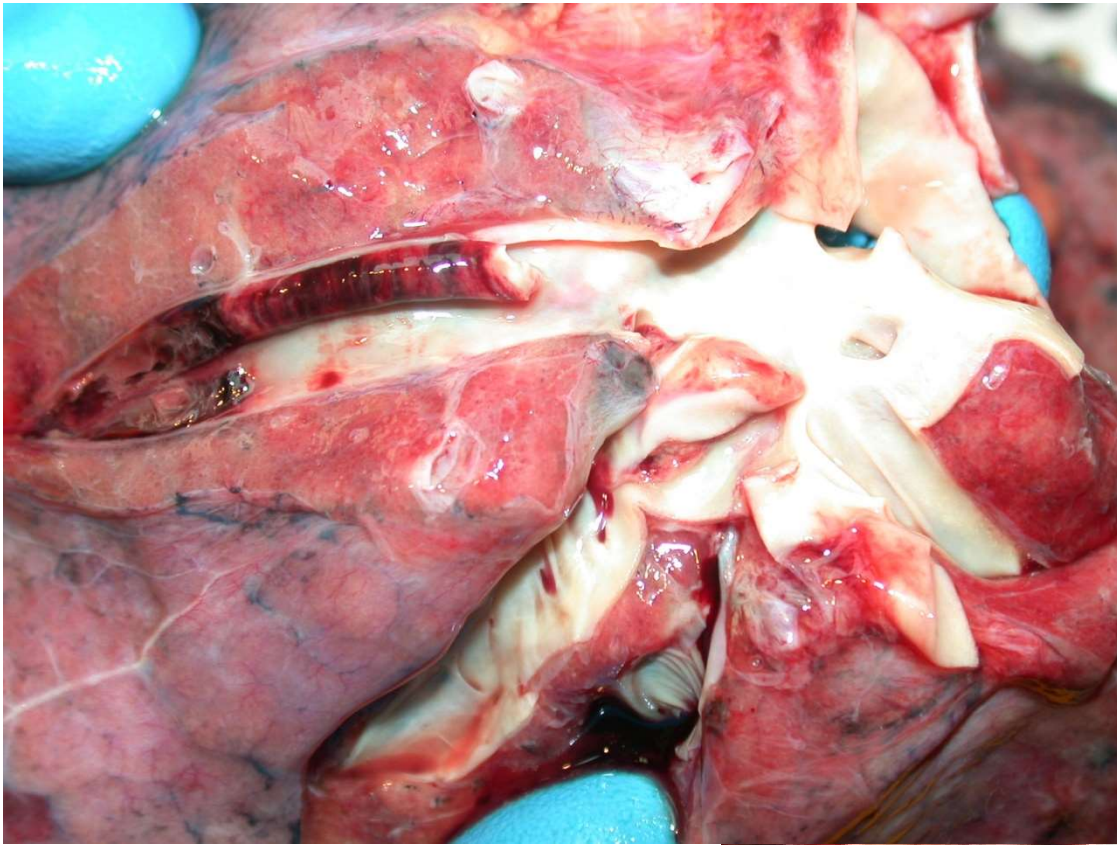
**Source:** deep venous thrombosis of lower extremities

**Possible complications:**

- sudden death (saddle embolus)
- pulmonary hypertension, cor pulmonale
- hemorrhage, hemorrhagic infarction



# Pulmonary embolism



# 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