Fluid and Hemodynamic Disorders

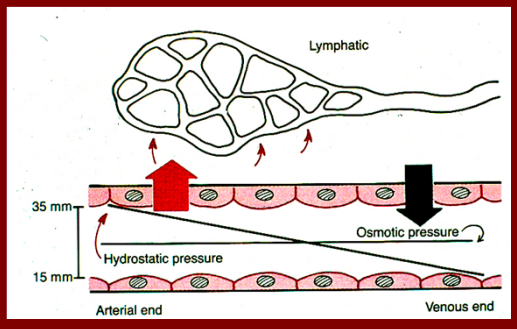
Where's my water?

- Intracellular
  - Ions
  - Ion specific gates in cell membrane
  - Cellular proteins
- Extracellular
  - Interstitial (between the cells) Lymph
  - Intravascular
    - Blood
    - Lymphatic fluid

Movement of water in the vascular system

- Hydrostatic, the pumping pressure
  - Heart
  - Skeletal muscle action
- Oncotic or osmotic, holds fluid in.
  - Proteins such as albumin
  - Cellular elements such as RBCs

Intracellular & Extracellular Water



Things can go wrong

- Heart failure
- Kidney failure
- Myocardial infarction
- Pulmonary emobolus
- Tissue congestion
- Edema

Edema

- Too much extracellular fluid.
  - Swelling
    - tumor
  - Localized or
  - Generalized
  - Dependent
    - action of gravity

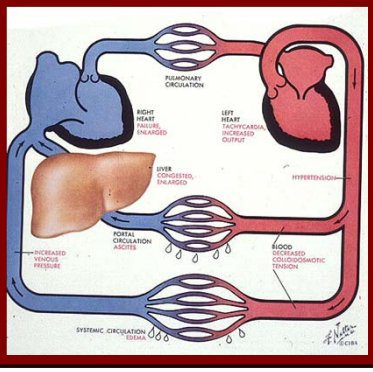
Tansudate or Exudate?

- Exudate
  - Inflammatory water
  - Part of the inflammatory reaction
    - Rubor, dolor, calor, tumor
  - Purposeful and intentional
  - Localized

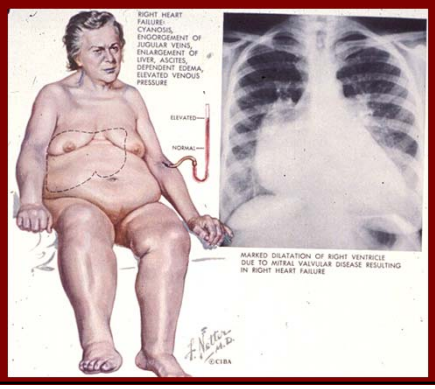
Tansudate or Exudate?

- Transudate
  - Leakage, not part of healing
  - Increased hydrostatic pressure
    - Heart failure
    - Lymphatic obstruction
  - Decreased oncotic pressure
    - Decreased albumin

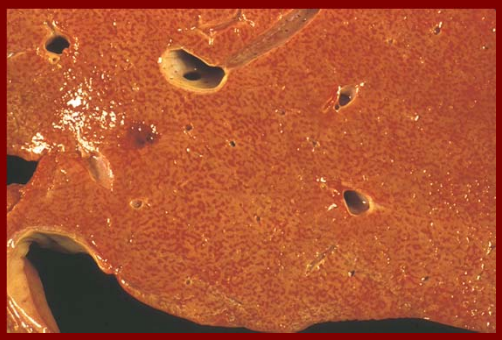
Congestive Heart Failure



Congestive Heart Failure

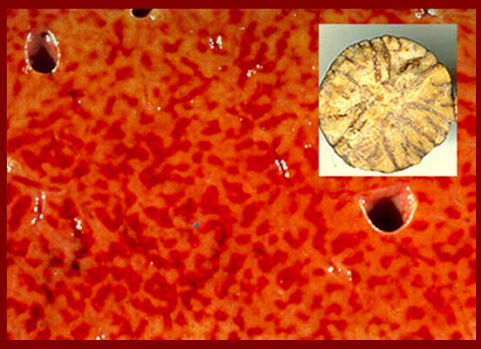


Passive Congestion



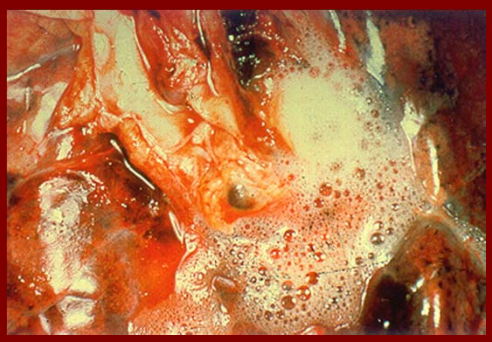
Chronic Passive Congestion, Nutmeg Liver

Chronic Passive Congestion

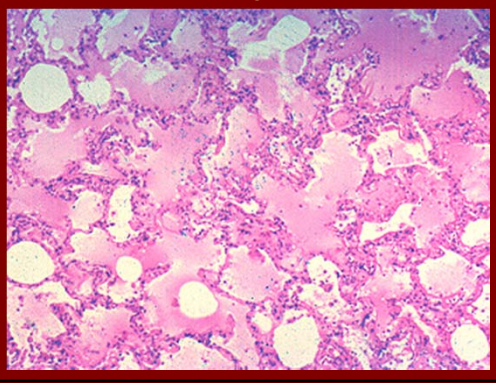


Pulmonary Edema

Pulmonary Edema



Pulmonary Edema



Pitting Edema

Lymphedema

Papilledema

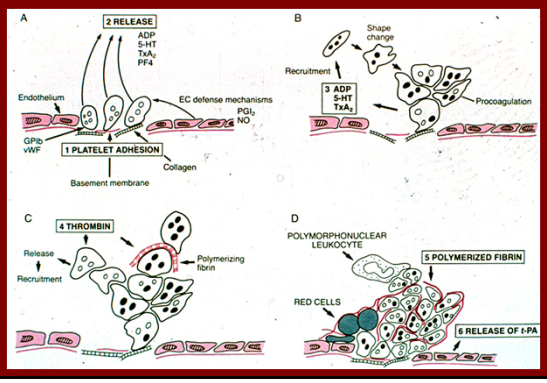
Water in Hollow Spaces

- Hydrothorax
- Hydropericardium
- Hydroperitoneum
  - Ascites

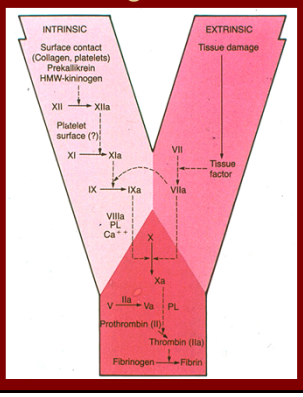
Healthy Blood Clotting

- Platelets
- Vessels
- Clotting Proteins

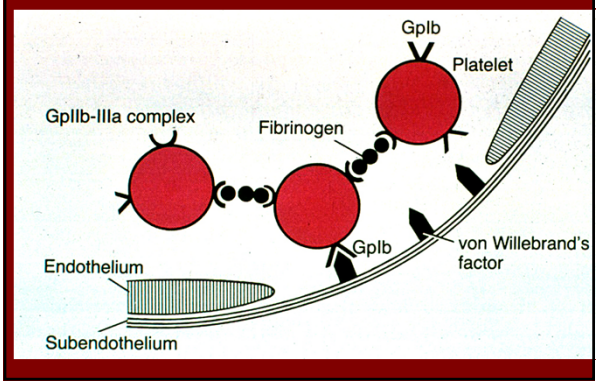
Healthy Clotting



Clotting Factors



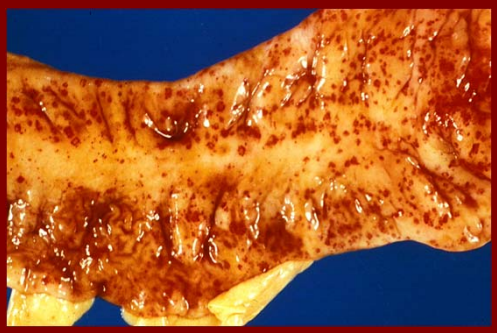
Factor Activation



ANTITHROMBOTIC	PROTHROMBOTIC
Inhibition of Platelet Aggregation	**Stimulation of Platelet Aggregation Adhesion**
• PGI_2 • NO • ADPase	• von Willebrand's factor • Platelet-activating factor (PAF)
Anticoagulant—Binding and Inhibition of Thrombin	**Procoagulation Factors**
• Antithrombin III acceleration by heparin-like molecules • Thrombomodulin activation of protein C/S • $alpha_2$-macroglobulin	• Tissue factor • Binding factors IXa, Xa • Factor V
Fibrinolysis	**Inhibition of Fibrinolysis**
• Tissue plasminogen activator (t-PA)	• t-PA inhibitor

Hematoma

Petechiae



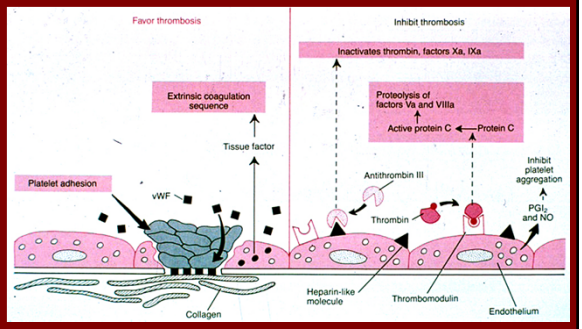
Thrombosis

- A pathological clot
- A clot forming in the fixed vascular system.

Thrombosis

1. Endothelial damage
2. Stasis and clotting factor activation
3. Clotting factor abnormalities
   - Too many clotting proteins
     - Pregnancy
     - Cancers
   - Too little inhibition
   - Abnormal factors
     - Leiden Factor (abnormal V)

Thrombosis

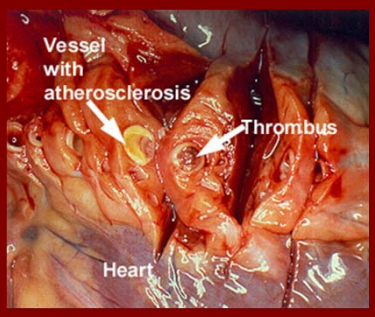


Thrombosis

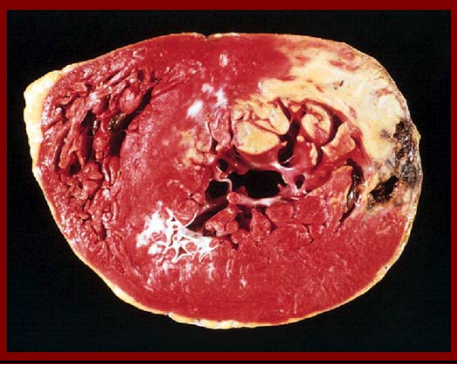
- Arterial Side Thrombi
  - Platelet activation
  - Endothelial cell injury
- Venous Side Thrombi
  - Stasis
  - Clotting factor activation
  - Endothelial cell injury

Coronary Artery Thombosis

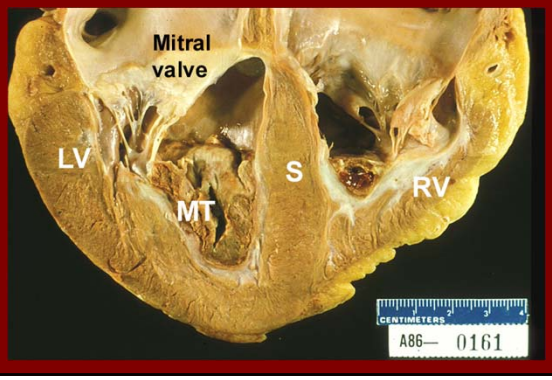
- Angiogram



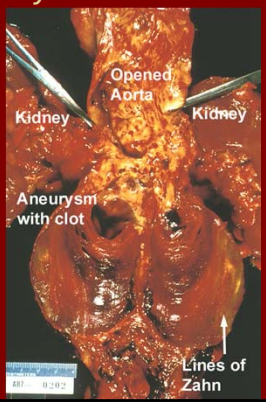
Acute Myocardial Infarction



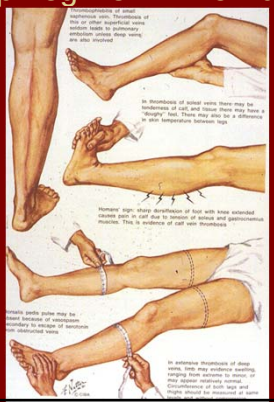
Mural Thrombus



Aneurysm with Thrombus



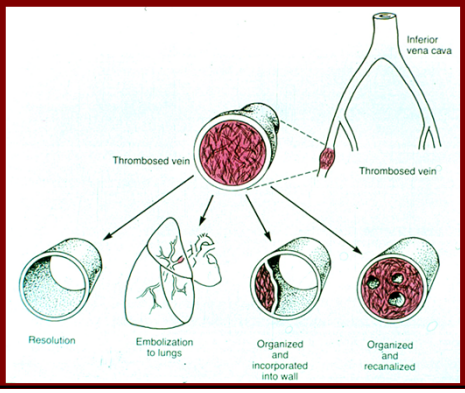
Deep Leg Vein Thrombosis



Airplane Travel

- Gunner turret

Outcomes of a DVT

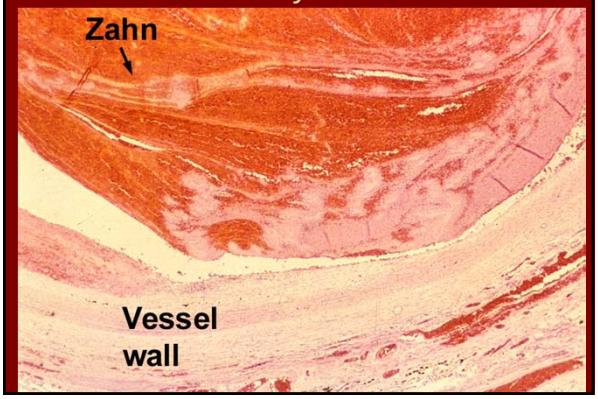


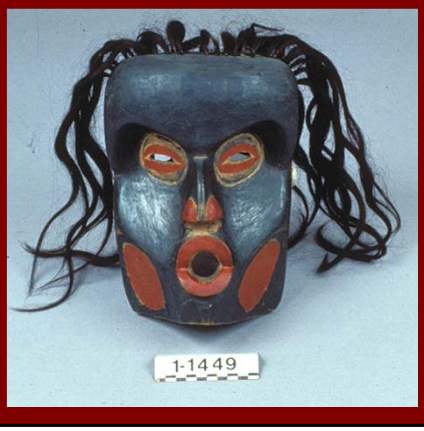
Embolus

- Space occupying mass moving in the fixed vascular system
  - Blood clot
  - Bone Fragments
  - Amniotic Fluid
  - Air

Pulmonary Embolus

Pulmonary Embolus



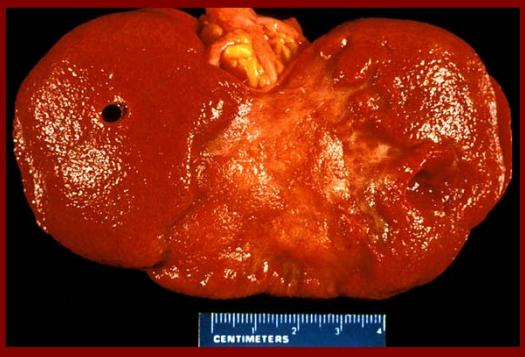


Infarction

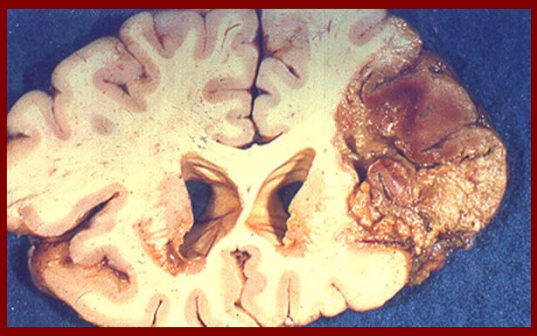
- Anemic
  - End artery supply
  - No blood
  - White
- Hemorrhagic
  - Venous occlusion
  - Loose tissues
  - Dual blood supply
  - Red

Anemic Infarct

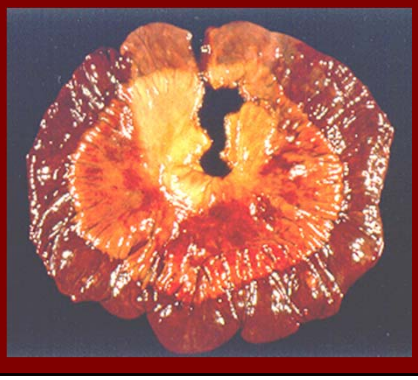
Anemic Infarct



Cerebral Infarction



Hemorrhagic Infarct



Shock

- Poor perfusion
- Tissue hypoxia
- Tissue acidosis
- Many causes
  - Poor pumping by heart
  - Low blood volume
  - Loss of fluid
  - Overwhelming infections

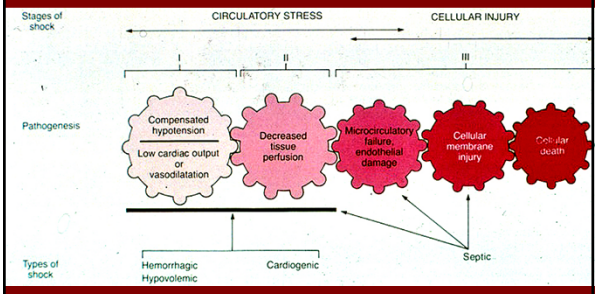
Types of Shock

- Cardiogenic
  - Decreased output
- Hypovolemic
  - Blood loss
  - Fluid loss
- Anaphylaxis
  - IgE and histamine
- Septic
  - Gram negative rods
  - Toxins

What Happens Next?

- Compensated
  - Fluid shifts
- Decompensated
  - Progression possible
- Irreversible
  - No recovery

The Shock Spiral



Summary

- Fluid shifts
  - Oncotic & Hydrostatic Pressures
- Excessive tissue water
  - Exudate vs. Transudate
- Clot formation
  - Vessels, platelets & proteins
- Thrombosis
  - Pathological clot
  - Arterial = endothelial damage & platelet activation.
  - Venous = stasis and factor activation

Summary

- Infarction
  - Ischemic = end artery organ
  - Hemorrhagic = venous or dual blood supply
  - Tissue vulnerability
    - Brain
    - Kidney
    - muscle