Thrombosis

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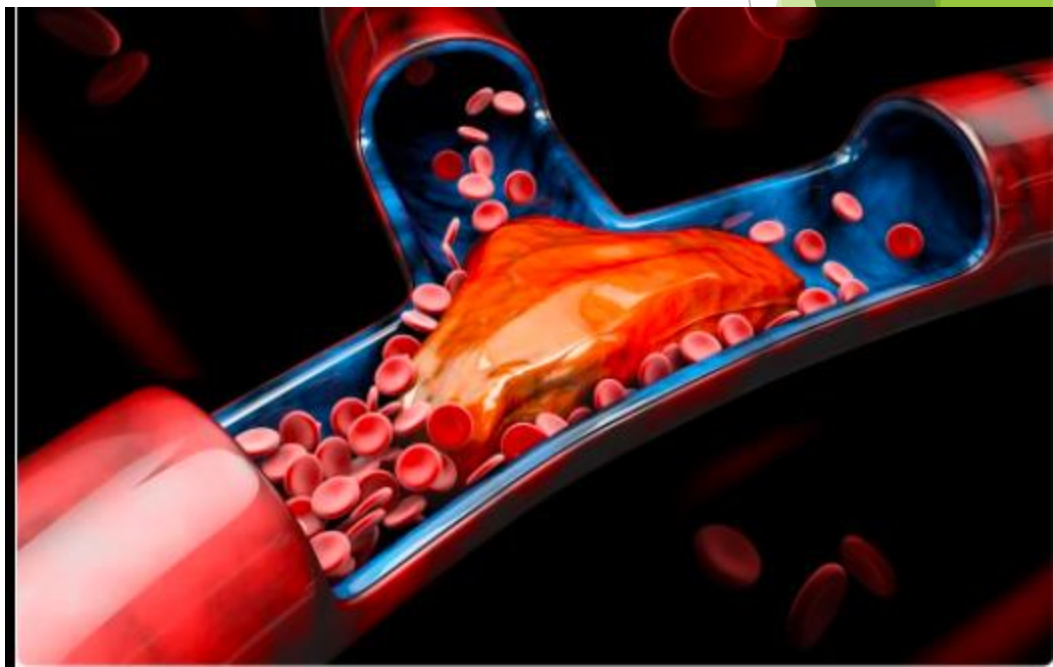
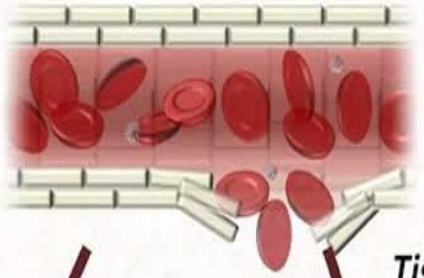


Major Components of Hemostasis



Vascular Injury

Collagen

Tissue factor

Vasoconstriction

Platelet Activation

Coagulation Cascade

Antithrombotic Control Mechanisms

vWF, fibrinogen

Thrombin

Platelet Plug

Fibrinogen → *Fibrin*

Blood Clot

Plasmin

Fibrinolysis & Clot Degradation

Primary Hemostasis

Secondary Hemostasis

Thrombosis

- **Thrombosis** is the formation of a blood clot, known as a thrombus, within a blood vessel.

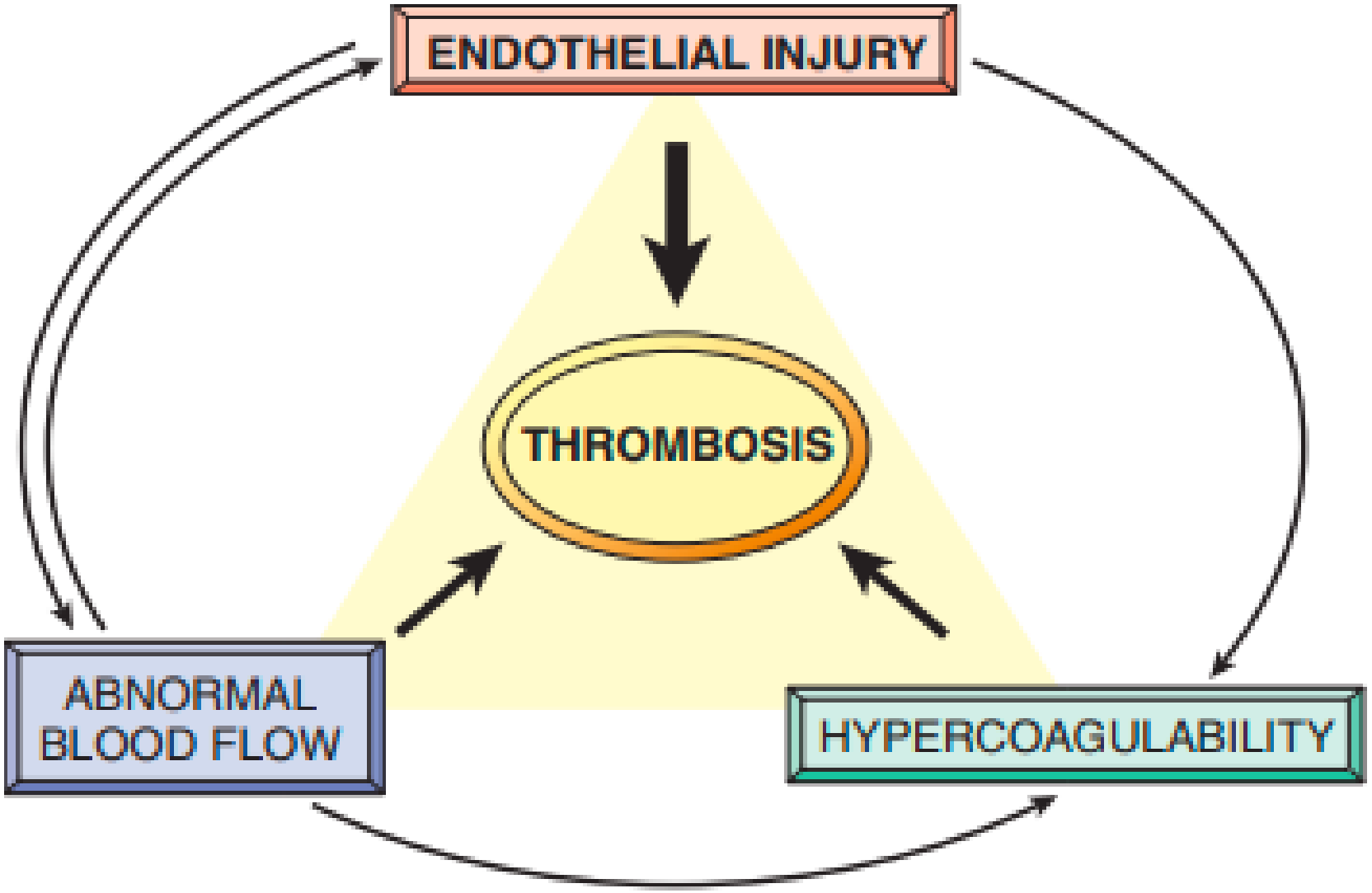
- The primary abnormalities that lead to intravascular thrombosis are:

- (1) Endothelial injury.

- (2) Stasis or turbulent blood flow.

- (3) Hypercoagulability of the blood

- (the so-called “Virchow triad”)



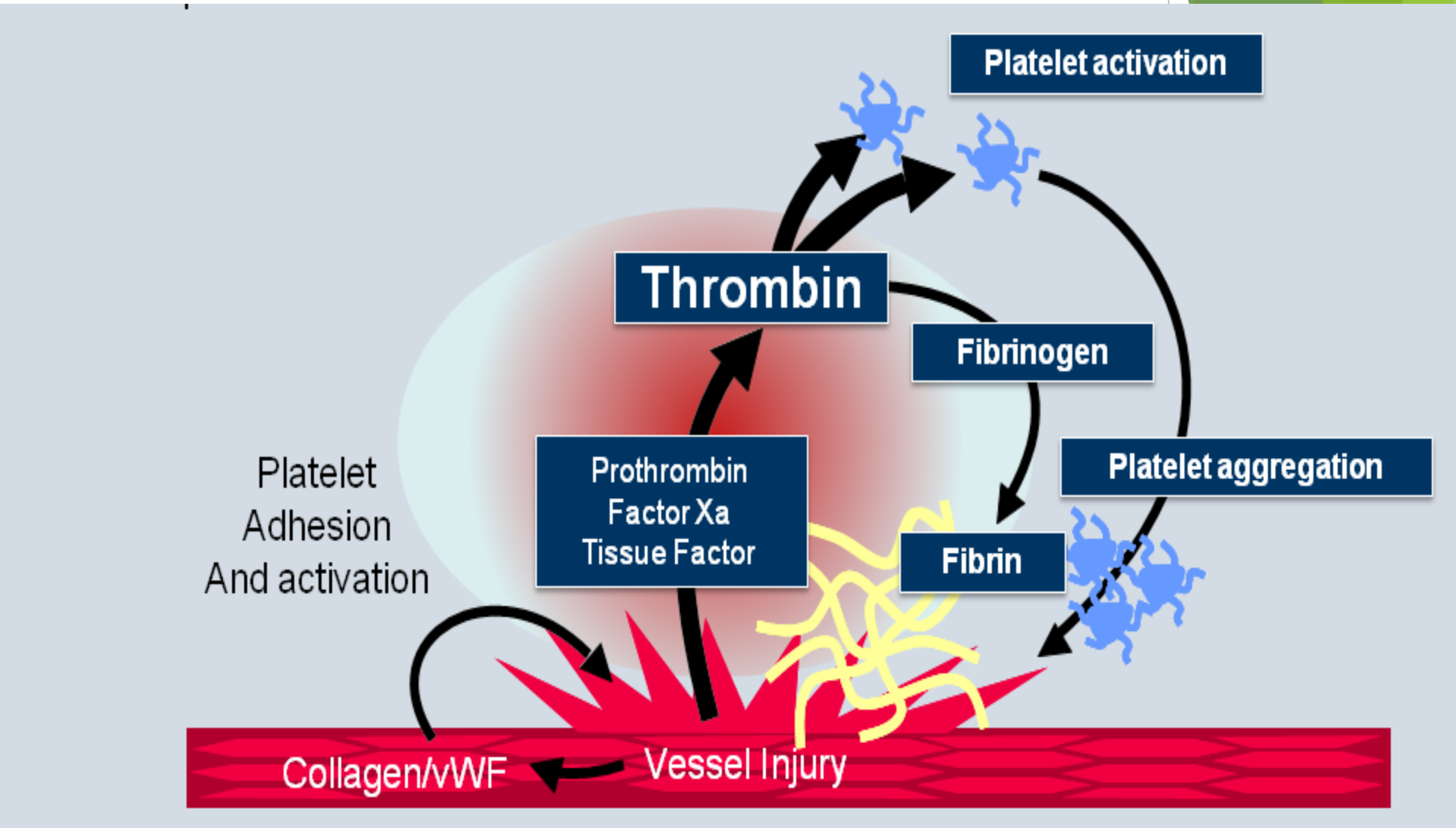
1. Endothelial Injury

- Endothelial injury leading to platelet activation.

- Cardiac and arterial clots are typically rich in platelets.

- Endothelial injury may be caused by:
  - Physical injury.
  - Infectious agents.
  - Inflammatory mediators.
  - Metabolic abnormalities, such as hypercholesterolemia or homocystinemia,
  - Toxins absorbed from cigarette smoking.

Severe endothelial injury may trigger thrombosis by exposing VWF and tissue factor

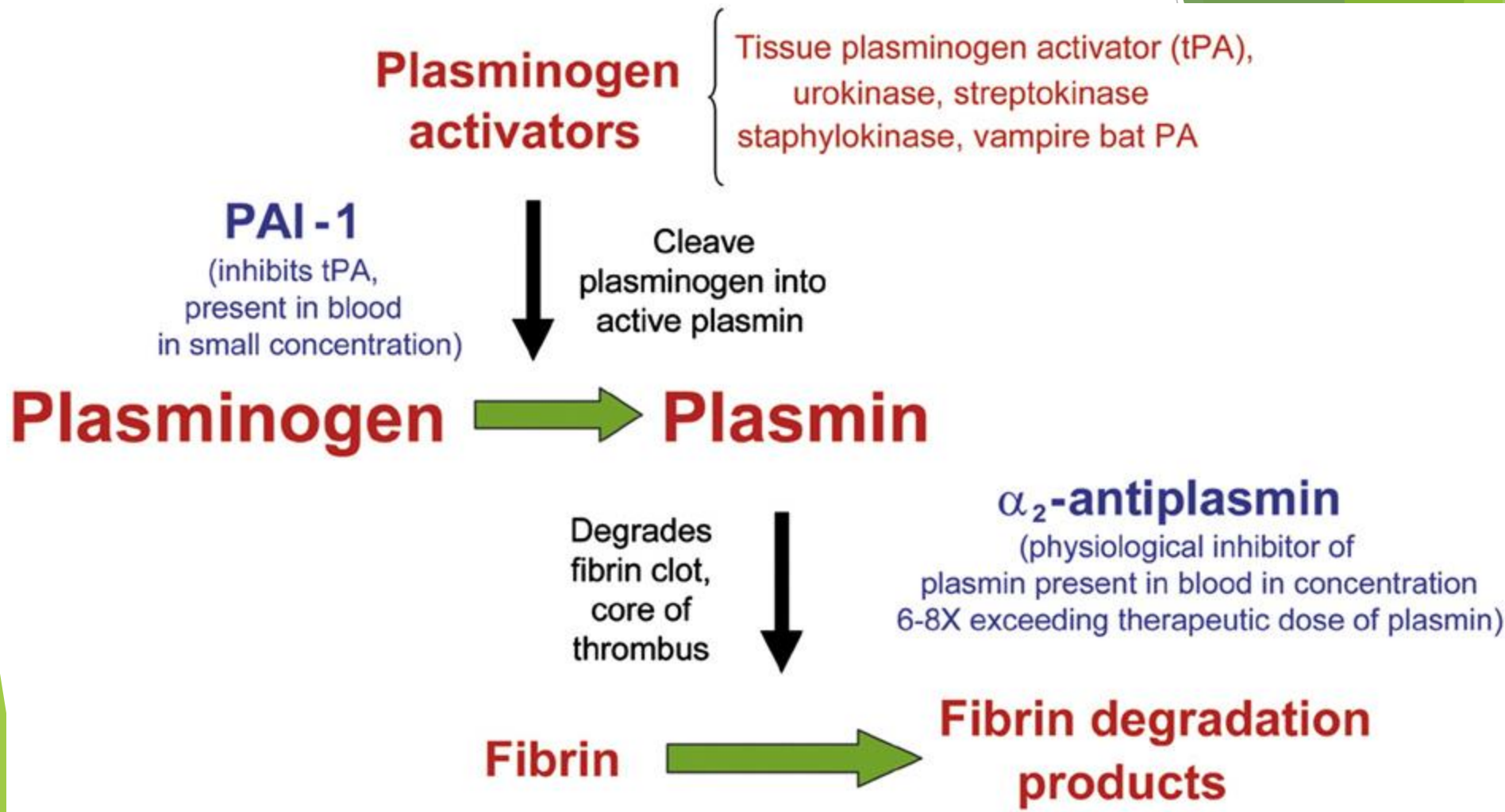


- Endothelial injury …..that's mean:

- platelet activation: exposed VWF, TF.
- Endothelial dysfunction : <u>prothrombotic endothelium</u>.

- Procoagulant changes:
- ↓ thrombomodulin, ↑ thrombin

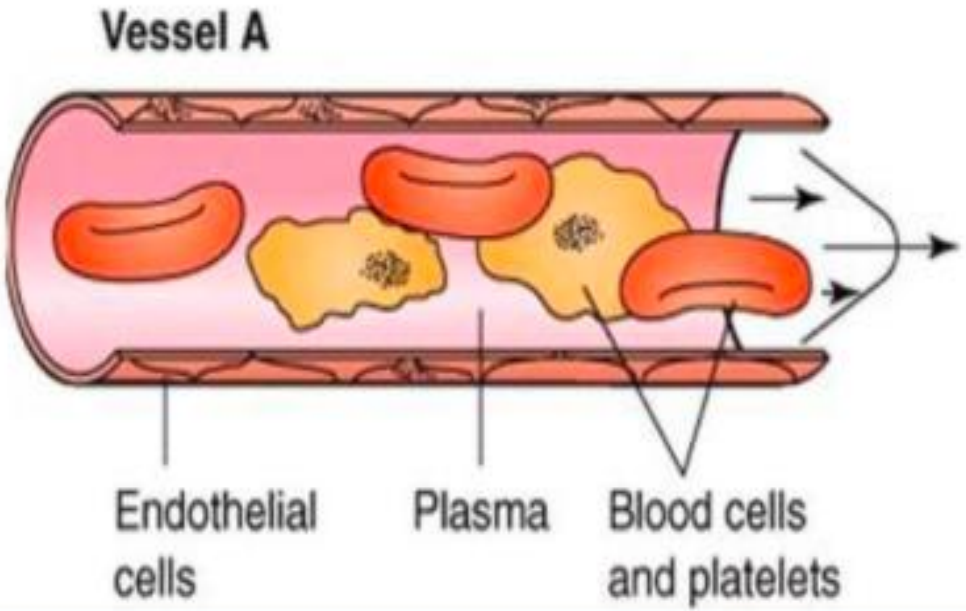
- Anti-fibrinolytic effects:
- ↑ Plasminogen activator inhibitors (PAI).
- ↓ t-PA.


Plasminogen activators
Tissue plasminogen activator (tPA), urokinase, streptokinase staphylokinase, vampire bat PA
PAI-1
(inhibits tPA, present in blood in small concentration)
Cleave plasminogen into active plasmin
Plasminogen
Plasmin
Degrades fibrin clot, core of thrombus
α2-antiplasmin
(physiological inhibitor of plasmin present in blood in concentration 6-8X exceeding therapeutic dose of plasmin)
Fibrin
Fibrin degradation products

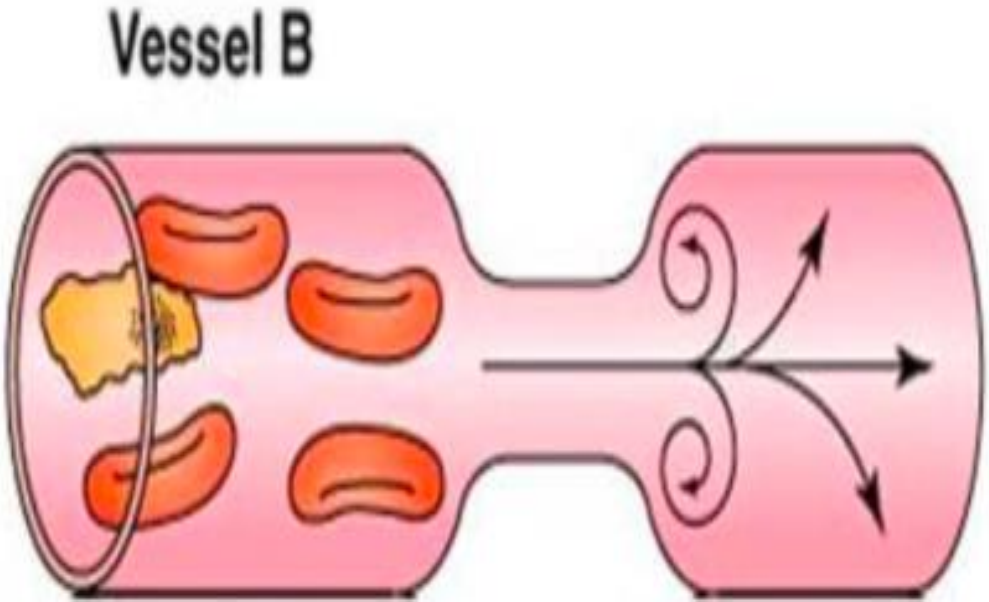
2. Abnormal Blood Flow

- Stasis is a major factor in the development of venous thrombus.
- Stasis and turbulence have the following effects:
  - Stasis allows platelets and leukocytes to come into contact with the endothelium when the flow is sluggish.
  - Stasis also slows the washout of activated clotting factors and impedes the inflow of clotting factor inhibitors.

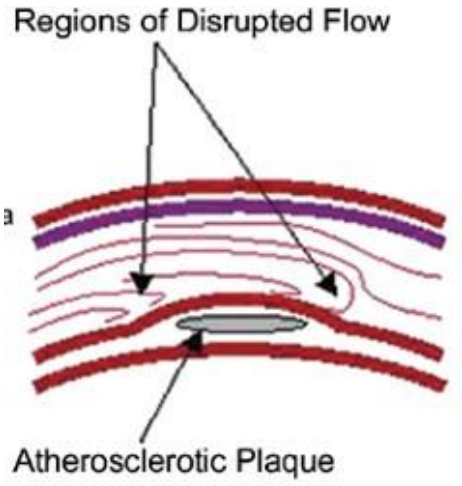
- Normally laminar, with the blood components arranged in layers
- The plasma forms the outer layer & slides smoothly along the endothelium
- Blood cells form the 'axial' layer in the centre of the blood stream
- This allows the blood to flow smoothly, layers slide over each other, axial part moves fastest.

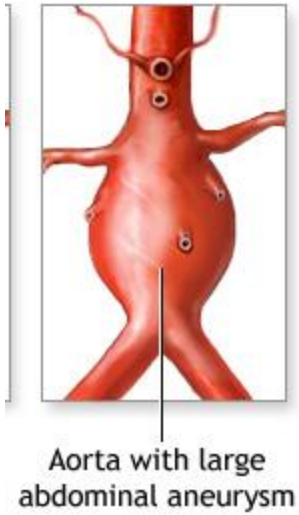


- When we take a blood pressure the sounds we here are caused by turbulent flow of blood
- Turbulent flow -caused by change in vessel diameter, increase in velocity, & low blood viscosity



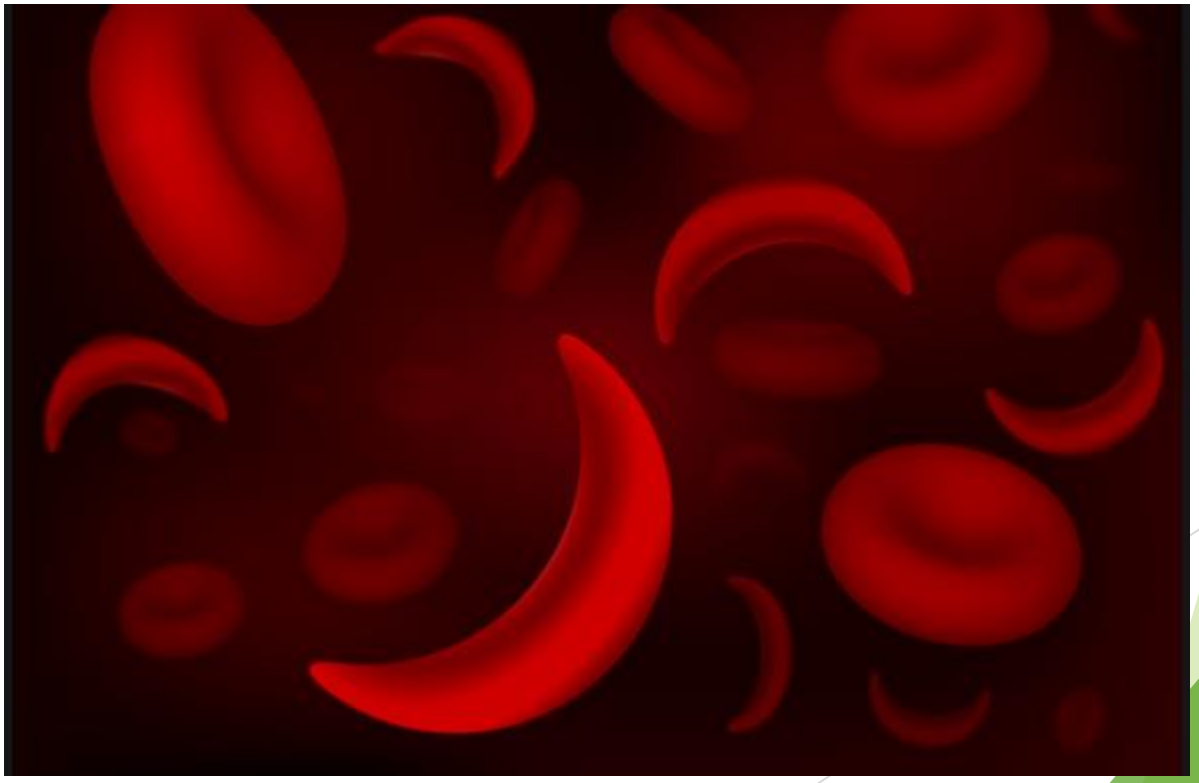
- **Turbulent and static blood flow contributes to thrombosis in a number of clinical setting:**
- **1. Ulcerated atherosclerotic plaques.**
- **2. Aortic aneurysms create local stasis and consequently are fertile sites for thrombosis**





- 3. Hyperviscosity syndromes (such as polycythemia vera) increase resistance to flow and cause small vessel stasis.

- 4. sickle cell anemia:
- The deformed red cells in cause vascular occlusions.



3. Hypercoagulability

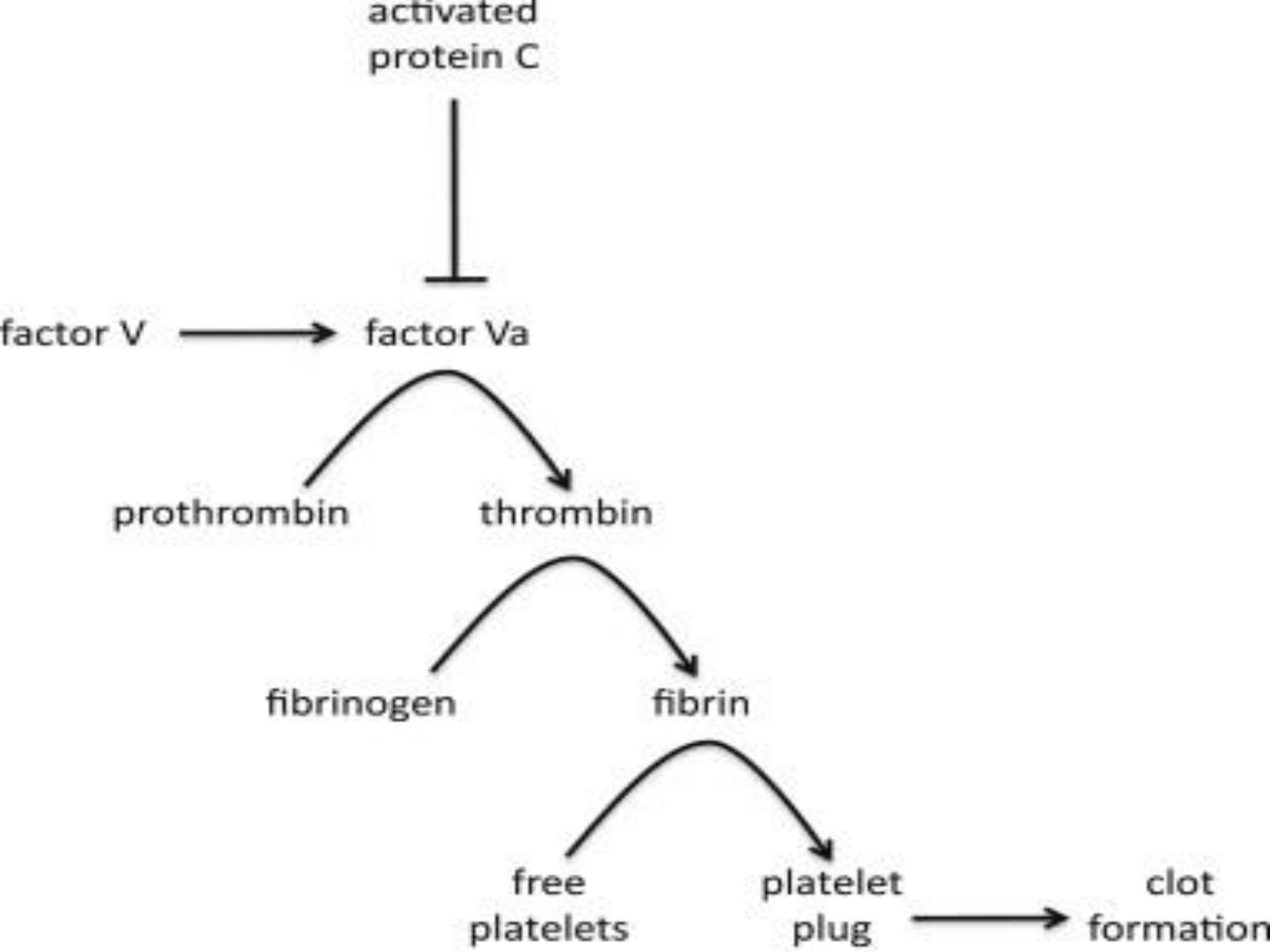
- **Hypercoagulability refers to an abnormally high tendency of the blood to clot, and is typically caused by alterations in coagulation factors.**

- **Is an important underlying risk factor for venous thrombosis**

- The alterations of the coagulation pathways that predispose affected persons to thrombosis can be divided into:

- **Primary (genetic):**
  - Mutations in the factor V .
  - Elevated levels of homocysteine *

- **Secondary (acquired) disorders:**
  - Oral contraceptive.
  - Pregnancy**.
  - Cancers***.


activated
protein C
factor V
factor Va
prothrombin
thrombin
fibrinogen
fibrin
free
platelets
platelet
plug
clot
formation

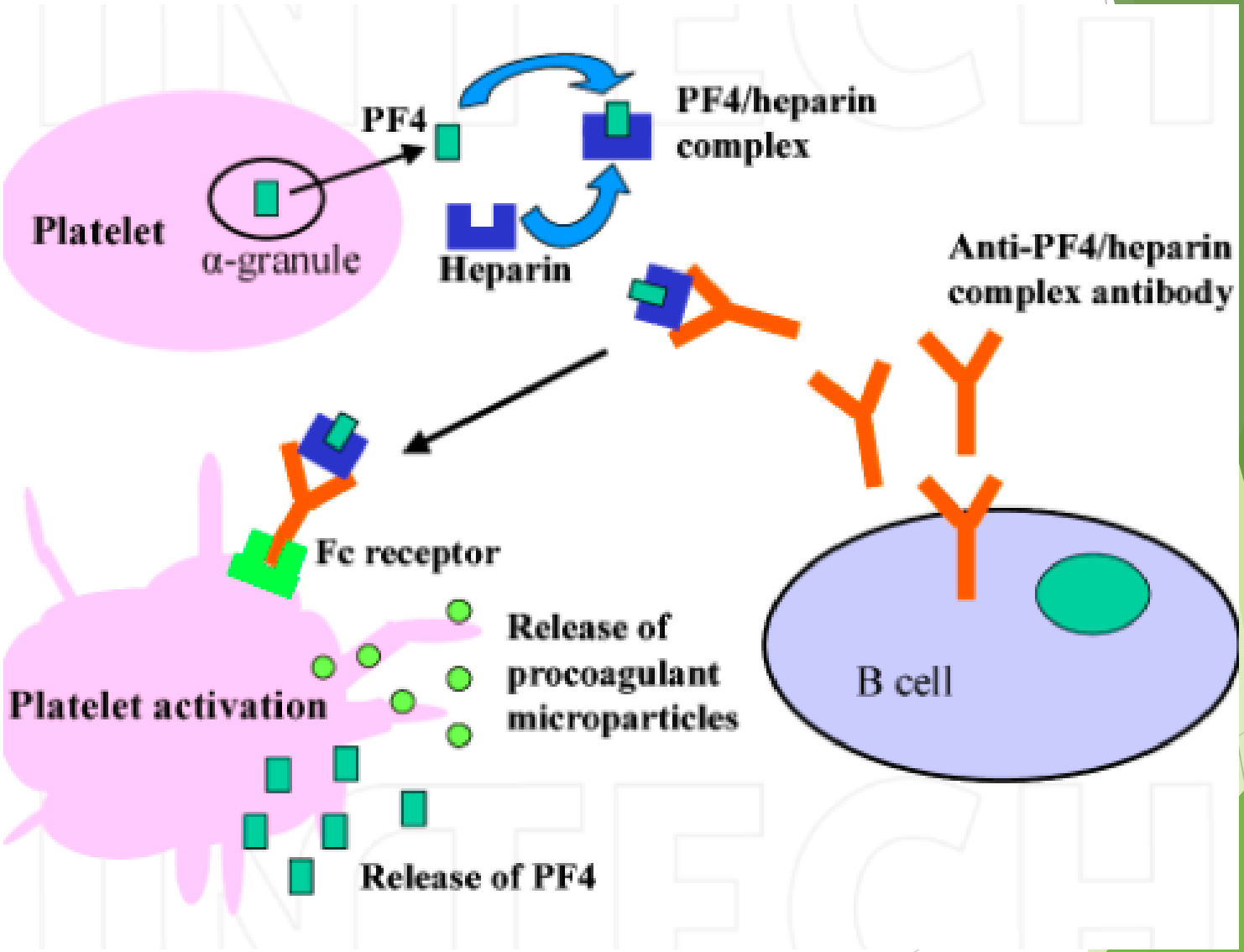
- Among the acquired thrombophilic states, two are particularly important clinical problems and deserve special mention:

- **1. Heparin-induced thrombocytopenia (HIT) syndrome:**

- occurs in patients treated with unfractionated heparin.

- It is marked by the development of autoantibodies that bind complexes of heparin and platelet membrane protein (platelet factor-4).

- Its resulting in platelet activation, aggregation, and consumption (hence thrombocytopenia), as well as causing endothelial cell injury.


PF4
PF4/heparin
complex
Platelet
α-granule
Heparin
Anti-PF4/heparin
complex antibody
Fc receptor
Release of
procoagulant
microparticles
Platelet activation
B cell
Release of PF4

- **2. Anti-phospholipid antibody syndrome**:

- Acquired antibodies against phospholipid - protein complexes.
- Suspected antibody targets include β2-glycoprotein I,

a plasma protein that associates with the surfaces of endothelial cells, trophoblasts, and prothrombin

- clinical manifestations, including :
- Recurrent thromboses.
- Repeated miscarriages.
- Cardiac valve vegetations.
- Thrombocytopenia

- Depending on the vascular bed involved, the clinical presentations can include:

- **Pulmonary embolism** (following lower extremity venous thrombosis).

- **Pulmonary hypertension** (from recurrent subclinical pulmonary emboli)

- **Stroke.**

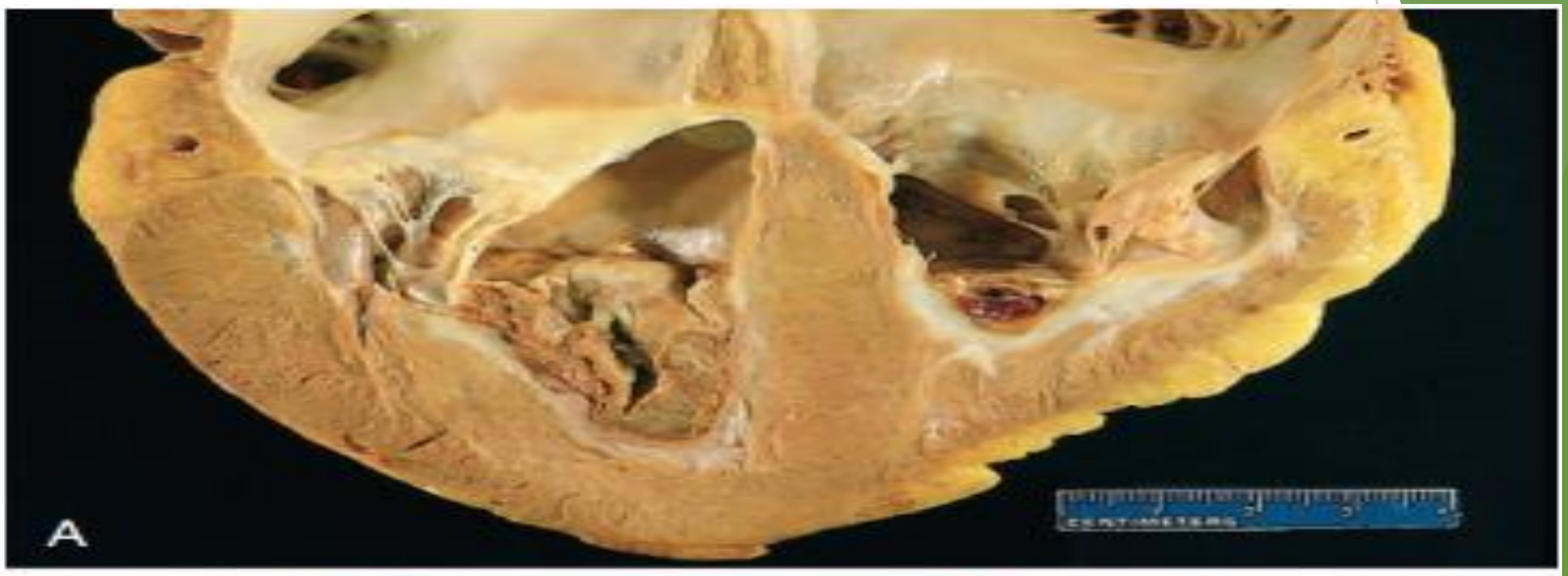
- **Bowel infarction**.

- **Renovascular hypertension**.

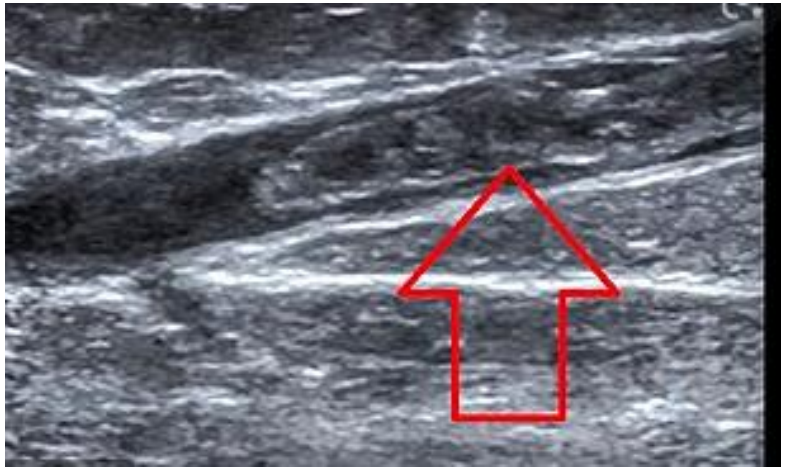
MORPHOLOGY

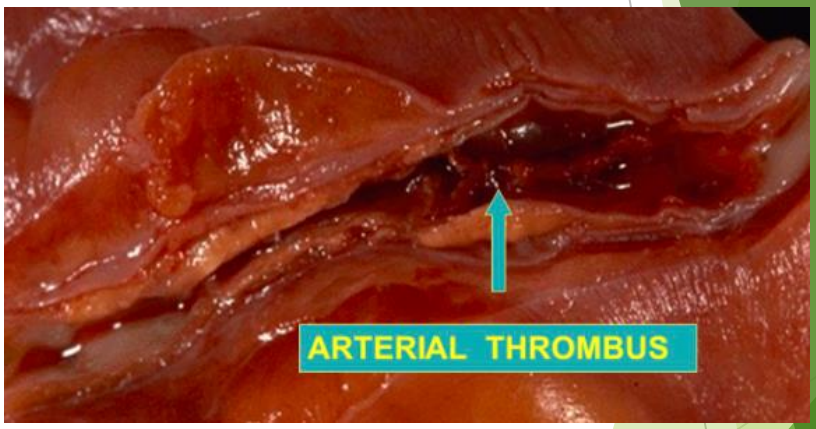
- Thrombi can develop anywhere in the cardiovascular system.
- Arterial or cardiac thrombi typically arise at sites of endothelial injury or turbulence.
- venous thrombi characteristically occur at sites of stasis.

- Mural thrombi:
- Thrombi occurring in heart chambers or in the aortic lumen



*Arterial thrombi are frequently occlusive. They are typically rich in platelets

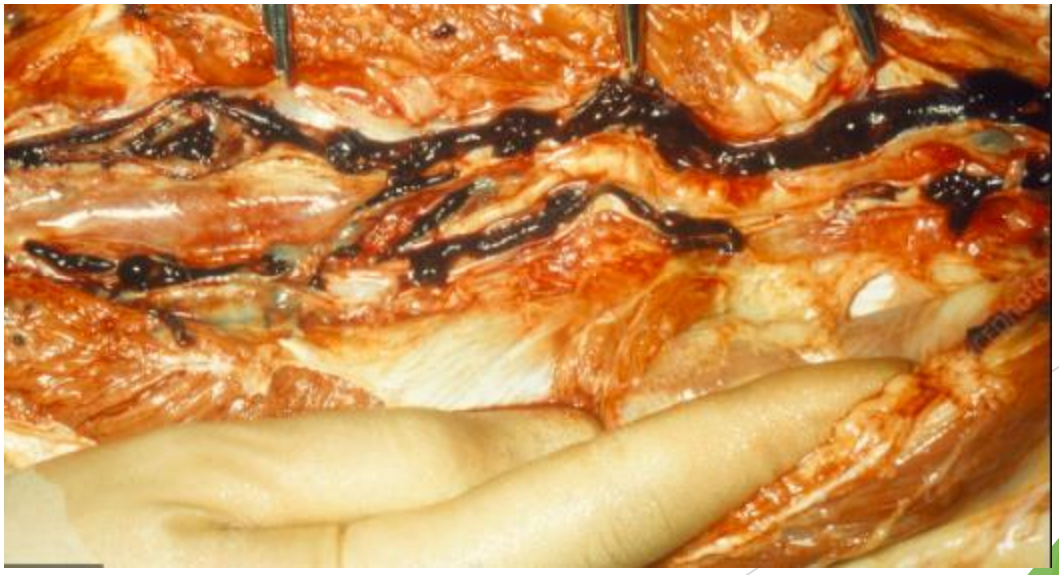


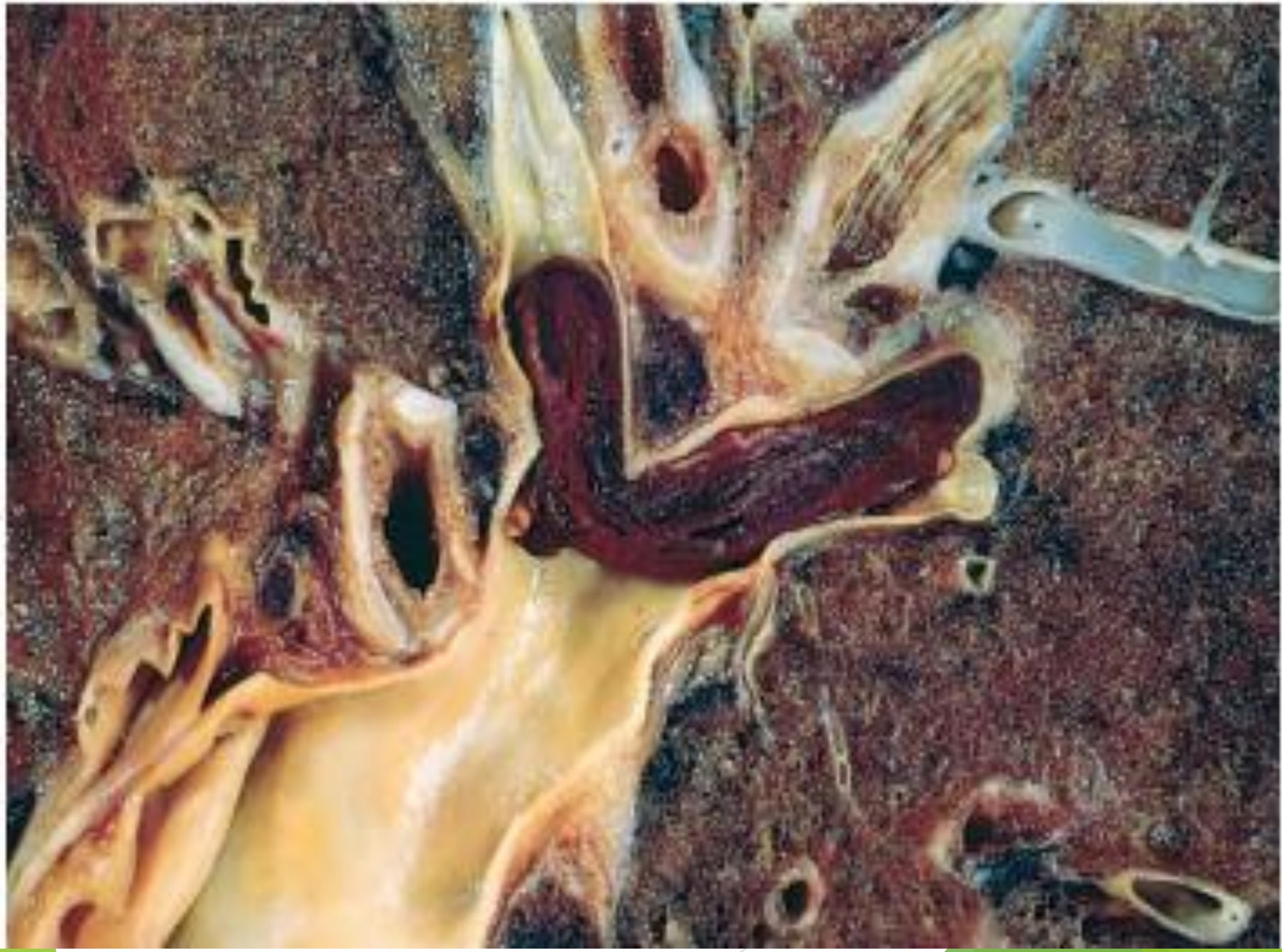


Venous thrombi (phlebothrombosis):

- They frequently propagate some distance toward the heart, forming a long cast within the vessel lumen that is prone to give rise to emboli.

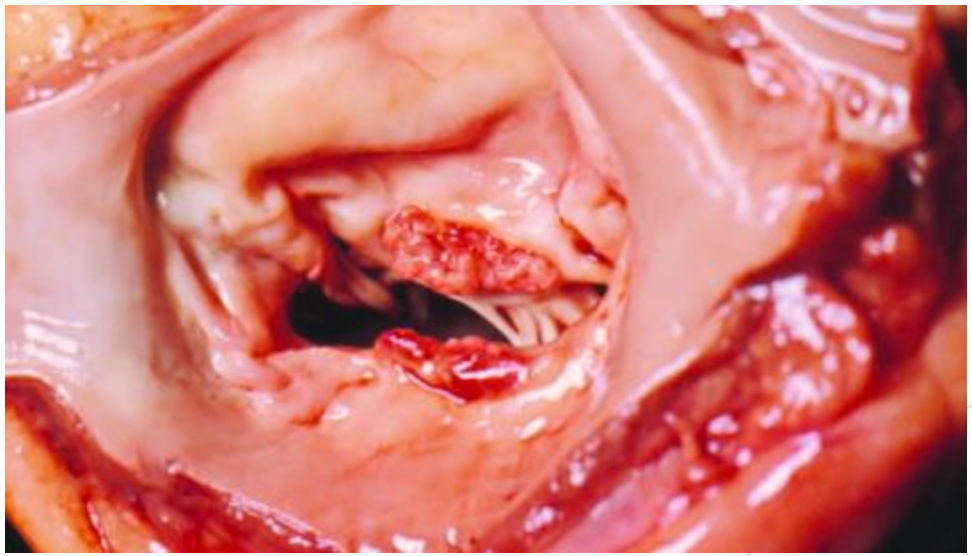
- They tend to contain more red cells.



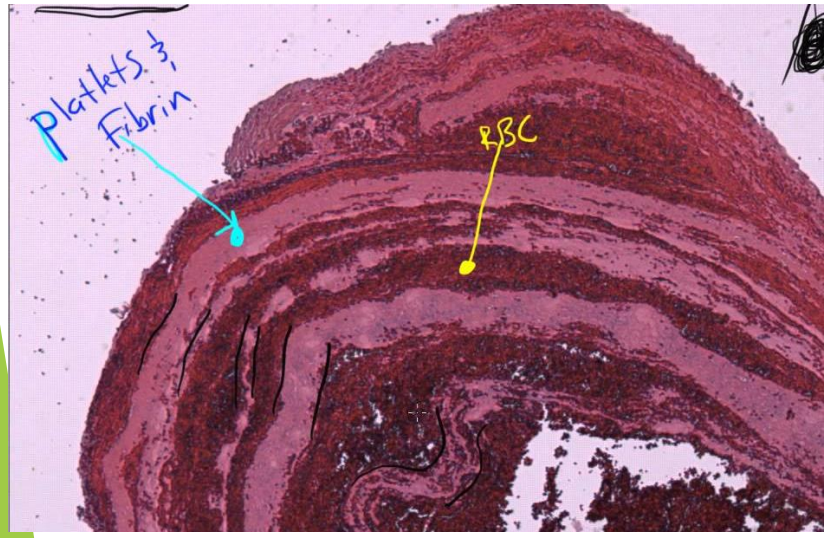


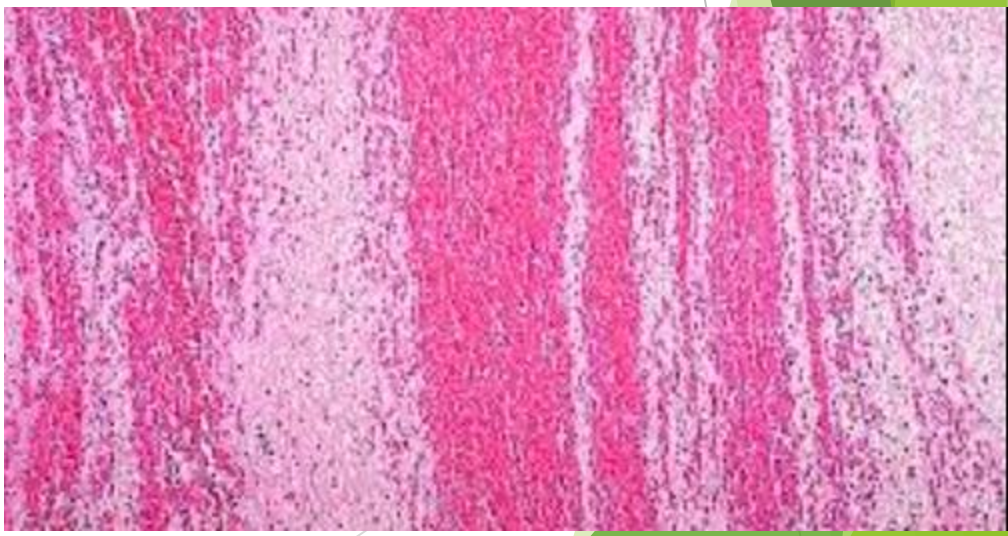
- Vegetations: Thrombi on heart valves , divided into :

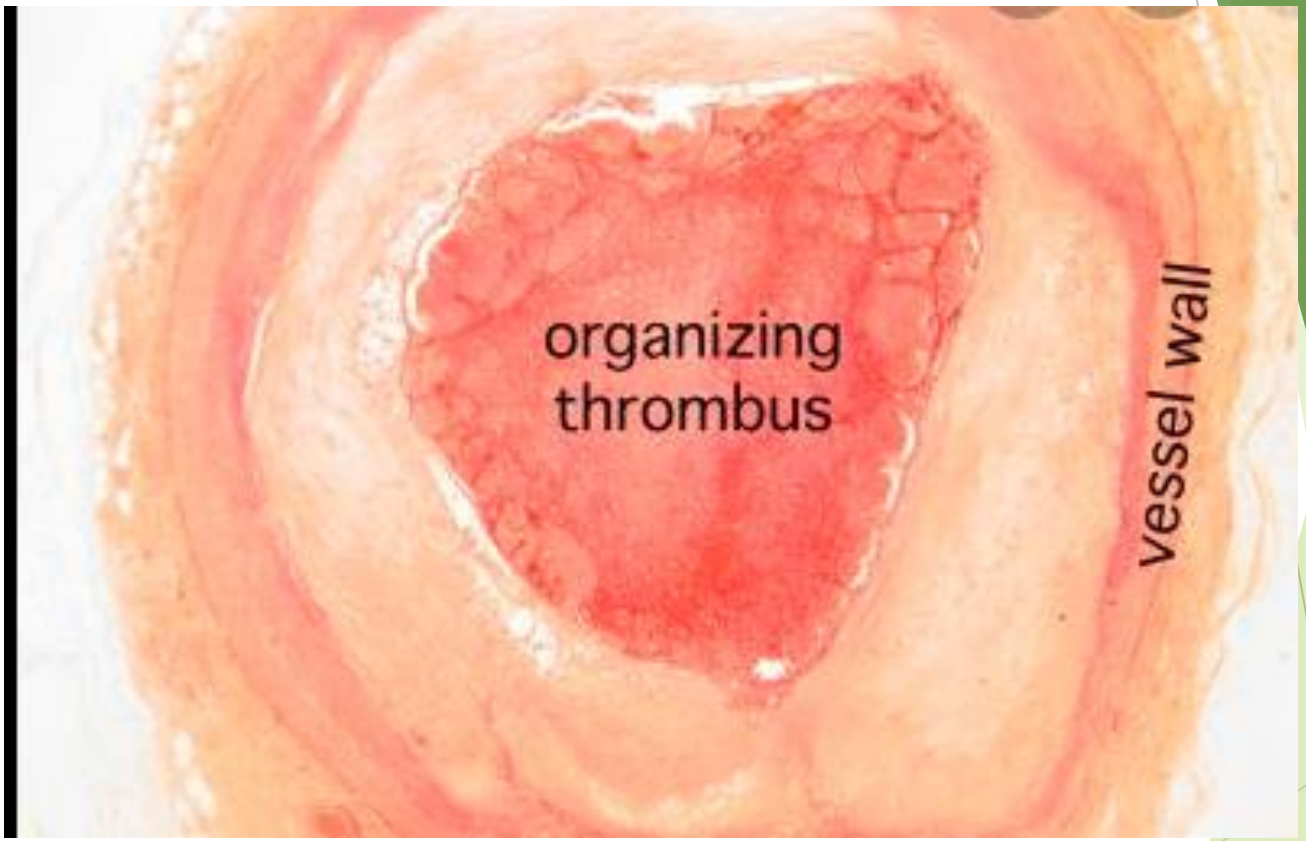
- **Infective endocarditis**: Infective thrombotic masses
- **Nonbacterial thrombotic endocarditis**: Sterile vegetations.
- **LibmanSacks endocarditis**: Sterile, occur in the systemic lupus erythematosus.

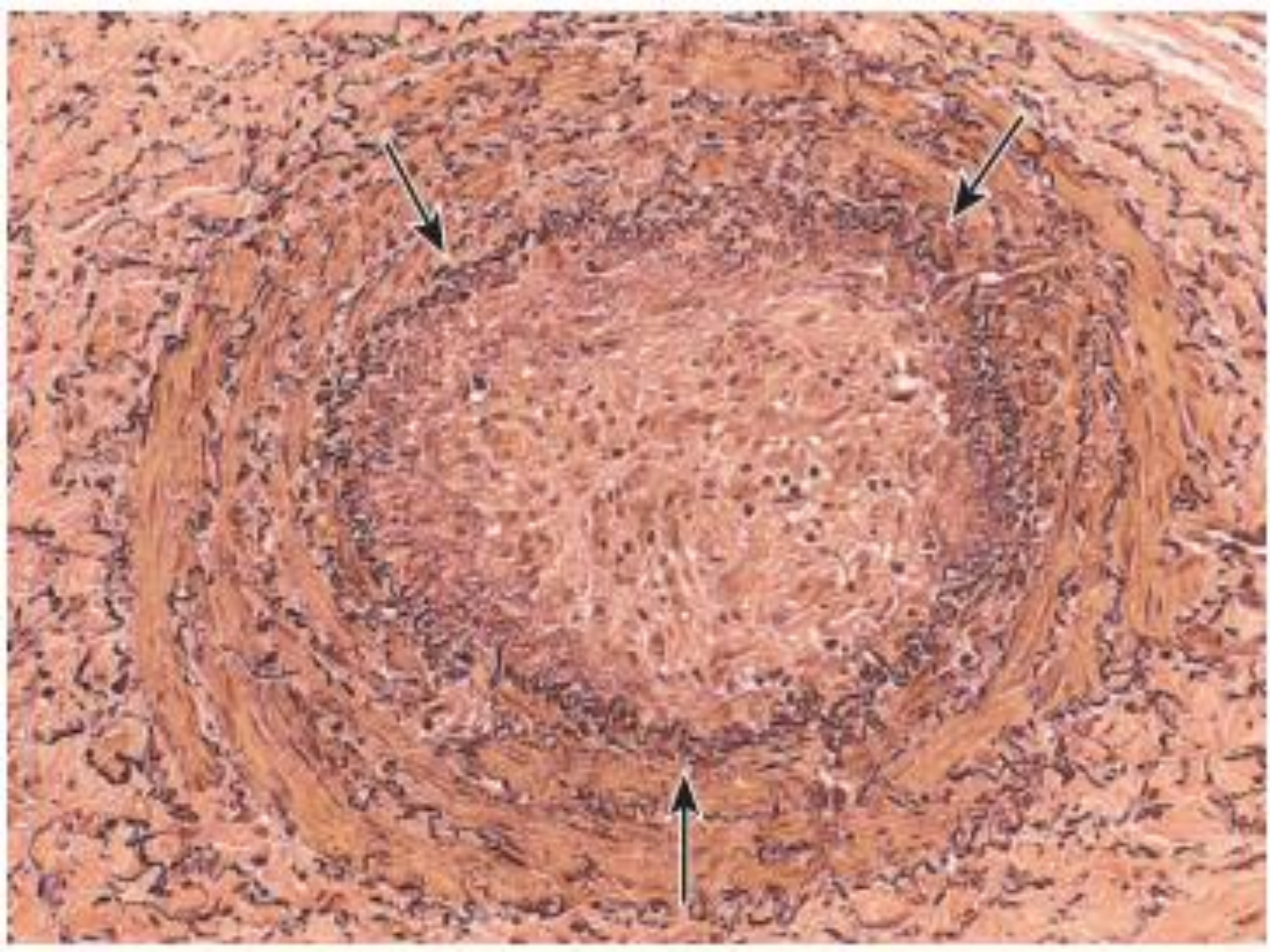


- Thrombi can have grossly (and microscopically) apparent laminations called lines of Zahn; these represent pale platelet and fibrin layers alternating with darker red cell–rich layers.






organizing
thrombus
vessel wall

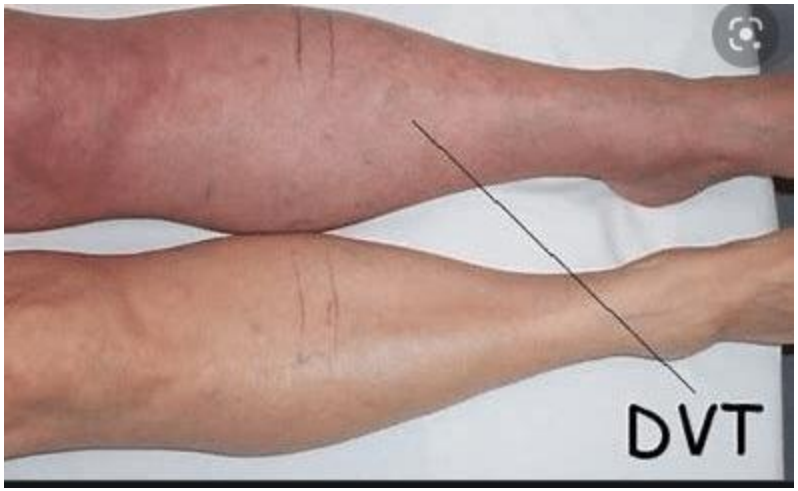


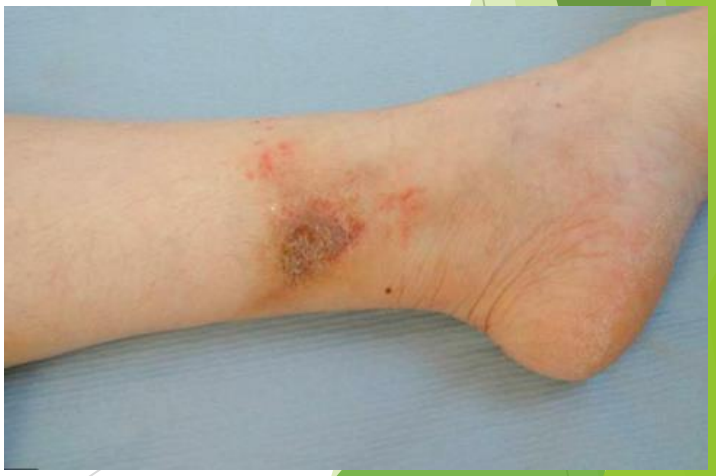
Fate of the Thrombus

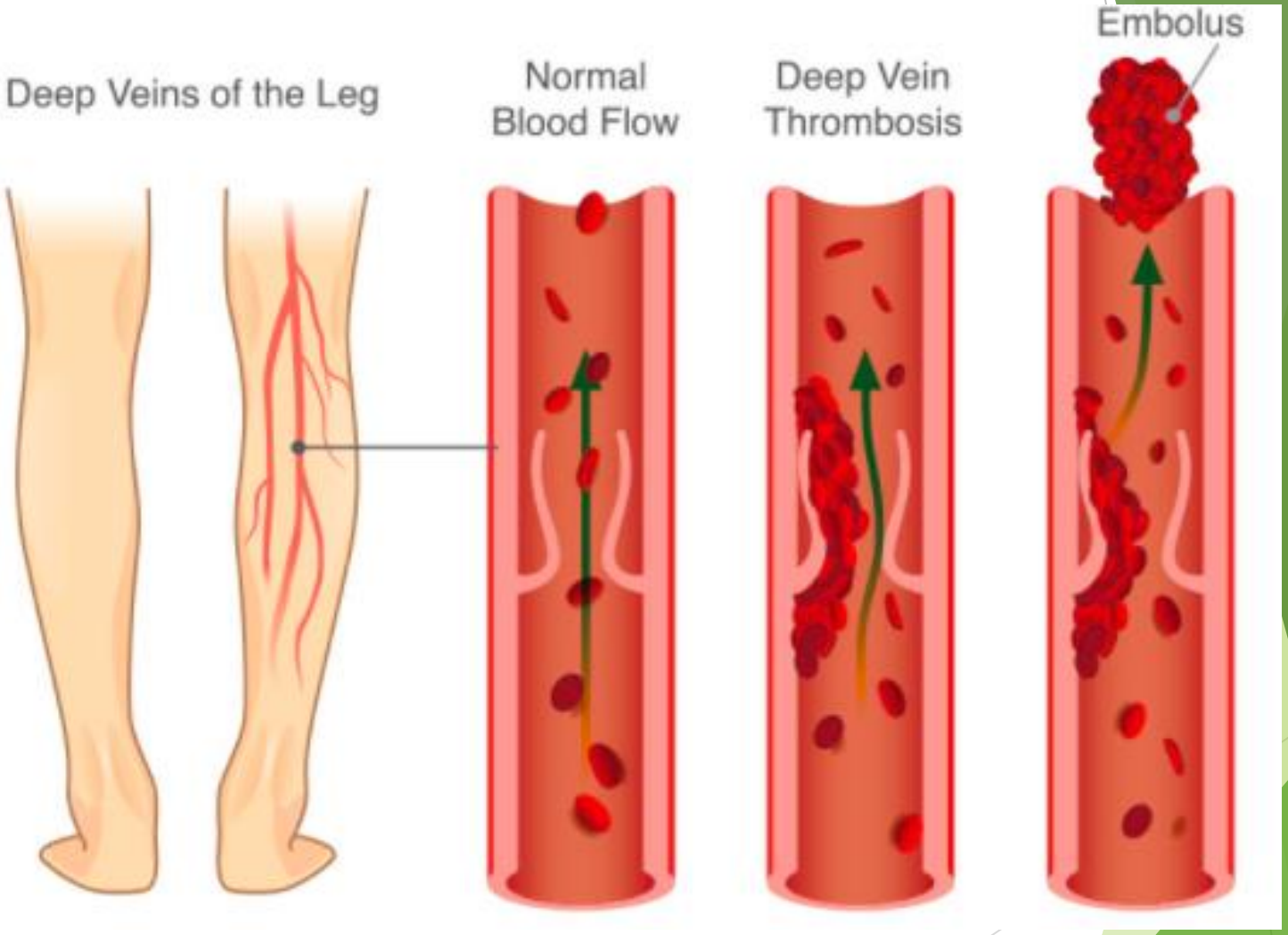
- 1. Propagation: The thrombus enlargment.
- 2. Embolization: transported in the vasculature.
- 3. Dissolution: shrinkage and complete dissolution.
- 4. Organization : ingrowth of endothelial cells, smooth muscle cells, and fibroblasts.
- 5. Recanalization: capillary channels are formed create canal along the length of the thrombus, thereby reestablishing the continuity of the original lumen.

Clinical Features

- 1. Venous Thrombosis (Phlebothrombosis)
- Pain.
- Local congestion and swelling from impaired venous outflow.
- Varicose ulcers.
- Rarely embolize.





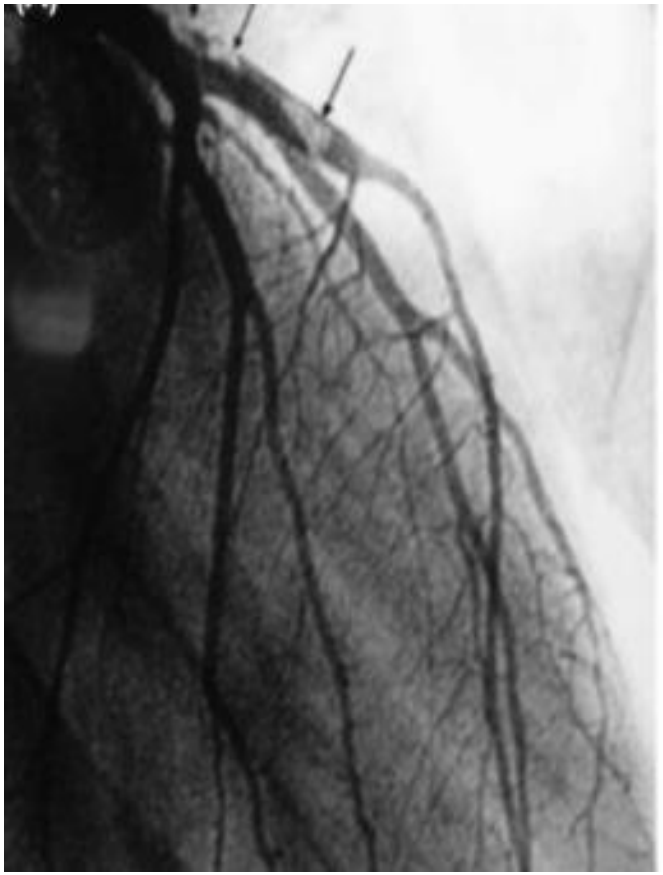

Deep Veins of the Leg
Normal Blood Flow
Deep Vein Thrombosis
Embolus

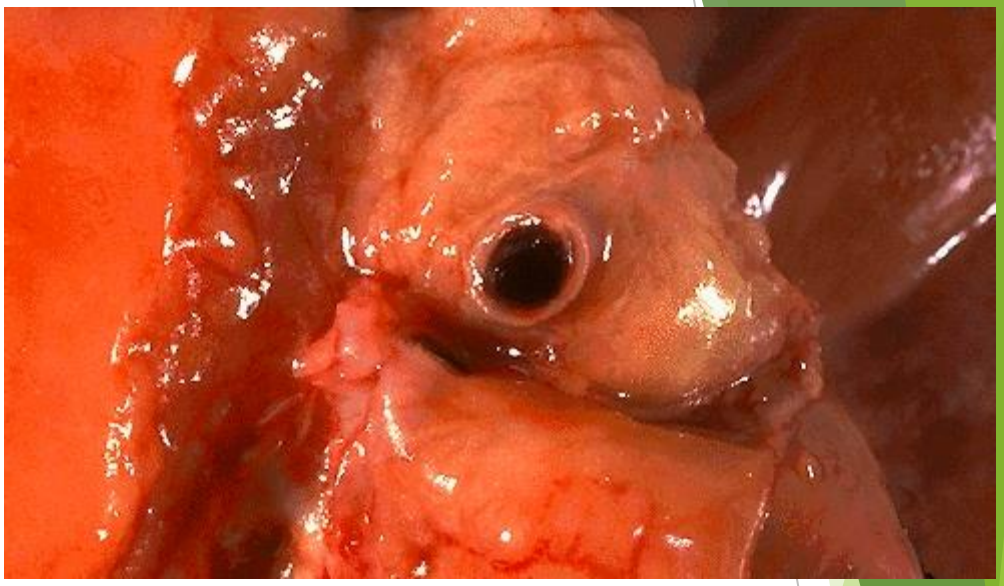
- 2. Arterial and Cardiac Thrombosis;

- Atherosclerosis is a major cause of arterial thromboses because it is associated with the loss of endothelial integrity and with abnormal blood flow.

- Both cardiac and aortic mural thrombi are prone to embolization.

- The brain, kidneys, and spleen are particularly likely targets because of their rich blood supply.



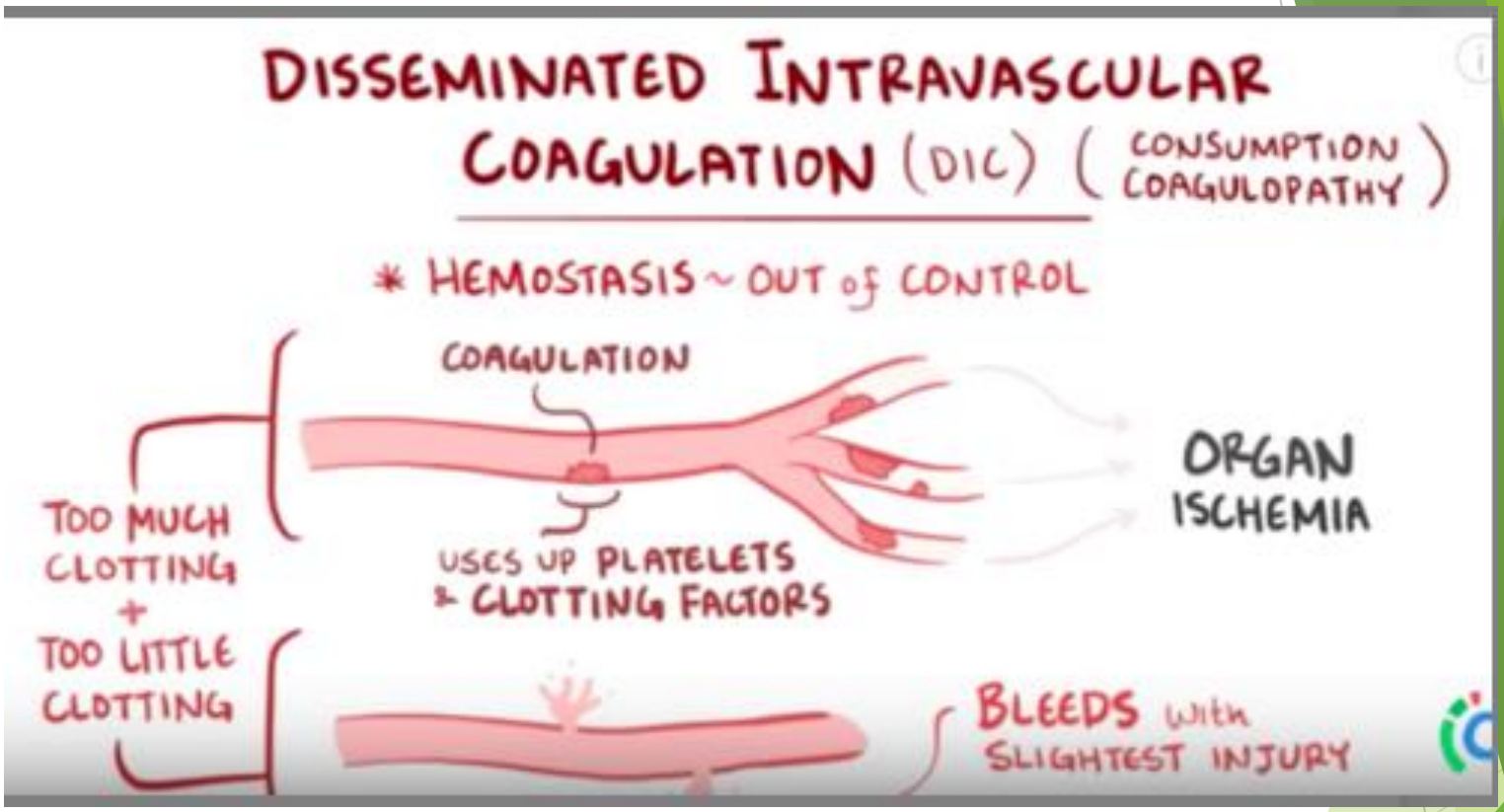


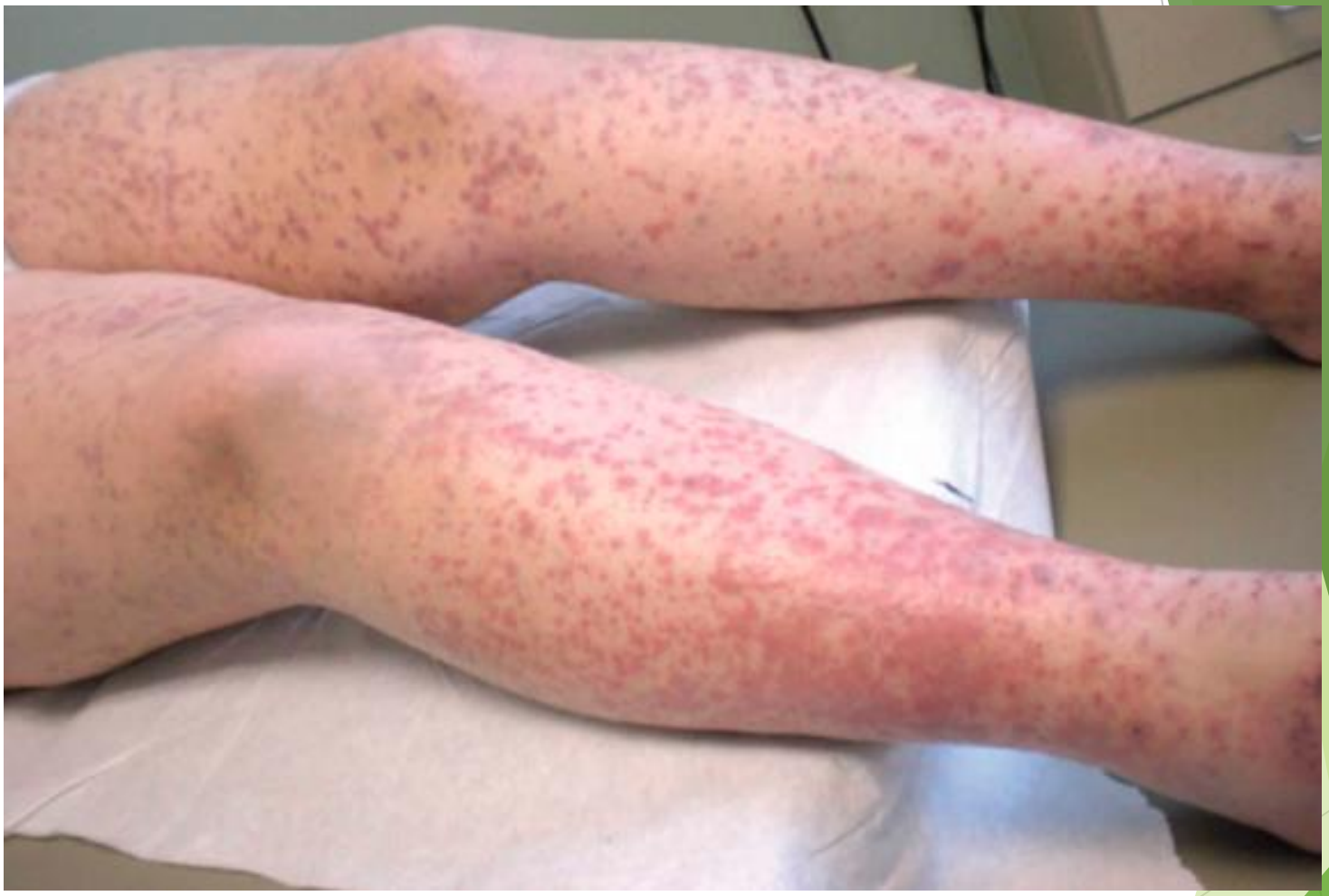
thrombosis of a coronary artery

Massive thrombosis (*arrows*) from distal portion of left main coronary artery

Disseminated Intravascular Coagulation (DIC)

- DIC is widespread thrombosis within the microcirculation that may be of sudden or insidious onset.
- DIC= widespread microvascular thrombosis + fibrinolytic mechanisms activation.
- DIC consumes platelets and coagulation proteins (hence the synonym consumptive coagulopathy).


DISSEMINATED INTRAVASCULAR COAGULATION (DIC) (CONSUMPTION COAGULOPATHY)
* HEMOSTASIS ~ OUT of CONTROL
COAGULATION
TOO MUCH CLOTTING + TOO LITTLE CLOTTING
USES UP PLATELETS & CLOTTING FACTORS
ORGAN ISCHEMIA
BLEEDS with SLIGHTEST INJURY



Excessive hemorrhage (Bruising, petechiae).

The End

Good Luck