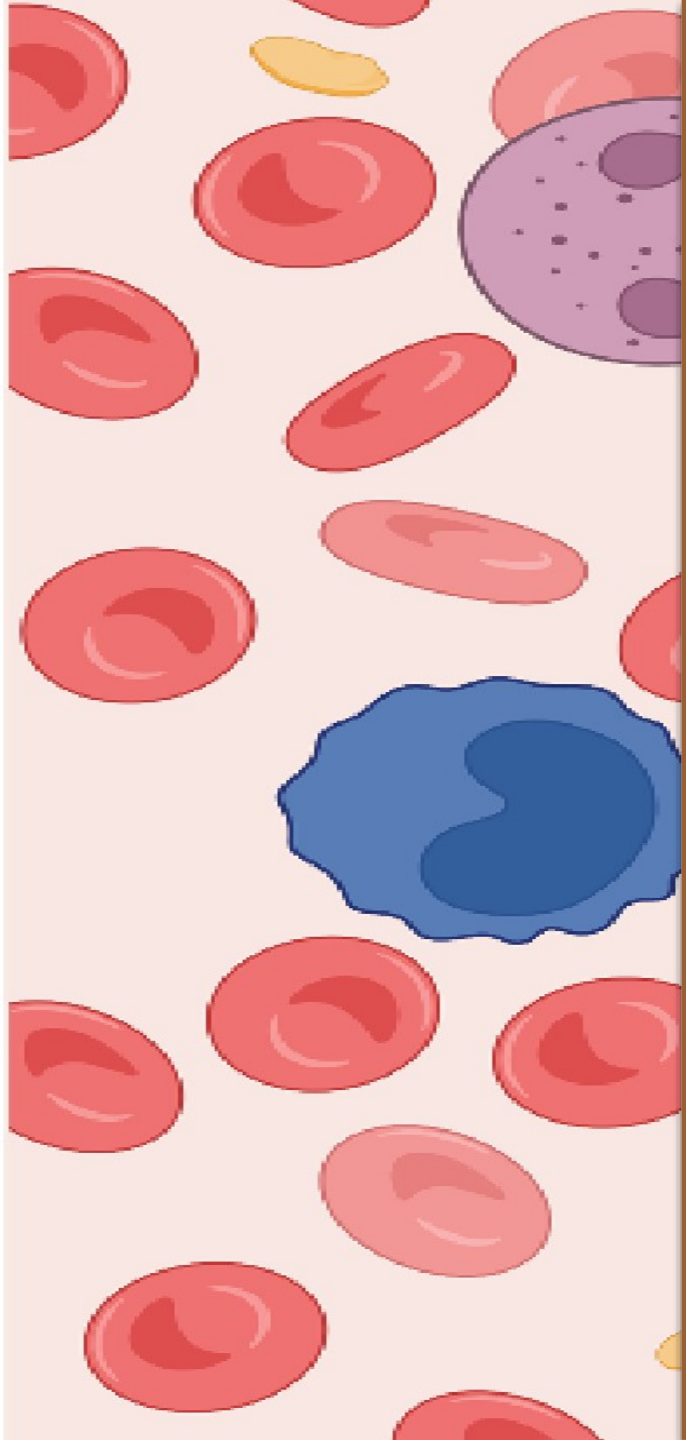




HEMATOLOGY PHYSIOLOGY

Platelets (Thrombocytes) & Hemostasis

Integrated lecture slides + supplied study sheet

Original lecture: Fatima Daoud, MD, PhD.

Platelets: overview

What are platelets?

- Platelets are cell fragments, not complete cells.
- They are also called thrombocytes.
- They lack nuclei but retain organelles and enzyme systems that support energy production and secretion.
- They play a central role in the formation of the platelet plug.

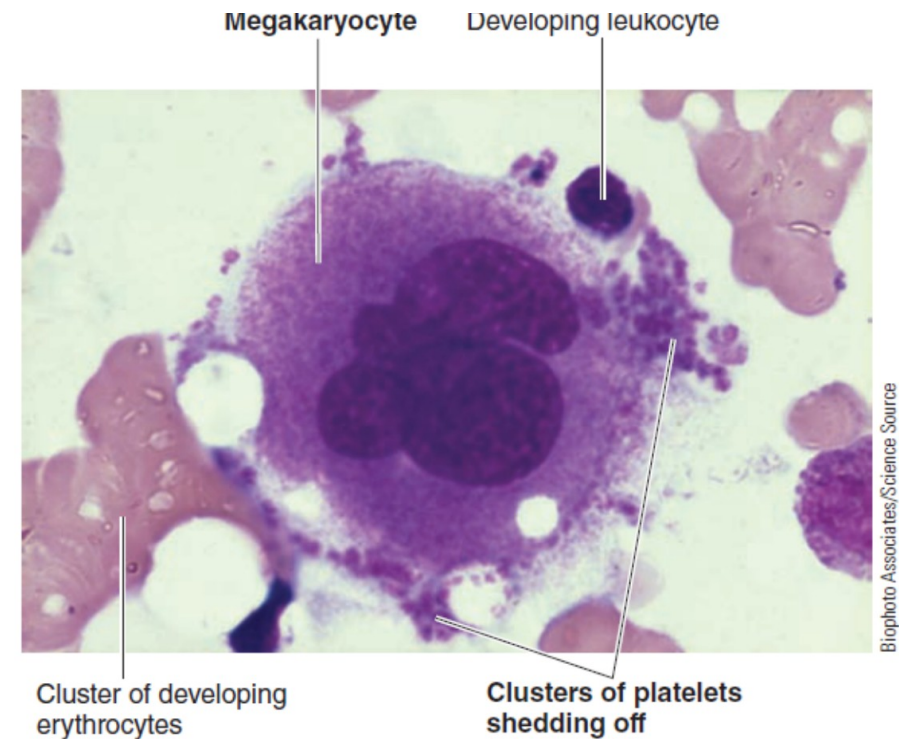
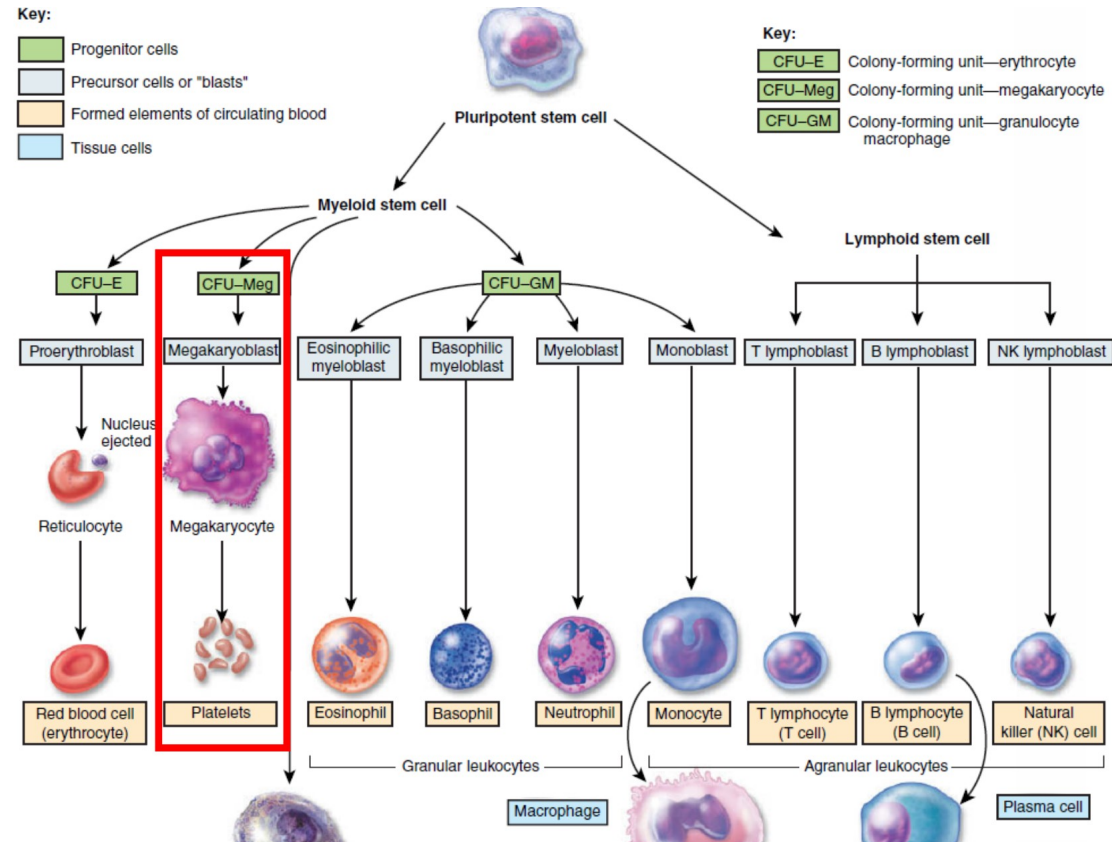


Figure 11-10 A megakaryocyte forming platelets.

Hemopoiesis & platelet lineage

Formation pathway

- Site of formation: Bone marrow.
- Platelets are formed from megakaryocytes, very large cells of the hematopoietic series in the bone marrow.
- Myeloid stem cells → Megakaryocytes → Platelets.



Thrombopoiesis: megakaryocytes

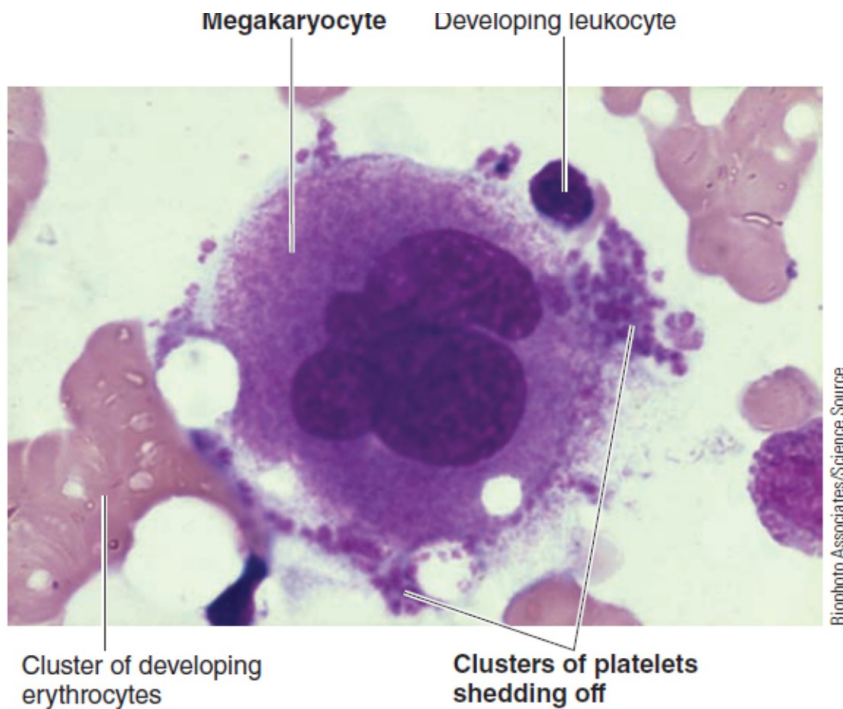


Figure 11-10 A megakaryocyte forming platelets.

- Thrombopoietin: a hormone produced in the liver that stimulates megakaryocyte production and platelet formation.
- Platelets separate from the outer cytoplasm of megakaryocytes; the supplied notes estimate about 1,000 platelets per megakaryocyte.
- Megakaryocyte diameter: approximately 60 μm (from supplied notes).
- Platelet size: 2–4 μm (from supplied notes).

Platelet characteristics

Counts, lifespan, and removal

- The normal concentration of platelets in the blood is between 150,000 and 450,000/ μL .
- Half-life in the blood of 8 to 12 days (wording as stated in the lecture); approximately 10 days in the supplied notes.
- Eliminated from the circulation mainly by tissue macrophages, especially in the spleen; the supplied notes also mention the liver.
- Platelets are cell fragments without nuclei.

Platelet cytoplasm: contractile system

Platelets have no nuclei; however, they contain:

- 1. Contractile proteins: actin, myosin, and thrombosthenin.
- Actin and myosin: contraction and strengthening of the platelet plug.
- Thrombosthenin: contractile protein.
- 2. Residuals of both the endoplasmic reticulum and the Golgi apparatus.
- 3. Mitochondria (ATP production).

Platelet cytoplasm: mediators & growth

- 4. Enzyme systems that synthesize prostaglandins.
- 5. Fibrin-stabilizing factor: important in blood clot stabilization.
- 6. Growth factors for vascular endothelial cells, vascular smooth muscle cells, and fibroblasts.
- Growth factors promote growth/proliferation of vascular endothelial cells, vascular smooth muscle cells, and fibroblasts.
- Although platelets lack nuclei, they contain organelles and enzyme systems that support energy production and secretion.

Platelet membrane: two crucial roles

Glycoprotein coat

- There is a coat of glycoproteins that repulses adherence to normal endothelium and yet causes adherence to injured areas of the vessel wall.
- Especially where collagen is exposed.

Membrane phospholipids

- Contains large amounts of phospholipids that activate multiple stages in the blood-clotting process.
- Remember: Glycoproteins → adhesion; Phospholipids → support coagulation.

Thrombocytopenia: clinical manifestations

Decreased platelet count

- Thrombocytopenia is a decreased platelet count, which increases the tendency to bleed.
- Cutaneous and mucosal bleeding.
- Easy bruising.
- Petechiae.
- Increased bleeding time.



Petechiae & bleeding risk

- Petechiae: small red or purple hemorrhagic spots caused by small areas of bleeding into tissues.
- Numerous small hemorrhagic areas can occur beneath the skin and in internal tissues when platelet numbers are low.

Platelet count	Significance in the supplied notes
150,000–450,000/ μ L	Normal range
Below 50,000/ μ L	Increased risk of severe bleeding after surgery or trauma
Below 10,000/ μ L	Spontaneous bleeding may occur

Bleeding manifestations may be due to a low platelet count or platelet dysfunction.

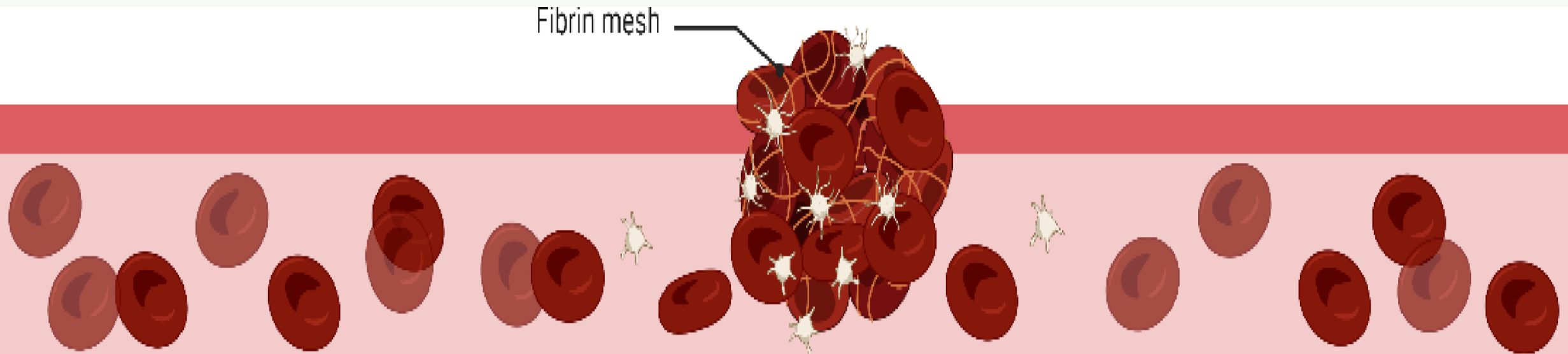
Bleeding time & platelet function

Clinical significance

- Bleeding time can be used to assess platelet function.
- Thrombocytopenia can cause prolonged bleeding time.
- Platelet dysfunction can also cause bleeding manifestations despite the presence of platelets.

Hemostasis

Prevention of blood loss

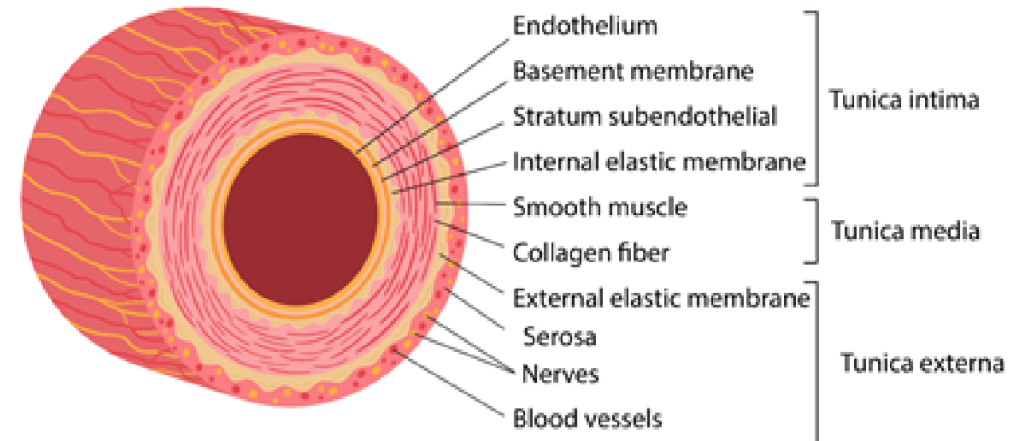


Blood vessel wall: key anatomy

Structural layers

- 1. Endothelial layer.
- 2. Basement membrane, associated with collagen.
- 3. Vascular smooth muscle layer.
- 4. Outermost connective tissue layer.
- Intact endothelium normally prevents platelet adhesion; injury disrupts it and exposes underlying collagen.

Blood vessel anatomy



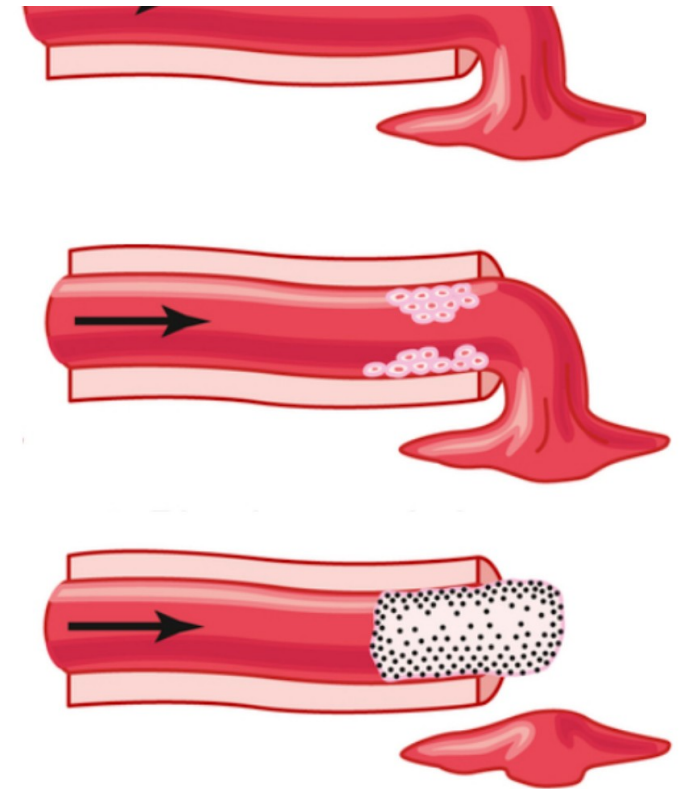
Conditions for bleeding

- A break must be present in the vessel wall.
- Pressure inside the vessel must exceed pressure outside the vessel.
- Minor injuries to capillaries, arterioles, and venules are common; normal hemostatic mechanisms usually seal these small defects.
- Bleeding from medium or large vessels may not be stopped by hemostatic mechanisms alone. Arterial bleeding is generally more profuse because arterial pressure is higher than venous pressure.
- The lecture mentions external pressure to temporarily control severe bleeding. Elevating the affected part may help reduce venous pressure.

Four events of hemostasis

Hemostasis means prevention of blood loss

- (1) Vascular constriction.
- (2) Formation of a platelet plug.
- (3) Formation of a blood clot as a result of blood coagulation.
- (4) Growth of fibrous tissue into the blood clot to close the hole in the vessel permanently.



1. Vascular constriction: immediate effect

Response immediately after vessel injury

- Immediately → smooth muscle contraction.
- Reduces the flow of blood from the ruptured vessel.
- The spasm can last for many minutes or even hours, during which time the processes of platelet plugging and blood coagulation can take place.
- Main role: reduce blood loss and provide time for later stages; constriction alone may not stop bleeding completely.

Vascular constriction: three mechanisms

01 Local myogenic spasm

Local contraction of vascular smooth muscle.

02 Local autacoid factors

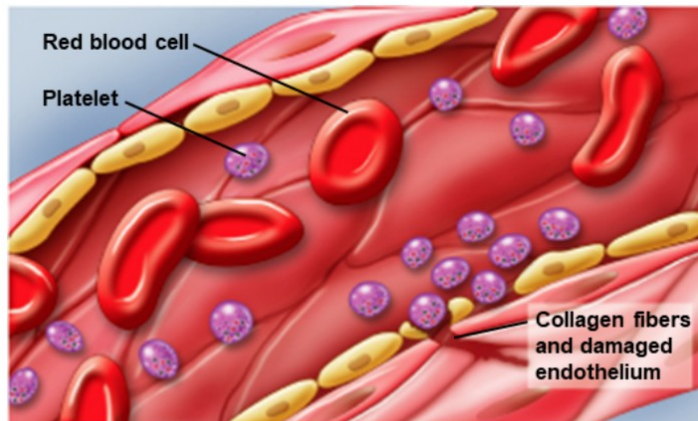
Factors from traumatized tissues, vascular endothelium, and blood platelets.

03 Nervous reflexes

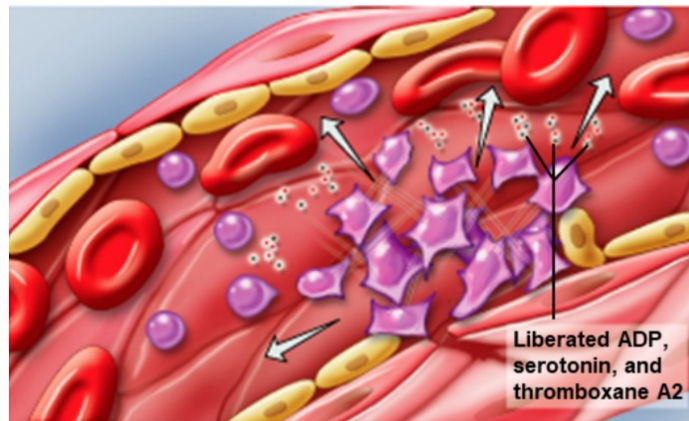
A reflex contribution to immediate vasoconstriction.

2. Platelet plug formation: three stages

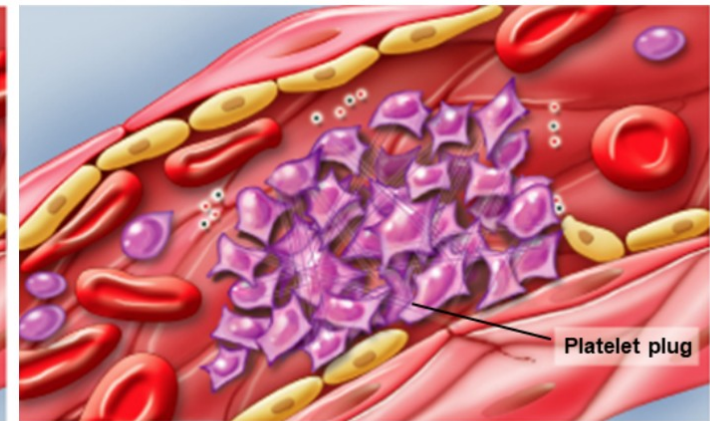
ADHESION → ACTIVATION / SECRETION → AGGREGATION



1 Platelet adhesion



2 Platelet release reaction



3 Platelet aggregation

Platelet adhesion: collagen & vWF

- Platelets normally do not adhere to the smooth endothelial lining of intact vessels, but they adhere to damaged vessels.
- Vessel injury exposes collagen beneath the endothelium.
- Von Willebrand factor (vWF), a plasma protein present in plasma and released by megakaryocytes, platelets, and endothelial cells as described in the lecture, binds to exposed collagen.
- vWF acts as a bridge between platelets and the injured vessel wall.

Vessel injury → Exposed collagen → vWF binds collagen → Platelet adhesion

Platelet activation / secretion

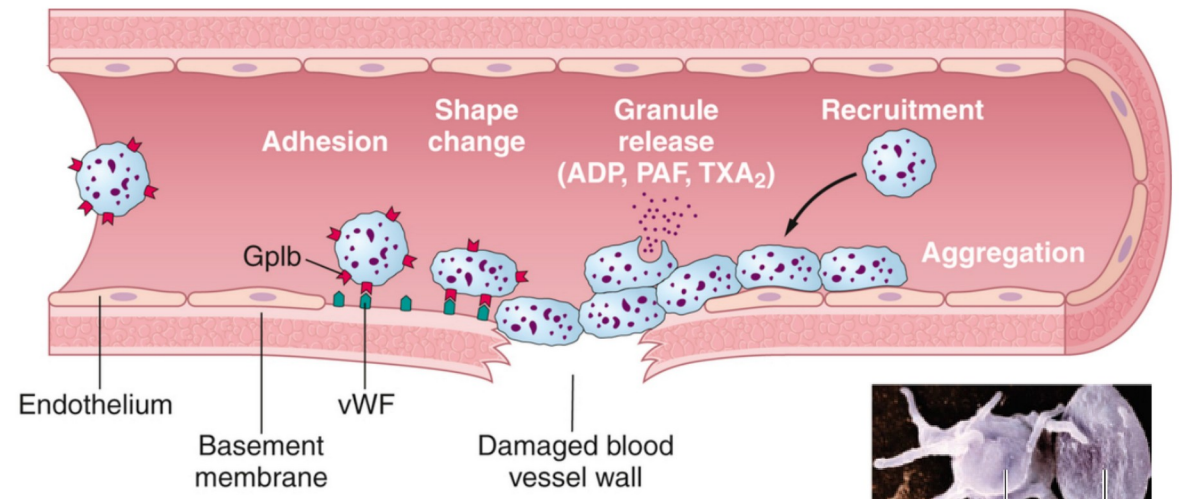
Platelets swell, become irregular, develop numerous pseudopods, contract, and release granule contents.

Substance	Main effect
ADP	Activates nearby platelets
Thromboxane A ₂ (TXA ₂)	Contributes to vasoconstriction and supports platelet recruitment
Other granule contents	Help recruit and activate additional platelets

Platelet aggregation

Formation of the platelet plug

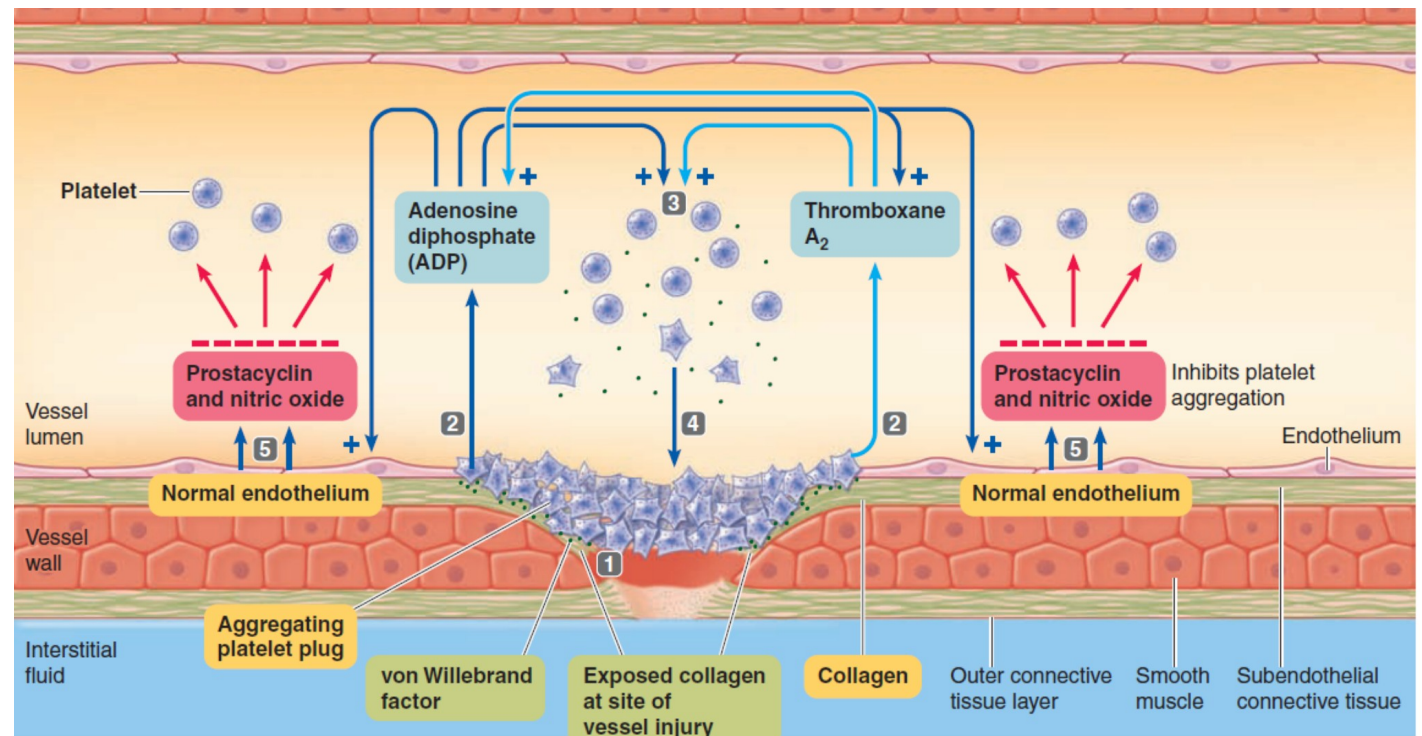
- Platelets adhere to one another and accumulate at the injury site to form a platelet plug.
- Adhesion = platelets attach to vessel wall.
- Aggregation = platelets attach to each other.



Control of platelet plug formation

Healthy endothelium limits the plug

- Healthy neighboring endothelium releases prostacyclin (PGI_2) and nitric oxide (NO).
- Both inhibit platelet aggregation and help limit the plug to the injured area.



Regulation: activation vs inhibition

Substance	Effect on platelet plug
ADP	Activates nearby platelets
TXA ₂	Contributes to vasoconstriction
Prostacyclin (PGI ₂)	Inhibits platelet aggregation
Nitric oxide (NO)	Inhibits platelet aggregation

ADP / TXA₂ help activation and recruitment; prostacyclin / NO inhibit aggregation.

Functions of the platelet plug

The aggregated plug physically seals the break and also:

- (1) The actin–myosin complex within the aggregated platelets contracts to compact and strengthen the plug.
- (2) The platelet plug releases several powerful vasoconstrictors that induce profound constriction.
- (3) The platelet plug releases other chemicals that enhance blood coagulation; membrane phospholipids support multiple coagulation stages.
- (4) Growth factors promote growth/proliferation of endothelial cells, smooth muscle cells, and fibroblasts, supporting vessel wall repair.

Platelet plug vs. blood clot

Platelet plug	Blood clot
Forms through platelet adhesion, activation, and aggregation.	Forms as a result of blood coagulation.
May seal very small, frequently occurring vascular defects.	Needed to achieve more complete hemostasis in larger defects.
Is the second event of hemostasis.	Is the third event of hemostasis.

Complete hemostasis: flowchart

- 1 Vessel injury: damage to vessel wall; collagen becomes exposed.
- 2 Vascular constriction: smooth muscle contraction, myogenic spasm, local factors, nervous reflexes.
- 3 Platelet plug: adhesion → activation/secretion → aggregation.
- 4 Blood coagulation: formation of a blood clot.
- 5 Fibrous tissue growth: fibrous tissue grows into the clot to close the defect permanently.

High-yield quick review: terminology (I)

Term	Essential point
Megakaryocyte	Bone marrow cell from which platelets form
Thrombopoietin	Hormone involved in megakaryocyte production and platelet formation
Thrombocytopenia	Decreased platelet count
Petechiae	Small red or purple hemorrhagic spots
Hemostasis	Prevention of blood loss
Adhesion	Platelets attach to the injured vessel wall
Activation / secretion	Platelets change shape and release granule contents
Aggregation	Platelets adhere to one another

High-yield quick review: terminology (II)

Term	Essential point
vWF	Bridge between platelets and exposed collagen
ADP	Activates nearby platelets
TXA ₂	Contributes to vasoconstriction
Prostacyclin and NO	Inhibit platelet aggregation
Actin–myosin	Compacts and strengthens the platelet plug
Phospholipids	Support multiple stages of coagulation

Key comparisons (I)

Adhesion vs. aggregation

Adhesion = platelets attach to vessel wall; aggregation = platelets attach to each other.

ADP vs. prostacyclin

ADP activates nearby platelets; prostacyclin inhibits platelet aggregation.

Glycoproteins vs. phospholipids

Glycoproteins support adhesion; phospholipids support coagulation.

Key comparisons (II)

Vascular constriction vs. platelet plug

Constriction reduces blood flow; the plug forms a temporary seal.

Platelet plug vs. blood clot

Plug forms through platelet interactions; clot forms through coagulation.

Lecture references

- 1. Hall, John E., and Michael E. Hall. Guyton and Hall Textbook of Medical Physiology (14th Edition).
- 2. Lauralee Sherwood. Human Physiology: From Cells to Systems (9th Edition).
- 3. Gerard J. Tortora and Bryan Derrickson. Principles of Human Anatomy & Physiology (15th Edition).
- 4. Uptodate.com