16.5A: Overview of Hemostasis

Hemostasis is the natural process that stops blood loss when an injury occurs.

Learning Objectives

- Explain the steps involved in hemostasis

Key Points

- Hemostasis is the natural process that stops blood loss when an injury occurs. It involves three steps: (1) vascular spasm (vasoconstriction); (2) platelet plug formation; and (3) coagulation.
- Vasoconstriction is a reflex in which blood vessels narrow to increase blood pressure.
- Next, platelet plug formation involves the activation, aggregation, and adherence of platelets into a plug that serves as a barrier against blood flow.
- Coagulation involves a complex cascade in which a fibrin mesh is cleaved from fibrinogen.
- Fibrin acts as a "molecular glue" during clot formation, holding the platelet plug together.

Key Terms

- **hemostasis**: The process of slowing and stopping the flow of blood to initiate wound healing.
- **coagulation**: The process by which blood forms gelatinous clots.
- **heparin**: A fibrinolytic molecule expressed on endothelial cells or produced as a blood thinner medicine. It prevents activation of platelets and clotting factors.
Hemostasis is the natural process in which blood flow slows and a clot forms to prevent blood loss during an injury, with hemo- meaning blood, and stasis meaning stopping. During hemostasis, blood changes from a fluid liquid to a gelatinous state.

**Steps of Hemostasis**

Hemostasis includes three steps that occur in a rapid sequence: (1) vascular spasm, or vasoconstriction, a brief and intense contraction of blood vessels; (2) formation of a platelet plug; and (3) blood clotting or coagulation, which reinforces the platelet plug with fibrin mesh that acts as a glue to hold the clot together. Once blood flow has ceased, tissue repair can begin.

**Angiogenesis Generates New Blood Vessels**: Blood vessel with an erythrocyte (red blood cell) within its lumen, endothelial cells forming its tunica intima or inner layer, and pericytes forming its tunica adventitia (outer layer).

**Vasoconstriction**

Intact blood vessels are central to moderating blood’s clotting tendency. The endothelial cells of intact vessels prevent clotting by expressing a fibrinolytic heparin molecule and thrombomodulin, which prevents platelet aggregation and stops the coagulation cascade with nitric oxide and prostacyclin. When endothelial injury occurs, the endothelial cells stop secretion of coagulation and aggregation inhibitors and instead secrete von Willebrand factor, which causes platelet adherence during the initial formation of a clot. The vasoconstriction that occurs during hemostasis is a brief reflexive contraction that causes a decrease in blood flow to the area.
Platelet Plug Formation

Platelets create the "platelet plug" that forms almost directly after a blood vessel has been ruptured. Within twenty seconds of an injury in which the blood vessel’s epithelial wall is disrupted, coagulation is initiated. It takes approximately sixty seconds until the first fibrin strands begin to intersperse among the wound. After several minutes, the platelet plug is completely formed by fibrin.

Contrary to popular belief, clotting of a skin injury is not caused by exposure to air, but by platelets adhering to and being activated by collagen in the blood vessels’ endothelium. The activated platelets then release the contents of their granules, which contain a variety of substances that stimulate further platelet activation and enhance the hemostatic process.

When the lining of a blood vessel breaks and endothelial cells are damaged, revealing subendothelial collagen proteins from the extracellular matrix, thromboxane causes platelets to swell, grow filaments, and start clumping together, or aggregating. Von Willebrand factor causes them to adhere to each other and the walls of the vessel. This continues as more platelets congregate and undergo these same transformations. This process results in a platelet plug that seals the injured area. If the injury is small, the platelet plug may be able to form within several seconds.

Coagulation Cascade

If the platelet plug is not enough to stop the bleeding, the third stage of hemostasis begins: the formation of a blood clot. Platelets contain secretory granules. When they stick to the proteins in the vessel walls, they degranulate, thus releasing their products, which include ADP (adenosine diphosphate), serotonin, and thromboxane A2 (which activates other platelets).

First, blood changes from a liquid to a gel. At least 12 substances called clotting factors or tissue factors take part in a cascade of chemical reactions that eventually create a mesh of fibrin within the blood. Each of the clotting factors has a very specific function. Prothrombin, thrombin, and fibrinogen are the main factors involved in the outcome of the coagulation cascade. Prothrombin and fibrinogen are proteins that are produced and deposited in the blood by the liver.

When blood vessels are damaged, vessels and nearby platelets are stimulated to release a substance called prothrombin activator, which in turn activates the conversion of prothrombin, a plasma protein, into an enzyme called thrombin. This reaction requires calcium ions. Thrombin facilitates the conversion of a soluble plasma protein called fibrinogen into long, insoluble fibers or threads of the protein, fibrin. Fibrin threads wind around the platelet plug at the damaged area of the blood vessel, forming an interlocking network of fibers and a framework for the clot. This net of fibers traps and helps hold platelets, blood cells, and other molecules tight to the site of injury, functioning as the initial clot. This temporary fibrin clot can form in less than a minute and slows blood flow before platelets attach.

Next, platelets in the clot begin to shrink, tightening the clot and drawing together the vessel walls to initiate the process of wound healing. Usually, the whole process of clot formation and tightening takes less than a half hour.
Vasoconstriction: Microvessel showing an erythrocyte (E), a tunica intima of endothelial cells, and a tunica adventitia of pericytes.