16.6B: Plasma and Blood Volume Expanders

A volume expander is a type of intravenous therapy that provides fluid replacement for the circulatory system.

Learning Objectives

• Evaluate the use of blood volume expanders

Key Points

• During blood loss, the amount of oxygen that can be delivered to the tissues is reduced due to lost red blood cells and decreased blood volume, which also causes a decrease in blood pressure.

• Although they cannot replace lost red blood cells, blood volume expanders can help improve oxygen delivery in instances of blood loss by increasing blood volume and blood pressure so that blood can flow to the tissues.

• Survival is possible with low red blood cell and hemoglobin levels as long as blood volume and blood pressure are maintained so blood continues to reach tissues.

• Hypovolemic shock occurs when tissue oxygenation drops due to a decrease in blood volume.

• Crystalloids volume expanders are aqueous solutions of mineral salts or other water-soluble molecules. Although they decrease the osmotic pressure by diluting the red blood cells, they increase both vascular and interstitial volume.

• Colloids volume expanders contain larger insoluble molecules, such as gelatin or hydroxyethyl starch, and theoretically increase the intravascular volume but not interstitial and intracellular volumes.
Key Terms

- **crystalloid**: Aqueous solutions of mineral salts or other water-soluble molecules, such as saline solution.
- **hypovolemic shock**: Shock due to decreased blood volume, such as through severe bleeding or vomiting. It activates dangerous compensatory mechanisms that maintain blood flow to the brain while causing other organs to fail.
- **colloid**: Blood volume expander containing larger insoluble molecules that exert osmotic pressure.

When blood is lost, the greatest immediate need is to stop further blood loss, then lost volume must be replaced. Blood volume is directly proportional to the blood pressure in the body, and when both decrease the flow of blood to important tissues may be inhibited. The remaining red blood cells can still oxygenate body tissue. A volume expander is a type of intravenous therapy that provides blood volume for the circulatory system. It may be used for fluid replacement.

Blood Volume and Oxygen Transport

Normal human blood has a significant excess oxygen transport capability because not all of the hemoglobin molecules are loaded with oxygen under normal conditions. As long as pulmonary function is sufficient for gas exchange and there is enough blood volume to have sufficient blood pressure, very low hemoglobin levels will be enough to sustain the patient. Those with low hemoglobin content will not be able to tolerate situations where a greater amount of oxygen is required (exercise, for example) until their hemoglobin levels are restored.

The body has compensatory feedback mechanisms to deal with lower hemoglobin levels. For instance, the heart pumps more blood with each beat, which increases blood pressure. Blood pressure is detected by the renal system, which increases blood volume and blood pressure by excreting less water during blood filtration. As a result of partial pressure gradient changes, more oxygen is released to the tissues. These adaptations are so effective that if only half of the red blood cells remain, oxygen delivery will still be around 75% of normal. A patient at rest only uses 25% of the oxygen available in their blood. In extreme cases, patients have survived with a hemoglobin level of about $1/7$ the normal (i.e. 2 g/dl), although levels this low are very dangerous.

When blood loss is significant, the red blood cell level ultimately drops to a level that is too low for adequate tissue oxygenation. This is marked by hypoxia and hypovolemic shock, a condition in which tissue oxygenation drops from a lack of blood volume and harmful compensatory mechanisms activate, causing more damage. In these situations, the only alternatives are blood transfusion, packed red blood cells, or oxygen therapy.
Types of Volume Expanders

**Saline solution**: A bag of saline. Saline can be used to increase blood volume when a blood transfusion is not possible.

There are two main types of volume expanders: crystalloids and colloids. Crystalloids are aqueous solutions of mineral salts or other water-soluble molecules. Colloids contain larger insoluble molecules, such as gelatin; blood itself is a colloid. There are also a few other volume expanders that may be used in certain situations:

- **Colloids**: These solutions preserve a high-colloid osmotic pressure (protein-exerted pressure) in the blood, while this parameter is decreased by crystalloids due to hemodilution. The higher osmotic pressure from colloids draws fluids inward, preventing it from leaking out into the tissues as easily, which increases intravascular blood volume.
- **Crystalloids**: The most commonly used crystalloid fluid is normal saline, a solution of sodium chloride at 0.9% concentration, which is close to the concentration in the blood (isotonic). Saline solution is administered intravenously (IV drips) and increases both intravascular and interstitial volume. They decrease osmotic pressure by diluting the blood.
- **Dextrose Water**: This solution contains dextrose, a form of glucose. It is given to patients who have dangerously low blood sugar levels (important for cellular metabolism) as well as low blood volume.
Another common volume expander includes hydroxyethyl starch (HES/HAES, common trade names: Hespan, Voluven) which is considered a colloid. An intravenous solution of hydroxyethyl starch is used to prevent shock following severe blood loss caused by trauma, surgery, or another problem. It increases the blood volume, allowing red blood cells to continue to deliver oxygen to the body. When tissue blood perfusion is maintained, shock is averted as the dangerous compensatory mechanisms of shock aren’t activated.