forth lecture

# Hemodynamic Disorders

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# homeostasis and Hemodynamic disorders

## Learning objectives

After studying this subject you should confidently able to :

1. Define and describe shock  and its pathogenesis.
2. Discuss stages and classification of shock

# Shock

Also called cardio-vascular collapse, is defined as systemic hypo-perfusion caused by reduction either in cardiac output or in the effective circulating blood volume. The end results are :

1. Hypotension.
2. Impaired tissue perfusion.
3. Cellular hypoxia.

Initially, cellular injury is reversible, followed in sustained shock by cell death.

# Shock is categorized by

1. Cardiogenic.

2. Hypovolemic.

3. Septic.

4. Neurogenic.

5. Anaphylactic.

# Three Major Types of Shock

Table 4.3 Three Major Types of Shock

| Type of Shock | Clinical Examples | Principal Pathogenic Mechanisms |
|---|---|---|
| Cardiogenic | Myocardial infarction<br>Ventricular rupture<br>Arrhythmia<br>Cardiac tamponade<br>Pulmonary embolism | Failure of myocardial pump resulting from intrinsic myocardial damage, extrinsic pressure, or obstruction to outflow |
| Hypovolemic | Hemorrhage<br>Fluid loss (e.g., vomiting, diarrhea, burns, trauma) | Inadequate blood or plasma volume |
| Septic | Overwhelming microbial infections<br>Gram-negative sepsis<br>Gram-positive septicemia<br>Fungal sepsis<br>Superantigens (e.g., toxic shock syndrome) | Peripheral vasodilation and pooling of blood; endothelial activation/injury; leukocyte-induced damage; disseminated intravascular coagulation; activation of cytokine cascades |

# Other less common types of shock

neurogenic shock:

from a loss of vascular tone associated with anesthesia or secondary to a spinal cord injury or severe pain following fracture bone.

Anaphylactic shock :initiated by type 1 hypersensitivity reaction →systemic vasodilatation and increase in vascular permeability.

## *Cardiogenic shock*

results from low cardiac output as a result of myocardial pump failure. It may be caused by myocardial damage (infarction), ventricular arrhythmias, extrinsic compression (cardiac tamponade), or outflow obstruction (e.g., pulmonary embolism).

## *Hypovolemic shock*

results from low cardiac output due to loss of blood or plasma volume (e.g., resulting from hemorrhage or fluid loss from severe burns).

# *Septic shock*

*is triggered by microbial infections and is associated with severe systemic inflammatory response syndrom (SIRS).*

In addition to microbes, SIRS may be triggered by a variety of insults, including burns, trauma, and pancreatitis.

Septic shock is most frequently triggered by gram positive bacterial infections, followed by gram-negative bacteria and fungi.

## Factors that play major roles in the pathophysiology of septic shock include :

*Inflammatory and counterinflammatory responses*. In sepsis, various microbial cell wall constituents engage receptors on cells of the innate immune system, triggering pro inflammatory responses.

Likely initiators of inflammation in sepsis are signaling pathways that lie downstream of Toll-like receptors (TLRs) , which recognize a host of microbe-derived substances containing so-called “pathogen-associated molecular patterns”(PAMPs). On activation, innate immune cells produce numerous *cytokines*, including TNF, IL-1, IFN-γ, IL-12, and IL-18, and other inflammatory mediators. Markers of acute inflammation such as C-reactive protein and procalcitonin are also elevated. The latter is a clinically useful indicator of septic shock.

# Factors that play major roles in the pathophysiology of septic shock include

*Endothelial activation and injury.*

The pro inflammatory state and endothelial cell activation associated with sepsis lead to widespread vascular leakage and tissue edema.

Activated endothelium upregulates production of nitric oxide (NO) and other vasoactive inflammatory mediators (e.g., C3a, C5a), which may contribute to vascular smooth muscle relaxation and systemic hypotension.

## Factors that play major roles in the pathophysiology of septic shock include

*Induction of a procoagulant state:*

The derangement in coagulation is sufficient to produce massive complication of *disseminated intravascular coagulation* in up to half of septic patients. Sepsis alters the expression of many factors so as to favor coagulation.

## Factors that play major roles in the pathophysiology of septic shock include

*Metabolic abnormalities*. Septic patients exhibit insulin resistance and hyperglycemia. Cytokines such as TNF and IL-1, stress-induced hormones (such as glucagon,growth hormone, and glucocorticoids), and catecholamines all drive gluconeogenesis. At the same time, the pro inflammatory cytokines suppress insulin release while simultaneously promoting insulin resistance in the liver and other tissues. Hyperglycemia decreases neutrophil function—thereby suppressing bactericidal activity—and causes increased adhesion molecule expression on endothelial cells.

*Organ dysfunction*. Systemic hypotension, interstitial edema, and small vessel thrombosis all decrease the delivery of oxygen and nutrients to the tissues that,because of cellular hypoxia, fail to properly use those nutrients that are delivered. Mitochondrial damage resulting from oxidative stress impairs oxygen use.High levels of cytokines and secondary mediators diminish myocardial contractility and cardiac output,and increased vascular permeability and endothelial injury can lead to the *acute respiratory distress syndrome*

Ultimately, these factors may cause failure of multiple organs, particularly the kidneys, liver, lungs, and heart.

# Stages of shock

1-An initial non progressive stage during which reflex compensatory mechanisms are activated and vital organ perfusion is maintained by neurohumoral mechanisms include catecholamine release, activation of the renin-angiotensin axis, antidiuretic hormone (ADH) release, and generalized sympathetic stimulation with tachycardia, peripheral vasoconstriction, and renal conservation of fluid to support tissue perfusion.

2-A progressive stage characterized by tissue hypoperfusion

and onset of worsening circulatory and metabolic derangement, including anaerobic glycolysis, and lactic acidosis.

3- An irreversible stage in which cellular and tissue injury, hypoxia, marked metabolic acidosis, activation of coagulation pathways with consumption of coagulation factors, multiple organ failure, and leakage of lysosomal and cytosolic enzymes, such as lactate dehydrogenase (LDH), even if the hemodynamic defects are corrected, survival is not possible.

# morphology

The cellular and tissue effects of shock are essentially those of hypoxic injury and are caused by a combination of **hypoperfusion** and **microvascular thrombosis.** Although any organ can be affected, the brain, heart, kidneys, adrenals, and gastrointestinal tract are most commonly involved. **Fibrin thrombi** can form in any tissue but typically are most readily visualized in kidney glomeruli. **Adrenal cortical cell lipid depletion** is seen in all forms of stress and reflects increased use of stored lipids for steroid synthesis.

In hypovolemic shock occurring after hemorrhage, sepsis or trauma will precipitate diffuse alveolar damage leading to so-called "**shock lung.**"

## *Clinical Features*

The clinical manifestations of shock depend on the precipitating insult. In hypovolemic and cardiogenic shock, patients exhibit hypotension, a weak rapid pulse, tachypnea, and cool, clammy, cyanotic skin.

*In septic shock, the skin may be warm and flushed owing to peripheral vasodilation.* The primary threat to life is the underlying initiating event (e.g., myocardial infarction, severe hemorrhage, bacterial infection). However, the cardiac, cerebral, and pulmonary changes rapidly aggravate the situation. If patients survive the initial period, worsening renal function can provoke a phase dominated by progressive oliguria, acidosis, and electrolyte imbalances.

# Prognosis

varies with the origin of shock and its duration,thus, more than 90% of young, otherwise healthy patients with hypovolemic shock survive with appropriate management; by comparison, septic or cardiogenic shock is associated with substantially worse outcomes.

# Case scenario

20-year-old man develops palpitations within 1 hour after a gunshot wound to the abdomen. On examination his heart rate is 112/minute and blood pressure 80/30 mm Hg. His skin is cool and clammy to the touch. Which of the following organ-specific changes is most likely to occur within 2 days after this injury?

1-Acute hepatic infarction

2-Cerebral basal ganglia hemorrhage

3-Gangrenous necrosis of the lower legs

4-Pulmonary diffuse alveolar damage

5-Renal passive congestion

30-year-old man is cutting wood alone in the forest and incurs a deep cut to his leg from his chain saw. He loses a large amount of blood. He is not found until the next day. A marked increase in which of the following blood analytes is most likely to indicate that he has reached an irreversible stage of shock:

1. Antidiuretic hormone

2.Bicarbonate

3.Catecholamines

4. Lactate dehydrogenase

5.Prothrombin