EDEMA, HYPEREMIA, HEMORRHAGE, AND SHOCK

Learning Objectives

1. To recognize and classify hemodynamic disorders
2. To understand the underlying causes of hemodynamic disorders

Vascular/Hemodynamic Consequences of Various Disease Processes
Edema - Increased Tissue Water Content

1. Intracellular
2. Interstitial
3. Body Cavities
Causes of Interstitial Edema

1. Decreased osmotic pressure gradient
2. Increased venous hydrostatic pressure

Causes of decreased osmotic pressure gradient

1. Not enough intravascular albumin
2. Too much interstitial albumin

Causes of Hypoalbuminemia

1. Inadequate synthesis
2. Excessive loss
Causes of Inadequate Albumin Synthesis

1. Liver failure
2. Protein malnutrition

Causes of Excessive Albumin Loss

1. Nephrotic syndrome
2. Protein-losing gastroenteropathy

Nephrotic Syndrome

1. Proteinuria (esp. albumin, >3.5 gm/day)
2. Hypoalbuminemia (<3 gm/dl)
   normal = 3.5 - 5.5 gm/dl
3. Generalized edema
4. Hyperlipidemia and hyperlipiduria
Edema resulting from hypoalbuminemia is usually generalized.

Edema due to a decrease in the osmotic pressure gradient between intravascular and interstitial compartments

1. Hypoalbuminemia

2. Increased vascular permeability (inflammation)

Edema due to hypoalbuminemia or increased venous hydrostatic pressure is a transudate (fluid with low protein content and low specific gravity, <1.012)

Edema due to inflammation is an exudate (fluid with high protein content and specific gravity > 1.02)
Edema from lymphatic obstruction

1. Cancer growing in lymphatics
2. Surgical interruption of lymphatics
3. Postradiation fibrosis
4. Parasitic invasion of lymphatics
Edema from increased venous pressure

1. Physical obstruction to venous drainage
2. Increased venous pressure due to heart failure
3. Increased intravascular volume due to sodium retention

Increased venous pressure

1. Congestion (passive increase in blood volume in veins due to increased venous pressure)
2. Contrast to active hyperemia (increase in blood volume due to increase in blood flow)

Edema from obstruction of venous drainage

1. Superior vena cava syndrome
2. Inferior vena cava syndrome
3. Deep vein thrombosis in leg
4. Cirrhosis
5. Constrictive pericarditis
Edema in Heart Failure

Manifestations of Congestive Heart Failure

Left-sided Heart Failure --->

?- Left atrial pressure
?- Pulmonary venous pressure
?- Pulmonary congestion
?- Right atrial pressure

Manifestations of Congestive Heart Failure

Left-sided Heart Failure --->

Left atrial pressure increases
Pulmonary venous pressure increases
Pulmonary congestion is hallmark of left-sided heart failure, and can lead to pulmonary edema if severe
Right atrial pressure does not change initially but can rise if right-sided heart failure ensues
Edema in Heart Failure

Manifestations of Congestive Heart Failure

Right-sided Heart Failure --->

? Right atrial pressure
? Systemic venous pressure
? Congestion, where ??

Right atrial pressure increases
Systemic venous pressure increases
Congestion occurs in the liver (centrilobular congestion) and edema develops in ankles and lower legs
Jugular venous distension

Heart failure is characterized by increased atrial pressure (backward failure), which causes most of the obvious symptoms, and by diminished cardiac output (forward failure). Diminished cardiac output results in renal hypoperfusion, which ultimately results in decreased sodium and water excretion. Likewise, accumulation of fluid in body cavities results in decreased effective blood volume and therefore decreased sodium and water excretion.
Fluid Accumulation in Body Cavities

1. Ascites - hydroperitoneum
2. Pleural effusion - hydrothorax
3. Pericardial effusion - hydropericardium

Which is correct regarding water movement at the arteriolar end of capillaries, under normal conditions?

A. Fluid leaves the vascular space because interstitial osmotic pressure is higher at this end of the capillary
B. Fluid enters the vascular space because intravascular osmotic pressure is higher at this end
C. Fluid leaves because capillaries are leakier at this end
D. Fluid leaves because hydrostatic pressure is higher than osmotic pressure at this end
E. Little if any fluid enters or leaves

Which of the following is correct regarding water movement in capillary beds, normally?

A. >10% of cardiac output exits from the arteriolar end of capillaries and most is reabsorbed at the venular end
B. Water leaving capillaries contains sodium but very little protein
C. Most of the water that leaves capillaries ultimately ends up in lymphatics
D. Colloid osmotic pressure is primarily due to immunoglobulin
Which of the following is an important contributor to edema formation following a bee sting?

A. Arteriolar dilatation
B. Increased permeability of capillary membranes
C. Venular dilatation
D. Decreased colloid osmotic pressure gradient at the venular end of the capillary bed
E. All of the above

Illustrations of Congestion and Edema

1. Pulmonary edema
2. Chronic pulmonary congestion
3. Centrilobular hepatic congestion
nutmeg
Pathophysiologic Categories of Edema

Increased Hydrostatic Pressure
- CHF, venous obstruction, constrictive pericarditis, cirrhosis (ascites), sodium retention
- Hypoalbuminemia
  - nephrotic syndrome, liver failure, malnutrition
- Lymphatic Obstruction
  - neoplastic, postsurgery
- Increased capillary permeability
  - inflammation, burns

SHOCK

Syndrome resulting from generalized decrease in tissue perfusion

Causes of Shock

1. Cardiogenic Shock
2. Hypovolemic Shock
3. Shock due to Venous Pooling
**Cardiogenic Shock**

Cardiac output is markedly decreased due to inadequate cardiac function (often several large myocardial infarcts).

**Hypovolemic Shock**

Blood Loss (Hemorrhagic shock)
Loss of Plasma (severe thermal burns)
Severe Diarrhea or Dehydration

**Shock due to Venous Pooling**

Septic Shock - endotoxin causes increased vascular permeability (generalized edema) and cardiac depressant factors
Anaphylactic shock - massive histamine release and marked vasodilation
Compensatory Mechanisms

1. Vascular autoregulation to maintain blood flow to heart & brain
2. Sympathetic activation
   - Cardiac contractility & heart rate
   - Vasoconstriction (skin, muscle, GI, renal)
3. Shift water from interstitial to intravascular space (hemodilution)
4. Renal sodium and water reabsorption

Shock - Complications

Acute Tubular Necrosis (ATN) and acute renal failure
Pulmonary Edema (ARDS - septic shock)
Pancreatitis
GI Mucosal Hemorrhage and Necrosis
Centrilobular Necrosis in Liver
Watershed Infarcts in Brain
Hemorrhagic necrosis of adrenal glands
Cardiogenic shock can be distinguished from CHF (congestive heart failure) by which of the following?

A. Atrial pressures are usually increased in CHF but not in cardiogenic shock
B. Hypotension is common in cardiogenic shock but rare in CHF
C. Renal vasoconstriction is common in CHF but rare in cardiogenic shock
D. Hypoalbuminemia is common in CHF but rare in cardiogenic shock
E. Increased capillary permeability to proteins is common in CHF but rare in cardiogenic shock