

Hemodynamic Disorders

Edema, Hyperemia/Congestion, Hemorrhage

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M2 Pathology Course
Lecture #12
Monday, September 8, 2003
8:30 – 9:20

Reading assignment: Robbins Pathologic Basis of Disease, 6th Edition, Chapter 5, pp. 113-118.

Lecture and Reading Objectives

1. Describe the distribution of fluid in the normal human body.
2. Define edema, anasarca, pitting edema, nonpitting edema, hyperemia, congestion, petechiae, purpura, ecchymosis.
3. Compare and contrast transudate and exudate.
4. List the pathophysiologic categories of edema and give examples of each.
5. Describe the sequence of events that leads to edema in patients with congestive heart failure, protein malnutrition, liver disease, renal disease/nephrotic syndrome, and ascites (Figure 5-2, page 115).
6. Describe why lymphatic obstruction leads to edema.
7. Explain the term “dependent” edema and its significance.
8. Describe the gross findings in lungs with pulmonary edema.
9. Explain the general clinical significance of subcutaneous edema. Why is pulmonary edema clinically important? What are the potential consequences of severe brain edema?
10. Compare and contrast hyperemia and congestion.
11. Explain the relationship of congestion and edema.
12. Outline the consequences of long-standing congestion (chronic passive congestion).
13. Describe the morphologic appearance (gross and microscopic) of tissues with congestion.
14. Discuss the clinical significance of hemorrhage.

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Why is it important that a patient comes to clinic because her eyelids are suddenly puffy or her legs are swollen? Normal fluid homeostasis is critical to orderly cellular functioning, and although mild edema may be simply annoying, pulmonary or cerebral edema may be rapidly fatal.

I. Fluid distribution

- ~60% of lean body weight is water
 - ~2/3 is intracellular
 - ~1/3 is extracellular (mostly interstitial)
- ~5% of total body water is in blood plasma

II. Edema – increased fluid in the interstitial tissue spaces

- A. Fluid collections in different body cavities may have various designations

Hydrothorax (pleural effusion)
Hydropericardium
Hydroperitoneum (usually called ascites)

Anasarca is severe, generalized edema with profound subcutaneous tissue swelling

B. Etiologies of Edema

Categories of Edema – Table 5-1

Increased Hydrostatic Pressure
Reduced Plasma Osmotic Pressure
Lymphatic Obstruction
Sodium Retention
Inflammation

largely related to local increases in vascular permeability

(Edema occurring in hydrodynamic derangements is usually a *transudate*: protein-poor, specific gravity < ~1.012 to 1.015, usually with few cells. Edema occurring in inflammatory conditions is usually an *exudate*: protein-rich, specific gravity > ~1.015 to 1.020, often with inflammatory components such as leucocytes, fibrin, etc. What are some examples of situations in which a transudate occurs versus an exudate?)

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1. Increased Hydrostatic Pressure

- a. Local
e.g., Impaired venous outflow, such as in deep venous thrombosis, or lower extremity inactivity with prolonged dependency
- b. Generalized
e.g., Congestive heart failure, affecting right ventricular function (Figure 5-2, page 115)

2. Reduced Plasma Osmotic Pressure

- a. Excessive loss or reduced synthesis of albumin (which is the serum protein most responsible for maintaining colloid osmotic pressure)
 - i. Nephrotic syndrome
 - Leaky glomerular capillary wall, albumin loss, and generalized edema
 - ii. Diffuse liver pathology or protein malnutrition
 - Reduced albumin synthesis
- b. Decreased albumin leads to reduced plasma osmotic pressure, with subsequent net movement of fluid into interstitial tissues and resultant plasma volume contraction. In spite of sodium and water retention, plasma volume deficit cannot be corrected because low serum protein persists.

3. Lymphatic obstruction – usually localized; inflammatory versus neoplastic

- a. Filariasis – elephantiasis
- b. Carcinoma
 - i. Obstruction
 - ii. Secondary to therapy – e.g., axillary node dissection at time of diagnosis (as with breast carcinoma) or post-irradiation

4. Sodium and water retention – although a “secondary” factor in many forms of edema, salt retention may also be primary

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Increased salt (with accompanying water) causes:

- a. Increased hydrostatic pressure due to intravascular fluid volume expansion
- b. Diminished vascular colloid osmotic pressure

C. Morphology of Edema

1. Usually recognized “grossly” rather than microscopically, in which edema is seen as subtle cell swelling with clearing and separation of extracellular matrix elements

2. Subcutaneous tissues

Different distributions depending on etiology of edema

- a. Diffuse distribution – e.g., renal dysfunction, nephrotic syndrome
 - i. Affects all parts of body equally
 - ii. Initially may be more obvious in tissues with loose connective tissue matrix such as eyelids (periorbital edema)
- b. More conspicuous in site of higher hydrostatic pressure – “dependent”
Prominent feature of congestive heart failure (particularly right heart failure)
- c. “Pitting edema” versus “nonpitting edema”

3. Pulmonary edema

- a. Typical in left heart failure, but also in renal failure, adult respiratory distress syndrome, infection (pneumonia), hypersensitivity reactions
- b. Grossly, lungs are heavy with frothy, blood-tinged fluid that is mixture of air, edema fluid, and red blood cells

4. Brain edema

- a. Localized to sites of injury
 - i. Abscess
 - ii. Neoplasm

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- b. Generalized – brain is grossly swollen with narrowed sulci and distended, flattened gyri
 - i. Encephalitis
 - ii. Hypertensive crises
 - iii. Obstruction to venous outflow
- c. Trauma may cause localized or generalized edema

D. **Clinical correlations**

May be annoying; may signal underlying disease; may be life-threatening

III. **Hyperemia and Congestion** – local increased volume of blood in a particular tissue or area

- A. *Hyperemia* – active process resulting from augmented tissue inflow because of arteriolar dilation; tissue is redder than surrounding areas because of engorgement with oxygenated blood
 - 1. Skeletal muscle during exercise
 - 2. Sites of inflammation
- B. *Congestion* – passive process resulting from impaired outflow; systemic or local; tissue becomes blue-red (cyanotic), as worsening congestion leads to accumulation of deoxygenated hemoglobin
 - 1. Systemic
 - 2. Local
- C. Congestion and edema commonly occur together: congestion of capillary beds is related to development of edema
- D. Long-standing congestion (chronic passive congestion) results in stasis of poorly oxygenated blood and chronic hypoxia
 - 1. May result in parenchymal cell degeneration, cell death, microscopic scarring
 - 2. Capillary rupture may cause small hemorrhagic foci
 - 3. Breakdown and phagocytosis of red cell debris may result in hemosiderin-laden macrophages

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E. Morphology

1. Cut surfaces of affected tissues – hemorrhagic and wet
2. Pulmonary
 - a. Acute congestion – engorged alveolar capillaries, alveolar septal edema, intra-alveolar hemorrhage
 - b. Chronic congestion – thickened and/or fibrotic septae, hemosiderin-laden macrophages
3. Hepatic
 - a. Acute congestion – central vein/sinusoids distended with blood, may see central hepatocyte degeneration. Periportal hepatocytes suffer less severe hypoxia.
 - b. Chronic congestion – central regions of lobules grossly red-brown and slightly depressed (loss of cells)
“*Nutmeg liver*”: microscopically, centrilobular necrosis with hepatocyte dropout, hemorrhage, hemosiderin-laden macrophages.
Severe, longstanding hepatic congestion may lead to hepatic fibrosis (often associated with heart failure: “cardiac cirrhosis”).

Central portion of lobule is last to receive blood, so centrilobular necrosis can occur whenever there is reduced hepatic blood flow.

IV. Hemorrhage – extravasation of blood because of vessel rupture

Capillary bleeding can occur under conditions of chronic congestion.

Hemorrhagic diatheses – variety of clinical disorders with increased tendency to hemorrhage from usually insignificant injury.

- A. Rupture of large artery or vein is usually due to vascular injury such as trauma, atherosclerosis, erosion.
 1. Hemorrhage may be external or may be enclosed within a tissue. Accumulation of blood is called a *hematoma*. Hematomas may be insignificant, such as a bruise, or may result in death, such as massive retroperitoneal hematomas.

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2. *Petechiae* – 1- to 2-mm hemorrhages into skin, mucous membranes, or serosal surfaces
Typically associated with locally increased intravascular pressure, low platelet counts, platelet function defects, clotting factor deficits
3. *Purpura* – Slightly larger hemorrhages (≥ 3 mm)
Typically associated with similar pathologies as petechiae, as well as trauma, vasculitis, increased vascular fragility
4. *Ecchymoses* – Larger hemorrhages (>1 to 2 cm), typical after traumas
Red blood cells are degraded and phagocytized by macrophages, hemoglobin degraded into bilirubin, then hemosiderin
5. Larger accumulations of blood in a body cavity called *hemoperitoneum*, *hemothorax*, etc. Jaundice may develop from blood breakdown.

B. Clinical significance

1. Depends on volume and rate of blood loss
2. Site of hemorrhage is also important
3. Loss of iron and subsequent iron-deficiency anemia may become a diagnostic consideration