McCance: Pathophysiology, 6th Edition

Chapter 02: Altered Cellular and Tissue Biology

Key Points – Print

SUMMARY REVIEW

Cellular Adaptation

1. Cellular adaptation is an alteration that enables the cell to maintain a steady state despite adverse conditions.
2. Atrophy is a decrease in cellular size. The mechanisms probably include decreased protein synthesis, increased protein catabolism, or both.
3. Physiologic atrophy occurs with early development; for example, the thymus gland involutes and atrophies. Pathologic atrophy occurs as a result of decreases in workload, use, pressure, blood supply, nutrition, hormonal stimulation, and nervous stimulation.
4. Aging causes brain cells and endocrine-dependent organs, such as the gonads, to become atrophic.
5. Hypertrophy is an increase in the size of cells by increased work demands or hormonal stimulation. Hypertrophy can be physiologic or pathologic. Amounts of protein in the plasma membrane, endoplasmic reticulum, microfilaments, and mitochondria are increased.
6. Hyperplasia is an increase in the number of cells caused by an increased rate of cellular division. Compensatory hyperplasia enables certain organs to regenerate. Hormonal hyperplasia is stimulated by hormones to replace lost tissue or support new growth, such as during pregnancy.
7. Pathologic hyperplasia is the abnormal proliferation of normal cells in response to excessive hormonal stimulation of growth factors on target cells.
8. Dysplasia, or atypical hyperplasia, is an abnormal change in the size, shape, and organization of mature tissue cells.
9. Metaplasia is the reversible replacement of one mature cell type by another less mature cell type. Metaplasia is thought to develop from a reprogramming of stem cells existing in most epithelia or of undifferentiated mesenchymal cells in connective tissue.

Cellular Injury

1. Most diseases begin with cell injury. Injured cells may recover (reversible injury) or die (irreversible injury).
2. Cellular injury is caused by a lack of oxygen (hypoxia), free radicals, caustic or toxic chemicals, infectious agents, unintentional and intentional injury, inflammatory and immune responses, genetic factors, insufficient nutrients, or physical trauma from many causes.

3. Cell injury can be acute or chronic, and it can be reversible or irreversible. It can involve necrosis, apoptosis, accumulation, or pathologic calcification.
4. Four biochemical themes are important to cell injury: (a) ATP depletion, (b) oxygen and oxygen-derived free radicals, (c) intracellular calcium and loss of calcium steady state, and (d) defects in membrane permeability.
5. The sequence of events leading to cell death is commonly decreased ATP production, failure of active transport mechanisms (the sodium-potassium pump), cellular swelling, detachment of ribosomes from the endoplasmic reticulum, cessation of protein synthesis, mitochondrial swelling as a result of calcium accumulation, vacuolation, leakage of digestive enzymes from lysosomes, autodigestion of intracellular structures, lysis of the plasma membrane, and death.
6. The initial insult in hypoxic injury is usually ischemia—the cessation of blood flow into vessels that supply the cell with oxygen and nutrients.
7. An important mechanism of membrane damage is injury caused by free radicals. Free radicals are difficult to control and initiate chain reactions.
8. Free radicals can cause (a) lipid peroxidation or the destruction of unsaturated fatty acids, (b) alterations of proteins, and (c) alterations in DNA.
9. The initial insult in chemical injury is damage or destruction of the plasma membrane. Examples of chemical agents that cause cellular injury include lead, carbon monoxide, ethanol, mercury, and social or street drugs.
10. Unintentional and intentional injuries are an important health problem in the United States. Death caused by injuries is more common for men than women and higher among blacks than whites and other racial groups.
11. Injuries by blunt force are the result of the application of mechanical energy to the body resulting in tearing, shearing, or crushing of tissues. The most common types of blunt force injuries include motor vehicle accidents and falls.
12. A contusion is bleeding into the skin or underlying tissues as a consequence of a blow. A collection of blood in soft tissues or an enclosed space may be referred to as a *hematoma*.
13. An abrasion (scrape) results from removal of the superficial layers of the skin caused by friction between the skin and injuring object. Abrasions and contusions may have a patterned appearance that mirrors the shape and features of an injuring object.
14. A laceration is a tear or rip resulting when the tensile strength of the skin or tissue is exceeded.
15. An incised wound is a cut that is longer than it is deep. A stab wound is a penetrating sharp force injury that is deeper than it is long.
16. Gunshot wounds may be either penetrating (bullet retained in the body) or perforating (bullet exits). The most important factors determining the appearance of a gunshot injury are whether it is an entrance or an exit wound and the range of fire.
17. Asphyxial injuries are caused by a failure of cells to receive or use oxygen. These injuries can be grouped into four general categories: suffocation, strangulation, chemical, and drowning.

18. Injury from microorganisms lies in their ability to survive and proliferate in the human body. Injury depends on the microorganisms' ability to invade and destroy cells, produce toxins, and produce damaging hypersensitivity reactions.
19. Activation of inflammation and immunity, which occurs after cellular injury or infection, involves powerful biochemicals and proteins capable of damaging normal (uninjured and uninfected) cells.
20. Genetic disorders injure cells by altering the nucleus and the plasma membrane's structure, shape, receptors, or transport mechanisms.
21. Deprivation of essential nutrients (proteins, carbohydrates, lipids, vitamins) can cause cellular injury by altering cellular structure and function, particularly of transport mechanisms, chromosomes, the nucleus, and DNA.
22. Injurious physical agents include temperature extremes, changes in atmospheric pressure, ionizing radiation, illumination, mechanical stresses (e.g., repetitive body movements), and noise.

Manifestations of Cellular Injury

1. Cellular manifestations of cellular injury include accumulations of water, lipids, carbohydrates, glycogen, proteins, pigments, hemosiderin, bilirubin, calcium, and urate.
2. Accumulations harm cells by "crowding" the organelles and by causing excessive (and sometimes harmful) metabolites to be produced during their catabolism. The metabolites are released into the cytoplasm or expelled into the extracellular matrix.
3. Cellular swelling, the accumulation of excessive water in the cell, is caused by the failure of transport mechanisms and is a sign of many types of cellular injury.
4. Accumulations of organic substances—lipids, carbohydrates, glycogen, proteins, and pigments—are caused by disorders in which (a) cellular uptake of the substance exceeds the cell's capacity to catabolize (digest) or use it or (b) cellular anabolism (synthesis) of the substance exceeds the cell's capacity to use or secrete it.
5. Dystrophic calcification (accumulation of calcium salts) is always a sign of pathologic change because it occurs only in injured or dead cells. Free calcium in the cytosol can cause activation of protein kinases, activation of phospholipases and membrane damage, and damage or disassembly of the cytoskeleton. Metastatic calcification, however, can occur in uninjured cells in individuals with hypercalcemia.
6. Disturbances in urate metabolism can result in hyperuricemia and deposition of sodium urate crystals in tissue, leading to a painful disorder called *gout*.
7. Systemic manifestations of cellular injury include fever, leukocytosis, increased heart rate, pain, and serum elevations of enzymes in the plasma.

Cellular Death

1. Two main types of cell death are necrosis and apoptosis.
2. Necrosis is the sum of the changes after local cell death and includes the processes of inflammation and cellular lysis.
3. The four major types of necrosis are coagulative, liquefactive, caseous, and fat. Different types of necrosis occur in different tissues.
4. Structural signs that indicate irreversible injury and progression to necrosis are the dense clumping and disruption of genetic material and the disruption of the plasma and organelle membranes.
5. Gangrenous necrosis, or gangrene, is tissue necrosis caused by hypoxia and subsequent bacterial invasion.
6. Apoptosis, a different type of cellular death, is a process of selective cellular self-destruction called programmed cell death. Other forms of programmed cell death have been determined, including autophagic (“eat oneself”) cell death.

Aging

1. It is difficult to determine the physiologic (normal) from the pathologic changes of aging.
2. Humans have an inherent maximal life span (80 to 100 years) that is dictated by currently unknown intrinsic mechanisms.
3. Although the maximal life span has not changed significantly over time, the average life span, or life expectancy, has increased. However, this increase in life expectancy in the United States for all Americans is not happening.
4. The emerging focus in the biology of aging includes endocrine regulation from endocrine signaling pathways, nuclear architecture and genomic instability, decline in cell renewal by adult stem cells, and accumulated cell damage related to cancer and aging.
5. Frailty is imprecisely defined as a wasting syndrome of aging that leaves a person vulnerable to falls, functional decline, disease, and death. Women have a higher risk of frailty than men.

Somatic Death

1. Somatic death is death of the entire organism. Postmortem change is diffuse and does not involve the inflammatory response.
2. Manifestations of somatic death include cessation of respiration and circulation, gradual lowering of body temperature, pupil dilation, loss of elasticity and transparency in the skin, muscle stiffening (rigor mortis), and skin discoloration (livor mortis). Signs of putrefaction are obvious about 24 to 48 hours after death.