Histopathology

Lecture 7

Cellular Adaptations of Growth and Differentiation

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Lesson contents

- Cellular adaptation
- Hyperplasia
- Hypertrophy
- Atrophy
- Metaplasia

CELLULAR ADAPTATION

Overview: The four basic types of cellular adaptation to be discussed in this section are hyperplasia, hypertrophy, atrophy, and metaplasia.

HYPERPLASIA

Basic description: Increase in the number of cells.

- Hyperplasia is characterized by an increase in cell number because of proliferation of differentiated cells
- Hyperplasia is an adaptive response in cells capable of replication,
- Hyperplasia takes place if the tissue contains cell populations capable of replication; it may occur concurrently with hypertrophy and often in response to the same stimuli.
- Hyperplasia can be physiologic or pathologic. In both situations, cellular proliferation is stimulated by growth factors that are produced by a variety of cell type.
- The two types of physiologic hyperplasia are

(1) Hormonal hyperplasia, exemplified by the proliferation of the glandular epithelium of the female breast at puberty and during pregnancy

(2) Compensatory hyperplasia, in which residual tissue grows after removal or loss of part of an organ. For example, when part of a liver is resected.

- Most forms of **pathologic hyperplasia** are caused by excessive hormonal or growth factor stimulation. For example after a normal menstrual period there is a burst of uterine epithelial proliferation that is normally tightly regulated by stimulation through pituitary hormones and ovarian estrogen and by inhibition through progesterone. However, a disturbed balance between estrogen and progesterone causes endometrial hyperplasia, which is a common cause of abnormal menstrual bleeding.
- Hyperplasia also is an important response of connective tissue cells in wound healing, in which proliferating fibroblasts and blood vessels aid in repair. In this process, growth factors are produced by white blood cells (leukocytes) responding to the injury and by cells in the extracellular matrix.

- Stimulation by growth factors also is involved in the hyperplasia that is associated with certain viral infections; for example, **papillomaviruses** cause skin warts and mucosal lesions composed of masses of hyperplastic epithelium. Here the growth factors may be encoded by viral genes or by the genes of the infected host cells **(**Figure 1**).**

HYPERTROPHY

Basic description: Increase in the size of the cell.

- Hypertrophy is an increase in the size of cells resulting in increase in the size of the organ.
- In pure hypertrophy there are no new cells, just bigger cells containing increased amounts of structural proteins and organelles.
- Hypertrophy occurs when cells have a limited capacity to divide.
- Hypertrophy can be physiologic or pathologic and is caused either by increased functional demand or by growth factor or hormonal stimulation.

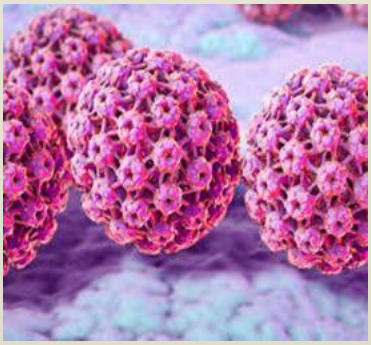
Types of hypertrophy

■ Physiologic hypertrophy: Occurs due to a normal stressor. For example, enlargement of skeletal muscle with exercise.

■ Pathologic hypertrophy: Occurs due to an abnormal stressor. For example, increase in the size of the heart due to aortic stenosis. Aortic stenosis is due to a change in the aortic valve, which obstructs the orifice, resulting in the left ventricle working harder to pump blood into the aorta

Morphology of hyperplasia and hypertrophy: Both hyperplasia and hypertrophy result in an increase in organ size; therefore, both cannot always be distinguished grossly, and microscopic examination is required to distinguish the two (Figure 2).

Figure 1. human papillomaviruses HPV infection is a viral infection that commonly causes skin or mucous membrane growths (warts). Some types of human papillomavirus (HPV) infection cause warts, and some can cause different types of cancer.



ATROPHY

Basic description: Decrease in the size of a cell that has at one time been of normal size.

Types of atrophy

■ Physiologic atrophy: Occurs due to a normal stressor. For example, decrease in the size of the uterus after pregnancy.

■ Pathologic atrophy: Occurs due to an abnormal stressor. In general, atrophy is due to the loss of stimulus to the organ. Specific types of loss of stimulus include loss of blood supply or innervation, loss of endocrine stimulus, disuse, mechanical compression, decreased workload, or aging.

Gross morphology of atrophy (Figure 3): The organ is smaller than usual. Atrophy occurs in a once normally developed organ. If the organ was never a normal size (i.e., because it did not develop normally), the condition is called hypoplasia.

METAPLASIA

Basic description: Change of epithelium at a site, or location, from one type of epithelium to another type. In metaplasia, the epithelium is normal in appearance but in an abnormal location.

Mechanism of metaplasia: The epithelium normally present at a site cannot handle the new environment so it converts to a type of epithelium that can adapt.

Examples: Barrett esophagus is due to reflux of gastric contents into the esophagus, which causes the epithelium type to convert from squamous to glandular (Figure 4 A and B). Squamous metaplasia in the lungs is due to exposure of respiratory epithelium to toxins in cigarette smoke.

Figure 2. Cross-section of the heart of a patient with systemic hypertension. The patient had high blood pressure, which increased the workload of the left ventricle and resulted in concentric hypertrophy of the left ventricular myocardium. In response to the increasing pressure load, the cardiac myocytes increased their content of contractile proteins, resulting in enlargement of individual myocytes

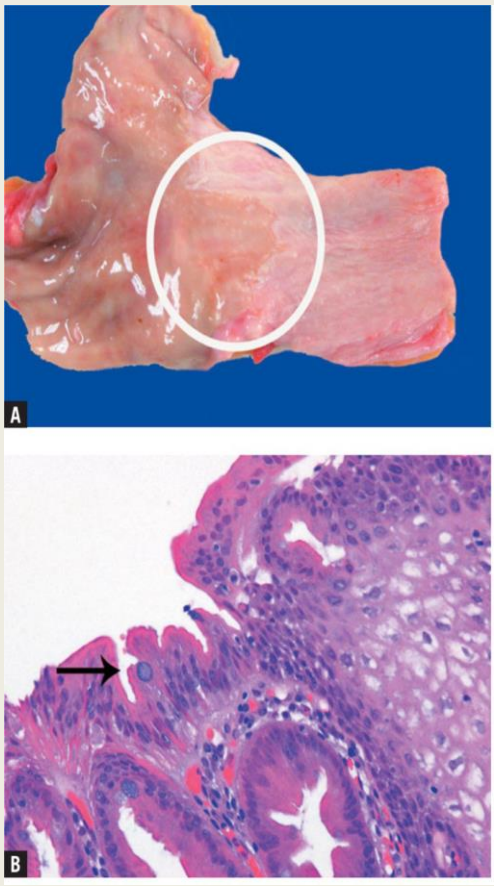


Figure 4. Barrett esophagus (glandular metaplasia). A, This specimen is taken from the region of the gastroesophageal junction and includes a segment of proximal stomach (on the left side) in continuity with the distal esophagus (on the right side). A small patch of mucosa with an appearance similar to the gastric mucosa extends proximally (circle), above the gastroesophageal junction. In this area, the normal stratified squamous epithelium of the esophagus has been replaced by glandular epithelium. Glandular metaplasia of the esophagus occurs in response to gastric acid reflux. B, The right side of the image shows stratified squamous epithelium, and the left side shows glandular epithelium, with goblet cells present (arrow). Transformation of one type of tissue to another type of tissue is termed metaplasia; in this case, stratified squamous epithelium was transformed to intestinal-type epithelium.

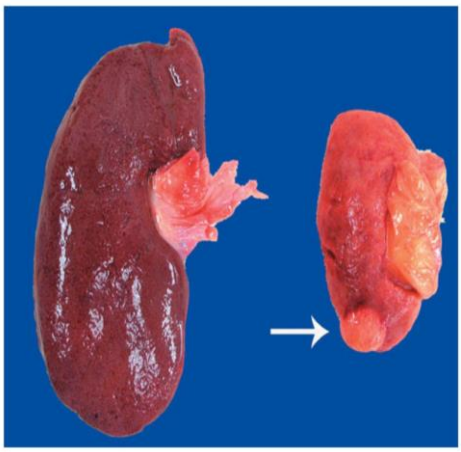


Figure 3. Kidneys from two different patients. The kidney on the left is normal in size, whereas the kidney on the right is atrophic. The kidney on the right was from a patient who had severe atherosclerosis of the renal artery, which led to ischemia (i.e., decreased perfusion) of the organ. Due to an insufficient supply of oxygen and nutrients, the cells of the kidney decreased in size to adapt. An incidental renal cell carcinoma is visible near the pole of the atrophic kidney (arrow).