Synopsis of Pathophysiology in Nuclear Medicine

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To
My granddaughters Laila and Niveen

Preface

Nuclear medicine is a unique and dynamic field which requires diverse knowledge which includes many basic science components such as physics, chemistry, radiation biology, dosimetry, and others. Knowledge of the pathophysiological features of diseases is of crucial importance to the understanding and practice of nuclear medicine. This concept has an increasing importance since nuclear medicine has changed to study molecular changes of normal and diseased organs. This was behind the book on pathophysiological basis of nuclear medicine, and its third edition will appear soon. The idea of the synopsis came from the readers and colleagues who demanded a simplified text of the subject to help students, including technology students, technologists, residents, and practicing physicians, while the other text remains as a comprehensive reference with more details.

In this book, simple presentation of the basic understanding of the principles of pathophysiology, normal and abnormal cells, cell biology, and basis of radiopharmaceutical uptake and distribution in physiological and different pathological processes are included. Since clinical nuclear medicine is simply the application of such basic principle in the study of many conditions of virtually every organ in the body, the pathophysiological features of relevant disease processes are discussed in several chapters of organ systems along with essentials in imaging and its clinical significance.

This book starts by an introductory chapter defining and explaining basic pathophysiology, followed by a chapter on the features of different cells and tissues with biological features. The mechanisms of radiopharmaceutical uptake by different tissues and effects of pathophysiological changes on its distribution are included in a separate chapter. These basic parts are followed by several chapters for organ systems in addition to chapters on inflammation, oncology, and hematology. The pathophysiological basis of the therapeutic effects of radionuclides and applications in treating relevant diseases are included in one chapter, followed by a concluding short chapter on biologic effects of ionizing radiation.

The objective of this volume is to provide a brief, simple, readable, easy-to-use, yet comprehensive and informative enough text to help the readers, students, and professionals understand nuclear medicine in depth which will be reflected on practice and patient care.

Safat, Kuwait Abdelhamid H. Elgazzar, MD, FCAP, ABNM

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1.1 Introduction

Understanding the pathophysiology of disease is essential for all who study and work in any field of medicine. Since nuclear medicine deals with functional and molecular changes, it becomes crucial to understand the pathophysiological changes of relevant diseases and disease-like conditions to properly study and practice the field.

Pathophysiology has been changing and expanding with added new knowledge. Since the late 1970s, tremendous developments in molecular biology and genetics have provided medical science with an unprecedented chance to understand the molecular basis of disease. Disease can now be defined on the basis of abnormal deviation from normal regional biochemistry. Since pathophysiology is a bridge between pathology and physiology, it is imperative to understand the principles of both disciplines.

1.2 Pathology

Pathology is concerned with the study of the nature of disease, including its causes, development, and consequences with emphasis on the structural changes of diseases. Specifically, pathology describes the origin of disease, its etiologies, and how it progresses and manifests clinically in individuals in order to determine its treatment. Pathology plays a vital role across all

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facets of medicine throughout life, and currently it extends to the examination of molecules within organs, tissues, or body fluids.

1.3 Definition of Disease

The precise definition of disease is as complex as an exact definition of life. It may be relatively easier to define disease at a cellular and molecular level than at the level of an individual. Throughout the history of medicine, two main concepts of disease have predominated: ontological and physiological [1].

The ontological concept views a disease as an entity that is independent and self-sufficient and runs a regular course with a natural history of its own. The physiological concept, on the other hand, defines disease as a deviation from normal physiology or biochemistry; the disease is a statistically defined deviation of one or more functions from those of healthy people under circumstances as close as possible to those of a person of the same sex and age of the patient. Most diseases begin with cell injury, which occurs if the cell is unable to maintain homeostasis.

1.3.1 Homeostasis

The term homeostasis is used by physiologists to mean maintenance of static, or constant, conditions in the internal environment by means of positive and negative feedback of information. About 56 % of the adult human body is fluid. Most of the fluid is intracellular, and about one third is extracellular fluid that is in constant motion throughout the body and contains the ions (sodium, chloride, and bicarbonate) and nutrients (oxygen, glucose, fatty acids, and amino acids) needed by the cells to maintain life. Extracellular fluid was described as the internal environment of the body and hypothesized that the same biological processes that make life possible are also involved in disease [1]. As long as all the organs and tissues of the body perform functions that help to maintain homeostasis, the cells of the body continue to live and function properly [1].

1.3.2 The Genome

At birth, molecular blueprints collectively make up a person's genome or genotype that will be translated into cellular structure and function. A single gene defect can lead to biochemical abnormalities that produce many different clinical manifestations of disease, or phenotypes, a process called pleiotropism. Many different gene abnormalities can result in the same clinical manifestations of disease—a process called genetic heterogeneity. Thus, diseases can be defined as abnormal processes as well as abnormalities in molecular concentrations of different biological markers, signaling molecules, and receptors.

1.4 Physiology

Physiology is the study of normal, healthy bodily function. It is concerned with the science of the mechanical, physical, bioelectrical, and biochemical functions of humans in good health, their organs, and the cells of which they are composed. It is a broad science which aims to understand the mechanisms of living, from the molecular basis of cell function to the integrated behavior of the whole body.

1.5 Pathophysiology

Pathophysiology is a convergence of pathology and physiology. It deals with the disruption of normal mechanical, physical, and biochemical functions, either caused by a disease or resulting from a disease or abnormal syndrome or condition that may not qualify to be called a disease and now includes the molecular mechanisms of disease. In the year 1839, Theodor Schwann discovered that all living organisms are made up of discrete cells [2]. In 1858, Rudolph Virchow observed that a disease could not be understood unless it were