Clinical Nuclear Medicine

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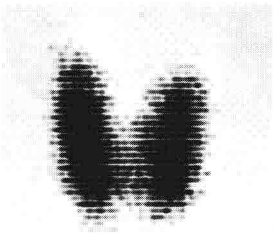

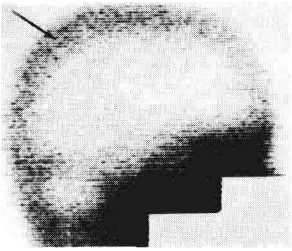

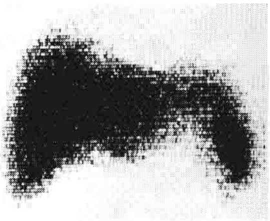

DEDICATION

To the practicing physicians and administration of the North Carolina Baptist Hospital and The Bowman Gray School of Medicine whose foresight in recognizing the potential of Nuclear Medicine has stimulated the rapid growth of this field at our institution.

preface

During the past decade the field of Nuclear Medicine has expanded so rapidly and extensively that many practicing physicians trained prior to this growth are unaware of the numerous, valuable radioisotopic procedures now available to them. Likewise, medical students and residents, particularly those with brief rotations through a nuclear medicine laboratory, are in the process of learning the multiple applications of radioisotopic tracer techniques in medical diagnosis. This book is intended to provide these groups with a simple, practical source of information concerning the principles involved, the patient preparation necessary, the procedure followed, and the value and limitations of the commonly employed radioisotopic studies.

This book is in no way meant to be a complete text, for such works are presently available. It deals only with the most commonly utilized procedures, or those likely to become widely employed in the near future, and emphasizes their clinical aspects. Infrequently used procedures or those applicable mainly in research have not been included.

A standardized format has been deliberately followed for each chapter, to expedite the location of desired information. In an effort to make the description of each procedure an entity in itself, some repetition has been inevitable. It also should be noted that the whole body and "critical" organ radiation exposure doses quoted are appoximations accumulated from the literature and have been included to provide the clinician with an estimation of radiation exposure with each diagnostic test.

It is hoped that this book will introduce the medical student, resident, and practicing physician to the field of Nuclear Medicine and will be a ready reference to aid them in applying these procedures to the everyday practice of medicine.

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C.D.M.

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radiopharmaceuticals and instrumentation

Introduction

During the past 5 to 10 years, nuclear medicine has progressed from a minor sub-specialty under the jurisdiction of several fields, primarily radiology, pathology, and internal medicine, to a position in which full recognition as a separate specialty is under consideration. This rapid growth has been due to many factors: the simplicity and low morbidity associated with the procedures; the valuable information not attainable by any other means; the awareness of the clinician as to the worth of the tests; and the increased accessibility due to the introduction of nuclear medicine into hospitals of all sizes. Without question, however, the two major causes for this surge have been the introduction and availability of many new and better radiopharmaceuticals and the development of improved radioisotopic imaging devices.

All persons interested in the application of nuclear medicine in clinical practice should have at least a limited acquaintance with radiopharmaceuticals and instrumentation. With a basic understanding of these subjects, the physician can more logically select the appropriate tests, more skillfully supervise the procedure, and more wisely interpret the results he obtains.

RADIOPHARMACEUTICALS

To understand the principles involved in all radioisotopic procedures, one must have a working knowledge of the composition of the radiopharmaceuticals employed, how they are obtained, their desirable and undesirable characteristics, and how they are utilized to obtain the information sought. Radiopharmaceuticals differ from other medically employed drugs in two ways: (1) they are not generally used to produce a pharmacological effect, and (2) they all contain a radionuclide (radioisotope) which is used for localization and/or measurement in diagnostic procedures and for radiation effects in therapy. No pharmacological response is elicited with the majority of drugs used in nuclear medicine because only very minute quantities are necessary. Radiation effects are apparent only with therapeutic doses.

RADIONUCLIDES

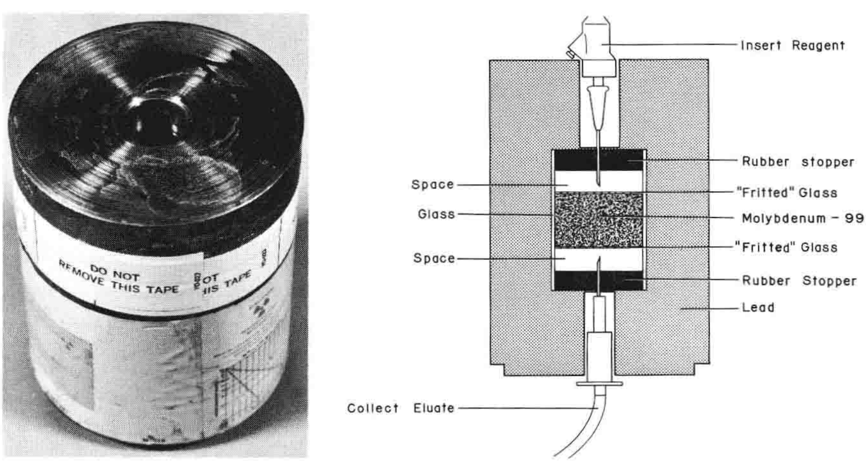
A radionuclide (radioisotope), which is essential to all radiopharmaceuticals, behaves chemically in a manner similar to its nonradioactive counterpart. The difference lies in the fact that the binding energy of the nucleus of the radioactive atom is not sufficient to hold it together, and it disintegrates. In so doing, it emits energy of two types: either *particulate*, such as alpha and beta particles, or *electromagnetic*, such as gamma or X rays. The electromagnetic radiations are employed in most diagnostic tests, particularly with external detection systems (liver scanning, thyroid uptake determination), while the particulate radiations are utilized for internal therapy (treatment of hyperthyroidism) although they can also be satisfactorily employed for sample counting (urine, plasma, etc.) with specialized equipment.

Radionuclides disintegrate at a constant rate, with the time required to reach 50% of the original number of atoms referred to as the *physical half-life*. Every radionuclide has a fixed half-life ranging from seconds to years. Most of those used in clinical nuclear medicine have half-lives in the range of minutes to days. Radionuclides generally are measured in terms of the amount of radioactive substance that disintegrates in 1 second. The specific units employed are referred to as *curies*, named after Marie Curie, and a single curie equals 3.7×10^{10} disintegrations per second. The most commonly employed units in nuclear medicine are the *millicurie* (mCi), which is 3.7×10^{7} disintegrations/second, and the *microcurie* (μCi), which is 3.7×10^{4} disintegrations/second.

There are a limited number of naturally occurring radioactive elements, mainly among the heavier elements, and these are of little importance in nuclear medicine today. The majority of the radionuclides utilized clinically are obtained by converting stable elements into radioactive forms by means of nuclear reactors or cyclotrons. These unstable forms are "created" by bombarding stable elements with other particles, mainly neutrons. Since most hospital laboratories employing radionuclides in daily practice are not near such installations, the radionuclides available to them are "half-life" limited; that is, their half-life must be long enough to allow for transportation from the maker to the user since radioactive decay naturally occurs during this transit period. Radionuclides with short half-lives, such as fluorine-18 with a half-life of 1.8 hours, are therefore available only to institutions located near these devices.

NUCLIDE GENERATORS

Because of the desirability of short-lived nuclides to reduce patient exposure and to allow the administration of larger amounts to achieve better counting statistics, the *nuclide generator* (Figure 1-1), commonly referred to as a "cow", has been introduced to help solve this problem. These generators consist of a longer-lived parent nuclide that produces a short-lived daughter in its decay scheme (Figure 1-2). The daughter can be separated as needed from the parent and utilized in diagnostic procedures. The necessity for replacement of the generator depends upon the half-life of the parent.



A B

FIG. 1-1. *A. Replaceable "cow" obtained commercially. B. Schematic drawing of the main components of the generator system.*