DIAGNOSTIC RADIOLOGY

FOR THE HOUSE OFFICER

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WILLIAMS & WILKINS

Diagnostic Radiology for the House Officer

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Preface

Radiology has become an increasingly complex diagnostic system. A vast number of radiologic procedures are available to the requesting physician and it has become more and more difficult to determine which of the many examinations is indicated in evaluating his particular patient. This handbook is designed to help non-radiologists to understand more about radiologic procedures and hopefully to be more selective in ordering these procedures. Direct consultation with the Radiology Department is clearly the appropriate step to take before ordering a radiologic procedure. This is not always possible for a number of reasons and this handbook will help serve as a radiologic consultation. It cannot answer questions in every specific instance but the broad concepts should prove useful in evaluating a particular patient.

At the end of each chapter are several algorithms for a suggested approach to a particular clinical problem. The approach to this problem might vary somewhat in your particular hospital due to different bias or capabilities of your Radiology Department.

This handbook is the outgrowth of a similar manual used by the house staff at the Hospital of the University of Pennsylvania. The authors of this text are very grateful to the many radiologists at that hospital who helped in the preparation of that manual.

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Chapter 1

Introduction

X-RAYS

When he made the first exciting recognition of the nature of x-rays in 1895, Wilhelm Konrad Roentgen had little concept of the far reaching consequences of his discovery. X-rays have become one of the most widely used medical tools and are the backbone of the medical investigation of the symptomatic patient.

X-rays are a form of radiant energy which take their place in the electromagnetic spectrum with ultraviolet rays, visible light, infrared, radar and television signals. Because of their very short wave length, x-rays have the ability to penetrate various bodies which are opaque to light. The varying degree of absorption of x-rays by materials of different densities allows the formation of a negative image of the absorption characteristics of that body. This image is directly or indirectly the basis of all radiographic examinations.

Various manipulations of x-rays or radiographic image have led to the development of different aspects of the radiographic examination.

Fluoroscopy is the direct observation of the radiographic image on a fluorescent screen. The fluoroscopic image is a relatively poor one; it can be made sharper and more distinct by converting the fluoroscopic image into an electronic one, passing it through a series of photomultiplier tubes and projecting it upon a television screen.

Fluoroscopy allows the direct visualization of internal structures within a patient and allows the radiologist to observe a moving image. This is essential in certain examinations such as the upper G.I. series and the barium enema and is important in manipulating catheters or other devices within the body in the many interventional techniques which now form a major part of radiology.

Tomography is a technique in which the tube and film move in a reciprocal plane of motion about a designated fulcrum within the patient's body. This causes blurring of the radiographic image in all planes within the body except the plane of the fulcrum and allows the creation of an image of a thin slice of the body.

Computerized axial tomography is a different technique of obtaining a slice of the patient's body. In this technique, a fan beam of x-rays is passed through the patient in an axial direction as the x-ray source rotates about the patient's body. Opposite the x-ray source is an array of crystalline detectors which measure the amount of transmitted radiation. These measurements are then recorded in a computer and used in a series of complex mathematical calculations to determine the radiopacity (or relative amount of transmitted radiation) for each small area of the body being scanned. The resultant image is an accurate and extremely sensitive cross sectional radiograph of the body.

Digital radiography is a technique in which a television camera scans the radiographic image recorded on an image intensifier. The output of this television camera is then recorded in a digital computer where the resultant image can be stored, manipulated or displayed on command. This technique offers the promise of long-term, inexpensive storage of radiographic images and perhaps the elimination of the film system of recording radiographic images.

A major application of digital radiography at present is digital subtraction angiography. In this technique an image of the body is formed prior to performing an angiogram; this image can then be subtracted from the image formed following injection of contrast material into the blood vessels. Thus, only the image of the blood vessels remains. This technique allows visualization of various structures following intravenous injection of contrast material where previously intraarterial selective catheterization of the vessel was required. It also allows very precise images following intraarterial injection of small amounts of contrast material.

RADIONUCLIDES

Soon after the discovery of x-rays by Roentgen, other scientists recognized that there were various naturally occurring substances which emitted rays (gamma rays) quite similar to x-rays. These substances are radioactive and emit various particles along with photons of energy (gamma rays) from their nuclei as these nuclei, which are physically unstable, seek a stable configuration (decay). These naturally occurring radioactive substances, plus other substances which are not encountered naturally but which can be generated in a cyclotron, are the radionuclides which form the basis for another branch of radiology. These radionuclides can be administered to the patient orally or intravenously and the subsequent distribution of the radionuclide to a particular organ system or area of the body can be measured by a series of sensitive crystalline detectors which detect the gamma rays being emitted from the radionuclide concentrated within the body. This is the basis of radionuclide imaging.

Radionuclides can also be used to assess various biologic processes within the body by tracer techniques. A small amount of radioactive material is administered, and after it reaches equilibrium in a certain body fluid or tissue, this fluid or tissue can be collected and examined for the radioactive material that it contains. Various calculations can then be used to estimate the total amount of that fluid or tissue within the body; this allows determinations of certain physiologic parameters such as blood volume and red cell mass.

Radionuclide images typically have very poor definition, so that in order to gain a high quality radionuclide image, some special technique must be used. In one technique, radioisotopes are used that emit positrons as they decay. When a positron combines with an electron, annihilation radiation occurs in which two similar photons are emitted at 180^0 from one another. This annihilation coincidence radiation can be recognized by strategically placed detectors and the location of the original positron can be plotted. Using computers, a high resolution image of the involved organ can be reconstructed. This technique is called positron emission transaxial tomography (PETT). A cyclotron is required to generate the short-lived positron emitting isotopes, so that this technique is expensive and limited to a small number of centers.

ULTRASOUND

Ultrasound is another imaging modality which has become available to the medical community and, in most instances, is used primarily by the Radiology Department. This technique has a tremendous advantage over the use of x-rays in that there are no significant hazards to the patient from the sound waves themselves at the levels used in diagnostic examinations. This cannot be said of x-rays.

Ultrasound waves are generated by electrical stimulation of a piezoelectric crystal which causes high frequency vibrations. These vibrations (sound waves) pass through the body and are reflected, transmitted or attenuated to a varying degree depending upon the acoustic properties of the underlying tissues. The ultrasound transducers serve a dual purpose, first emitting the sound waves and then detecting the reflected sound waves. These are electronically amplified and displayed upon an oscilloscope where photographic images can be made. Sonographic images are somewhat more difficult to interpret than radiographic images and the characteristic of sonolucency has different implications from radiolucency.

NUCLEAR MAGNETIC RESONANCE

Nuclear magnetic resonance is another new and promising imaging technique which is not yet available in most medical institutions. Like ultrasound, this technique has a major advantage in that it uses a form of energy (radio waves) which is not harmful to the human body at the levels at which it is utilized. The basis of nuclear magnetic resonance is essentially as follows. In a strong magnetic field, the nuclei of elements with uneven numbers (such as hydrogen) will spin along a stable axis. The direction of the spin can be reversed by exposing these nuclei to radio waves of a specific frequency. When the radio waves are stopped, the unstable state ceases to exist and the direction of the nuclear spin reverts to its original state. As this occurs, the energy absorbed in the original departure from the stable state is released in the form of radio waves of the same frequency as the ones abosorbed. These radio waves can be detected and mapped so that the distribution of hydrogen (or other) nuclei can be plotted and an image of the internal structure of the involved tissue can be reconstructed.

INTERVENTIONAL PROCEDURES

In the early years of radiology, the function of the radiologist was to make diagnostic images by non-invasive techniques. Contrast material might be injected into the G.I. tract or G.U. tract through some naturally occurring orifice or an intravenous injection of contrast material given which was subsequently excreted into the organ which was desired to be imaged. In recent years, techniques have developed in which needles or catheters are introduced percutaneously into various organs. Material can be aspirated from these organs for culture or cytology, portions of the organ involved may be opacified by injection of contrast material or catheter techniques may be utilized to dilate or bypass an area of narrowing in a tubular structure. This new direction in radiology has allowed the radiologist to participate in the therapy as well as the diagnosis of various disease.

THE COST OF RADIOGRAPHIC STUDIES

Physicians, for the most part, have not concerned themselves with the cost of diagnostic examinations. These examinations are paid for by third party payers. The patient often does not know the cost of the examination and does not complain. Medical care costs have increased dramatically over the past 30 years, at least in part due to the large number of diagnostic tests being performed. It behooves the informed physician to know the approximate cost of each study being considered, to approach the diagnostic problem in the most judicious and efficient way possible and to refrain from ordering studies which are duplicatory or which yield only dubious additional information. In this manner, a start may be made toward keeping down the cost of medical care.

The cost of radiologic examinations at your particular institution can be obtained from the hospital billing office or the Radiology Department. The following is a list of a few common radiologic examinations and their cost in a large eastern teaching hospital. The cost of each examination in your institution should probably be the same or lower. By knowing the cost of a chest x-ray in your institution and comparing it with list below, an approximate cost of each examination can be estimated.

CHEST

PA and lateral $50

LUMBOSACRAL SPINE

PA, lateral and obliques $88

CERVICAL SPINE

PA, lateral and obliques $80

ANY JOINT

PA, lateral and obliques $52

LONG BONE

PA and lateral $49

UPPER G.I. SERIES $163

BARIUM ENEMA

Single contrast $111

Double contrast $144

INTRAVENOUS UROGRAM $125

RETROGRADE PYELOGRAM $113

CYSTOGRAM $118

ORAL CHOLECYSTOGRAM $83

SKULL X-RAY $68

PARANASAL SINUSES $50

FACIAL BONES FOR FRACTURE $79