Radiology for Surgeons in Clinical Practice

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Foreword by Johannes Zacherl

Springer

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ISBN: 978-1-84800-095-7 e-ISBN: 978-1-84800-096-4
DOI: 10.1007/978-1-84800-096-4

British Library Cataloguing in Publication Data
Radiology for surgeons in clinical practice
1. Interventional radiology 2. Diagnosis, Surgical
I. Sala, Evis
616′ .0757
ISBN-13: 9781848000957

Library of Congress Control Number: 2007943248

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Printed on acid-free paper

9 8 7 6 5 4 3 2 1

Springer Science+Business Media
springer.com

Foreword

In the daily medical routine, recent refinements of several modern imaging techniques enable us to enhance diagnostic accuracy. Tremendous efforts in radiology have been made to help us to avoid inappropriate interventions and treatments by a misleading diagnosis and to obviate false-negative results, too.

The rapid development of imaging techniques requires continuing theoretical updating in this field by publications like the current compendium. Theoretical principles of radiology methods are brought up in a concise manner, and according to the composition of modern medical university curricula, the pathology findings are arranged and described in dependence on clinical symptoms rather than as a listing of diseases. This configuration therefore turns the opus in front of you into a useful and valuable companion during surgical education. The initial tentativeness of young trainees and of the nonradiology "old hand" in the face of modern imaging techniques and new contrast agents, will rapidly disappear and turn into enlightened familiarity, helping one to use those fine arts in discovering the patient's problem and in the planning of treatment strategy.

In the era of interdisciplinary boards and discussion, surgeons traditionally are an essential driving force. This position demands an expertise in imaging, which may be strengthened by a special advantage: the surgeon is in the unique position to immediately compare radiology findings with the intracorporeal situation during surgery, what we often might call "the clinical truth." This circumstance allows for an accurate learning effect, which should be a central aspect of training in clinical decision making. A further advantage of close-to-the-patient disciplines is the correlation between clinical signs and radiology findings. I do not want to end this foreword without emphasizing the need of keeping an eye on the clinical signals and additionally on information delivered by modern technology.

My first mentor repeated the claim that "the surgeon is the better radiologist." Thanks to the authors of this book, this sentence may again become true.

Johannes Zacherl

Preface

Hamilton Bailey, in his time perhaps the foremost teacher of surgery in the English language, described assessment of the acute abdomen in his book, *Demonstration of Physical Signs in Clinical Surgery* (1960), as follows:

> Physical signs and their interpretation reach a high pinnacle of importance in the diagnosis of acute abdominal disease. Frequently an urgent and all important diagnosis has to be formulated by their aid alone.

How times have changed and the perspective from nearly half a century later is completely different.

The history and clinical examination still remain the bedrock of diagnosis but virtually no patient today will pass through the hands of a surgeon without some form of radiological imaging, from the simple plain radiographic image to complex 3D reformats of data sets acquired during CT and MR examinations. In this context, diagnostic imaging has revolutionized the way surgery is practiced. It thus behooves the surgical trainee to remain abreast of all the techniques available and to be cognizant of their advantages and disadvantages.

In this small book, the authors – all radiologists – have attempted to look at the patient from the clinical perspective of symptoms and signs, and then to formulate the relevant imaging which would be appropriate for their management.

Our intention has been to produce a radiological guide for the surgical trainee, without delving too deeply into the technological processes of image acquisition and manipulation. We hope it helps.

Our particular thanks go to Melissa Morton of Springer UK for the encouragement to produce this book and to Barbara Chernow and all the production team at Springer who have been responsible for bringing it to fruition.

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Part I
Principles of Imaging

Imaging investigations are an essential part of the management of patients presenting with surgical problems. To have a logical plan of investigation for a particular clinical situation, an understanding of the imaging techniques is required including the method of generating an image, costs, strengths, weaknesses, and associated risks. This chapter introduces the basic concepts of the available imaging modalities and their advantages and disadvantages in clinical practice.

1.1 Plain Radiographs, or X-rays

X-rays are electromagnetic radiation with an energy and frequency substantially greater than visible light. They are generated within an X-ray tube, in which electrons are accelerated at a small metal target from which X-rays are then emitted. These are then collimated into a shaped beam and directed at the relevant part of a patient. Depending upon the intervening tissue's attenuation properties, a characteristic pattern of X-rays is transmitted through the imaged part. Conventionally, these X-rays are then converted by phosphor screens into light photons, which expose photographic film subsequently processed to create the *X-ray film* or *radiograph* viewed on a lightbox. Increasingly, these systems are being replaced by solid-state X-ray detectors (e.g., selenium-based or amorphous silicon–based materials), which convert X-rays indirectly (computed radiography; CR) or directly (direct radiography; DR) into electrical signals, providing digital and *filmless* acquisition. These are usually reviewed on workstations but can be converted to film if needed. Image contrast relies on the fact that different parts of the body attenuate (stop) X-rays better than others. Lungs are mostly gas, and most X-rays pass straight through, whereas bones are high in calcium, which absorbs X-rays to a high degree. A tissue structure is often only visible if it lies adjacent to another tissue of different density. In general terms, the major attenuation differences occur between gas, soft tissues, fat, and bone. Therefore, radiographic examinations are particularly good for directly imaging bony structures and those containing gas, such as the lungs. Conventional radiographs are *projection* techniques providing no intrinsic *depth* information, therefore interpreting abdominal and pelvic examinations requires some skill, for example to understand the patterns of normal and abnormal gas and fluid distribution.

An additional feature of X-rays is that they may be used to obtain dynamic information using an image intensifier. This is termed *fluoroscopy* and allows real-time observation during a range of diagnostic and therapeutic procedures. Despite newer, more sophisticated forms of imaging, a plain radiograph remains one of the cheapest, fastest, and simplest ways of detecting many problems; however, they lack sensitivity and specificity. The diagnostic advantage of the use of X-rays typically outweighs the risks from the effects of ionizing radiation (see Section 1.3.2).

Advantages	*Disadvantages*
• Fast	• Uses ionizing radiation
• Relatively inexpensive	• Limited soft tissue contrast
• High spatial resolution	• Projection method lacking any true depth discrimination
• Widely available	

1.2 Contrast Medium Studies

A limitation of plain X-ray examination is that most of the soft tissue structures of the body are of similar radiographic density. To visualize these various soft tissue structures, contrast agents were developed and improved during the 20th century. Although negative contrast using gas was widely used, most studies now employ positive contrast media that attenuate X-rays by means of their high atomic number. These agents include barium sulfate used mainly in the gastrointestinal tract and water-soluble agents containing bound iodine that may also be used intravenously.

1.2.1 Oral Contrast Medium Studies

Barium sulfate is an inert, insoluble substance that can be taken orally and used to outline the various portions of the gastrointestinal tract. Improved results and higher sensitivity are achieved with *double-contrast* studies combining both gas distension and barium coating of the luminal surface of the organ being examined.

An important issue is the choice of contrast media in case of suspected esophageal tear or gastrointestinal perforation. Barium in the mediastinal or peritoneal cavity is harmful and may cause mediastinal or peritoneal fibrosis. Water-soluble non-ionic contrast media are safer, although they lack the level of anatomic definition created by barium. Similarly, if aspiration is suspected or likely, water-soluble, non-ionic contrast media should always be used first, followed by barium if there is no obvious leak. Ionic, water-soluble contrast media such as Gastrografin (Schering Health Care Ltd., Burgess Hill, West Sussex, UK) should be avoided as they cause severe pulmonary edema if aspirated.
Examples of barium studies are as follows:

Barium swallow: This is used for the imaging of the pharynx and the esophagus. It is one of the first-line investigation methods for esophageal disorders, particularly in cases of dysphagia. Good fluoroscopy is important, and video recordings are made as the barium is swallowed if a motility disorder is suspected.

Barium meal: Used for examination of the lower esophagus, stomach, and duodenum. Double-contrast techniques provide excellent detail of the mucosal surface of the stomach and duodenum. Although considered the basic technique for radiologic investigation of the stomach, it has been largely replaced by endoscopy.

Small bowel study: Used to examine the structure and motility of the small bowel. Barium can be given either orally (barium *follow-through*) or administered via a tube placed into the distal duodenum or proximal jejunum (small bowel enema or enteroclysis). Barium introduced directly into the small bowel offers exquisite visualization by creating an uninterrupted column of contrast medium distending the jejunum and ileum. This facilitates detection of any structural abnormality that might be present. Capsule endoscopy has replaced this technique for subtle lesions with no morphologic changes (e.g., some arterio-vascular malformations).

Barium enema: Double contrast using barium and air via a rectal tube to outline the lumen and mucosa of the large bowel. Despite the increasing role of colonoscopy, double-contrast barium enema remains widely used for examination of the large bowel. Limited single-contrast studies can be used to demonstrate and confirm the level of a colonic obstruction or a fistula.

1.2.2 Intravenous Contrast Medium Studies

Intravenous contrast medium is used to enhance vessel and tissue contrast in various X-ray–dependent imaging modalities. After intravenous administration, the contrast agent passes through the venous and arterial system, thus rendering these vessels visible. During circulation, a certain amount of the contrast medium passes through the vessel wall and distributes to the extracellular fluid of the surrounding tissue/organs producing the necessary contrast to show anatomic and pathologic details. The contrast medium is then excreted through the kidneys and finally delineates the urinary tract.

Intravenous contrast media that are used for X-ray examinations are based on iodine. They can be categorized as ionic and non-ionic, depending on their molecular structure and osmotic behavior in the blood. Non-ionic contrast media such as Iopamidol (Bracco UK Ltd., Wooburn Green, Buckinghamshire, UK) have less risk of adverse reactions (in part related to their low osmolarity) but are typically more expensive than their ionic equivalents. Side effects include nephrotoxicity and allergic reactions ranging from mild skin alterations to anaphylaxis. Therefore, elevated serum creatinine levels and a previous history of contrast medium allergy represent relative contraindications, and an alternative imaging modality such as ultrasound (US) or magnetic resonance imaging (MRI) should be considered. If the use of an iodine-based contrast medium is unavoidable, high-risk patients should receive a premedication with corticosteroids (prednisolone 30 mg orally 12 and 2 hours before contrast medium) and antihistamines. To reduce nephrotoxicity, all patients should be adequately hydrated before the contrast medium injection, and intravenous fluids may be needed for those with known renal impairment.

1.2.2.1 Intravenous Urography

Intravenous urography (IVU) is used to investigate urinary tract disorders, especially renal colic. It provides some anatomic and functional renal information but is most useful for demonstrating the ureters and pelvicaliceal systems 5 to 20 minutes after injection of intravenous contrast medium. An initial plain radiograph (to look for renal tract calcification) is always obtained. In the case of acute renal colic, IVU has been partially replaced by low-dose unenhanced computed tomography (CT) in many institutions. The latter yields not only higher sensitivity and specificity but offers also additional information of all other abdominal organs.