全国高等医药院校规划双语教材

Bailey & Love

外科学

SHORT PRACTICE OF SURGERY

第24版

原著 R.C.G. Russell
Norman S. Williams
Christopher J.K. Bulstrode

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主审 裘法祖 吴孟超

第1卷

外科学基础

人民卫生出版社

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秘书 陈义发 张万广

人民卫生出版社

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INTRODUCTION

LEARNING OBJECTIVES

- **To understand the process of surgery**
- **To think about the process of history-taking**
- **To consider clinical examination**

The undergraduate or graduate approaching surgery, either as a student attached to a surgical department or as a new intern, may well wonder what is different about surgery. Why is it a separate department? That question is being considered more and more as the barriers between the medical and surgical aspects of subject specialties merge. In the past, and to a large extent this is still true today, the surgeon was primarily a doctor who treats patients by physical means, undertaking excising and repair by hand, rather than by opinion and pharmacological means. This distinction is now less clear in that physicians treat patients not only with sophisticated pharmaceuticals but also with their hands, often using instruments, such as catheters and endoscopes, and biopsy techniques to achieve a therapeutic objective. The physician rarely ventures into the operating theatre, but may, in the endoscopy suite or department of radiology, perform procedures of equal magnitude to those undertaken by surgeons.

What perhaps focuses the surgical mind is the question 'Does this patient need an operation or will the diagnosis suggested by the patient's symptoms best be improved by a surgical intervention in the operating room, or is a non-surgical or conservative approach more applicable to relieve the symptoms and achieve rehabilitation and a normal quality of life?' The abruptness of the surgical question focuses the mind and demands a decision that requires action, which distinguishes the surgical approach. A decision to act is not a process without intellectual input. To make this decision, the surgeon must balance the advantages and disadvantages and the benefits and the risks, as well as the wishes of the patient and the patient's relatives.

The basis on which such a process starts is the simple procedure of taking a clinical history, examining the patient and creating a differential diagnosis from which the surgeon can select the best investigation to define and confirm that diagnosis. Once the diagnosis has been made, the decision to operate becomes self-evident on the basis of 'evidence-based surgery'. The data or the knowledge, together with experience, are available to make the decision for the patient and, hopefully, attain the best outcome. It is important to grasp that the surgeon is involved in diagnosis, in treatment and, indeed, in aftercare. Nevertheless, the surgeon's role is largely confined to the 'episode' and, for the long-term care, the patient is managed by the physician or family doctor. It is this philosophy of 'episode' that underlines the surgeon's approach to disease management; hence the quest for less invasive techniques, more rapid recovery and less damaging therapies that has marked surgical advance (Box 1.1).

In the study of surgery, it is essential to understand the anatomy, physiology and pathology of the disease as well as its natural history. A large part of this book is taken up with these subjects to ensure a 'thinking attitude' to surgery. The process of surgery, the technical skill, is not well conveyed by a text, except to understand the outline of a procedure. The place to learn surgery is in the skills laboratory and in theatre; to a large extent, it is a process of apprenticeship, which is facilitated by a sound and detailed knowledge of anatomy, pathology and physiology. No operation can be performed by 'rote' otherwise development of the art of surgery will falter.

HISTORY-TAKING IN SURGERY

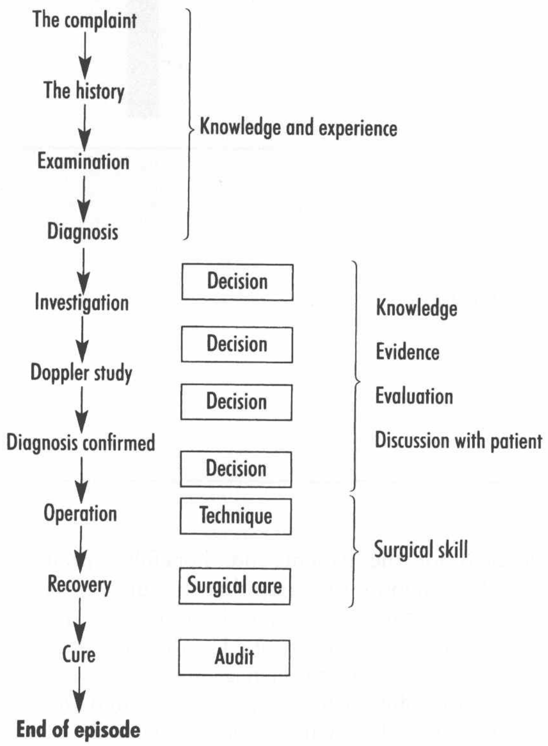
The process of surgery begins with the history, which is the single most important part of making a diagnosis. The history directs the clinician to search for the physical abnormalities at the earliest possible stage, thus facilitating further management.

The skilled clinician becomes knowledgeable about the pattern of disease; indeed, experience 'fine tunes' this process of pattern recognition, such that the skilled clinician will ask fewer questions yet achieve the same information. Nevertheless, it is essential to *listen* to patients and determine what their complaints are. The clinician must not shape, elaborate, flavour or direct a history into a particular preconceived diagnosis; let the history flow, but keep to fact and precise detail. The history emerges from the patient's description of the problem, directed by your planned questioning.

Henry Hamilton Bailey | **1894–1961 and**
Robert John McNeil Love | **1891–1974. Surgeons, The Royal Northern Hospital, London, England. Published the first edition of *A Short Practice of Surgery* in 1932.**

Christian Johann Doppler | **1803–1853. Professor of Experimental Physics, Vienna, Austria. Enunciated the 'Doppler principle' in 1842.**

Box 1.1
The surgical episode



Thus, history-taking will elicit the patient's name, age and marital state, the presenting complaint or complaints, preferably in the patient's own words, and then the detail of each complaint. Here, specific questions are asked to hone down on the precise detail. Soon a pattern emerges, limiting the problem to a major system or even a specific diagnosis. The questions are then related to that system and disorder. Once the complaint has been 'ordered' in your mind or on the case sheet, any previous history related to that complaint is sought, the past medical history, a history of drugs and allergies, social and personal history, family history and a review of the systems. It is important to develop your own style and technique for taking the history and recording the detail.

Each specialty develops its own list of specific and appropriate questions, and these will be considered in each section. An example of the type of detailed questioning that is required is considered in taking the history of pain.

PAIN

Pain is probably the most important symptom, one that requires careful definition in history-taking. The site of the pain should be defined, whether it is local or diffuse, and whether it radiates from the site of origin to other regions of the body. Referred pain implies pain occurring at a site far removed from the originating disease. It is due to visceral nerve impulses stimulating somatic afferent pathways of the same dermatome. Pain on the shoulder tip from irritation of the diaphragm is a classic example. Pain is fickle; it is not always the same, and circumstances and surroundings adjust it. Thus, minute detail is rarely of value, but it is the picture that the detail makes that is important for diagnosis. The timing of the pain is important; it is necessary to know the onset, which may be sudden or gradual, and, in particular, the rapidity of the build-up. The progress and the pattern of the pain is informative. Colic pain is due to waves of contraction and comes in all sizes and patterns. Previous bouts of pain are important; most people can rarely describe pain, but as soon as it recurs recall is precise. The offset is less important, being gradual or sudden, yet it is a point rarely remembered by the patient, who suddenly realises that the pain is no longer present. Severity of the pain is important, but observer error is considerable in that all pains when they occur are the 'worst' pains, as anxiety and ambience influence. In order to limit this, a scale, such as 0 to 10, can be used, but this is rarely of value. The quality of the pain is difficult to define, but terms such as 'sharp', 'stabbing' and 'knife-like' relate to cuts or wounds, whereas 'throbbing' implies inflammation and 'tight', 'gripping' and 'twisting' tend to be used for colic. 'Crushing', particularly when associated with gripping of the right hand, is often used for chest pain. 'Bloated', 'distended' or 'bursting' may be accurate descriptions of obstruction or a full bladder.

Modification of the pain by aggravating or relieving factors contributes to the picture, often defining an unclear image. Pain aggravated by walking and relieved by rest can be none other than claudication until disproved. Associated symptoms, although not true modifiers, can clinch the diagnosis, for example the change in colour of the skin of the leg on walking.

It is customary to ask the patient for the cause of the pain; although this rarely helps, it not infrequently produces a series of descriptive adjectives that help define the pain more than the previous questioning.

GENERAL PHYSICAL EXAMINATION

Every patient who presents should undergo a full general examination, yet it is remarkable how rarely this reveals additional information in a community that receives above-average health care. Nevertheless, it takes only a few minutes and conveys to the patient that the surgeon cares about their well-being. The focus of the examination must be centred on the system defined by the history. It is here that care and accurate recording are fundamental to good surgical practice. In order not to miss basic signs, it is essential to have a disciplined approach to the surgical examination. As part of 'good surgical practice', it is essential to record details in the patient record related to the part under consideration for a surgical diagnosis. Start with the site and print the side, not using an abbreviation but in full; 'right' or 'left'. Check this again before you sign the notes. When recording the site, use standardised anatomical terms with a description of the tissue of origin and the relationship to other structures, preferably defined anatomically. Thinking of the anatomy, the muscle, the name of the bone, the particular nerve or artery, applies the mind to the diagnosis and avoids simple error (Box 1.2).

Box 1.2
General approach

Record:

- Site
- External appearance
- Internal nature
- Effect on surroundings

LUMPS

The presence of a swelling or a simple lump is a common presentation of a patient to a surgeon. Lumps, correctly, make patients anxious, and an undiagnosed lump is correctly a cause of concern, particularly as it may be a manifestation of an underlying cancer. History is important: How did the patient notice the lump? Was there a history of trauma or was the lump uncomfortable or painful? It is important to determine when it first appeared and whether it has changed since it first became apparent. Changes in size can often relate to difficulties in feeling the lump and, in particular, prominence of the lump in certain positions. For instance, a saphena varix will vary according to position, and a swollen submandibular gland due to a stone in the duct will vary according to the stimulus of eating, increasing in size, sometimes painfully, after a meal.

Painful lumps are commonly due to trauma and inflammation, but malignant lumps may also be painful when rapidly expanding, breaking down or invading nervous tissue. A previous history of the lump or other similar lumps may help the diagnosis. Congenital lumps may be associated with multiple abnormalities. With the history of the detail of the lump itself, it is important to determine if there are any *systemic changes*, such as general malaise, fever, loss of appetite or disturbance of sleep. Before examining the patient, ask the patient precisely where the lump is, as being unable to find the lump causes embarrassment to the patient and the doctor, and even a loss of confidence, or, quite simply, it may appear only in certain positions. This is particularly true of a hernia.

Exterior of a lump (Box 1.3)

First, record the *size* of the lump in centimetres, after measurement with a ruler or a tape measure. Lumps are three-dimensional, so three measurements should be recorded. Do not compare the lump with fruit, as fruit varies markedly in size. The *shape* should be recorded using standard terms, such as 'round', 'oval', 'flattened', 'triangular', 'rectangular', 'square' or even 'irregular'. Many lumps are poorly defined, and all these features should be noted. Superficial lumps may be raised above the skin surface, and this should be recorded. The surface should be described in standard terms such as 'smooth' and 'regular' as opposed to 'rough' and 'irregular'. Surface lesions may have a characteristic appearance, such as the irregularity of a seborrhoeic wart, or a pit such as a pilonidal sinus or a punctum, as occurs in a sebaceous cyst. Even deep lesions may affect the skin surface by tethering the skin. This is an important sign in carcinoma of the breast. The pattern of an irregular surface is often difficult to describe, but the terms 'nodule' or 'nodular', 'lobulate', 'cobblestone' and 'bosselated' are useful descriptive terms. The edge of a flattened or projective lump may be clearly or poorly defined and can be described using the terms 'sharp', 'rounded', 'regular' or 'irregular'. The use of easily understood terms is most important and part of the language of surgery.

The *colour* of the lump refers particularly to skin lesions, although deep lesions that are large can change the appearance and so the colour of the skin by their size. All such changes are important observations. Pigmentation is critical in melanoma and other skin lesions. Xanthelasmata are yellowish in colour, whereas gouty tophi are the white of their content. Vascular lesions such as varicose veins and, in particular, venous stasis are associated with brown pigmentation from iron pigments.

Changes on the skin due to heat, erythema *ab igne*, can be an indication of prolonged pain. Infiltration of the skin by tumour, or as a result of tissue use, is an important observational point in the gathering of information for achieving a diagnosis. *Temperature changes* are related to blood flow and changes in the circulation. Comparison of temperature between adjacent parts is important; the back of the hand is a better temperature discriminator than the palm.

Tenderness may accompany trauma, inflammation and malignant lumps. It should be emphasised that the presence of tenderness must be enquired about before feeling a lump, as some lumps, such as those due to an abscess, are exquisitely tender. While examining a lump, always watch the patient's face as this will define the anxiety and tenderness associated with a lump. Always record such details.

Box 1.3
External appearance of a lump

- Size
- Shape
- Surface edge
- Colour
- Temperature
- Tenderness
- Mobility

Mobility

Some lumps are mobile because they move under the skin, whereas others are mobile because the part to which they are attached moves. It is this dynamic that helps determine the site of origin of the lump. The layer in which the lump arises can be defined by moving or clenching the muscle to determine the attachments of the lump. Bursae and ganglia around a joint may have different appearances in different positions but are not truly mobile; this is helpful in determining diagnosis, particularly in the examination of the joints. *Crepitus* may occur when moving inflamed tendons. Assessment of the abdominal mass for movement is extremely important. The relationship to respiration defines whether the mass is related to the diaphragm. Retroperitoneal lesions do not move with respiration. The direction of movement is important and the spleen will move towards the umbilicus, whereas the liver moves longitudinally. Organs and masses attached to the liver and spleen will move likewise. The ability to 'ballot' an enlarged kidney between the lumbar-placed hand and the hand on the abdomen elucidates the organ of origin of the mass.

Interior of a mass

When feeling a mass, it is important to consider its content (Box 1.4). The contents are variable: a solid mass is due to cellular growth while a fluid one indicates the formation of fluid by the cells lining the mass wall, degeneration of a tumour due to necrosis of the cells or simple liquefaction of a haematoma. The mass may be full of gas if it is due to a twisted loop of bowel. The gas may escape, as in a ruptured oesophagus, and give rise to swollen tissues that crinkle when compressed (crepitus: invariably a dire sign).

The *consistency* of a lump ranges from stony hard, like bone, to firm, like clenched muscle, to soft, like skin or fat. Various comparisons are used, but the simple classification of 'hard', 'firm'

Box 1.4
Interior or substance of a mass

- Consistency
- Reducibility
- Indentation
- Fluctuation
- Pulsation
- Transillumination
- Compressibility
- Cough impulse
- Discharge
- Fluid thrill
- Expansion
- Bruit

and 'soft' covers most lumps. Occasionally, the mass will alter on pressure (*compressibility*), which can occur with bursae or haemangiomas, reforming as soon as the hand is removed. Reducibility implies that the lump can be pushed away but does not return immediately (a hernia is the commonest example), only to recur when the patient strains or coughs – the 'cough impulse'.

Indentation is a valuable sign in which solid or semisolid material can be compressed with the finger, and the imprint will remain as seen in oedema. Indentation occurs with faeces, and sebum in sebaceous cysts.

Fluctuation can be elicited whenever fluid is confined to a cavity, such as occurs in a large cyst. To be reproducible, it is necessary to elicit the thrill in two directions with use of a third hand between the eliciting and receiving hands. A lipoma may occasionally fluctuate in one direction but never in two planes.

A *fluid thrill* is a more complex sign. In the abdomen, it can be elucidated in ascites when the patient coughs, or in a hernia sac; this should be differentiated from a cough impulse, which occurs in the patient with an inguinal hernia who coughs. The thrill, to be confirmatory, must be *expansile*, that is the contents of the hernia sac increase in size with the cough, as opposed to *transmitted*, in which there is no change in the size of the swelling. The best example of the fluid thrill is the saphena varix with valvular incompetence; the thrill, which is expansile, is felt on coughing or by tapping the saphenous vein.

Discharge usually occurs with skin lesions in which there is a punctum, or as a result of an abscess that contains fluid. It is important to record the nature of the discharge, as well as the smell, which can be characteristic.

Pulsation is a most important sign and must be both tested and elicited if present. If there is doubt, a Doppler examination must be performed. Pulsation can be transmitted, that is the mass lies on an artery and moves with each pulse. To determine if the swelling is pulsatile, test for expansion; vessels distend with each pulse. If there is a high flow of blood in the swelling, a thrill will be palpable. Post-traumatic aneurysms used to be the commonest cause, but the best example is now a surgically created arteriovenous fistula such as that used in renal dialysis.

Transillumination is a sign that is of value in determining the presence of clear fluid, most commonly used in the scrotum to determine the presence of a hydrocele or epididymal cyst. Cystic hygromas, ganglia, bursae and branchial cysts will all transilluminate to a greater or lesser extent.

Tissues adjacent to the lump

Observation of the tissues around the lump are important; the body's reaction to the mass indicates the nature of the pathological process. Probably the most important is *induration*; this is thickening, swelling and firmness of the surrounding tissues. Oedema is present and can be due to an inflammatory reaction or blockage of the lymphatics by tumour. Occasionally, the thickening is caused by infiltration of the dermis by tumour. The thickened tissue associated with malignancy has the appearance of an orange skin and is described by the term '*peau d'orange*'. In the breast it is a sombre sign of advanced disease.

The mobility of the tumour in relationship to surrounding structures is extremely important in the assessment of surgical approach. Tethering of tissues away from the mass is important as it may indicate infiltration of supporting tissues and incurability. On the other hand, simple shortening of the ligaments of Astley Cooper in the breast has minimal prognostic significance. Although the signs are the same, their significance in different areas and in different structures are not the same. It is only experience and understanding of local anatomy and specific pathology that make the sign interpretable in a logical way.

Invasion

Direct invasion of a structure has to be elucidated to determine the surgical approach. Thus, it is essential to exclude involvement of nerves by appropriate examination. One of the commonest causes of litigation is the removal of an innocent lump only to find that a nerve is involved by the mass or indeed is the structure of origin. Beware of tumours arising from the nerves in the arms in thin subjects. The relationship to blood vessels is almost as important, because bleeding encountered during surgery for which there has been inadequate preparation can be dangerous to the life of the patient. Always feel for pulsation and think anatomically; think what vessels supply the area and what is the venous drainage. If there is doubt, turn to Doppler ultrasound in order to define the vascular anatomy.

No examination of a mass is complete without examination of the draining lymph nodes. Enlargement must be explained and included in the diagnostic profile of the lump (Box 1.5).

Box 1.5
Surroundings of a lump

- Induration
- Tethering
- Invasion
- Lymph nodes

ULCERS (Box 1.6)

Ulcers should be considered in the same manner as a lump, in that many start as a lump and proceed to ulceration. Thus, the history, the site and the surrounds are considered as for a lump, but emphasis must be laid on the edge, floor and base of the ulcer as these are clinical signs that will inform the diagnosis. The site is important because some ulcers can only occur in certain positions, for instance the venous ulcer at the ankle, the arterial ulcer, usually on the foot, and the basal cell carcinoma, usually in exposed areas such as the face. The size of the ulcer should be

Box 1.6
Ulcers

- Edge
- Flat sloping
- Punched out
- Undermined
- Raised
- Everted
- Floor
- Depth
- Covering
- Discharge
- Base
- Penetration
- Fistulation

accurately measured, as well as its shape; an accurate diagram, to scale, is most useful, or better a digital picture with a measure. The depth of the ulcer must also be recorded. This is all part of the patient record and is essential care.

Edge

This should be examined with care and the colour noted, along with the presence of healing epithelium and the presence of adjacent pigmentation. Touching the ulcer should only be done with gloves and with care, as some ulcers are extremely tender. If pain is absent, consideration should be given to the ulcer being neuropathic in origin and the appropriate examination performed. The characteristics of the ulcer are observed and possible diagnoses considered.

Floor

Observe the covering, the discharge and structures visible in the base. The structures, which are usually fascial or tendinous, should be described accurately and the name of the tendons defined to determine whether they can be sacrificed. Decisions may have to be made about the emergency provision of skin cover, for which specialist advice is required. As the ulcer heals, so the floor becomes covered with red granulation tissue and the edges show healthy epithelial tissue. If there is a delay in healing, consider the cause. Are the nerves intact? Is the blood supply adequate? Is there adequate drainage? Is the diagnosis correct? Beware of the presence of a cancer and, if doubt exists, a biopsy should be taken.

Base

A cause for delayed healing is that the base of the ulcer is infected or avascular. When examining an ulcer be aware of the underlying anatomical structure and the possibility of communication with another structure. An unusual site for an ulcer that refuses to heal may indicate an underlying *sinus* or *fistula*. A sinus is a tract, lined by granulation tissue, connecting an abnormal cavity to an epithelial surface. The cavity usually starts out as an abscess whose normal healing process is impaired; this can be due to a particular pathology or a foreign body, for example hair, as in a pilonidal sinus. Appropriate diagnosis, treatment and surgery are required. A fistula is an abnormal tract between two epithelial surfaces. The reason for a fistula remaining open is invariably mechanical obstruction by the internal epithelial surface, such that the discharge is not eliminated by the normal pathway. Full investigation and treatment of the underlying pathology are required.

SUMMARY

History-taking is about listening and thoughtful questioning, whereas examination involves observation and interpretation. The interpretation of the history and examination relies on a knowledge of the anatomy, physiology and pathology in order to create a diagnostic hypothesis. The hypothesis is confirmed by the appropriate radiological and laboratory tests. Defining the appropriate investigations saves time and expense, and enables the patient to proceed on the rest of the surgical episode to achieve a cure for his or her initial complaint.

FURTHER READING

Lumley, J.S.P. (1997) *Hamilton Bailey's Physical Signs*. Arnold, London.

小结

在学习外科学时，掌握解剖知识，了解疾病的生理、病理和自然发展史均十分重要。

外科医生决定行手术治疗以前必须权衡手术治疗的利与弊、优点和缺点，同时须考虑到病人和家属的意愿。外科工作的基本过程包括采集病史、体格检查、提出诊断和鉴别诊断、合理选择有利于明确诊断的最佳辅助检查方法。只有明确了诊断，才能决定应否进行手术、手术的急缓和手术的方式。病史采集过程是疾病诊断环节中最重要的一部分，倾听病人主诉、了解其不适尤为重要。这一工作是在医生提问、病人回答的过程中完成的，由此可知病人的姓名、年龄、婚姻状况、发病情况等。以疼痛为例，医生采集病史时需了解疼痛的部位、严重程度、局限性或弥漫性、突发性或渐发性、有无放射痛、有无节律性、自行缓解方法等等。病人对疼痛性质的描述也有助于诊断，如锐痛、刺痛或刀割样疼痛与创伤有关。

一般体格检查是帮助医生做出诊断的另一重要环节，体检的重点应该集中在病人主诉最为不适的器官系统。在记录病人的体征时应使用标准化的解剖学术语，如疾病的组织来源、表面特征以及患病器官与毗邻组织的关系等。临床上许多病人因发现身体某一部位的肿块而就诊，在进行体检时应描述：肿块所在的解剖部位；肿块的形状，如圆形、卵圆形、扁平状、三角形、立方形、不规则形；肿块的大小，以厘米尺测量，记录其三维径距；肿块边缘是否整齐；表面是否光滑或有分叶；对体表可见肿块，还需要描述其颜色和温度；触诊时是否有压痛、易推动或固定、质地、可复性、指压征、波动感或搏动感，同时还要注意检查肿块边界是否清楚，

是否为浸润性生长或周围有肿大淋巴结。总之，病史采集主要来源于病人的主诉和医生有目的性的提问；体格检查则有赖于医生的细心观察和发现体征，然后运用解剖学、生理学和病理学知识对所得到的资料进行分析，得出疾病的初步诊断，结合适当、合理的放射学和实验室辅助检查的结果，对疾病做出最后诊断，最终目的是使病人得到最好的治疗效果。

（刘允怡）

CHAPTER 2

DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY

LEARNING OBJECTIVES

- To recognise the impact of imaging on the diagnostic process
- To understand the basic principles of the different imaging modalities
- To be aware of the legal requirements in relation to the use of ionising radiation
- To understand the basic techniques involved in interventional radiological procedures
- To gain an overview of the clinical applications of interventional techniques
- To be familiar with the potential complications of interventional procedures and strategies for their prevention and treatment

INTRODUCTION

Accurate diagnosis is the key to good surgical practice. Over the last two decades, the introduction and increased availability of new imaging modalities have made the diagnostic process easier. Imaging helps to resolve the uncertainties of diagnosis based on physical signs and clinical judgement. To achieve the optimum diagnostic potential, it is necessary to understand the complexities of modern imaging and to recognise the most appropriate test to fit the clinical context. Communication between the clinician and radiologist is vital for each to understand the clinical problem, and the strengths and weaknesses of the imaging test selected. An ability to interpret images gives a new depth of understanding of the disease process and of the nature and timing of surgical intervention.

There is no standard approach to imaging although some basic principles apply. It is generally good practice to perform the simplest and least expensive test first if this will provide the answer. For example, the plain abdominal film remains the diagnostic cornerstone in assessing the acute abdomen; in a patient with a clear history of biliary colic, a simple ultrasound examination may be sufficient to determine management. However, in a patient with a more complex clinical presentation, it may be more cost-effective to perform a more expensive test [e.g. computerised tomography (CT) scan] early in the diagnostic work-up as this may lead to a more confident diagnosis and management, and potentially shorten the hospital stay. Cost-effectiveness requires that more complex tests are not merely layered on top of existing more standard procedures. Through consultation, the best test must be determined. The selection of the best investigation for a particular clinical context has been made more complex by the rapid changes in existing technology. The development of spiral (helical) CT, and now 'multislice' scanning, has created new diagnostic possibilities based on the patterns of arterial and venous blood flow, providing information not previously available on older equipment. Decision-making, therefore, must be tailored to both the available technology and local expertise. It is also essential to view the imaging results in conjunction with the clinical condition of the patient and to treat the patient rather than the radiographs. In a patient with inflammatory bowel disease, for example, the extent and severity of the abnormality demonstrated on a small bowel barium examination may have

Figure 2.1 Barium follow-through in a patient with Crohn's disease. Despite the presence of multiple strictures the patient was entirely asymptomatic.

little correlation with the patient's clinical presentation (Fig. 2.1). In contrast, a patient with fulminant colitis may be clinically toxic, but there may be only minimal signs on the plain film before the reflex dilatation signalling toxic megacolon develops.

There is a general increase in public awareness of the adverse effect of radiation in the induction of cancer and genetic defects. Most of the received ionising radiation comes from the sun and the earth's core. However, medical radiation accounts for approximately 12% of the total received by humans.

As more non-radiation-dependent imaging techniques become more widely available [e.g. ultrasound, magnetic resonance imaging (MRI)], radiation hazard is an increasingly important factor influencing the selection of investigation, particularly in children and young people. There are statutory European regulations requiring all those involved in patient care to reduce the unnecessary exposure of individuals to radiation. The effective dose imparted by a CT scan, for example, is equivalent to 400 chest radiographs (Box 2.1). However, this theoretical risk must be balanced against the likely diagnostic yield of the examination in terms of benefit to the patient. The aim must be to reduce unnecessary investigations, which not only add needlessly to patient irradiation but also waste limited resources and increase waiting times.

Various guidelines are available for investigations most likely to contribute to the clinical diagnosis and management in particular clinical situations. One from the British Royal College of Radiologists highlights the chief causes of wasteful use of radiology (Box 2.2). Other factors must also be taken into consideration when deciding on the appropriate investigation, including the age and condition of the patient and his or her ability to undergo the chosen investigation (Box 2.3).

DIAGNOSTIC IMAGING

Imaging techniques

Conventional radiology

Conventional radiographs depend on the differential absorption by soft tissue, bone, gas and fat of X-rays passing through the body. The unabsorbed rays blacken a photographic film, contained within light-sensitive screens, which is then processed to produce the hard copy. Modern radiology involves the use of many technical modifications to reduce the dose of X-rays to the patient. Plain radiographs remain the primary diagnostic tools in the chest and abdomen, and in trauma and orthopaedics. With careful interpretation, accurate diagnosis can be achieved, and it is vital that the plain film is not jettisoned in favour of more complex and expensive imaging techniques.

When X-rays strike a fluorescent screen, light is emitted, which, by means of an imaging intensifier, can be projected on a television screen. This is the basis of *fluoroscopy* (screening),

Box 2.1

Typical effective doses from diagnostic medical exposure in the 1990s

Diagnostic procedure	Typical effective dose (mSv)	Equivalent no. of chest radiographs	Approximately equivalent period of natural background radiation[a]
Radiographic examinations			
Limbs and joints (except hip)	< 0.01	<0.5	<1.5 days
Chest (single posteroanterior film)	0.02	1	3 days
Skull	0.07	3.5	11 days
Thoracic spine	0.7	35	4 months
Lumbar spine	1.3	65	7 months
Hip	0.3	15	7 weeks
Pelvis	0.7	35	4 months
Abdomen	1.0	50	6 months
Intravenous urography (IVU)	2.5	125	14 months
Barium swallow	1.5	75	8 months
Barium meal	3	150	16 months
Barium follow-through	3	150	16 months
Barium enema	7	350	3.2 years
CT head	2.3	115	1 year
CT chest	8	400	3.6 years
CT abdomen or pelvis	10	500	4.5 years
Radionuclide studies			
Lung ventilation (^{133}Xe)	0.3	15	7 weeks
Lung perfusion (^{99m}Tc)	1	50	6 months
Kidney (^{99m}Tc)	1	50	6 months
Thyroid (^{99m}Tc)	1	50	6 months
Bone (^{99m}Tc)	4	200	1.8 years
Dynamic cardiac (^{99m}Tc)	6	300	2.7 years
PET head (^{18}F-FDG)	5	250	2.3 years

a. UK average background radiation = 2.2 mSv per year: regional averages range from 1.5 to 7.5 mSv.
From: *Making the Best Use of a Department of Clinical Radiology*, 4th edn. Royal College of Radiologists, 1998.

Box 2.2

Wasteful use of radiology

- Results unlikely to affect patient management
  - positive finding unlikely
  - anticipated finding probably irrelevant for management
- Investigating too often
  - before disease could be expected to have progressed or resolved
- Repeating investigations done previously
  - other hospital (?)
  - GP (?)
- Failing to provide adequate information
  - therefore wrong test performed or essential view omitted
- Requesting wrong investigation
  - discuss with radiologist
- Overinvestigating

Do I need it?

Do I need it now?

Has it been done already?

Have I explained the problem?

Is this the best test?

Are too many investigations being performed?

After: *Making the Best Use of a Department of Clinical Radiology*, 4th edn. Royal College of Radiologists, 1998.

Box 2.3

Potential hazards in imaging

Intravenous contrast: IVU/CT scan

- Asthma, allergy, previous contrast reactions: patients may have increased incidence of an adverse reaction and usually require steroid premedication
- Renal failure: scanning may have a temporary adverse effect on renal function
- Myeloma: scanning may have temporary adverse effect on renal function
- Diabetes (especially if treated with metformin): scanning may have temporary adverse effect on renal function

MRI

- Absolute contraindications
  - metallic foreign bodies
  - pacemakers
  - cochlear implants
  - cranial aneurysm clips
- Relative contraindications
  - first-trimester pregnancy
  - claustrophobia

Barium enema

- Prosthetic valves: risk of subacute bacterial endocarditis (SBE); may require antibiotic prophylaxis
- Age/incontinence: stressful examination for patient; consider CT, conventional or spiral pneumocolon

which allows continuous monitoring of a moving process. It also provides guidance for many interventional and angiographic procedures and for barium investigations of the gastrointestinal tract. Barium studies remain a standard technique for evaluating disorders of swallowing and oesophageal function and for the small bowel. The role of the barium meal and enema is challenged by the expansion of endoscopy. However, there is little evidence to indicate that in the diagnosis of significant disease, for example ulcer/cancer, endoscopy is superior (Fig. 2.2). Choice of examination depends on local expertise and availability. Endoscopy is preferable when there is gastrointestinal bleeding (upper or lower) or inflammatory bowel disease and, of course, enables biopsy for histology.

Figure 2.2 Double-contrast barium study of duodenum demonstrating a central ulcer crater.

Intravenous contrast contains iodine, which absorbs X-rays by virtue of its high atomic number. It provides arterial or venous opacification depending on the route and timing of injection. Contrast injected intravenously is excreted rapidly by the kidneys, which forms the basis of *intravenous urography* (IVU), in which the nephrographic (renal parenchymal) and pelvicalyceal (collecting system) phases, ureters and bladder are successively demonstrated and recorded over approximately 30 minutes following contrast injection. IVU currently remains the best method for investigating renal stones and haematuria. No other technique is equal to it in visualising the pelvicalyceal systems and ureters (Fig. 2.3).

Ultrasound

Ultrasound is inexpensive, quick, reliable and non-invasive and is an excellent initial investigation method for a wide range of clinical problems. It is technically demanding, and it takes an

Figure 2.3 Intravenous urogram demonstrating a small left kidney with bilateral calyceal blunting and deformity in a patient with bilateral reflux nephropathy.

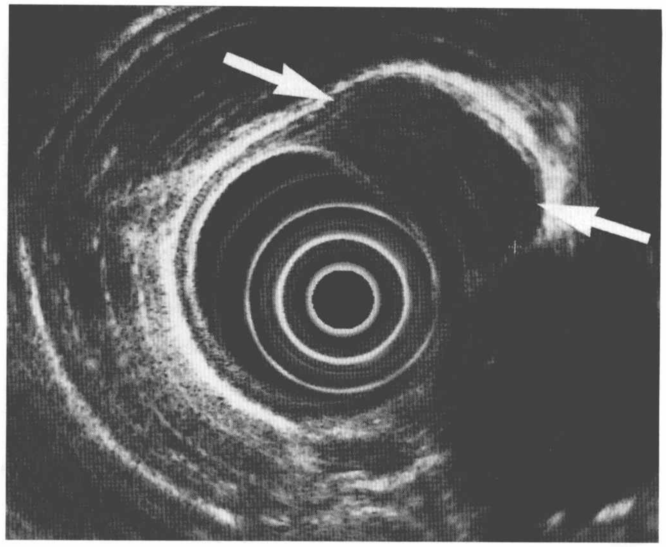


Figure 2.4 Endoscopic ultrasound of the oesophagus showing a well-defined mass arising in the muscle wall (arrows), suggesting a leiomyoma.

experienced operator to maximise the potential of the examination. Despite the advances in technology, there are still problems with gas (which reflects sound completely) and obese patients, who are often unsuitable for ultrasound. As ultrasound is so accessible, there is a tendency to overload departments with requests that may be on the margins of appropriateness. As with all investigations, clinicians should consider whether the request for ultrasound is justified as to its likely yield and its subsequent effect on patient management (Box 2.4).

Ultrasound depends on the generation of high-frequency sound waves, usually of between 3 and 7 MHz, by a transducer placed on the skin. Sound is reflected by tissue interfaces in the body, and the echoes generated are picked up by the same transducer and converted into an image, which is then displayed in real time on a monitor. The scope of ultrasound has increased vastly over the last decade, with higher frequency probes of diminishing size producing high-resolution images. The current range of ultrasound includes probes measuring only millimetres and operating at 20 MHz, which can be introduced via a catheter into a blood vessel to image the vessel wall; probes combined with fibreoptic endoscopes to visualise the gut wall at echo endoscopy (EUS) (7.5–20 MHz) (Fig. 2.4); endoluminal probes for transvaginal and transrectal scanning (7.5 MHz); dedicated very high-frequency probes of up to 15 MHz for scanning the breast and other superficial structures and musculoskeletal work; and an increasing array of specialised probes for abdominal scanning. Ultrasound is the first-line investigation in hepatobiliary disease and suspected pancreatic, aortic and many other intra-abdominal disorders (Fig. 2.5).

There is an increasing recognition of the value of intraoperative ultrasound scanning, acknowledging the fact that visualisation at surgery is frequently incomplete, the surgeon seeing only the exposed surfaces. These limitations are accentuated by the restrictions imposed by minimally invasive and laparoscopic surgery.

Box 2.4
Ultrasound

- Non-radiation
- Inexpensive
- First-line investigation for abdominal pain/mass
- Hepatic/pancreatic/biliary disease
- Gynaecological disease – transvaginal
- Small parts
  - thyroid
  - testes
  - breast etc.
- Doppler studies: evaluate blood flow

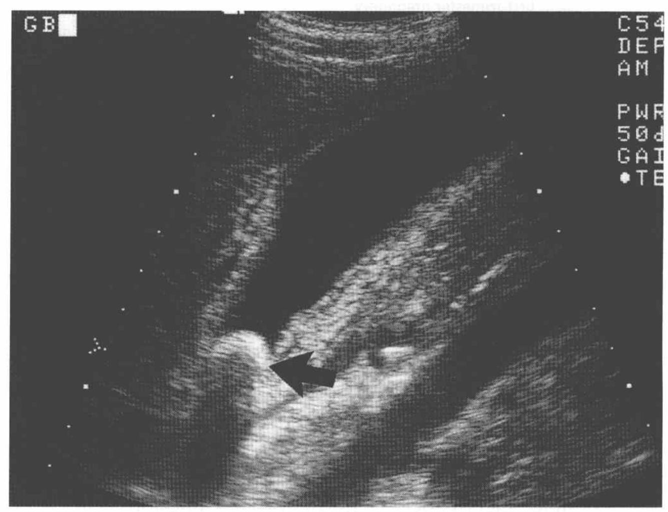


Figure 2.5 Acute cholecystitis. Ultrasound in a patient with acute right upper quadrant pain and tenderness. The gall bladder is distended with a thickened wall and an impacted stone (arrow) is seen in the gall bladder neck.

Doppler ultrasound measures the shift in frequency between transmitted and received sound and can therefore measure blood flow. The spectral Doppler wave form and ultrasound image are combined in duplex scanning. Colour Doppler imaging displays flowing blood as red or blue, depending on its direction, towards or away from the transducer (Fig. 2.6). Power Doppler is not dependent on frequency or direction of flow but is exquisitely sensitive to low flow and has the potential to demonstrate tissue perfusion (Fig. 2.7). Contrast agents have been developed based on microbubbles to enhance the Doppler effect. These techniques have revolutionised the diagnosis of both arterial and venous vascular disease.

Computerised tomography

To create a computerised tomography (CT) scan, a thinly collimated beam of X-rays is passed through an axial 'slice' of tissue and strikes an array of very sensitive detectors that can distinguish very subtle differences in tissue density. By analysis of the collected data, the digital information is translated to a grey-scale image in which the attenuation value of tissues is related to that of water, which is given a CT number of zero Hounsfield units (HUs). Tissue densities range from +1000 (bone) down to –1000 (air). An observer working at a viewing console can display, by varying the range and centring of densities represented (window width/level), an image appropriate to the tissue being examined (Fig. 2.8).

In conventional CT, a series of individual scans is acquired during suspended respiration. Helical and spiral CT are supplanting conventional scanning and involve continuous rotation of the X-ray tube, with the beam tracing a spiral path around the patient such that a volume of tissue is scanned (Box 2.5). In this way, during a single breath-hold of up to 30 s, 3 cm or more of tissue can be covered in one acquisition. Further developments with new multislice scanners have enabled thinner collimation and the ability to cover greater distances. The volumetric data can be processed to produce conventional transaxial images or multiplanar (sagit-

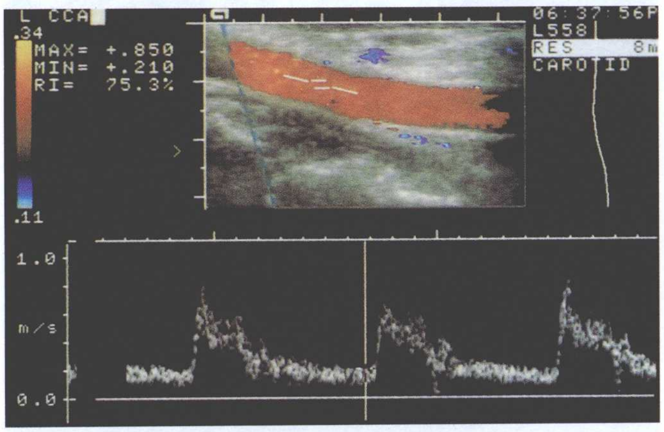


Figure 2.6 Normal carotid artery. Colour Doppler showing the gate where the flow–velocity waveform has been taken. Bottom: flow–velocity waveform. The peaks represent systolic blood flow.

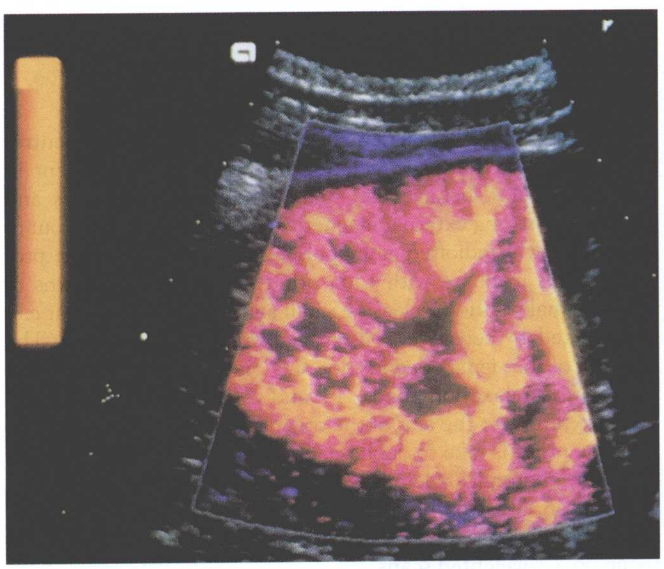


Figure 2.7 Power Doppler perfusion scan of kidneys.

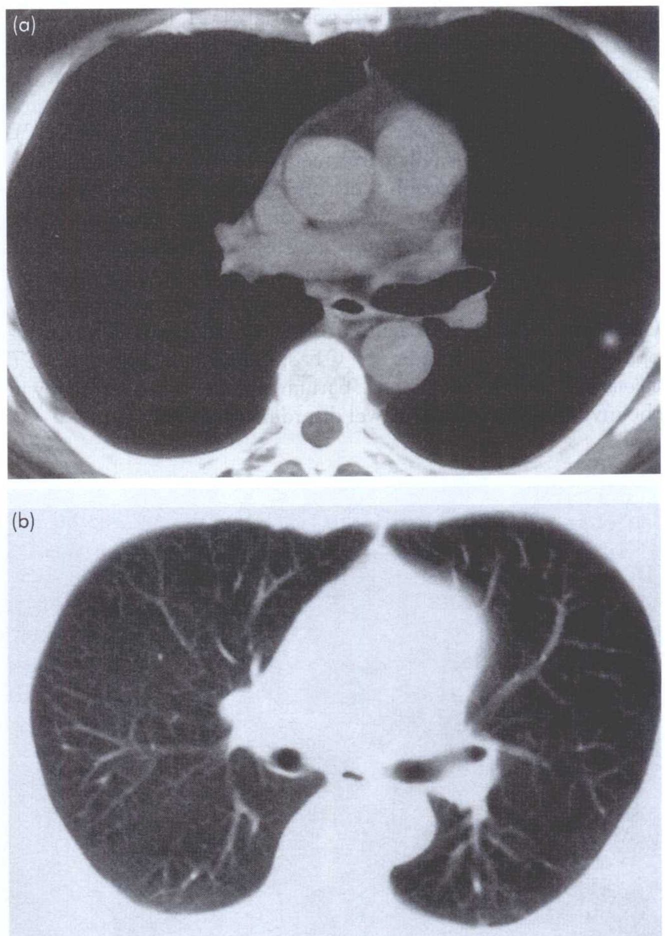


Figure 2.8 Computerised tomography (CT) scan. The effect of varying window width and level. (a) At soft-tissue settings (width 400 HU, level 40 HU) the normal mediastinal structures are shown. (b) At lung settings (width 1000 HU, level 700 HU) soft-tissue and bone detail is lost but the lung parenchyma is seen.

Christian Johann Doppler | 1803–1853. Austrian physicist.

Godfrey Newbold Hounsfield | b.1919. British engineer.

Box 2.5

Computerised tomography (helical or 'multislice')

- Radiation dependent
- Rapid acquisition of image
- Imaging at peak levels of contrast: arterial and venous phase
- Overcomes the problem of 'misregistration', lesion 'missed' because of different depth of respiration
- Ability to review and reconstruct data retrospectively – improved lesion detection
- Multiplanar and three-dimensional analysis
  - CT angiography
  - complex joints
  - CT colonography
  - virtual endoscopy

tal and coronal) and three-dimensional images (Fig. 2.9). The development of spiral and multislice scanning has greatly enhanced the diagnostic potential of CT. It is now possible to exploit the enhancement characteristics of tissues in both the arterial and venous phases of imaging, and this modification has opened up the fields of CT angiography, three-dimensional imaging and 'virtual endoscopy' of the bronchial tree and colon (Fig. 2.10).

CT scanning is usually performed after simpler investigations such as plain radiography or ultrasound. In many centres, however, CT is frequently used as a first-line examination in the evaluation of abdominal trauma and severe pancreatitis. It has a major role in cancer staging and an increasing role in 'problem-solving' in the chest and abdomen. Some centres advocate early CT in assessment of the acute abdomen (see below). The development of the technique of CT spiral pneumocolon or CT *colonography* is challenging the barium enema and colonoscopy in the investigation of large bowel disorders (Fig. 2.11).

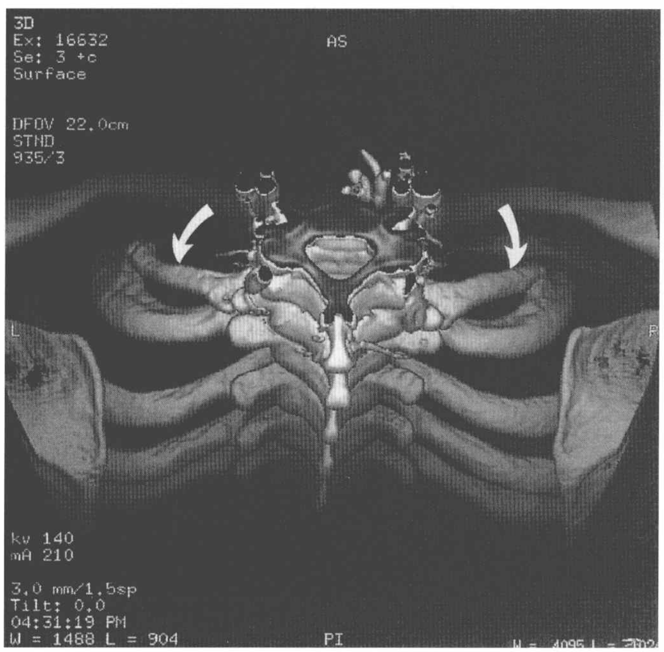


Figure 2.9 Three-dimensional CT reconstruction of bilateral cervical ribs (arrows).

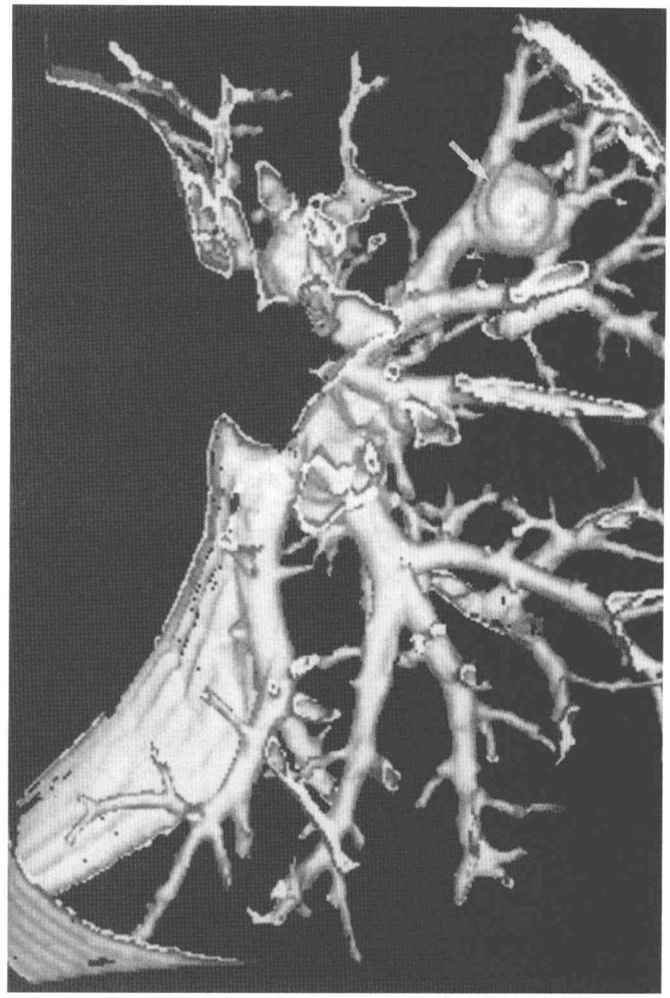


Figure 2.10 Three-dimensional reconstruction of the pulmonary vasculature. The relationship of small nodule to the adjacent vessels is clearly seen (arrow).

Magnetic resonance imaging (Box 2.6)

The basic principle of magnetic resonance imaging (MRI) centres on the concept that the nuclei of hydrogen, most prevalent in water molecules, behave like small spinning bar magnets and align with a strong external magnetic field. When knocked out of alignment by a radiofrequency pulse, a proportion of these protons rotates in phase with each other and gradually returns to their original position, releasing small amounts of energy that can be detected by sensitive coils placed around the patient. The strength of the signal depends not only on the proton density, but also on the relaxation times, T1 and T2. T1 reflects the time taken to return to the axis of the original field and T2 reflects the time the protons take to dephase. T1 images usually demonstrate exquisite anatomical detail because of the high soft-tissue discrimination. Most pathological processes increase T2 relaxation times, producing a higher signal than the surrounding normal tissue on T2-weighted scans.

Magnetic resonance imaging | Paul C. Lauterbur and Peter Mansfield were awarded the Nobel Prize in Physiology or Medicine 2003 for their discoveries concerning magnetic resonance imaging.

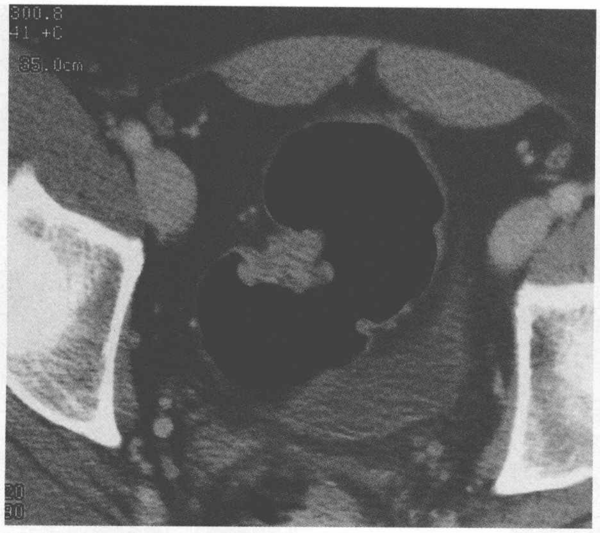


Figure 2.11 CT spiral pneumocolon. A polypoid tumour of the sigmoid colon is clearly seen arising from the wall of the gas-distended bowel. The transmural extent of the disease can be evaluated.

The complexity of the imaging process is compounded by the variety of pulse sequences available. In general, image acquisition time is longer than with CT. Respiratory and cardiac motion degrade the image, but this can largely be overcome with cardiac and respiratory gating. Technological developments are fast and scanning times are shortening. Intravenous gadolinium acts as a contrast agent by reducing T1 relaxation and enhancing lesions, which then appear as areas of high signal intensity (Fig. 2.12). Other MRI-specific contrast agents are in use for characterising liver lesions and detecting infiltrated lymph nodes.

Specific sequences have been developed to demonstrate flowing blood and produce images resembling conventional angiography. This technique of *magnetic resonance angiography* (MRA) can be achieved without the risks of intravascular injection of contrast and may ultimately replace conventional studies (Fig. 2.13). Heavily T2-weighted sequences that demonstrate fluid-filled structures as areas of very high signal intensity have been developed to show the biliary and pancreatic ducts in *magnetic resonance cholangiopancreatography* (MRCP). This technique is rapidly replacing diagnostic but not therapeutic *endoscopic retrograde cholangiopancreatography* (ERCP) (Fig. 2.14).

Box 2.6
Magnetic resonance imaging

- Non-radiation
- Usually long examination (although scan time is reducing)
- Limited availability/expensive
- Excellent soft-tissue contrast
- Best imaging modality for
  - intracranial
  - spine
  - musculoskeletal
- Expanding use of
  - magnetic resonance cholangiopancreatography (MRCP)
  - magnetic resonance angiography (MRA)
- Increased use in pelvic malignancy

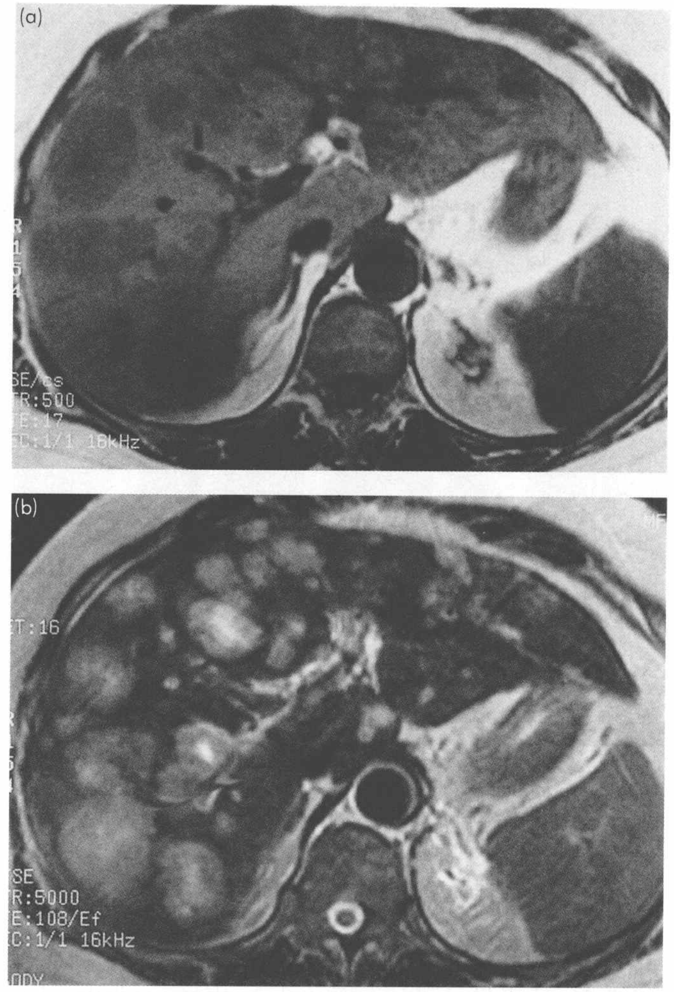


Figure 2.12 Magnetic resonance imaging (MRI) scan of the liver demonstrating multiple metastases as low signal on (a) T1-weighted and high signal on (b) T2-weighted images.

The major strength of MRI is in intracranial, spinal and musculoskeletal imaging, in which it is superior to any other imaging technique because of its high-contrast resolution and multiplanar imaging capability. Cardiac MRI is firmly established, and the value of breast MRI, particularly in multifocal and recurrent cancer, is increasingly recognised. It is currently the best investigation for staging cervical and endometrial cancer and for anorectal sepsis (Fig. 2.15).

Open access magnets have been developed, which allow interventional procedures to be performed with MRI guidance, and there is no doubt that this will revolutionise the operating theatre of the future (Fig. 2.16). There is a vast potential for MRI in the assessment of disease in the abdomen and pelvis, and undoubtedly the role of MRI will continue to expand.

Radionuclide imaging (Box 2.7)

Radionuclides can be tagged to substances that concentrate selectively in certain tissues of the body. These radiopharmaceuticals are injected intravenously and, in general, emit gamma radiation detected by a gamma camera. The emitted radiation strikes a sodium iodide crystal, which generates a small flash of