Abstract

The newly revised medical exposure directive (97/43/Euratom) lays down the general principles of radiation protection of individuals in relation to medical exposure. Member States had to transpose it into national legislation until 13 May 2000. Article 6(2) of the directive requires Member States to ensure that recommendations concerning referral criteria for medical exposure are available to the prescribers of medical exposure.

This booklet sets out referral guidelines that can be used by health professionals qualified to refer patients for imaging, in order to ensure that all examinations are well justified and optimised.

This booklet has evolved from that previously published by the UK Royal College of Radiologists in 1998 and is entitled: Making the best use of a department of clinical radiology: guidelines for doctors. These referral guidelines have been adapted by experts representing European radiology and nuclear medicine, in conjunction with the UK Royal College of Radiologists, and may now be adopted as models for the Member States.

These referral guidelines are not binding on Member States, and form part of a number of technical guides drawn up to facilitate implementation of the medical exposure directive. Local variations may be required according to healthcare practice and provision.

Continued use of recommendations of this kind should improve clinical practice and lead to a reduction in the number of referrals for investigation and consequently to a reduction in associated medical radiation exposure.

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RADIATION PROTECTION 118

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Referral guidelines for imaging

EN

Radiation Protection 118

Referral guidelines for imaging

Adapted by experts representing European radiology and nuclear medicine

In conjunction with the UK Royal College of Radiologists

Co-ordinated by the European Commission

European Commission
Directorate-General for the Environment
2000

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Preface

These referral guidelines for imaging have evolved from the booklet 'Making the best use of a department of clinical radiology: guidelines for doctors', which was published by the UK Royal College of Radiologists in 1998 (1). They have been adapted by various expert groups from several countries and comments have also been gathered from radiological societies and nuclear medicine societies of Member States through the European Association for Radiology and Nuclear Medicine. The European Commission co-ordinated this process. The referral guidelines may now be adopted as models for the Member States, even though it is recognised that further local adaptation may be needed according to varying health care practice and provision. The next edition of the guidelines will be prepared by the Royal College of Radiologists (Chairman of the working party: Professor Gillian Needham, Aberdeen), in conjunction with the European Commission and the various expert bodies within the European Community. They will be even more evidence-based and take into account European as well as UK practice.

The EU Council Directive 1997/43/Euratom (2) declared that Member States shall promote the establishment and use of diagnostic reference levels for radiological examinations and guidance thereof. These referral guidelines can be used for the above purposes.

This publication would not have been possible without the work of a sub-committee which met three times in 1999:

Professor Dr W Becker, Nuclear Medicine, Göttingen, DE

Professor Angelika Bischof Delaloye, President, European Association of Nuclear Medicine, Lausanne, CH

Dr Vittorio Ciani, European Commission, Directorate-General for Environment, Brussels, B

Professor Adrian K Dixon, Royal College of Radiologists, Cambridge, UK

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Dr Keith Harding, Nuclear Medicine, Birmingham, UK

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Professor Iain McCall, President, UEMS Radiology Section, Oswestry, UK

Professor Gillian Needham, Royal College of Radiologists, Aberdeen, UK

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Dr Bruno Silberman, Hon. General Secretary, UEMS, Paris, F

Dr Diederik Teunen, European Commission, Directorate-General for Environment, Brussels, B

Dr Ciska Zuur, Ministry of Housing, Spatial Planning and the Environment,
The Hague, NL

We owe them all a lot of thanks.

P Armstrong
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Royal College
of Radiologists
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Prof Hans Ringertz,
President (1999),
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Stockholm, SE

Prof. Angelika Bischof Delaloye,
President (1999),
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Contents

Foreword to the fourth edition (1998) of the Royal College of Radiologists (RCR) guidelines (1)

This booklet has been prepared to help referring clinicians make the best use of a department of clinical radiology. Continued use of recommendations of this kind leads to a reduction in the number of referrals for investigation and also to a reduction in medical radiation exposure (3–7). Nevertheless the primary objective of this booklet is to improve clinical practice. Such recommendations work best if they are used in conjunction with clinico-radiological dialogue and as part of the audit process. They are intended to be used by both hospital doctors (all grades) and primary care physicians. The editor (Adrian Dixon, Cambridge) has been assisted by the other members of the working party: Dr John Bradshaw (Bristol), Dr Michael Brindle (President of the Royal College of Radiologists, King's Lynn), the late Dr Claire Dicks-Mireaux (London), Dr Ray Godwin (Bury St Edmunds), Dr Adrian Manhire (Chairman of the RCR audit sub-committee, Nottingham), Dr Gillian Needham (Aberdeen), Dr Donald Shaw (London), Mr Chris Squire (RCR clinical audit advisor), Dr Iain Watt (Bristol) and Professor J Weir (Dean of the Faculty of Radiology, Aberdeen). Mr Barry Wall from the National Radiological Protection Board (NRPB) has again kindly provided data regarding radiation doses for a variety of investigations.

Since the third edition there has been yet further advance within magnetic resonance imaging (MRI), and this is reflected in the recommendations. This edition also includes recommendations for some of the new niche roles for ultrasound (US), computed

tomography (CT) and nuclear medicine (NM), including positron emission tomography (PET). The system based approach introduced in 1995 has been retained; most feedback has suggested that this format was more useful than the previous arrangement.

Once again we have indicated whether the statements included within the booklet are based on rigorous scientific evidence. In line with UK National Health Service Executive policy on the development of clinical guidelines (8), we have adopted the following classification:

(A) randomised controlled trials (RCTs), meta-analyses, systematic reviews; or

(B) robust experimental or observational studies; or

(C) other evidence where the advice relies on expert opinion and has the endorsement of respected authorities.

Interestingly, such grading systems have now become quite commonplace in many aspects of health care, now that 'evidence-based medicine' has become accepted practice (9–10). Review of the evidence has been very time consuming. The working party is very grateful to Dr Rachael Harrison who did much of the initial data trawl as part of the REALM project funded by the Royal College of Radiologists (RCR). Subsequent literature searches have been performed by individual members of the working party and by various members of specialist imaging groups who have provided very useful data.

Around 85 000 copies of the third edition (1995) of the booklet have been distributed and the contents have, at various times, been commended by the National Health Service Executive (NHSE) (8,11), the UK chief medical officers and the Audit Commission (12). It is of note that they have been adopted by several purchasers, many of whom now link the use

of the RCR's recommendations to contracts with departments of clinical radiology. They have been adopted in the private sector and adopted and translated by the radiological societies of other countries. The recommendations are also extensively used as a standard for audit studies (13). A number of forward-looking hospitals have obtained electronic versions of these recommendations which can be incorporated into hospital information systems. This fourth edition has already been endorsed by the Academy of Medical Royal Colleges and been approved by the Guidelines Appraisal Unit at St George's Hospital, London, in the United Kingdom.

With such serious implications now attached to these recommendations, the working party has been fully aware of the importance of getting it 'as right as reasonably achievable'. We believe that this fourth edition, which has been produced following wide consultation (see Appendix), represents a current reasonable view of how departments of clinical radiology should be used for some of the more common clinical problems. There will, undoubtedly, be some unpopular decisions; we have occasionally received diametrically opposite advice. However, this is probably inevitable in one of the most rapidly developing specialties within medicine.

We hope that this fourth edition will prove useful and trust that we will continue to receive advice and referenced comments so that the development of these recommendations can continue. The next edition of the RCR guidelines is planned for 2002.

Adrian K Dixon on behalf of the RCR guidelines working party

Introduction

Why are guidelines and referral criteria needed?

A useful investigation is one in which the result — positive or negative — will alter management or add confidence to the clinician's diagnosis. A significant number of radiological investigations do not fulfil these aims and may add unnecessarily to patient irradiation (14). The chief causes of the wasteful use of radiology are:

(1) Repeating investigations which have already been done: e.g. at another hospital, in an outpatient department, or in the accident and emergency department.
HAS IT BEEN DONE ALREADY? Every attempt should be made to get previous films. Transfer of digital data through electronic links may assist in this respect in future years.

(2) Investigation when results are unlikely to affect patient management: because the anticipated 'positive' finding is usually irrelevant, e.g. degenerative spinal disease (as 'normal' as grey hairs from early middle age) or because a positive finding is so unlikely.
DO I NEED IT?

(3) Investigating too often: i.e. before the disease could have progressed or resolved or before the results could influence treatment. DO I NEED IT NOW?

(4) Doing the wrong investigation. Imaging techniques are developing rapidly. It is often helpful to discuss an investigation with a specialist in clinical radiology or nuclear medicine before it is requested. IS THIS THE BEST INVESTIGATION?

(5) Failing to provide appropriate clinical information and questions that the imaging investigation should answer. Deficiencies here may lead to the wrong technique being used (e.g. the omission of an essential view). HAVE I EXPLAINED THE PROBLEM?

(6) Over-investigating. Some clinicians tend to rely on investigations more than others. Some patients take comfort in being investigated. ARE TOO MANY INVESTIGATIONS BEING PERFORMED?

What advice is available?

In some clinical situations firm guidelines have been established. Guidelines are:

> *systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances... (Field & Lohr 1992, 15).*

Just as the term implies, a guideline is not a rigid constraint on clinical practice, but a concept of good practice against which the needs of the individual patient can be considered. So while there have to be good reasons for ignoring them they are not absolute rules. No set of recommendations will command universal support and you should discuss any problems with your radiologists.

The preparation of guidelines has become something of a science, with numerous papers emerging within the evolving guidelines discipline. In particular, experts have provided detailed methodology as to how guidelines should be developed, produced and appraised (8, 15–21). Using such methodology, the development of a single scientifically robust guideline represents a major piece of academic endeavour. For the 280 clinical problems in this booklet, such expenditure of time and resources is somewhat impractical. Nevertheless much of the philosophy of the methodology for the preparation of guidelines has been

followed during the preparation of these recommendations. In particular there has been extensive literature review with key references analysed. The Royal College of Radiologists holds an archive of references upon which statements within the text are based. Every opportunity has been given to workers in other disciplines and those representing patients to put forward their views. Many groups have been encouraged to comment on points of fact, local policies, etc. In particular appropriate specialty imaging groups have provided active support. There has been extensive dialogue with other professional groups, including patients' representatives and all the royal colleges, culminating in endorsement by the Academy of Medical Royal Colleges (see Appendix). Indeed one of the strongest features of these recommendations is that they have been reviewed and modified during the development of four editions since 1989.

Another concurrent development has been the production of 'appropriateness criteria' by the American College of Radiologists (22). Rather than pronouncing on what is perceived to be the optimal investigation, the ACR lists all possible investigations and awards an appropriateness score (out of 10). These have been developed using a modified Delphi technique with consensus reached amongst experts. The RCR has kept a watching brief on this interesting development and has incorporated some of the ACR conclusions.

Throughout the booklet the strength of the evidence (8) for the various statements is indicated by:

(A) randomised controlled trials (RCTs), meta-analyses, systematic reviews; or

(B) robust experimental or observational studies; or

(C) other evidence where the advice relies on expert opinion and has the endorsement of respected authorities.

In some clinical situations (e.g. the role of US in normal pregnancy) there are conflicting data within a large body of excellent scientific reports. Thus no firm recommendations are given and the evidence is classified as C. It should also be noted that there are very few randomised trials comparing different radiological diagnostic procedures – they are difficult to perform and ethical approval may be denied.

What images are taken?

All imaging departments should have protocols for each common clinical situation. Therefore no definite recommendations are given about this aspect. Suffice it to say that all examinations should be optimised to obtain maximum information with the minimum of radiation. It is important to be aware of this as the patient may not get what the referring clinician expects.

For whom are the guidelines designed?

These guidelines are intended to be used by all health professionals entitled to refer patients for imaging. In the hospital setting they are likely to be of most use to newly qualified doctors and many hospitals give a copy to each newly appointed junior doctor to stimulate good practice.

The range of investigations available to different health professionals must be determined in consultation with local specialists in radiology and nuclear medicine, bearing in mind the available resources. The recommendations are also of value to those interested in audit of a department's referral pattern and workload (13).

Using the guidelines

This booklet tends to highlight areas of difficulty or controversy. The pages are mostly composed of four columns: the first sets the clinical situation for requesting an examination; the next lists some possible imaging techniques (and the band of

radiation exposure involved); the third gives the recommendation (and the grade of available evidence) on whether or not the investigation is appropriate; and the fourth provides explanatory comments.

The recommendations used are:

(1) Indicated. This shows the investigation(s) most likely to contribute to clinical diagnosis and management. This may differ from the investigation requested by the clinician: e.g. US rather than venography for deep vein thrombosis.

(2) Specialised investigation. These are complex or expensive investigations which will usually be performed only for doctors who have the relevant clinical expertise to evaluate the clinical findings and act on the imaging results. They usually justify individual discussion with a specialist in radiology or nuclear medicine.

(3) Not indicated initially. This includes situations where experience shows that the clinical problem usually resolves with time; we therefore suggest deferring the study for three to six weeks and only performing it then if symptoms continue. Shoulder pain is a typical example.

(4) Not indicated routinely. This emphasises that while no recommendation is absolute, the request will only be carried out if a clinician gives cogent arguments for it. An example of such a justification would be plain radiography in a patient with backache in whom there were clinical findings to suggest something more than a degenerative disease (e.g.? Osteoporotic vertebral fracture).

(5) Not indicated. Examinations in this group are those where the supposed rationale for the investigation is untenable (e.g. intravenous urogram (IVU) for hypertension).

Pregnancy and protection of the foetus

- Irradiation of a foetus should be avoided whenever possible (23–25). This includes situations where pregnancy is not suspected by the woman herself. The prime responsibility for identifying such patients lies with the referring clinician.

- Women of reproductive age presenting for an examination in which the primary beam irradiates directly, or by scatter, the pelvic area (essentially any ionising irradiation between the diaphragm and the knees), or for a procedure involving radioactive isotopes, should be asked whether they are or may be pregnant. If the patient cannot exclude the possibility of pregnancy, she should be asked if her period is overdue.

- If there is no possibility of pregnancy the examination can proceed, but if the patient is definitely, or probably, pregnant (i.e. menstrual period overdue) the justification for the proposed examination should be reviewed by the radiologist and the referring clinician, with a decision taken on whether to defer the investigation until after delivery or until the next menstrual period has occurred. However, a procedure of clinical benefit to the mother may also be of indirect benefit to her unborn child and a delay in an essential procedure until later in pregnancy may increase the risk to the foetus as well as to the mother.

- If pregnancy cannot be excluded, but the menstrual period is NOT overdue and the procedure gives a relatively low dose to the uterus the examination may proceed. However, if

the examination gives relatively high doses (in most departments, the common examinations in this category will probably be abdominal and pelvic CT, IVUs, fluoroscopy and NM studies), there will be discussion in line with locally agreed recommendations.

- In all cases, if the radiologist and referring clinician agree that irradiation of the pregnant or possibly pregnant uterus is clinically justified, this decision should be recorded. The radiologist must then ensure that exposure is limited to the minimum required to acquire the necessary information.

- If it becomes obvious that a foetus has been inadvertently exposed, despite the above measures, the small risk to the foetus of the exposure is unlikely to justify, even at the higher doses, the greater risks of invasive fetal diagnostic procedures (e.g. amniocentesis) or those of a termination of the pregnancy. When such inadvertent exposure has occurred, an individual risk assessment should be made by a radiation physicist and the results discussed with the patient.

- The RCR has recently co-authored (with the NRPB and the College of Radiographers) a guidance booklet on the protection of the foetus during the diagnostic investigation of its mother (25).

Optimising radiation dose

The use of radiological investigations is an accepted part of medical practice, justified in terms of clear clinical benefits to the patient which should far outweigh the small radiation risks. However, even small radiation doses are not entirely without risk. A small fraction of the genetic mutations and malignant diseases occurring in the population can be attributed to natural background radiation. Diagnostic medical exposures, being the major source of man-made radiation exposure of the population, add about one sixth to the population dose from background radiation.

The 1997 EU directive (2) requires all concerned to reduce unnecessary exposure of patients to radiation. Responsible organisations and individuals using ionising radiation must comply with these regulations. One important way of reducing the radiation dose is to avoid undertaking investigations unnecessarily (especially repeat examinations).

The effective dose for a radiological investigation is the weighted sum of the doses to a number of body tissues, where the weighting factor for each tissue depends upon its relative sensitivity to radiation induced cancer or severe hereditary effects. It thus provides a single dose estimate related to the total radiation risk, no matter how the radiation dose is distributed around the body.

Typical effective doses for some common diagnostic radiology range over a factor of about 1 000 from the equivalent of a day or two of natural background radiation (0.02 mSv for a chest radiograph) to 4.5 years (eg, for computed tomography of the abdomen). However, there is substantial variation in the background radiation between and within countries. The doses for conventional x-ray examinations are based on results compiled by the NRPB from patient

Typical effective doses from diagnostic medical exposures in the 1990s

Diagnostic procedure	Typical effective dose (mSv)	Equivalent No. of chest x-rays	Approximate equivalent period of natural background radiation ([1])
X-ray examinations:			
Limbs and joints (except hip)	<0.01	<0.5	<1.5 days
Chest (single PA 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
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 (Xe-133)	0.3	15	7 weeks
Lung perfusion (Tc-99m)	1	50	6 months
Kidney (Tc-99m)	1	50	6 months
Thyroid (Tc-99m)	1	50	6 months
Bone (Tc-99m)	4	200	1.8 years
Dynamic cardiac (Tc-99m)	6	300	2.7 years
PET head (F-18 FDG)	5	250	2.3 years

([1]) UK average background radiation = 2.2 mSv per year: regional averages range from 1.5 to 7.5 mSv per year.

With advice from Wall, B. National Radiological Protection Board.

dose measurements made in 380 hospitals throughout the UK from 1990 to 1995. They are mostly lower than those given in earlier editions of this booklet which were based on data from the early 1980s, indicating a gratifying trend towards improved patient protection. The doses for CT examinations and radionuclide studies are based on national surveys conducted by the NRPB and BNMS and are unlikely to have changed significantly since then.

Low-dose examinations of the limbs and chest are the most common radiological investigations but relatively infrequent high-dose examinations such as body CT and barium studies make the major contribution to the collective population dose. The doses from some CT examinations are particularly high, show no sign of decreasing and the use of CT is still rising. CT now probably contributes almost half of the collective dose from all x-ray examinations. It is thus particularly important that requests for CT are thoroughly justified and that techniques are adopted which minimise dose while retaining essential diagnostic information. Indeed some authorities estimate the additional lifetime risk of fatal cancer for an abdominal CT examination in an adult is around 1 in 2 000 (compared with the risk for a chest x-ray at 1 in a million) (26). However, this is a small excess risk compared with the very high overall risk of cancer (nearly 1 in 3) and is usually more than offset by the benefit gained from the CT examination.

In these referral guidelines the doses have been grouped into broad bands to help the referrer understand the order of magnitude of radiation dose of the various investigations.

TABLE Classification of the typical effective doses of ionising radiation from common imaging procedures

Class	Typical effective Dose (mSv)	Examples
0	0	US, MRI
I	<1	CXR, limb XR, pelvis XR
*II**	1–5	IVU, lumbar spine XR, NM (e.g. skeletal scintigram), CT head & neck
III	5–10	CT chest and abdomen, NM (e.g. cardiac)
IV	>10	Some NM studies (e.g. PET)

* The average annual background dose in most parts of Europe falls in Band II.

Communications with a department of clinical radiology

Referral for an imaging examination is generally regarded as a request for an opinion from a specialist in radiology or nuclear medicine. The outcome of this request for opinion should be presented in the form of a report to assist in the management of a clinical problem.

Request forms should be completed accurately and legibly in order to avoid any misinterpretation. You should state clearly the reasons for the request and give sufficient clinical details to enable the imaging specialist to understand the particular diagnostic or clinical problems that you are attempting to resolve by radiological investigation.

In some cases the best investigation for resolving the problem may be an alternative imaging examination.

If you are in doubt as to whether an investigation is required or which investigation is best, you should consult with an appropriate specialist in radiology or nuclear medicine. Indeed imaging departments are always pleased to discuss investigations with referring doctors. Regular clinico-radiological meetings provide a useful format for such discussion and are considered good practice (27).

While it should be noted that these recommendations have been widely endorsed, it is recognised that a few departments will adapt them according to local circumstances and policies.

Technique-based imaging

Computed tomography (CT)

CT is now quite widely available throughout Europe. Furthermore there have been recent important advances due to the development of spiral and multislice CT which allows breath-hold volume data acquisition. Such advances have opened up new diagnostic opportunities, such as the use of spiral CT in the diagnosis of pulmonary embolism. Nevertheless different hospitals will have their own policies about accepting CT requests. It is worth remembering that CT is a relatively expensive study and imparts a high x-irradiation dose. Thus it is always worth considering alternatives, especially in view of the increasing role of MRI. Indeed the UK National Radiological Protection Board have published several general recommendations with regard to CT in *Protection of the patient in x-ray computed tomography* (26), some extracts from which are reproduced here:

> *In view of the potential high doses CT should only be carried out after proper clinical justification by an experienced radiologist. Examinations on children require a higher level of justification, since such patients are at greater risk from radiation.*
>
> *When clinically appropriate, the alternative use of safer non-ionising techniques (US and MRI) or of low dose x-ray techniques should be considered.*
>
> *CT should not be carried out on the abdomen or pelvis of pregnant patients without sound clinical reasons and particular attention to low-dose techniques.*
>
> *Care should always be taken to minimise exposure to the eyes, particularly for patients likely to undergo multiple examinations.*

As for all radiological requests, any CT referral which falls outside established guidelines should be discussed with a radiologist. Because of the need to

minimise the extent of the examination (and thereby the cost and radiation dose), it is helpful if the clinical notes and previous imaging investigations are available for review at the time of CT.

A few further points:

- CT remains the optimal investigation for many clinical problems within the chest and abdomen, despite the radiation risks.
- CT is still widely used for intracranial problems, especially CVA and trauma.
- CT remains a simple method of staging many malignant diseases (e.g. lymphoma) and in monitoring the response to therapy.
- CT provides valuable pre-operative information about complex masses and is widely used for post-operative complications.
- CT allows accurate guidance for drainage procedures, biopsies and anaesthetic nerve blocks.
- CT has an important role in trauma.
- CT images may be degraded by prostheses, fixation devices, etc.
- CT provides better anatomical detail in obese patients than US. In thinner patients and children, US should be used wherever possible.
- CT of the abdomen imparts a radiation dose equivalent to about 500 CXRs.

Interventional radiology (including angiography and minimal access therapy)

This area of radiology is currently undergoing rapid expansion. While all departments of clinical radiology have been undertaking angiography and associated

procedures (e.g. angioplasty) for many years, several new techniques have emerged recently. Most abscesses in the abdomen are now treated by percutaneous drainage procedures using radiological guidance. Likewise the majority of liver biopsies are now performed by radiologists (using US guidance). Lymph node biopsies are routine in most US and CT units.

New technology is rapidly widening the range of interventional radiology yet further. These innovations include:

- percutaneous diskectomy for lumbar disk herniation (often using CT control);
- percutaneous insertion of grafts for abdominal aortic aneurysms;
- various techniques to treat inoperable hepatic lesions (e.g. laser ablation under imaging control);
- interventional MRI with 'real-time' imaging to allow monitoring of therapeutic manoeuvres.

These examples of recent innovations require close collaboration with clinical colleagues. The precise arrangements vary considerably according to local expertise and availability of equipment. There is continuing discussion at national level about the best arrangement for these interventional procedures. Inevitably requests for all such procedures involve detailed discussion between various specialists.

Magnetic resonance imaging (MRI)

There has been a substantial recent increase in the number of MRI systems across Europe. Accordingly there are numerous recommendations for the use of MRI. Indeed, with the recent technical advances and increasing experience, the role of MRI continues to expand and the limiting factor for further expansion is now often financial.

Because MRI does not use ionising radiation, MRI should be preferred where both CT and MRI would provide similar information and when both are available. However MRI is in danger of being subjected to inappropriate demands which may lead to long waiting times. Thus, all requests for MRI should be agreed with a radiologist.

A few further points:

- MRI usually provides more information than CT about intracranial, head and neck, spinal and musculoskeletal disorders because of high contrast sensitivity and multiplanar imaging capability. This helps to establish the diagnosis and institute appropriate management with greater confidence. It is increasingly being used in oncology.

- Major recent advances include: breast and cardiac MR imaging; angiographic and interventional techniques; MRCP and other fluid-sensitive MR techniques; functional MR imaging of the brain. However, many of these techniques await full evaluation.

- MRI is not approved during the first trimester of pregnancy. However it may well prove to be safer than some of the alternative options. Discuss all imaging in pregnancy with the radiology department.

- There are some definite contraindications to the use of MRI: metallic foreign bodies (FBs) in the orbits, aneurysm clips, pacemakers, cochlear implants, etc. Furthermore MRI will give reduced image quality close to prostheses, etc. The full list of contraindications is provided in several textbooks and monographs. Any uncertainty about contraindications should be discussed with the imaging department well in advance.

Nuclear medicine (NM)

In EU countries NM is an independent specialty, the use of unsealed sources of radionuclides for diagnosis and therapy being restricted to NM specialists. In some countries other specialists, usually radiologists, can also provide NM services. Whatever the local arrangements, an experienced specialist will be available to discuss the appropriate NM techniques in a given clinical situation. They will also be able to advise on which particular NM investigation should be used. Accordingly referring clinicians should indicate the precise clinical problem requiring investigation, because this will determine which radionuclide (or alternative) investigation is used.

Despite some misconceptions, the radiation doses imparted by most NM techniques compare favourably with those of many other imaging investigations which are regarded as 'safe'. As shown in the chart displayed in the section on minimising radiation dose, the effective dose associated with most routine NM studies is considerably less than that for abdominal CT.

There is particular value in the functional data which can be provided by NM techniques. At a basic level, NM can determine whether a distended renal pelvis shown by US is merely due to a capacious collecting system, or caused by an obstructing lesion. The same investigation can provide data on the percentage of overall renal function provided by each kidney. More complex studies can indicate the ejection fraction of the left ventricle or the distribution of blood flow to the cerebral cortex.

PET has recently made large strides and there is a gradual increase in its availability. Because of the short-lived nature of the key radionuclides (the glucose analogue F-18 fluorodeoxyglucose, FDG, is widely used), PET can only be offered close to a

cyclotron and radionuclide pharmacy. However, the development of double-headed gamma cameras with modified PET capabilities is a significant advance which should increase availability; it is currently the focus of much research. Because PET can identify small foci of viable tumours, it offers exceptional opportunities in the staging of various cancers (e.g. bronchus) and in cancer follow-up (e.g. lymphoma), where other imaging techniques may be unable to distinguish between residual fibrotic masses and active disease. PET can also provide unique data about brain metabolism and myocardial viability and there are several research units studying these aspects. Over the next few years there will be an increasing uptake of PET into clinical practice and its potential use is flagged for certain clinical problems in the ensuing recommendations.

Nuclear medicine therapy

Although not considered further in these referral guidelines, it is worth considering the important role of NM in the treatment of both benign and malignant disease. The thyroid gland is still the most important target but the field is rapidly expanding. Other indications include neuroendocrine tumours, painful skeletal metastases, some arthropathies, polycythaemia, malignant effusions. NM treatment options are being investigated in the leukaemias/lymphomas and some liver tumours.

Ultrasound (US)

Since the previous edition of these guidelines, most departments of clinical radiology have experienced a large increase in referrals for US examinations. During this period US equipment and expertise have advanced and the scope of referrals (Colour Doppler, Power Doppler, transvaginal (TV) gynaecological work, etc.) has widened. These trends are to be welcomed because US does not employ ionising radiation. However there is scant evidence that the increase in US has been accompanied by much reduction in referrals for other radiological investigations and a consequent reduction in total radiation dose to the public.

In fact, the rising US workload has developed while the demand for other radiological investigations has also continued to increase. The one notable exception is the IVU which is required much less often since the advent of US. However, because US is non-invasive, the total number of patients investigated with uroradiological problems has increased. Departments of clinical radiology have developed different local policies for dealing with the increasing US workload.

The actual acquisition of US images has to be undertaken by an experienced operator; even such an operator may not be able to gain perfect images in every patient. For example US can be difficult and unsatisfactory in obese patients. Furthermore the distribution of bowel gas may mask certain features. Nevertheless the cheap, quick, reliable and non-invasive nature of US make it an excellent initial investigation for a wide range of clinical referrals. Accordingly US has been recommended as the appropriate investigation wherever possible.

Because US avoids ionising radiation and is relatively inexpensive, it is often recommended where more expensive studies (e.g. CT) cannot be justified or

resources are limited. Conversely, it is difficult to refuse a request for US on grounds of invasiveness or expense. There is thus a danger of US departments being overloaded with requests which may be on the margins of appropriateness. Accordingly, referring clinicians still have a duty to consider carefully whether each request for US is justified and whether the result (e.g. the presence of gallstones) will affect management (see *Introduction, why are guidelines needed?*).

GLOSSARY

ABBREVIATION	*DEFINITION*
XR	Plain radiography one or more films
CXR	Chest radiograph
AXR	Abdominal radiograph
US	Ultrasound
Skeletal survey	A series of XRs to show the presence and extent of involved skeleton
Mammogram	Breast radiography
Ba swallow/ meal/FT	Barium swallow/ meal/follow through
Small bowel enema	Detailed Barium study via nasoduodenal intubation
Ba enema	Barium enema
IVU	Intravenous urogram
CT	Computed tomography
CTA	CT angiography
HRCT	High resolution CT
NM	Nuclear medicine
SPECT	Single photon emission tomography
MRI	Magnetic resonance imaging
MRA	MR angiography
MRCP	Magnetic resonance cholangio pancreatography
DSA	Digital subtraction angiography
ERCP	Endoscopic retrograde cholangio pancreatography
PET	Positron emission tomography

A. Head (including ENT problems)

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Congenital disorders ***(for children see Section M)*** **A1**	*MRI (0)*	Indicated (C)	Definitive exam for all malformations and avoids x-irradiation. 3D CT may be needed for bone anomalies. Sedation usually required for young children. Consider US in neonates.
Cerebrovascular accident (CVA); stroke **A2**	*CT (II)* *MRI (0) and NM (II)* *US carotids(0)*	Indicated (C) Specialised investigation (B) Not indicated routinely (C)	CT adequately assesses most cases and shows haemorrhage. MRI and NM more sensitive than CT in early infarction and for posterior fossa lesions. Exceptions for: (a) those with full recovery in whom carotid surgery is contemplated. (b) an evolving CVA where dissection or embolus suspected.
Transient ischaemic attack (TIA) ***(see also B5)*** **A3**	*US carotids (0)*	Indicated (B)	If doubt about diagnosis or surgery contemplated. Much depends on local policy and available expertise. US (with Colour Doppler) provides functional data about bifurcation disease. Angiography, MRA and CTA are more expensive alternatives to show the vessels. MRI and NM can be used to show function.

Demyelinating and other white matter disease **A4**	*MRI (0)*	Indicated (A)	MRI much more sensitive than CT for demyelinating disease. But MRI may still be negative in up to 25% of those with established multiple sclerosis. MRI also superior to CT in delineating extent and location of other white-matter disease.
Space-occupying lesion (SOL) **A5**	*CT (II) or MRI (0)*	Indicated (B)	MRI more sensitive for early tumours, in resolving exact position (useful for surgery) and for posterior fossa lesions. MRI may miss calcification. CT more widely available; and often sufficient in supratentorial lesions and subdural haematomas. MRI superior in the posterior fossa and for vascular lesions. NM may be useful in certain circumstances — tumour viability post-therapy, especially post-radiotherapy.
Headache: acute, severe **A6**	*CT (II)*	Indicated (B)	CT provides adequate data in most cases of subarachnoid and other intracranial haemorrhage and associated hydrocephalus. NB: A negative CT does not exclude SAH and where suspected lumbar puncture should follow, assuming no contraindications (e.g. obstructive hydrocephalus). Lumbar puncture may also be needed to exclude meningitis.
	MRI (0) or NM (II)	Specialised investigation (C)	MRI better than CT for inflammatory causes. NM may be the most sensitive investigation for encephalitis and can provide evidence of circulation derangement in migraine.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Headache: chronic	*XR skull, sinus, C spine (I)*	Not indicated routinely (B)	Radiography of little use in the absence of focal signs/symptoms. See A13 below.
(for children see Section M) **A7**	*CT (II) or MRI (0)*	Not indicated routinely (B)	Some exceptions for specialists or if evidence of raised intracranial pressure, posterior fossa or other signs.
Pituitary and juxta-sellar problems	*MRI (0)*	Specialised investigation (B)	Demonstration of microadenomas may not be helpful for management. CT if MRI not available. Urgent referral when vision deteriorating. Some centres use specific NM agents.
A8	*SXR (I)*	Not indicated routinely (C)	Patients who require investigation need MRI or CT.
Posterior fossa signs **A9**	*MRI (0)*	Indicated (A)	MRI much better than CT. CT images often degraded by beam hardening artefacts.
Hydrocephalus	*CT (II)*	Indicated (B)	CT adequate for most cases; MRI sometimes necessary and may be more appropriate in children. US first choice for infants. NM used in some centres, especially for shunt function.
(for children see Section M) **A10**	*XR*	Indicated (C)	XR can demonstrate whole valve system.

Middle or inner-ear symptoms (including vertigo) **A11**	*CT (II)*	Specialised investigation (B)	Evaluation of these symptoms requires ENT, neurological or neurosurgical expertise.
Sensorineural deafness ***(for children see Section M)*** **A12**	*MRI (0)*	Specialised investigation (B)	MRI much better than CT, especially for acoustic neuromas. For deafness in children see M4.
Sinus disease ***(for children see Section M)*** **A13**	*Sinus XR (I)*	Not indicated routinely (B)	Thickened mucosa is a non-specific finding and may occur in asymptomatic patients.
	CT (II)	Specialised investigation (B)	CT is more rewarding and provides unique information about ostial anatomy. Low dose technique desirable. Indicated when maximal medical treatment has failed, when complications arise or if malignancy suspected.
Dementia and memory disorders, first onset psychosis **A14**	*SXR (I)*	Not indicated routinely (B)	Consider investigation if clinical course unusual or in younger patient.
	CT (II) or MRI (0) or NM (III)	Specialised investigation (B)	CT and SPECT a good combination for Alzheimer's disease. MRI better for structural changes and assessment of 'normal pressure hydrocephalus'. PET and SPECT readily provide functional data. Cerebral blood flow studies may differentiate Alzheimer's from other forms of dementia.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Orbital lesions **A15**	*CT (II) or MRI (0)*	Specialised investigation (B)	CT provides better anatomical detail, particularly of bony structures (e.g. nasolacrimal duct). MRI avoids radiation dose to lens (but contraindicated when ferromagnetic FB suspected). Consider US for intra-ocular lesions.
Orbits Metallic FB (before MRI) **A16**	*XR orbits (I)*	Indicated (B)	Especially for those who have worked with metallic materials, power tools, etc. Some centres use CT. (see Trauma Section K for acute injury.
Visual disturbances **A17**	*SXR (I)*	Not indicated routinely (C)	Plain XRs rarely contributory. Specialists may require CT or MRI.
Epilepsy (adult)	*SXR (I)*	Not indicated routinely (B)	Evaluation requires specialist expertise. Late onset seizures should normally be investigated but imaging may be unnecessary if clearly alcohol-related.
(for children see Section M) **A18**	*CT (II), MRI (0) or NM (III)*	Specialised investigation (B)	Partial/focal seizures may require detailed evaluation if surgery is being considered. Ictal SPECT maximises likelihood of localising focus. Interictal functional imaging also important. Much depends on local policy which will determine combinations of procedures.

B. Neck *(for the spine see Sections C [The spine] and K [Trauma])*

Soft tissues

Thyroid nodules and enlargement **B1**	*US (0) and NM (I)*	Indicated (B)	Demonstrates morphology; allows guided aspiration for cytology or biopsy for histology. Some clinicians will proceed to aspiration with no imaging. Contemporary CXR needed to show trachea.
Thyrotoxicosis **B2**	NM (I), US (0)	Indicated (B)	Can differentiate between Graves' disease, toxic nodular goitre and subacute thyroiditis. Provides functional information about nodules. Also useful in thyroiditis.
Ectopic thyroid tissue (e.g. lingual thyroid) **B3**	*NM (I)*	Indicated (C)	NM excellent for small ectopic rests of thyroid tissue. In generalised thyroid enlargement or multinodular goitre US readily shows retrosternal extension; real time studies show effect of neck extension, etc. CT/MRI needed to demonstrate full retrosternal extent and tracheal compromise.
Hyperparathyroidism **B4**	*Imaging*	Specialised investigation (C)	Seek advice. Diagnosis made on clinical/biochemical grounds. Imaging can assist in pre-operative localisation but may not be needed by experienced surgeons. Much depends on local policy and available technology and expertise. US, NM, CT and MRI all accurate in the un-operated neck.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Asymptomatic carotid bruit **B5**	*US carotids (0)*	Not indicated routinely (B)	Significant internal carotid artery lesions are rarely found.
Swallowed or inhaled foreign body (FB) **B6**			See Trauma K 30.
Mass of unknown origin **B7**	*US (0)*	Indicated (C)	US first-line investigation which can also direct biopsy. MRI or CT usually only if recommended after radiological or specialist clinical opinion.
Salivary obstruction **B8**	*US (0) or sialogram (II)* *XR*	Indicated (C) Not indicated routinely (C)	For intermittent, food related swelling. MR sialography may be preferred in some centres. Except in calculus in floor of mouth, where XR may be all that is required.
Salivary mass **B9**	*US (0)*	Indicated (B)	US extremely sensitive and, dependent on local expertise, should be first-line investigation. MRI excellent for extensive or recurrent disease. CT now of limited use. No indication for CT sialography.
Dry mouth — connective tissue disease **B10**	*US (0) or sialogram (II) or NM (II)*	Specialised investigation (C)	Not commonly required. Sialogram may be diagnostic but NM provides better functional assessment. MR sialography also used here.

Temporo-mandibular joint dysfunction **B11**	*XR (I)* *MRI (0) or arthrography (II)*	Specialised investigation (B) Specialised investigation (B)	Radiographs will demonstrate bony abnormalities, but are normal in great majority, as problems are usually related to articular disk dysfunction. Following failure of conservative treatment when internal derangement suspected. Arthrography offers a true dynamic demonstration.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
C. The spine			
General (for trauma see Section K)			
Congenital disorders	*XR (I)*	Specialised investigation (C)	e.g. Full-length standing radiograph for scoliosis. See Section M for back pain (M10).
	MRI (0)	Specialised investigation (B)	MRI defines all spinal malformations and excludes associated thecal abnormality. CT may be required to delineate bony detail, but remember large radiation burden.
(for children see Section M) **C1**			
Myelopathy: tumours, inflammation, infection, infarction, etc.	*MRI (0)*	Indicated (B)	MRI clear first choice for all spinal cord lesions and to evaluate cord compression. CT may be needed if better bony detail is required. Myelography only if MRI is unavailable or impossible. NM still widely used to screen for metastases and for identifying focal skeletal lesions (such as osteoid osteoma).
C2			

Cervical spine

Possible atlanto-axial subluxation **C3**	*XR (I)*	Indicated (C)	A single lateral cervical spine XR with the patient in supervised comfortable flexion should reveal any significant subluxation in patients with rheumatoid arthritis, Down's Syndrome, etc. MRI (flexion/extension) shows effect on cord when XR positive or neurological signs present.
Neck pain, Brachalgia, degenerative change **C4**	*XR (I)*	Not indicated routinely (B)	Degenerative changes begin in early middle-age and are often unrelated to symptoms which are usually due to disk/ligamentous changes undetectable on plain XR. MRI increasingly being used, especially when brachalgia is present.
	MRI (0)	Specialised investigation (B)	Consider MRI and specialist referral when pain affecting lifestyle or when there are neurological signs. Myelography (with CT) may occasionally be required to provide further delineation or when MRI is unavailable or impossible.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Thoracic spine			
Pain without trauma: degenerative disease	*XR (I)*	Not indicated routinely (B)	Degenerative changes are invariable from middle-age onwards. Examination rarely useful in the absence of neurological signs or pointers to metastases or infection. Consider more urgent referral in elderly patients with sudden pain to show osteoporotic collapse or other forms of bone destruction. Consider NM for possible metastatic lesions.
C5	*MRI (0)*	Specialised investigation (B)	MRI may be indicated if local pain persists, difficult to manage or if there are long tract signs.
Lumbar spine			
Chronic back pain with no pointers to infection or neoplasm	*XR (II)*	Not indicated routinely (C)	Degenerative changes are common and non-specific. Main value in younger patients (e.g. less than 20, spondylolisthesis, ankylosing spondylitis, etc.) or in older patients e.g. >55.
C6	*MRI (0) or CT (II) or NM (II)*	Specialised investigation (C)	In cases where management is difficult. Negative findings may be helpful.

Back pain with possible serious features such as: • onset < 20, > 55 yrs • sphincter or gait • sphincter or gait disturbance • saddle anaesthesia • severe or progressive motor loss • widespread neurological deficit • previous carcinoma • systematically unwell • HIV • weight loss • intravenous drug abuse • steroids • structural deformity • non-mechanical pain **C7**	*Imaging*	Indicated (B)	Together with urgent specialist referral; MRI is usually the best investigation. Imaging should not delay specialist referral. NM is also widely used for possible bone destruction, and in cases of chronic pain or where infection is suspected. ('NORMAL' PLAIN XR MAY BE FALSELY REASSURING). ***(for children see Section M)***

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Acute back pain: disk herniation; sciatica with no adverse features (see above).	*XR (II)*	Not indicated routinely (C)	Acute back pain is usually due to conditions which cannot be diagnosed on plain XR (osteoporotic collapse an exception). 'Normal' plain XRs may be falsely reassuring. Demonstration of disk herniation requires MRI or CT and should be considered immediately after failed conservative management.
	MRI (0) or CT (II)	Not indicated initially (B)	MRI generally preferred (wider field of view, conus, post-operative changes etc.) and avoids x-irradiation. Either MRI or CT is needed before intervention (e.g. epidural injection). MRI better than CT for post-operative problems.
C8			

D. Musculoskeletal system

Osteomyelitis	*XR (I) + NM (II) or MRI (0)*	Indicated (B)	The 2–3 phase skeletal scintigram is more sensitive than XR. However, findings are not specific and further specialised NM with alternative agents may be needed. Fat-suppressed MRI is becoming regarded as the optimal investigation.
D1	*CT (II) or US (0)*	Specialised investigations (C)	CT used to identify sequestra. Both CT and US can demonstrate appropriate site for guided percutaneous biopsy. US may be helpful, especially in children, if metalware causes artefacts on MRI/CT or if NM non specific due to recent surgery.
Primary bone tumour	*XR (I)*	Indicated (B)	XR may characterise the lesion.
D2	*MRI (0) or CT (II)*	Specialised investigations (B)	MRI useful for further characterisation and necessary for surgical staging; should be performed before any biopsy. CT can show bony detail better at some sites (e.g. spine) and for some small lesions and is needed if MRI unavailable. MRI more useful for assessment of extent. CT chest if CXR negative to assess pulmonary metastases for many primary malignant lesions. (see L41). These statements apply to adults and children.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Known primary tumour. Skeletal metastases	*NM (II)*	Indicated (B)	NM readily assesses the whole skeleton and is much more sensitive than plain XR, though less specific. Localised XRs may be needed to exclude other causes of increased activity, e.g. degenerative disease. In prostatic cancer biochemical markers (PSA) can be used to follow up progress of skeletal involvement. NM can also help characterise the lesion. (e.g. osteoid osteoma) and is useful in follow-up.
	Skeletal survey (II)	Not indicated routinely (C)	
D3	*MRI (0)*	Specialised investigation (C)	MRI more sensitive and specific than NM, especially for marrow-based lesions. However, field of view is limited.

Soft tissue mass tumour, possible recurrence **D4**	*MRI (0)*	Indicated (B)	MRI better than CT for exclusion, detection and staging of soft tissue tumours (superior contrast resolution, multiplanar capability, delineation of neurovascular bundle and muscle/compartment involvement). CT has greater sensitivity for calcification. Increasing interest in US for some anatomical sites. MR accepted as investigation of choice for possible recurrence although US has its proponents and can be used for biopsy. Consider NM (e.g. PET).
Bone pain **D5**	*XR (I)*	Indicated (B)	Local view of symptomatic areas only.
	NM (II) or MRI (0)	Indicated (B)	When symptoms persist and plain XRs negative.
Myeloma **D6**	*Skeletal survey (II)*	Indicated (C)	For staging and identifying lesions which may benefit from radiotherapy. Survey can be very limited for follow-up.
	NM (II)	Not indicated routinely (B)	Skeletal scintigraphy is often negative and underestimates disease extent; consider bone marrow studies.
	MRI (0)	Specialised investigation (B)	MRI very sensitive, even limited to spine, pelvis and proximal femora. Particularly useful in non-secretory myeloma or in the presence of diffuse osteopenia. Can be used for tumour-mass assessment and follow-up.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Metabolic bone disease	*Skeletal survey (II)*	Not indicated routinely (C)	Biochemical tests usually suffice. If needed, this should be limited (e.g. hands, CXR, pelvis and lateral lumbar spine). Bone densitometry may be needed. (see D9).
	NM *(II)*	Indicated (C)	Skeletal scintigram good for complications
Osteomalacia **D7**	*XR (0)*	Indicated (B)	Localised XR to establish cause of local pain or equivocal lesion on NM.
D8	*NM (II)*	Specialised	NM can show increased 'activity' and some local complications. Bone densitometry may be needed. (see D9).
Pain — osteoporotic collapse **D9**	*XR (II) lateral thoracic and lumbar spine*	Indicated (B)	Lateral views will demonstrate compression fractures. NM or MRI more useful in distinguishing between recent and old fractures and can help exclude pathological fractures. Bone densitometry (dual energy XR apsorptiometry (DEXA) or quantitative CT) provides objective measurements of bone mineral content; can also be used for metabolic bone disease (see D7, D8).

Arthropathy, presentation	*XR (I) affected joint*	Indicated (C)	May be helpful to determine cause although erosions are a relatively late feature.
	XR (I) hands/feet	Indicated (C)	In patients with suspected rheumatoid arthritis, XR feet may show erosions even when symptomatic hand(s) appear normal.
	XR (II) multiple joint(s)	Not indicated routinely (C)	
D10	*US (0) or NM (II) or MRI (0)*	Specialised investigations (C)	All can show acute synovitis. NM can show distribution. MRI can show articular cartilage.
Arthropathy, follow-up **D11**	*XR (I)*	Not indicated routinely (C)	XRs needed by specialists to assist management decisions.
Painful shoulder joint **D12**	*XR (I)*	Not indicated initially (C)	Degenerative changes in the acromio-clavicular joints and rotator cuff are common. Earlier XR if soft tissue calcification is expected.
Painful prosthesis	*XR (I) + NM (II)*	Indicated (B)	A normal NM study excludes most late complications. Further specialised NM studies can help distinguish loosening from infection.
D13	*US (0) or fluoroscopy (II)*	Specialised investigation (C)	Usually coupled with aspiration/biopsy/arthrography. Such intervention which provides a definitive result is increasingly being used.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Shoulder impingement	*MRI (0)*	Specialised investigation (B)	Although impingement is a clinical diagnosis, imaging is indicated when surgery is being considered and precise delineation of anatomy is required. But degenerative changes also common in the asymptomatic population.
D14	*US (0)*	Specialised investigation (B)	Subacromial and acromioclavicular joint impingement are dynamic processes which can be assessed by US.
Shoulder instability	*CT arthrography (II)*	Specialised investigation (B)	Glenoid labrum and synovial cavity are well delineated by both techniques. Some gradient echo MR techniques can show labrum well without arthrography.
D15	*MR arthrography (0)*	Specialised investigation (C)	
Rotator cuff tear	*Arthrography (II) or US (0) or MRI (0)*	Specialised investigation (B)	Much depends on local expertise and surgical plans. All three techniques demonstrate rotator cuff tears.
D16			

SI joint lesion **D17**	*XR SI joints (II)*	Indicated (B)	May help in investigation of sero-negative arthropathy. SI joints usually adequately demonstrated on AP lumbar spine.
	MRI (0) or NM (II) or CT (II)	Specialised investigation (C)	MRI or NM or CT when plain XRs equivocal; MRI carries no radiation dose.
Hip pain: full movement ***(for children see Section M)*** **D18**	*XR pelvis (I)*	Not indicated routinely (C)	XR only if symptoms and signs persist or complex history (e.g. chance of avascular necrosis, see D20) **NB: This recommendation does not apply to children.**
Hip pain: limited movement ***(for children see Section M)*** **D19**	*XR pelvis (I)*	Not indicated initially (C)	Symptoms often transient. XR if hip replacement might be considered or symptoms persist. PET may be helpful, if XR, MRI standard NM all normal. **NB: This recommendation does not apply to children.**
Hip pain: avascular necrosis **D20**	*XR Pelvis (I)*	Indicated (B)	Abnormal in established disease.
	MRI (0)	Specialised investigation (B)	MRI useful when XR normal, especially in high risk patients. NM and CT can also provide information here.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Knee pain: without locking or restriction in movement **D21**	*XR (I)*	Not indicated routinely (C)	Symptoms frequently arise from soft tissues and these will not be demonstrated on XR. OA changes common. XRs needed when considering surgery.
Knee pain: with locking, restricted movement or effusion (loose body) **D22**	*XR (I)*	Indicated (C)	To identify radio-opaque loose bodies.
Knee pain: arthroscopy being considered **D23**	*MRI (0)*	Specialised investigation (B)	MRI can assist the management decision as to whether or not to proceed with arthroscopy. Even in those patients with definite clinical abnormalities, warranting intervention, surgeons find pre-operative MRI helpful in identifying unsuspected lesions.
Hallux valgus **D24**	*XR (I)*	Specialised investigation (C)	For assessment before surgery.
Plantar fasciitis — calcaneal spur **D25**	*XR (I)*	Not indicated routinely (B)	Plantar spurs are common incidental findings. The cause of the pain is seldom detectable on XR. US, NM and MRI are more sensitive in showing inflammatory change but the majority of patients can be managed without imaging.

E. Cardiovascular system

Central chest pain myocardial infarction **E1**	*CXR (I)*	Indicated (B)	CXR must not delay admission to a specialised unit. CXR can assess heart size, pulmonary oedema, etc. and can exclude other causes. Department film preferable. Subsequent imaging involves specialised investigations (NM, coronary angiography, etc.) and depend on local policy. NM offers myocardial perfusion and ventriculography data. Increasing interest in MRI.
Chest pain: aortic dissection: acute **E2**	*CXR (I)*	Indicated (B)	Mainly to exclude other causes; rarely diagnostic.
	CT (III) or US (0) or MRI (0)	Indicated (B)	Seek advice from local radiologists. Much variation. Modern CT systems provide very accurate results. Often coupled with trans-thoracic US or, better, trans-oesophageal US. MRI probably the most accurate and increasingly used, despite logistic problems and constraints with some life-support systems. Angiography rarely necessary unless above examinations are equivocal.
Aortic dissection: chronic **E3**	*MRI (0)*	Specialised investigation (B)	MRI best investigation to assess change in longitudinal extent. Trans-oesophageal US and CT recommended.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Pulmonary embolus **E4**	*NM (II) or CT (III)*	Indicated (B)	Interpreted along with contemporary CXR. Equivocal findings (e.g. intermediate probability) may necessitate further clarification. Some centres use US to show thrombus in leg veins for further proof. A normal perfusion NM study excludes pulmonary embolism in most cases. Spiral CT used increasingly as the initial test, especially in patients with co-existing cardiorespiratory disease, and ahead of pulmonary angiography.
Pericarditis — pericardial effusion **E5**	*CXR (I)* *US (0)*	Indicated (B) Indicated (B)	May be normal; effusion volume/effect not determined. Extremely accurate: may be needed urgently for tamponade; can show best access for drainage. CT sometimes needed for calcification, loculation, etc.
Suspected valvular cardiac disease **E6**	*CXR (I) and cardiac US (0)*	Indicated (B)	Used for initial assessment and when there is a change in the clinical picture.
Clinical deterioration following myocardial infarction **E7**	*Cardiac US (0)*	Indicated (B)	US may show remediable complications (VSD, papillary rupture, aneurysm, etc.).

Follow-up of patients with heart disease or hypertension **E8**	*CXR (I)*	Not indicated routinely (B)	Only if signs or symptoms have changed, when comparison with the CXR obtained at presentation may be helpful.
Abdominal aortic aneurysm **E9**	*US (0) aorta*	Indicated (A)	Useful in diagnosis, determination of maximal diameter and follow-up. CT preferable for suspected leak but should not delay urgent surgery.
	CT (III) or MRI (0)	Indicated (A)	CT and MRI for relationship to renal vessels and iliacs. Increasing demand for detailed anatomical information because of increasing consideration for percutaneous stenting.
Deep-vein thrombosis **E10**	*US (0) lower limb veins*	Indicated (A)	More sensitive with colour-flow Doppler. Most clinically significant thrombi are detected. Increasing experience with US for calf vein thrombi. May show other lesions.
	Venography (II)	Not indicated routinely (C)	Extensive variation according to US expertise and local therapeutic strategy.
Ischaemic leg **E11**	*Angiography (III)*	Specialised investigation (A)	Local policy needs to be determined in agreement with vascular surgeons, especially with regard to therapeutic interventions. US used in some centres as first investigation. Spiral CT and MRI are being developed.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Myocardial evaluation **E12**	*NM (III)*	Indicated (A)	NM is the most established investigation for assessing myocardial perfusion. Cardiac MRI only available in a few centres.

F. Thoracic system

Non-specific chest pain **F1**	*CXR (I)*	Not indicated initially (C)	Conditions such as Tietze's disease show no abnormality on CXR. Main purpose is reassurance.
Chest trauma **F2**	*CXR (I)*	Not indicated routinely (C)	Showing a rib fracture after minor trauma does not alter management ***(see Trauma Section K).***
Pre-employment or screening medicals **F3**	*CXR (I)*	Not indicated	Not justified except in a few high-risk categories (e.g. at risk immigrants with no recent CXR). Some have to be done for occupational (e.g. divers) or emigration purposes (UK category 2).
Pre-operative **F4**	*CXR (I)*	Not indicated routinely (B)	Exceptions before cardio-pulmonary surgery, likely admission to ITU, suspected malignancy or possible TB. Anaesthetists may also request CXRs for dyspnoeic patients, those with known cardiac disease and the very elderly. Many patients with cardio respiratory disease have recent CXR available; a repeat CXR is then not usually needed.
Upper respiratory-tract infection **F5**	*CXR (I)*	Not indicated routinely (C)	
Chronic obstructive airways disease or asthma; follow-up **F6**	*CXR (I)*	Not indicated routinely (B)	Only if signs or symptoms have changed.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Pneumonia adults: follow-up ***(for children see Section M)*** **F7**	*CXR (I)*	Indicated (A)	To confirm clearing, etc. Pointless to re-examine at less than 10-day intervals as clearing can be slow (especially in the elderly).
Pleural effusion **F8**	*CXR (I)*	Indicated (B)	Small effusion can be missed, especially on a frontal CXR.
	US (0)	Indicated (B)	To prove fluid consistency; to guide aspiration. CT occasionally needed for better localisation, assessment of solid components, etc.
Haemoptysis **F9**	*CXR (I)*	Indicated (B)	PA plus lateral view.
	CT (III)	Specialised investigation (B)	Many centres use CT and then proceed to bronchoscopy; increasing use of CT first (see Cancer L7). Consider bronchial arteriography in massive haemoptysis.
ITU/HDU patient **F10**	*CXR (I)*	Indicated (B)	A CXR is most helpful when there has been a change in symptoms or insertion or removal of a device. The value of the routine daily CXR is being increasingly questioned.

Occult lung disease **F11**	*CT (II)* *NM (II)*	Indicated (B) Specialised investigation (B)	High resolution CT can show abnormalities not evident on CXR, especially interstitial disease. NM can assess disease activity (e.g. measure permeability in alveolitis) and monitor effects of therapy.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
G. Gastrointestinal system			
Gastrointestinal tract			
Difficulty in swallowing **G1**	*Ba swallow (II)* NM (I)	Indicated (B) Specialised investigation (B)	Ba studies are still recommended before possible endoscopy; they will accurately localise lesions and show the degree of obstruction caused by a stricture and its length. Webs and pouches are well demonstrated. Subtle strictures may be demonstrated by a marshmallow (or other bolus) study. Detailed fluoroscopy or NM needed for motility disorders. Video swallows for suspected pharyngeal dysfunction in conjunction with speech therapists.
Chest pain — hiatus hernia or reflux **G2**	*Ba swallow /meal (III)*	Not indicated routinely (C)	Although Ba swallow useful to demonstrate hernia, reflux and their complications, not all such patients need investigation. Reflux is common and not necessarily the cause of pain. NM may be oversensitive; pH monitoring is generally regarded as the ‘gold standard’ for acid reflux but gives no anatomical information. Metaplasia and oesophagitis are best detected by endoscopy which also allows biopsy. Increasing use of Ba studies before anti-reflux surgery.

Oesophageal perforation	*CXR (I)*	Indicated (B)	CXR may be sufficient, unless localisation for surgical repair is planned.
G3	*Swallow (II)*	Specialised investigation (B)	Swallow should be performed with water-soluble non- ionic contrast agents. Some centres use CT.
Acute GI bleeding: haematemesis	*AXR (II)*	Not indicated routinely (B)	Of no value.
	Ba studies (II)	Not indicated routinely (A)	Endoscopy provides diagnosis of upper GI lesions, allows injection of varices, etc. Ba studies preclude angiography.
	NM (II) (red cell study)	Specialised investigation (B)	After endoscopy. NM can detect bleeding rates as low as 0.1 ml/min; more sensitive than angiography. Red cell study is most useful in intermittent bleeding.
G4	*Angiography (III)*	Specialised investigation (B)	When considering surgery or intervention (e.g. embolisation) for uncontrollable bleeding.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Dyspepsia in the younger patient (e.g. under 45 yrs) **G5**	*Imaging (Ba meal (II)/ Endoscopy (0))*	Not indicated routinely (C)	Most patients under 45 yrs can be treated without complex investigations and will undergo a trial of therapy (anti-ulcer or reflux). Either Ba meal or endoscopy for those who fail to respond. Other alarm features pointing to early investigation include unintentional weight loss, anaemia, anorexia, GI bleeding, pain requiring hospitalisation, non-steroid anti-inflammatory drugs, vomiting, no improvement following treatment in those positive for Helicobacter pylori.
Dyspepsia in the older patient (e.g. over 45 yrs) **G6**	*Imaging (Ba meal (II)/ endoscopy (0))*	Indicated (C)	Endoscopy is often the first line investigation. However, Ba meal remains a reasonable alternative. The alternative investigation should be considered whenever symptoms continue after negative result. The main concern is the detection of early cancer, especially submucosal tumours.
Ulcer follow-up **G7**	*Ba studies (II)*	Not indicated routinely (B)	Scarring precludes accurate assessment. Endoscopy preferred to confirm complete healing and to obtain biopsies (e.g. Helicobacter pylori, etc.) where necessary. Some centres use NM studies (Carbon-14 breath test) to assess effect of treatment of Helicobacter pylori.

Previous upper GI surgery (recent) **G8**	*Water soluble contrast medium study (II)*	Indicated (B)	To assess anastomosis and transit through to small bowel.
Previous upper GI surgery (old) **G9**	*Ba studies (II)*	Not indicated routinely (B)	Gastric remnant best assessed by endoscopy (gastritis, ulceration, recurrent tumour, etc.). Cross-sectional imaging (US, CT, etc.) may be needed to assess extramural disease. Endoscopic US can demonstrate submucosal recurrence.
	NM (II)	Specialised investigation (B)	NM can provide functional data about emptying.
Intestinal blood loss, chronic or recurrent **G10**	*Ba small bowel study (II)*	Not indicated initially (C)	Only after upper and lower tract imaging (Ba studies or endoscopy).
	NM (II) (red cell or Meckel's study) and/or angiography (III)	Specialised investigation (B)	When all other investigations are negative.
Acute abdominal pain — perforation— obstruction **G11**	*CXR (I) (erect) and AXR (II)*	Indicated (B)	Decubitus AXR to show free air if CXR supine. Supine AXR usually sufficient to establish diagnosis and point to an anatomical level of obstruction.
	CT (II)	Specialised Investigation (B)	Consider erect AXR if supine AXR normal and strong clinical suspicion of obstruction. There is increasing use of CT here – e.g. to establish site and cause of obstruction.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Small bowel obstruction **G12**	*Contrast studies (II) or CT (III)*	Specialised investigation (B)	Studies with non-ionic agents can determine both the site and completeness of obstruction. Some centres use CT in this situation which can determine level and likely cause.
Small bowel obstruction: chronic or recurrent **G13**	*Small bowel Ba study (II)*	Indicated (B)	Small bowel enema is the examination of choice.
Small bowel disease suspected (e.g. Crohn's disease) **G14**	*Ba small bowel study (II)* *NM (white cell study) (III)*	Indicated (C) Specialised investigation (B)	Ba follow through tends to give a lower radiation dose than small bowel enema. Some centres use US and/or CT to assess bowel wall. Labelled white cell scintigraphy reveals activity and extent of disease. Complementary to Ba studies. CT and MRI reserved for complications.

Large bowel tumour or inflammatory bowel disease: pain, bleeding, change in bowel habit, etc. **G15**	*Ba enema (III)*	Indicated (B)	NB: Double contrast Ba is only useful if the bowel is properly prepared. Furthermore all patients should undergo rectal examination to assess suitability for Ba enema and to exclude a low rectal tumour. Good practice requires a sigmoidoscopy before Ba enema. Defer Ba enema for seven days after full thickness biopsy via a rigid sigmoidoscope. Biopsies taken during flexible sigmoidoscopy are usually superficial and the risk of subsequent perforation is low (ideally a 48 hour delay). Some centres use colonoscopy initially, reserving Ba enema for difficult or incomplete examinations. Some centres use CT for the frail elderly patient. Although the irritable bowel syndrome is the most common cause of a change in bowel habit, Ba enema or colonoscopy is needed to exclude other causes.
Large bowel obstruction: acute **G16**	*Enema (III)*	Specialised investigation (B)	Single contrast (ideally water-soluble contrast medium) study can show narrowed area and exclude ‘pseudo-obstruction’. Some centres use CT which can point to the likely cause.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Inflammatory bowel disease of colon **G17**	*AXR (II)*	Indicated (B)	Often sufficient for evaluation.
	NM (white cell study) (III)	Indicated (B)	Labelled white cell study best exam — will reveal activity and extent of disease.
	Ba enema (III)	Not indicated routinely (B)	Ba enema is dangerous when toxic megacolon present; unprepared enema in selected cases after discussion with radiologists.
Inflammatory bowel disease of colon: long-term follow-up **G18**	*Ba enema (III)*	Not indicated routinely (B)	Colonoscopy follow-up preferred to identify developing carcinoma in those at high risk, although Ba enema is still often used, particularly after complex intestinal surgery. Likewise Ba enema preferred for evaluating fistulae etc.
General abdominal problems			
Acute abdomen pain; (warranting hospital admission and surgical consideration) **G19**	*AXR (II) plus erect CXR (I)*	Indicated (B)	Local policy will determine strategy. Supine AXR (for gas pattern, etc.) is usually sufficient. Erect AXR not indicated routinely. Increasing use of CT as a 'catch-all' investigation here. US widely used as a preliminary survey.

Palpable mass	*AXR (II)*	Not indicated routinely (C)	
	US (0)	Indicated (B)	US usually solves the problem and is very reliable in thin patients, right upper quadrant and pelvis.
G20	*CT (III)*	Indicated (A)	CT is an alternative and useful to exclude a lesion; particularly good in fat patients.
Malabsorbtion	*Ba study of small bowel (II)*	Not indicated routinely (B)	Imaging is not required for the diagnosis of coeliac disease but may be indicated for jejunal diverticulosis or when biopsy is normal/equivocal. CT may be better if lymphoma suspected.
G21	*NM (I)*	Specialised investigation (B)	Numerous NM investigations available which should establish presence of malabsorption. Some of these are non-radiological (e.g. breath test).
Appendicitis	*Imaging*	Specialised investigation (C)	Wide range of policy varying accordingly to local availability of equipment and expertise and the body habitus of the patient. Appendicitis is usually a clinical diagnosis. Imaging (e.g. US with graded compression) can help in equivocal cases or in differentiation from gynaecological lesions. So too can NM (white cell study) and focused appendix CT (FACT). US recommended in children and young women.
G22			

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Constipation ***(for children see Section M)*** **G23**	*AXR (II)*	Not indicated routinely (C)	Many normal adults show extensive faecal material; although this may be related to prolonged transit time it is impossible to assess significance on AXR alone. But AXR can help certain specialists (e.g. geriatricians) in refractory cases.
Abdominal sepsis; pyrexia of unknown origin (PUO) **G24**	*US (0) or CT (III) or NM (III)*	Indicated (C)	Seek radiological advice; much depends on local availability and expertise. US often used first (speed, cost) and may be definitive, particularly when there are localising signs; especially good for subphrenic/subhepatic spaces and pelvis. CT probably best test overall: infection and tumour usually identified and excluded. Also allows biopsy of nodes or tumour and drainage of collections (especially recent post-operative). NM particularly good when there are no localising features: labelled WBC good for chronic post-operative sepsis; gallium will accumulate at sites of tumour (e.g. lymphoma) and infection.

Liver, gallbladder and pancreas

Hepatic metastases **G25**	*US (0)* *CT (II) or MRI (0)*	Indicated (B) Specialised investigation (B)	The majority of metastases will be demonstrated by US which also allows biopsy. US should be the initial investigation but metastases may show the same reflectivity as the hepatic parenchyma and thus be missed. CT/MRI used for further exclusion, where US equivocal or surprisingly normal and where full staging is needed or hepatic resection is planned (see also Cancer L13). Recent interest in dual-phase spiral CT. MRI being increasingly used here. Some recent interest in NM (somatostatin analogues and PET).
Hepatic haemangioma (e.g. on US) **G26**	*MRI (0) or CT (III)* *NM (red cell study) (III)*	Indicated (B) Specialised investigation (B)	MRI, CT and NM reliably show further characteristic features of haemangioma and many other solitary hepatic lesions.
Jaundice **G27**	*US (0)*	Indicated (B)	Sensitive for bile duct dilatation. But dilatation may be subtle in early obstruction and sclerosing cholangitis. Shows gallstones and most forms of hepatic disease. US also shows the level and cause of any obstruction to common bile duct. Discuss subsequent investigations (CT, ERCP, MRCP, etc.) with radiologist.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Biliary disease, (e.g. gallstones)	*AXR (II)*	Not indicated routinely (C)	Plain XRs only show about 10 % of gallstones.
	US (0)	Indicated (B)	US allows evaluation of other organs too. Cholecystography is now rarely needed (e.g. poor views at US). CT/endoscopy may be needed for further delineation. Increasing interest in MRCP.
G28	*NM (II)*	Specialised investigation (B)	Biliary scintigraphy shows cystic duct obstruction in acute cholecystitis. Also useful in chronic cholecystitis.
Pancreatitis: acute	*AXR (II)*	Not indicated routinely (C)	Unless diagnosis in doubt; then AXR needed to exclude other causes of acute abdomen pain (see G19). Some patients presenting with acute pancreatitis have underlying chronic pancreatitis which may cause calcification evident on AXR.
	US (0)	Indicated (B)	To show gallstones and to diagnose and follow pseudocyst development, especially good in thin patients.

G29	*CT (III) or MRI (0)*	Not indicated routinely (B)	Reserved for clinically severe cases (to assess extent of necrosis), in patients who do not improve on treatment or if there is uncertainty as to the diagnosis. CT can help predict morbidity and mortality. Some centres use MRI, especially if repeated follow-up likely.
Pancreatitis: chronic **G30**	*AXR (II)*	Indicated (B)	To show calcification.
	US (0) or CT (IV)	Indicated (B)	US may be definitive in thin patients; CT will show calcification to good effect.
	ERCP (II) or MRCP (0)	Specialised investigation (C)	ERCP shows duct morphology, but considerable risk of acute pancreatitis. Hence current interest in MRCP.
Post-operative biliary leak **G31**	*NM (II)*	Indicated (C)	US will usually have shown the anatomy of the collections, etc. NM study (HIDA) will show activity at site of leak. MRCP also used here. ERCP will show the anatomy of the leak and may allow intervention (e.g. stent).
Pancreatic tumour **G32**	*US (0) CT (III) or MRI (0)*	Indicated (B)	Especially in thin patients and for lesions in the head and body. Increasing use of endoscopic and laparoscopic US. CT (or MRI) good in the fatter patient and where US equivocal or where precise staging needed. ERCP/MRCP may also be indicated. NM (eg PET) may help distinguish carcinoma from pancreatitis.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Insulinoma **G33**	*Imaging*	Specialised	When biochemical tests are convincing. MRI emerging as the best examination although arterial phase spiral CT promising. Most centres seek two positive investigations before surgery (out of CT/NM/MRI /angiography). Endoscopic and intra-operative US also useful.

H. Urological, adrenal and genito-urinary systems

Haematuria macro- or microscopic **H1**	*US (0) + AXR (II) or IVU (II)*	Indicated (B)	There is a wide variation in local policy. Imaging strategies should be agreed with the local nephrologists and urologists. In many centres US + AXR are the initial studies, but if negative, IVU is still indicated in patients with continuing macroscopic haematuria or in the over 40s with microscopic haematuria. Conversely, patients in whom IVU and cystoscopy are normal who continue to bleed should undergo US, as IVU can fail to show a renal tumour and US will occasionally demonstrate a bladder lesion not seen at cystoscopy. Increasing use of CT.
Hypertension (without evidence of renal disease) **H2**	*IVU (II)*	Not indicated routinely (A)	IVU is insensitive for renal artery stenosis. See H3.
Hypertension: in the young adult or in patients unresponsive to medication	*US (0) kidneys*	Indicated (B)	To assess relative renal size and parenchymal pattern. Doppler US is not sensitive enough for use as a screening tool.
	NM (II) renogram	Indicated (B)	Captopril renography is an established method of determining functionally significant renal artery stenosis.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
H3	*Angiography (DSA (III), CTA (III) or MRA (0))*	Specialised investigation (C)	To show stenosis if surgery or angioplasty is considered as a possible treatment.
Renal failure **H4**	*US (0) + AXR (II)* *NM (II)*	Indicated (B) Indicated (B)	For renal size, structure, obstruction, etc. NB: a normal US does not exclude obstruction. When appropriate, renography can assess renal perfusion, function and obstruction.
Renal colic, loin pain **H5**	*IVU (II) or US (0) and AXR (II) or CT (III)*	Indicated (B)	Imaging should be performed as an emergency examination whilst the pain is present, as radiological signs disappear rapidly after passage of a stone. Delayed films (up to 24 hrs) may be needed to show the site of obstruction. A plain AXR on its own is of little value. Both CT and US are increasingly being used, especially in those with contraindications to contrast medium.
Renal calculi (in the absence of acute colic) **H6**	*US (0) + AXR (II)*	Indicated (C)	AXR alone may be appropriate follow-up for previously demonstrated calculi after an uncomplicated acute attack. An IVU may be required before treatment to show anatomy. NM may be needed to determine relative function.

Renal mass	*US (0)*	Indicated (B)	US is good at distinguishing between cystic and solid masses.
H7	*AXR (II) + IVU (II)*	Not indicated routinely (C)	CT or MRI preferable for further evaluation. NM may be needed to determine relative function.
Prostatism	*US 0) IVU (II)*	Indicated (B) Not indicated routinely (B)	US can also assess upper tract and bladder volumes before and after voiding, preferably with flow rates. It can also show bladder calculi.
H8			
Prostatic malignancy	*US (0)*	Specialised investigation (B)	Transrectal US with guided biopsies after clinical examination. Some interest in MRI and PET here.
H9			
Urinary retention	*US (0) IVU (II)*	Indicated (C) Not indicated routinely (C)	US to evaluate the upper tracts (after catheterisation and relief of bladder distension), particularly if urea levels remain raised.
H10			
Scrotal mass or pain	*US (0)*	Indicated (B)	Allows differentiation of testicular from extra-testicular lesions.
H11			
Testicular torsion	*US (0)*	Specialised investigation (C)	Torsion is usually a clinical diagnosis. Imaging investigations must not delay the priority that must be given to surgical exploration. Doppler US can be used, when clinical findings are equivocal in the post pubertal testis.
H12	*NM (II)*	Specialised investigation (C)	NM techniques can assist with this diagnosis but prompt results essential.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Urinary tract infection in adults ***(for children see Section M)*** **H13**	*US (0) + AXR (II) or IVU (II)*	Not indicated routinely (C)	The majority do not need investigation unless there are recurrent infections, renal colic or failure to respond to antibiotics. Slightly lower threshold to investigate male patients. **NB: This does not apply to children.**
Adrenal medullary tumours	*CT (III) or MRI (0)*	Specialised investigation (B)	Whilst US may identify lesions of this type, CT and MRI provide the best anatomical delineation. Imaging is rarely indicated in the absence of biochemical evidence of such tumours.
H14	*NM (II)*	Specialised investigation (B)	MIBG locates functioning tumours and is particularly useful for ectopic sites and metastases.
Adrenal cortical lesions, Cushing's and Conn's disease and syndrome **H15**	*CT (III), NM (IV) or MRI (0)*	Specialised investigation (B)	Local advice on the most appropriate examination should be sought. Both CT and MRI can differentiate between the different lesions. NM can distinguish between functioning and non-functioning adenomas. So too can various MRI techniques.

I. Obstetrics and gynaecology

NB: Transvaginal (TV) US equipment should be available in all departments performing pelvic US

Screening in pregnancy **I1**	*US (0)*	Indicated (C)	Screening US has not been shown to alter perinatal mortality, except where selective termination of pregnancy is applied in the presence of gross foetal abnormality. It does provide useful information about dating and multiple pregnancies. US is also of proven value in assessing placenta praevia and intra-uterine growth. In the specialist care of high-risk pregnancies, Doppler US of the umbilical artery assists management. There is wide variation in the use of obstetric US in different countries.
Suspected pregnancy **I2**	*US (0)*	Not indicated routinely (C)	Pregnancy testing most appropriate. US valuable where molar pregnancy suspected.
Suspected ectopic pregnancy **I3**	*US (0)*	Indicated (B)	After positive pregnancy test. TV US preferred. Colour flow Doppler increases sensitivity.
Possible non-viable pregnancy **I4**	*US (0)*	Indicated (C)	Repeat US after a week may be needed (especially when gestational sac < 20 mm or crown rump length < 6 mm). Pregnancy test required. Where doubt exists about the viability of a pregnancy, delay in evacuation of the uterus is essential.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Suspected pelvic mass **I5**	*US (0)*	Indicated (C)	Combination of trans-abdominal and TV US often required. US should confirm a lesion's presence and determine likely organ of origin. See Cancer Section L. MRI is the best second line investigation, although CT still widely used.
Pelvic pain, including suspected pelvic inflammatory disease and suspected endometriosis **I6**	*US (0)* *MRI (0)*	Indicated (C) Specialised investigation (B)	Especially when clinical examination difficult or impossible. Can be useful to localise the larger foci of endometriosis.
Lost IUCD **I7**	*US (0)* *AXR (II)*	Indicated (C) Not indicated routinely (C)	Unless IUCD is not seen in uterus on US.
Recurrent miscarriages **I8**	*US (0)* *MRI (0)*	Indicated (C) Specialised investigation (C)	Will show the major congenital and acquired problems. Supplements US for uterine anatomy. Some centres use hysterosalpingography.

Infertility **I9**	*US (0)*	Indicated (C)	For follicle-tracking during treatment. For assessment of tubal patency. Some centres use MRI and/or hysterosalpingography.
Suspected cephalopelvic disproportion **I10**	*XR (II)* *Pelvimetry* *MRI (0) or CT (II)*	Not indicated routinely (B) Specialised investigation (C)	The need for pelvimetry is increasingly being questioned. Local policy should be determined in agreement with obstetricians. Furthermore MRI or CT should be used wherever possible. MRI is best as it avoids x-irradiation. CT generally offers a lower dose than standard XR pelvimetry.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
J. Breast disease			
Asymptomatic patients			
Breast screening **J1–4**	*Mammography (I)*	Various indications	Various strategies have been adopted in different countries. This topic is not considered further.
Family history of breast cancer **J5**	*Mammography (I)*	Specialised examination (C)	At present there is no evidence of benefit but there is some evidence of harm. Screening should only be contemplated after genetic risk assessments and appropriate counselling as to the risks and unproven benefits. Consensus at the moment is that screening should only be contemplated when the lifetime risk of breast cancer is greater than 2.5 times average. Units should collect and audit their work. This topic is being rigorously discussed at the present time. Further evaluation is usually obtained by US, NM and MRI according to local expertise and availability.
Women < 50 yrs having or being considered for HRT **J6**	*Mammography (I)*	Not indicated routinely (A)	A meta-analysis has shown women < 50 yrs who have received HRT for > 11 yrs are not at increased risk of breast cancer compared to a peer group. Women on HRT 50 yrs and over can be appropriately monitored by breast screening programmes.

Asymptomatic women with augmentation mammoplasty **J7**	*Mammography (I)*		Best considered as part of whatever national breast screening policy applies (see J1–4).
Symptomatic patients			
Clinical suspicion of breast cancer (diagnosis)	*Mammography (I),*	Indicated (B)	Referral to a breast clinic should precede any radiological investigation.
	US (0)	Specialised investigation (B)	Mammography ± US should be used in the context of triple assessment — i.e. clinical examination, imaging and cytology/biopsy. Ultrasound can readily direct biopsy.
J8	*NM (III) or MRI (0)*	Specialised investigation (B)	NM or MRI sometimes a useful adjunct to triple assessment of an equivocal lesion.
Generalised lumpiness, generalised breast pain, or tenderness, or longstanding nipple retraction **J9**	*Mammography (I) or US (0)*	Not indicated routinely (C)	In the absence of other signs suggestive of malignancy, imaging is unlikely to influence management. Focal, rather than generalised pain may warrant investigation.
Cyclical mastalgia **J10**	*Mammography (I)*	Not indicated routinely (B)	In the absence of other clinical signs suggestive of malignancy and localised pain, investigation is unlikely to influence management.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Augmentation mammoplasty **J11**	*US (0)*	Indicated (B)	The assessment of integrity of breast implants or coincident masses requires specialist skills and facilities.
	MRI (0) or NM (III)	Specialised investigation (B)	MRI is now an established investigation for implant leakage. It can also show tumours. Scintimammography and PET also have a role when other investigations are unhelpful.
Paget's disease of the nipple **J12**	*Mammography (I)*	Indicated (C)	The prevalence of coexistent breast cancer varies in published studies, but its association is clear and justifies specialist referral.
Breast inflammation **J13**	*US (0)*	Indicated (B)	US can distinguish between an abscess requiring drainage and diffuse inflammation, and can guide aspiration when appropriate. Mammography may be of value where malignancy is possible.

Breast cancer Staging: axilla	*Breast/axilla* *breast NM* *axilla (III)*	Specialised investigation (C)	The role of sentinel node scintigraphy and localisation is currently being evaluated.
Staging: general **J14**	*NM skeletal (II)* *US liver (0)*	Indicated (B) Not routinely indicated (C)	For patients with a primary tumour >2cm and those with bone pain.
Breast cancer Follow-up (surveillance) **J15**	*Mammography (I)*	Indicated (A)	Principles of triple assessment apply. For locoregional recurrence, NM scintimammography and MRI have a role.

K. Trauma

Head: general

Head injury: Protocols for management of head injuries are constantly under review and will vary according to local availability of CT, distances involved in transportation to neurosurgical centres, etc. The recommendations given here may need to be adapted following consultation with the neurosurgical centre for your area in the light of local circumstances and policies.

The key management and clinical questions in head injury are:

Clinical: *Is there evidence of brain injury?*
Is there evidence of intracranial haemorrhage or raised intracranial pressure?
Is there clinical evidence of a skull fracture and, if so, is it depressed?
Are other systems/areas involved?

Management: *Does the patient need admission to hospital for observation?*
Is CT required?
Is a neurosurgical opinion required?

These questions underline key policies concerning management of patients. Decisions about imaging requirements cannot be separated from non-imaging issues such as admission.

The usual indications for admission include: confusion or depressed consciousness; fracture on SXR; neurological symptoms or signs; seizures; CSF or blood from nose or ear; coagulation disorders; lack of adult supervision at home; patient difficult to assess (non-accidental injury (NAI), drugs, alcohol, etc.). If a decision is made to admit for observation, imaging becomes less urgent, and the patient will be better examined when sober and more cooperative. CT is increasingly being used as the first investigation in those where there is a medium risk of intracranial injury, in which case SXR is usually unnecessary. Difficulties with image interpretation or the management of the patient may be resolved by referrals via image transfer systems to designated neuroscience centres.

Intracranial abnormalities suggesting need for urgent neurosurgical management include:

High or mixed attenuation intracranial lesion
Shift of mid-line structures (e.g. third ventricle)
Obliteration of third ventricle
Relative dilatation of a lateral ventricle(s)
Obliteration of basal cisterns
Intracranial air
Sub-arachnoid or intraventricular haemorrhage.

Children

Head injuries are relatively common in children; in the majority of cases, there is no serious injury: imaging and hospitalisation are unnecessary. If there is a history of loss of consciousness, neurological signs or symptoms (excluding a single vomit) or an inadequate or inconsistent history, imaging is required. CT is the simplest way of excluding significant brain injury. If non-accidental injury is suspected, a skull SXR as part of a skeletal survey is required. In addition, MRI of the brain may be required later to further document timing of the injury.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Head: low risk of intracranial injury			
• Fully orientated • No amnesia • No neurological defects • No serious scalp laceration • No haematoma **K1**	*SXR (I)* *CT (II)*	Not indicated routinely (C) Not indicated routinely (C)	These patients are usually sent home with head injury instructions to the care of a responsible adult. They may be admitted to hospital if no such adult is available.
Head: medium-risk of intracranial injury			
• Loss of consciousness or amnesia • Violent mechanisms of injury • Scalp bruise, swelling or laceration down to bone or > 5 cm • Neurological symptoms or signs (including headache, vomiting twice or more, return visit)	*CT (II) or SXR (I)*	Indicated (B)	CT is increasingly being used as the first and ONLY investigation in this group of patients, to confidently exclude cranial injury. If no fracture is seen, patients will usually be sent home with head injury instructions to the care of a responsible adult. If no responsible adult is available or if a fracture is present, the patient will usually be admitted. See Section M (M13) for non-accidental injury in children. MRI of the brain is the preferred investigation for intracranial injuries in NAI, but SXR may still be needed to exclude fractures missed on CT.

• Inadequate history or examination (epilepsy /alcohol/child/etc.) • Child below 5 yrs: suspected NAI, tense fontanelle, fall more than 60 cm or on to hard surface **K2**			
Head: high risk of intracranial injury			
• Suspected FB or penetrating injury to skull • Disorientated or depressed consciousness • Focal neurological symptoms or signs • Seizure • Skull fracture or sutural diastasis shown on SXR • CSF from nose or CSF/ blood from ear • Unstable systemic state precluding transfer to neurological unit • Diagnosis uncertain **K3**	*CT (II)*	Indicated (B)	These patients will usually have been admitted for observation. If there is any delay in getting CT on an urgent basis, seek neurosurgical opinion. **NB: CT should be available within four hours of admission in all patients with a skull fracture.** SXR is not required before CT. In rhinorrhoea/otorrhoea NM can identify site of leakage in chronic phase.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Head: very high risk of intracranial injury			
• Deteriorating consciousness or neurological signs (e.g. pupil changes) • Confusion or coma persistent despite resuscitation • Tense fontanelle or sutural diastasis • Open or penetrating injury • Depressed or compound fracture • Fracture of skull base **K4**	*CT (II)*	Indicated (B)	URGENT NEUROSURGICAL AND ANAESTHETIC REFERRAL INDICATED, which should not be delayed by imaging. **NB: CT should be performed as an emergency (see K3 above).**
Nasal trauma **K5**	*SXR (I)* *XR facial bones (I), XR nasal bones (I)*	Not indicated routinely (B)	Unless requested by a specialist. Poor correlation between radiological findings and presence of external deformity. Management of the bruised nose will depend on local policy: usually follow-up at an ENT or maxillo-facial clinic will determine the need for XR.

Orbital trauma: blunt injury **K6**	*XR facial bones (I)*	Indicated (B)	Especially in those where 'blow-out' injury possible MRI or low dose CT may eventually be required by specialists, especially when XRs or clinical signs equivocal.
Orbital trauma: penetrating injury **K7**	*XR orbits (I)* *US (0) or CT (II)*	Indicated (C) Specialised investigation (B)	When: (1) Radio-opaque intra-ocular FB is a possibility (see A16). (2) Investigation requested by ophthalmologist. (3) Suspicion of damage to orbital walls. US or low-dose CT may be required; MRI contraindicated with metallic FB (see A16).
Middle third facial injury **K8**	*XR facial bones (I)* *Low-dose CT (II)*	Indicated (B) Specialised investigation (B)	But patient cooperation essential. Advisable to delay XR in uncooperative patients. In children, XR often unhelpful. Discuss with maxillofacial surgeon who may require low-dose CT at an early stage.
Mandibular trauma **K9**	*XR Mandible (I) or orthopantomogram (OPG) (I)*	Indicated (C)	For non-traumatic TMJ problems see B11.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Cervical spine			
Conscious patient with head and/or face injury only **K10**	*XR C spine (I)*	Not indicated routinely (B)	In those who meet all of the following criteria: (1) Fully conscious. (2) Not intoxicated. (3) No abnormal neurological findings. (4) No neck pain or tenderness.
Unconscious head injury (see K3/4) **K11**	*XR C spine (I)*	Indicated (B)	Must be of good quality to allow accurate evaluation. But radiography may be very difficult in the severely traumatised patient and must avoid manipulation (see also K12).
Neck injury: with pain	*XR C spine (I)*	Indicated (B)	Cervical spine XRs can be very difficult to evaluate. Radiography also difficult and: 1. Must show C7/T1. 2. Should show odontoid peg (not always possible at time of initial study). 3. May need special views, CT or MRI especially when XR equivocal or complex lesions.
K12	*CT (II) or MRI (0)*	Specialised investigation (B)	Discuss with department of clinical radiology.

Neck injury: with neurological deficit **K13**	*XR (I)* *MRI (0)*	Indicated (B) Indicated (B)	For orthopaedic assessment. Some constraints with life support systems. MRI best and safest method of demonstrating intrinsic cord damage, cord compression, ligamentous injuries and vertebral fractures at multiple levels. CT myelography may be considered if MRI not available.
Neck injury: with pain but XR initially normal; suspected ligamentous injury **K14**	*XR C spine; flexion and extension (I)*	Specialised investigation (B)	Views taken in flexion and extension (consider fluoroscopy) as achieved by the patient with no assistance and under medical supervision. MRI may be helpful here.
Thoracic and lumbar spine			
Trauma: no pain, no neurological deficit **K15**	*XR (II)*	Not indicated routinely (B)	Physical examination is reliable in this region. When the patient is awake, alert and asymptomatic, the probability of injury is low.
Trauma: with pain, no neurological deficit or patient not able to be evaluated **K16**	*XR painful area (II)*	Indicated (B)	A low threshold to XR when there is pain/tenderness, a significant fall, a high impact RTA, other spinal fracture present or it is not possible to clinically evaluate the patient. Increasing use of CT and MRI here.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Trauma: with neurological deficit — pain **K17**	*XR (II)*	Indicated (B)	
	MRI (0)	Indicated (B)	Where technically possible. CT often used as patient undergoing CT for other reasons. But MRI best method of demonstrating intrinsic cord damage, cord compression and vertebral fractures at multiple levels.
Pelvis and sacrum			
Fall with inability to bear weight **K18**	*XR pelvis (I) plus lateral XR hip (I)*	Indicated (C)	Physical examination may be unreliable. Check for femoral neck fractures, which may not show on initial XR, even with good lateral views. In selected cases NM or MRI or CT can be useful when XR normal or equivocal.
Urethral bleeding and pelvic injury **K19**	*Retrograde urethrogram (II)*	Indicated (C)	To show urethral integrity, leak, rupture. Consider cystogram if urethra normal and suspicion of bladder leak.
Trauma to coccyx or coccydynia **K20**	*XR coccyx (I)*	Not indicated routinely (C)	Normal appearances often misleading and findings do not alter management.

Upper limb			
Shoulder injury **K21**	*XR shoulder (I)*	Indicated (B)	Some dislocations present subtle findings. As a minimum, orthogonal views are required. US, MRI and CT arthrography all have a role in soft tissue injury.
Elbow injury **K22**	*XR elbow (I)*	Indicated (B)	To show an effusion. Routine follow-up XRs not indicated in 'effusion, no obvious fracture' (see also Section M). Increasing use of CT and MRI here.
Wrist injury **K23**	*XR wrist (I) NM (II) or MRI (0)*	Indicated (B) Specialised investigation (B)	Scaphoid fractures can be invisible at presentation. Most centres repeat XR at 10–14 days if there are strong clinical signs and initial XR negative. Some departments use CT, NM or MRI to exclude fracture earlier than this. Increasing use of MRI as the only examination.
Lower limb			
Knee injury (fall/blunt trauma) **K24**	*XR knee (I)*	Not indicated routinely (B)	Especially where physical signs of injury are minimal. Inability to bear weight or pronounced bony tenderness, particularly at patella and head of fibula, merit radiography. CT/MRI may be needed where further information is required (see D23).

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Ankle injury **K25**	*XR ankle (I)*	Not indicated routinely (B)	Features which justify XR include: the elderly patient, malleolar tenderness, marked soft tissue swelling and inability to bear weight.
Foot injury **K26**	*XR foot (I)*	Not indicated routinely (B)	Unless there is true bony tenderness. Even then the demonstration of a fracture rarely influences management. Only rarely are XRs of foot and ankle indicated together; both will not be done without good reason. Clinical abnormalities are usually confined to foot or ankle.
Stress fracture **K27**	*XR (I)* *NM (II) or MRI (0)*	Indicated (B) Indicated (B)	Although often unrewarding. Provides a means of early detection as well as visual account of the biomechanical properties of the bone. Some centres use US here.
The Foreign Body (FB)			
Soft tissue injury: FB (metal, glass, painted wood) **K28**	*XR (I)*	Indicated (B)	All glass is radio-opaque; some paint is radio-opaque. Radiography and interpretation may be difficult; remove blood-stained dressings first. Consider US, especially in areas where radiography difficult.

Soft tissue injury: FB (plastic, wood) **K29**	*XR (I)* *US (0)*	Not indicated routinely (B) Indicated (B)	Plastic is not radio-opaque: wood is rarely radio-opaque. Soft-tissue US may show non-opaque FB.
Swallowed FB suspected in pharyngeal or upper oesophageal region ***(for children see Section M)*** **K30**	*XR soft tissues of neck (I)* *AXR (II)*	Indicated (C) Not indicated routinely (B)	After direct examination of oropharynx (where most FBs lodge), and if FB likely to be opaque. Differentiation from calcified cartilage can be difficult. Most fish bones invisible on XR. Maintain a low threshold for laryngoscopy or endoscopy, especially if pain persists after 24 hours (see K33). NB: for possible inhaled FB in children see Section M (M23).
Swallowed FB: smooth and small (e.g. coin) **K31**	*CXR (I)* *AXR (II)*	Indicated (B) Not indicated routinely (B)	The minority of swallowed FBs will be radio-opaque. In children a single, slightly over-exposed, frontal CXR to include neck should suffice. In adults, a lateral CXR may be needed in addition if frontal CXR negative. Majority of FBs that impact, do so at crico pharyngeus. If the FB has not passed (say within 6 days), AXR may be useful for localisation.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Sharp or potentially poisonous swallowed FB: (e.g. battery) **K32**	*AXR (II)*	Indicated (B)	Most swallowed foreign bodies that pass the oesophagus eventually pass through the remainder of the gastrointestinal tract without complication. But location of batteries is important as leakage can be dangerous.
	CXR (I)	Not indicated routinely (B)	Unless AXR negative.
Swallowed FB: large object (e.g. dentures) **K33**	*CXR (I)*	Indicated (B)	Dentures vary in radio-opacity; most plastic dentures are radiolucent. AXR may be needed if CXR negative, as may barium swallow or endoscopy. Lat CXR may be helpful.
Chest			
Chest trauma: minor **K34**	*CXR (I)*	Not indicated routinely (B)	The demonstration of a rib fracture does not alter management.
Chest trauma: moderate **K35**	*CXR (I)*	Indicated (B)	Frontal CXR for pneumothorax, fluid or lung contusion. A normal CXR does not exclude aortic injury and arteriography/CT/MRI should be considered.

Stab injury **K36**	*CXR (I)*	Indicated (C)	PA and/or other views to show pneumothorax, lung damage or fluid. US useful for pleural and pericardial fluid.
Sternal fracture **K37**	*XR lateral sternum (I)*	Indicated (C)	In addition to CXR. Think of thoracic spinal and aortic injuries too.
Abdomen (including kidney). Blunt or stab injury **K38**	*Supine AXR (II) + erect CXR (I)*	Indicated (B)	US valuable for detecting haematoma and possible injury to some organs, e.g. spleen, liver. CT may be needed (see K40–K42).
Renal trauma **K39**	*Imaging*	Indicated (B)	Discuss with radiologist. In agreement with local policy and availability. US often sufficient for minor local injury. Many centres use a limited IVU, merely to ensure normality of contralateral kidney. Some patients with major injury (see below) undergo CT, making IVU unnecessary. Consider renal artery damage, especially in deceleration injuries; arteriography may be needed. NM may be helpful to assess residual function.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Major trauma			
Major trauma — general screen in the unconscious or confused patient **K40**	*C-spine XR (I), CXR (I), pelvis XR (I), CT head (II)*	Indicated (B)	Stabilise patient's condition as a priority. Perform only the minimum XRs necessary at initial assessment. C-spine XR can wait so long as spine and cord suitably protected, but CT C-spine may be combined with CT head. Pelvic fractures often associated with major blood loss. See Head Injury K1–K4.
Major trauma — abdomen/pelvis **K41**	*CXR (I), Pelvis XR (I)* *CT abdo (III)*	Indicated (B) Indicated (B)	Pneumothorax must be excluded. Pelvic fractures which increase pelvic volume often associated with major blood loss. Sensitive and specific, but time-consuming and may delay surgery. CT should precede peritoneal lavage. Increasing interest in the use of US in emergency room to show free fluid plus solid organ-injury.
Major trauma – chest **K42**	*CXR (I)* *CT Chest (III)*	Indicated (B) Indicated (B)	Allows immediate management (e.g. pneumothorax). Especially useful to exclude mediastinal haemorrhage. Low threshold for proceeding to arteriography.

L. Cancer

Many of the clinical problems related to the diagnosis of cancer have already partly been covered within the individual system sections. Brief notes are provided here about the use of imaging in the diagnosis, staging and follow-up of some of the common primary malignancies. Paediatric malignancies are not included as their management is always at specialist level. For breast cancer see Section J. **A CXR is necessary at presentation for most malignant lesions to identify possible pulmonary Metastases. Concern about radiation in diagnostic imaging is generally less relevant in this section. CXR is also part of many follow-up protocols (e.g. testicular lesions). Follow-up investigations to monitor progress (e.g. post-chemotherapy) are often required; some are driven by trial protocols rather than clinical need and thus should be appropriately funded.**

Parotid			
Diagnosis	*US (0)*	Indicated (B)	To establish presence of a mass, particularly in superficial lesions.
L1	*MRI (0) or CT (II)*	Indicated (B)	Useful in the deep portion of the gland and before complex surgery.
Staging **L2**	*MRI (0) or CT (II)*	Indicated (B)	Especially when complex surgery contemplated; to see relations and involvement of deep lobe.
Larynx			
Diagnosis **L3**	*Imaging*	Not indicated routinely (B)	This is a clinical diagnosis.
Staging **L4**	*CT (II) or MRI (0)*	Indicated (B)	MRI has the advantage of direct coronal imaging. MRI will eventually supersede.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Thyroid			
Diagnosis **L5**	*US (0) and NM (I)*	Indicated (A)	See Neck Section B1. US guided core biopsy is increasingly being used, especially for 'cold' nodules on NM.
Staging **L6**	*CT (II) or MRI (0)* *NM (IV)*	Indicated (B) Indicated (B)	To assess local extent (e.g. retrosternal extension and nodes). After thyroidectomy. NM is also used in follow-up when recurrence is suspected.
Lung			
Diagnosis **L7**	*CXR PA and Lat (I)* *CT (III)*	Indicated (B) Indicated (B)	But can be normal, particularly with central tumours. Many centres proceed directly to bronchoscopy which allows biopsy. CT is superior in identifying lesions responsible for haemoptysis.
Staging	*CT chest, upper abdomen (III)*	Indicated (B)	Despite limitations in specificity of nodal involvement, etc. Some centres perform NM for possible skeletal metastases.

	MRI (0)	Specialised investigation (B)	Assists in estimating local invasion of chest wall, particularly for apical and peripheral lesions and mediastinal invasion. Helps distinguish adrenal adenoma from metastasis.
L8	NM (IV)	Specialised investigation (B)	FDG-PET as a single expensive investigation can identify small metastatic foci; may save a lot of other investigations and inappropriate surgery.
Oesophagus			
Diagnosis **L9**	*Barium swallow (II)*	Indicated (B)	Before endoscopy in dysphagia.
Staging	*CT (III)*	Indicated (B)	Despite limitations in sensitivity and specificity of nodal involvement. Simpler than MRI for lung, liver and intra-abdominal nodes.
L10	*Transoesophageal US (0)*	Indicated (A)	Increasing use of transoesophageal US for local staging where available.
Liver: primary lesion			
Diagnosis	*US (0)*	Indicated (B)	The majority of lesions will be identified.
L11	*MRI (0) or CT (III)*	Indicated (B)	If biochemical markers elevated and US negative or liver very cirrhotic. Enhanced MRI and arterial phase CT most accurate in delineating tumour extent.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Staging **L12**	*MRI (0) or CT (III)*	Indicated (B)	MRI probably the optimal investigation in assessing involved segments and lobes. Intra-operative US useful where available.
Liver: secondary lesion			
Diagnosis	*US (0)*	Indicated (B)	US will show the majority of metastases and guides biopsy.
	CT (III) or MRI (0) **L13**	Indicated (B)	When US negative and clinical suspicion high. MRI better for characterising lesions. CT arterial portography is sensitive but not specific, but many now use triple phase spiral CT techniques following intravenous enhancement. CT and MRI often part of other staging and follow-up protocols. Increasing interest in PET for very small metastatic foci.

Pancreas			
Diagnosis **L14**	*Imaging*	Indicated (B)	Much depends on local expertise and body habitus. US usually successful in thin patients; CT better in the more obese. MRI for clarification of problems. Biopsy using US or CT. ERCP or MRCP may also be needed. Endoscopic US, where available, most sensitive. Increasing interest in PET.
Staging **L15**	*CT (III) or MRI (0) abdomen*	Indicated (B)	Especially if radical surgery contemplated. Wide local variation: some centres use angiography, others spiral CT; laparoscopic US also used.
Colon and rectum			
Diagnosis **L16**	*Ba enema (III) or colonoscopy*	Indicated (B)	Much depends on local policy, expertise and availability. See Section G. Increasing interest in CT and MRI of the colon, especially with virtual endoscopic techniques.
Staging **L17**	*US (0)* *CT (II) or MRI (0) abdomen, pelvis*	Indicated (B) Indicated (B)	For liver metastases. Endoluminal US useful for local rectal spread. Local pre-operative staging to assess rectal lesions before pre-operative radiotherapy. Many centres now treat liver secondaries very aggressively, which may necessitate MRI and/or detailed CT. MRI and CT often complementary; both can assess other abdominal spread. Increasing interest in PET here.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Recurrence	*US (0) liver*	Indicated (B)	For liver metastases. Some debate about the value of routine US follow-up in asymptomatic patients.
	CT (III) or MRI (0) abdomen, pelvis	Indicated (B)	For liver metastases and local recurrence.
L18	NM (IV)	Specialised investigation (B)	PET and monoclonal antibodies can identify liver metastases and local recurrence.
Kidney			
Diagnosis **L19**	*US (0)*	Indicated (B)	See Renal Mass H7.
Staging	*CT (III) or MRI (0) abdomen*	Indicated (B)	For local extent, venous, nodal and ureteric involvement, opposite kidney etc.
	CT (III) Chest	Not indicated routinely (B)	The presence of lung metastases does not usually influence management.
L20	*NM (I)*	Specialised investigation (C)	Conventional NM can assess contralateral function. Increasing interest in PET.

Recurrence **L21**	*CT (III) abdomen*	Indicated (B)	For symptoms suggesting relapse around nephrectomy bed. Routine follow-up not recommended.
Bladder			
Diagnosis **L22**	*Imaging*	Not indicated routinely (B)	Cystoscopy is the optimal (although not infallible, e.g. diverticulum) investigation.
Staging **L23**	*IVU (II)*	Indicated (B)	To assess kidneys and ureters for further urothelial tumours.
	CT (III) or MRI (0) abdomen and pelvis	Indicated (B)	When radical therapy contemplated. MRI is probably more sensitive. CT widely used for radiotherapy planning.
Prostate			
Diagnosis **L24**	*Transrectal US (0)*	Indicated (B)	Some variation according to local availability and expertise. Transrectal US is widely used together with guided biopsies. Some interest in MRI and PET here.
Staging **L25**	*MRI (0)/CT (III) pelvis,*	Specialised investigation (B)	Some variation in range of investigative and therapeutic policies. Staging continued into the abdomen when pelvic disease found.
	NM (II)	Indicated (A)	To assess skeletal metastases, when PSA is significantly elevated.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Testicle			
Diagnosis **L26**	*US (0)*	Indicated (B)	Especially when clinical findings equivocal or normal.
Staging **L27**	*CT (III) chest, abdomen, pelvis*	Indicated (B)	Management now depends heavily on accurate radiological staging. Increasing interest in PET.
Follow-up	*CT (III) abdomen*	Indicated (B)	Some centres still routinely examine the chest as well, especially for patients without biochemical evidence of disease. Some debate as to whether whole pelvis is needed at follow-up unless there are identified risk factors.
L28	NM (IV)	Specialised investigation (C)	PET can assess viability of residual masses.
Ovary			
Diagnosis **L29**	*US (0)*	Indicated (B)	The majority of lesions are diagnosed by US (including TV with Doppler), laparoscopy or laparotomy. Some are identified by CT/MRI investigations for abdominal symptoms. MRI useful for elucidating problems.

Staging **L30**	*CT (III)/MRI (0) abdomen, pelvis*	Specialised investigation (B)	Many specialists require CT or MRI in addition to staging by laparotomy. CT is still more widely available.
Follow-up **L31**	*CT (III) abdomen, pelvis*	Specialised investigation (B)	Usually to assess response to adjuvant therapy. Also used, along with markers, to detect relapse.
Uterus: cervix			
Diagnosis **L32**	*Imaging*	Not indicated routinely (B)	Usually a clinical diagnosis. MRI may assist in complex cases.
Staging **L33**	*MRI (0) or CT (III) abdomen and pelvis*	Indicated (B)	MRI provides better demonstration of tumour and local extent. Also better for pelvic nodes. Para-aortic nodes and ureters must also be examined. Some centres now use transrectal US for local invasion.
Relapse **L34**	*MRI (0) or CT (III) abdomen and pelvis*	Specialised investigation (B)	MRI provides better information in the pelvis. Biopsy (e.g. of nodal mass) easier with CT.
Uterus: body			
Diagnosis **L35**	*US (0) or MRI (0)*	Indicated (B)	MRI can give valuable information about benign and malignant lesions.
Staging **L36**	*MRI (0) or CT (III)*	Specialised investigation (B)	Both CT and MRI can show extra-uterine disease. But MRI can also demonstrate intra-uterine anatomy.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Lymphoma			
Diagnosis	*CT (III)*	Indicated (B)	CT good at evaluating nodal sites throughout the body. Also allows biopsy although excision of whole node preferable where possible.
L37	*NM (III)*	Specialised investigation (B)	NM (gallium) can show foci of occult disease (e.g. mediastinum). PET used in some centres.
Staging **L38**	*CT (III) chest, abdomen, pelvis*	Indicated (B)	Depending on site of disease, head and neck may also need to be examined. Increasing interest in PET here.
Follow-up	*CT (III) or MRI (0)*	Indicated (B)	Increasing role for MRI in long term follow-up and residual masses.
L39	*NM (III)*	Specialised investigation (B)	Consider NM for gallium positive disease. Some centres use PET.

Musculoskeletal tumours			
Diagnosis **L40**	*XR (I) + MRI (0)*	Indicated (B)	Imaging and histology complementary. Best before biopsy: See Musculoskeletal Section D. NM needed to ensure that lesion is solitary.
Staging **L41**	*MRI (0) local disease + CT chest (III)*	Specialised investigation (C)	See Musculoskeletal Section D. CT for lung metastases.
Metastases from unknown primary tumour			
Diagnosis of primary lesion **L42**	*Imaging*	Not indicated routinely (C)	Rarely beneficial. Some exceptions for specialists, younger patients or favourable histology.
Breast — see Section J			

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
M. Paediatrics			
Minimise x-irradiation in children, especially those with long term problems			
(for head injury in children see Trauma Section K)			
CNS			
Congenital disorders **M1**	*MRI (0)*	Indicated (C)	Definitive exam for all malformations and avoids x-irradiation. Sedation usually required for young children. Consider US in neonates. 3D CT may be needed for bone anomalies.
Abnormal head appearance — hydrocephalus — odd sutures **M2**	*US (0)* *SXR (I)*	Indicated (B) Specialised investigation (C)	US indicated where anterior fontanelle is open. Where sutures are closed/closing. MRI indicated for older children. (CT may be appropriate if MRI not available.)
Epilepsy **M3**	*SXR (I)* *MRI (0) or NM (II)*	Not indicated routinely (B) Specialised investigation (B)	Poor yield. MRI usually more appropriate than CT. Ictal and inter-ictal SPECT also used to identify focus before surgery.

Deafness in children **M4**	*CT (II)* *MRI (0)*	Specialised investigation (C)	Both CT and MRI may be necessary in children with congenital and post-infective deafness.
Hydrocephalus —shunt malfunction (see A10) **M5**	*XR (I)* *US (0) or MRI (0)*	Indicated (B) Indicated (B)	XR should include whole valve system. US if practical, MRI in older children (or CT if MRI unavailable). NM used to evaluate shunt function.
Developmental delay — cerebral palsy **M6**	*Cranial MRI (0)*	Specialised investigation (B)	See also M15 for skeletal investigation of growth failure.
Headaches **M7**	*SXR (I)* *MRI (0) or CT (II)*	Not indicated routinely (B) Specialised investigation (B)	If persistent or associated with clinical signs refer for specialised investigations. In children MRI is preferable if available because of absence of x-irradiation. See also A6 for possible meningitis and encephalitis
Sinusitis see also A13 **M8**	*Sinus XR (I)*	Not indicated routinely (B)	Not indicated before 5 years as the sinuses are poorly developed; mucosal thickening can be a normal finding in children. A single under-tilted OM view may be more appropriate than the standard OM view depending on the child's age.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Neck and spine — For trauma see Section K			
Torticollis without trauma **M9**	*XR (I)*	Not indicated	Deformity is usually due to spasm with no significant bone changes. If persistent, further imaging (e.g. CT) may be indicated following consultation.
Back or neck pain **M10**	*XR (I)*	Indicated (B)	Back pain is uncommon in children without a cause. Follow-up is needed if infection is suspected.
	NM (II)	Specialised investigation (B)	When pain continues and XRs are normal. Useful in painful scoliosis.
	MRI (0)	Specialised investigation (B)	See also The Spine Section C. MRI defines spinal malformations and excludes associated thecal abnormality. MRI can also demonstrate juvenile disc lesions.
Spina bifida occulta **M11**	*XR (I)*	Not indicated routinely (B)	A common variation and not in itself significant (even in enuresis). However, neurological signs would require investigation.
Hairy patch, sacral dimple	*XR (I)*	Not indicated routinely (B)	May be helpful in older children.

	US (0)	Indicated (B)	US may be useful in the neonatal period to screen for underlying tethered cord, etc.
M12	*MRI (0)*	Specialised investigation (B)	MRI particularly if neurological signs are present.
Musculoskeletal			
Non accidental injury — child abuse (for head injury see Section K)	*XR (I) of affected parts*	Indicated (B)	Local policies will apply; close clinical/radiological liaison essential. Skeletal survey for those under two years after clinical consultation. May occasionally be required in the older child. CT/MRI of brain may be needed, even in the absence of cranial apparent injury.
M13	*NM (II)*	Indicated (B)	Sensitive for occult spine/rib fracture.
Limb injury: opposite side for comparison **M14**	*XR (I)*	Not indicated routinely (B)	Seek radiological advice.
Short stature, growth failure **M15**	*XR (I) for bone age*	Indicated at appropriate intervals (B)	2–18 yrs: left (or non-dominant) hand/wrist only. Premature infants and neonates: knee (specialised investigation). May need to be supplemented with a skeletal survey and MRI for hypothalamus and pituitary fossa (specialised investigations).

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Irritable hip **M16**	*US (0)*	Indicated (B)	US will delineate effusions which can be aspirated for diagnostic and therapeutic purposes. XRs can be delayed, but should be considered when the symptoms are persistent. Consider NM or MRI when Perthes' disease is suspected and plain XRs are normal.
Limp **M17**	*XR pelvis (I)*	Indicated (C)	Gonad protection is used routinely unless shields will obscure area of clinical suspicion. If slipped epiphyses is likely, lateral XRs of both hips are needed.
	US (0) or NM (II) or MRI (0)	Specialised investigation (B)	According to local policy, expertise and availability.
Focal bone pain **M18**	*XR (I) and US (0)*	Indicated (B)	XR may be normal initially. US can be helpful particularly in osteomyelitis.
	NM (II) or MRI (0)	Specialised investigation (B)	Increasing use of MRI here.
Clicking hip — dislocation **M19**	*US (0)*	Indicated (B)	XR may be used to supplement US examination or where expertise is not available. XR indicated in the older infant.

Osgood–Schlatter's disease **M20**	*XR knee (I)*	Not indicated routinely (C)	Although bony radiological changes are visible in Osgood–Schlatter's disease these overlap with normal appearances. Associated soft tissue swelling should be assessed clinically rather than radiographically.
Cardiothoracic			
Acute chest infection **M21**	*CXR (I)*	Not indicated routinely (B)	Initial and follow-up films are indicated in the presence of persisting clinical signs or symptoms or in the severely ill child. Consider the need for CXR in fever of unknown origin. Children may have pneumonia without clinical signs.
Recurrent productive cough **M22**	*CXR (I)*	Not indicated routinely (C)	Children with recurrent chest infection tend to have normal CXRs (apart from bronchial wall thickening). Routine follow-up CXR not indicated unless collapse present on initial CXR. Suspected cystic fibrosis requires specialist referral.
Inhaled FB (suspected) (see Section K) **M23**	*CXR (I)*	Indicated (B)	History of inhalation often not clear. Bronchoscopy is indicated, even in the presence of a normal CXR. NM/CT may be helpful to show subtle air trapping. Wide variation in local policy about expiratory films, fluoroscopy, CT and NM (ventilation scintigraphy).

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Wheeze **M24**	*CXR (I)*	Not indicated routinely (B)	Children with asthma usually have normal CXR apart from bronchial wall thickening. Sudden unexplained wheeze CXR indicated, may be due to inhaled FB (above).
Acute stridor **M25**	*XR neck (I)*	Not indicated routinely (B)	Epiglottitis is a clinical diagnosis, but consider FB (above).
Heart murmur **M26**	*CXR (I)*	Not indicated routinely (C)	Specialist referral may be needed; cardiac US often may be indicated.
Gastrointestinal — ***see also Section G for more general abdominal problems***			
Intussusception **M27**	*AXR (II)*	Indicated (C)	Local policies require close paediatric, radiological and surgical liaison. Where expertise is available, both US and contrast enema (air or barium) can confirm diagnosis and guide reduction.
	Further imaging	Specialised investigation (B)	

Swallowed FBs ***(see Section K)*** **M28**	*AXR (II)* *CXR (I) (including neck)*	Not indicated routinely (C) Indicated (C)	Except for sharp or potentially poisonous FBs, e.g. batteries. See Section K. If there is doubt whether the FB has passed, an AXR after 6 days may be indicated. If there is doubt whether the FB has passed, an AXR after 6 days may be indicated.
Minor trauma to abdomen **M29**	*AXR (II)*	Not indicated routinely (C)	US may be used as initial investigation but CT is more specific, particularly in visceral trauma. XRs may show bone injury in severe trauma. The principles for the investigation of major trauma in children similar to those in adults (see Major Trauma, K40–K42).
Projectile vomiting **M30**	*US (0)*	Indicated (A)	US can confirm the presence of hypertrophic pyloric stenosis, especially where clinical findings are equivocal.
Recurrent vomiting **M31**	*Upper GI contrast study*	Not indicated routinely (C)	This symptom covers a wide range from obstruction in the neonatal period to reflux, posseters and children with migraine. US may be helpful to confirm malrotation. However, upper GI contrast studies may be indicated to exclude malrotation even with normal abdominal XR. Contrast studies in neonates should be undertaken as a specialised investigation. Consider NM for gastric emptying and gastro-oesophageal reflux.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Persistent neonatal jaundice **M32**	*US (0)* *NM (II)*	Indicated (B) Indicated (B)	Early (< 10 weeks) and prompt investigation is essential. The absence of dilatation in the intrahepatic bile duct does not exclude an obstructive cholangiopathy.
Rectal bleeding **M33**	*NM (II)*	Specialised investigation (B)	If Meckel's diverticulum is a possibility do NM first. Small bowel contrast studies may also be necessary. NM also useful in investigation of inflammatory bowel disease. Endoscopy is preferable to Ba enema for assessment of polyps and inflammatory bowel disease. US can be used to diagnose duplication cysts.
Constipation **M34**	*AXR (II)* *Contrast enema*	Not indicated routinely (C) Not indicated routinely (B)	Many normal children show extensive faecal material; impossible to assess significance of radiological signs. But AXR can help specialists in refractory cases. If Hirschsprung's disease is suspected, specialist referral plus biopsy is preferred to radiological studies.
Palpable abdominal/ pelvic mass **M35**	*US (0) and AXR (II)*	Indicated (B)	If malignancy is suspected, further imaging should be performed in a specialised centre.

Uroradiology

Enuresis **M36**	*Imaging*	Not indicated routinely (B)	US and urodynamic studies may be needed in cases of persistent enuresis.
Continuous wetting **M37**	*US (0)* *IVU (II)*	Indicated (B) Indicated	Both examinations may be needed to evaluate duplex system with ectopic ureter.
Impalpable testis **M38**	*US (0)*	Indicated (B)	To locate inguinal testis. MRI may be helpful to locate an intra-abdominal testis, but increasingly laparoscopy is the investigation of choice.
Antenatal diagnosis of urinary tract dilatation **M39**	*US (0)*	Indicated (B)	Local protocols should be established. Mild dilatation can normally be monitored by US. Low threshold for specialist referral.

CLINICAL PROBLEM	INVESTIGATION {DOSE}	RECOMMENDATION {GRADE}	COMMENT
Proven urinary tract infection **M40**	*Imaging US (0) //NM (II)/ cystography (III)*	Specialised investigations (C)	There is wide variation in local policy. Much depends on local technology and expertise. Most patients should remain on prophylactic antibiotics pending the results of investigations. The age of the patient also influences decisions. There is much current emphasis on minimising radiation dose; hence AXR is not indicated routinely (calculi rare). Expert US is the key investigation in all imaging strategies at this age. Thereafter NM provides data about renal structure (DMSA) and has virtually replaced the IVU here. NM will establish function, exclude obstruction and can also be used for cystography (direct or indirect) to show reflux. Formal direct XR cystography is still needed in the young (e.g. < 2 yrs) male patient where delineation of the anatomy (e.g. urethral valves) is critical.

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Appendix

List of bodies involved in the consultation exercise for the 1998 UK RCR guidelines

Royal Colleges, etc

Academy of Medical Royal Colleges
Faculty of Accident and Emergency Medicine
Faculty of Dental Surgery, RCS
Faculty of Clinical Oncology, RCR
Faculty of Occupational Medicine
Faculty of Public Health Medicine
Royal College of Anaesthetists
Royal College of General Practitioners
Royal College of Paediatrics and Child Health
Royal College of Physicians of London
Royal College of Physicians and Surgeons of Glasgow
Royal College of Physicians of Edinburgh
Royal College of Physicians of Ireland
Royal College of Psychiatrists
Royal College of Obstetricians and Gynaecologists
Royal College of Ophthalmologists
Royal College of Pathologists
Royal College of Surgeons of Edinburgh
Royal College of Surgeons of England
Royal College of Surgeons of Ireland

Other organisations

British Institute of Radiology
British United Provident Association
Medical Defence Union
Medical Protection Society
National Radiological Protection Board
The Patients' Association

Speciality groups

Association of Chest Radiologists
British Society of Nuclear Medicine
British Society of Gastroenterology
British Society of Interventional Radiology
British Society of Neuroradiologists
British Medical Ultrasound Society
British Society of Skeletal Radiologists
Dental Radiology Group

Paediatric Radiologists
Magnetic Resonance Radiologists Association UK
RCR Cardiac Group
RCR Breast Group
RCR Clinical Directors' Group
RCR Interventional Radiology Sub-Committee
RCR Nuclear Medicine Sub-Committee
RCR Paediatric Group
RCR/RCOG Standing Committee on Obstetric US
RCR/RCP Standing Committee on Nuclear Medicine
UK Children's Cancer Study Group
UK Neurointervention Group

The adaptation of the 1998 UK RCR guidelines into EU 2000 referral criteria was performed in consultation with:

European Association of Nuclear Medicine
European Association of Radiology
Union of European Medical Specialists

European Commission

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