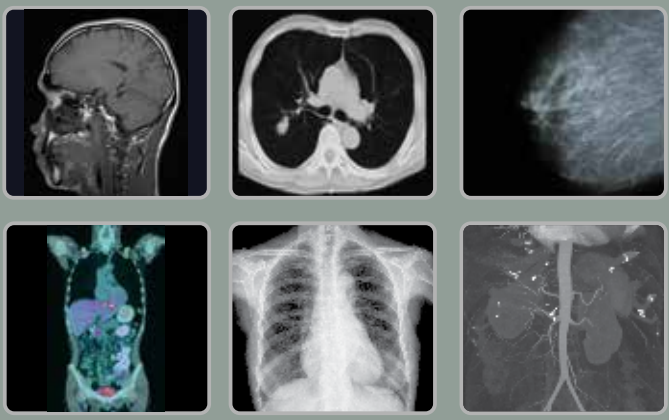
Ministry of Health Malaysia

COLLEGE OF RADIOLOGY
Academy of Medicine of Malaysia

Guidelines for Clinical Practice in Radiology

Second Edition

2017



MESSAGE FROM DIRECTOR GENERAL OF HEALTH

Datuk Dr Noor Hisham Abdullah
Director General of Health Malaysia.

There has been tremendous development in medical imaging technology in Radiology today. As the progress in clinical imaging has been phenomenal in the recent years, the 2nd edition of the Guidelines for Clinical Practice in Radiology was launched as a continuous effort to provide assistance to clinicians in selecting appropriate modalities in various clinical settings.

These evidence-based guidelines were formulated keeping in mind established practices in Malaysian context and are intended to guide practicing clinicians in arriving at the best possible solution to a given clinical problem. In our routine practice, good communication and discussion between radiologists and clinicians prior to effective utilisation of the various modalities in imaging, taking into consideration the risk from ionising radiation, is the best possible way in managing patients. However, shortfall in effective communication may happen in the process.

Thus, The International Commission of Radiological Protection (ICRP) recommends that the radiological examinations should be selected carefully and carried out only if the information obtained from such examinations is the most appropriate in arriving at the diagnosis. This approach of diagnostic imaging will be justified to the patients and lead to a more accurate diagnosis, less harm from radiation and cost-effective.

Nevertheless, these guidelines cannot replace the good communication among the clinicians and radiologists, and the best outcome will be achieved by adhering to these practices. I would like to thank the radiologists and clinicians from various disciplines who have come together to ensure that these guidelines will be implemented in line with our local settings and available resources in Malaysia.

Adhering to these guidelines will ensure that best practices in Radiology are achieved, and unnecessary exposure to ionising radiation is avoided. Hence, healthcare services provided to the patients in our country will be optimised.

Datuk Dr Noor Hisham Abdullah

MESSAGE FROM THE PRESIDENT OF CoR

Dr Amir Fuad Hussain
President (2016–2018)
College of Radiology,
Academy of Medicine of Malaysia.

The practice of radiology, in tandem with the practice of clinical medicine, has progressed tremendously and will continue to do so. With this progress, practices that were common then or previously may have become obsolete now or its role in the management of patients may have changed with the current practices.

Imaging and interventional techniques that were once considered advanced and performed at national referral centres or state hospitals are now commonly performed at even minor specialist hospitals with radiologists.

There are many similar guidelines available that have been produced in other parts of the world.

This document, however, aims to provide a guide and to assist clinicians based on current accepted practices and also available resources available in Malaysia.

With all these factors in mind, a move to review the Guidelines for Clinical Practice in Radiology was initiated.

On behalf of the College of Radiology, Academy of Medicine of Malaysia, I would like to congratulate the team of Malaysian radiologists from the public and private centres, as well as other clinical specialists from various disciplines, for their endless support and on a job well done.

With this document, it is hoped that the utilisation of radiology services in Malaysia will be more streamlined to reduce unnecessary examinations while ensuring that the management of patients is not compromised.

Dr Amir Fuad Hussain

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1. WHAT ARE THE GUIDELINES?

INTRODUCTION

There has been a tremendous advancement in medical imaging technology in recent years that has revolutionised every aspect of medicine. With such rapid progress in imaging technology and clinical practices, the College of Radiology (CoR), Academy of Medicine, Malaysia is launching the 2nd edition of the Guidelines for Clinical Practice in Radiology. These guidelines were adapted from the seventh edition of Royal College of Radiology UK incorporating the Malaysian clinical practice guidelines (CPG) where applicable. Radiologists from the subspecialty groups in the College of Radiology, together with the clinicians from the various clinical disciplines reviewed these guidelines to ensure current best practices are being followed, considering the local Malaysian settings and the available resources. The CoR hopes these guidelines will assist clinicians, radiologists, radiographers and other healthcare professionals to determine the most appropriate imaging procedure for a wide range of clinical problems. Practical guidance is based on the best available evidence, together with expert consensus for clinical applicability.

The role of the radiologists (or radiographers acting as radiological practitioners) in justifying the examination/procedure remains paramount and is dependent on the components of each clinical case. These guidelines should direct the clinician to the best possible way to solve a clinical problem while taking into consideration the small but appreciable risk from ionizing radiation. However, guidelines will never replace good communication and discussion between the radiologists and referring clinicians. Guidelines work best if they are used as part of the clinical-radiological dialogue and clinical audits.

The CoR would like to thank Dr Shantini Arasaratnam and Dr Noraini Abdul Rahim for their effort and significant contributions in the preparation of this guidelines.

A special thanks to Professor Ng Kwan Hoong for his guidance, support and encouragement in accomplishing these guidelines.

WHY ARE GUIDELINES NEEDED?

A useful investigation is one in which the result, be it positive or negative, will inform clinical management and/or add confidence to the clinician's diagnosis. A significant number of radiological investigations do not fulfil these aims and may add unnecessary patient irradiation. In order to avoid the wasteful use of radiology, the important questions to be asked are as follows:

1. HAS IT BEEN DONE ALREADY? Repeating investigations that have already been done: for example, investigations carried out at another hospital or in the emergency department. Every attempt should be made to obtain previous images and reports. Transfer of digital data through electronic links will assist in this respect. Although guidelines may not directly address this question, there are other initiatives that do.

2. DO I NEED IT? Undertaking investigations when results are unlikely to affect patient management or over investigating: because the anticipated positive finding is usually irrelevant- eg,degenerative spinal disease or because a positive finding is unlikely. Some clinicians and patients tend to rely on investigations more than others for reassurance.

3. DO I NEED IT NOW? Investigating too early: for example, before the disease could have progressed or resolved, or before the result could influence treatment. The need for investigation and treatment should be reviewed at a more appropriate time.

4. IS THIS THE BEST INVESTIGATION? Doing the wrong investigation: Imaging techniques undergo rapid change. It is often helpful to discuss an investigation with a specialist in clinical radiology or nuclear medicine before it is requested.

5. HAVE I EXPLAINED THE PROBLEM: Failing to provide appropriate clinical information and questions that the imaging investigation should answer: deficiencies here may lead to the use of the wrong technique or the report being poorly focused on the clinical problem.

Few guidelines have been formulated such as; The Management of Breast Cancer (2010), Consensus Statement on the Utilisation of Cardiac Computed Tomography (2015).

Clinical practice guidelines are defined as:

"Systematically developed statement to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances".

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 non-adherence, no set of recommendations will command universal support or be applicable in all circumstances and you should discuss any problems with your radiologist. All imaging departments should have protocols for each common clinical situation. The aim for all examinations should be to obtain maximum clinical information with minimum radiation exposure.

WHO ARE THE GUIDELINES FOR?

These guidelines will be of particular use to general practitioners (GPs) and referring clinicians including family medicine specialists. Guidelines may also be of use to health organisations to facilitate planning and to some patients who may need reassurance that the investigation requested by their doctor is appropriate. They are useful in both primary and secondary care and will assist in ensuring that imaging strategies are broadly similar nationally in public hospitals and private centres. They aim to promote the best use of imaging for the benefit of patients, minimise radiation dose and assist in the equitable use of expensive machinery, staff and other resources.

WHAT EVIDENCE INFORMS THE GUIDELINES?

Clarification of evidence levels for diagnostic studies has been based on the levels of evidence for primary research adapted from the Oxford Centre for Evidence-Based Medicine and *The Journal of Bone and Joint Surgery (Table 1)*.

Recommendations have been graded according to evidence levels. Grading is adapted from the Oxford Centre for Evidence-Based Medicine and based on the system originally developed by the US Department of Health and Human Services, Agency for Healthcare Policy and Research (now the Agency for Healthcare Research and Quality). The highest level of evidence relevant to the clinical problem has been used to determine the grade of recommendation. In many instances, a grade B or C reflects the supporting evidence base rather than the importance of these recommendations to the clinical problem addressed.

These grades are as follows:

(A) Any of the following

- High-quality diagnostic studies in which a new test is independently and blindly compared with a reference standard in an appropriate spectrum of patients
- Systematic reviews and meta-analyses of such high-quality studies

(B) Any of the following

- Studies with a blind and independent comparison of the new test with reference standard in a set of nonconsecutive patients or confined to a narrow spectrum of patients
- Studies in which the reference standard was not applied to all patients
- Systematic reviews of such studies

(C) Any of the following

- Studies in which the reference standard was not objective
- Studies in which the comparison of the new test with the reference standard was not blind or independent
- Studies in which positive and negative test results were verified using different reference standards
- Expert opinion

In some clinical situations, there are conflicting data within a large body excellent scientific reports. Thus, no firm recommendations are given and the evidence is graded C. It should be noted that there are very few randomised, controlled trials that compare different radiological procedures – they are difficult to perform and ethical approval may be denied. Assignment of evidence levels and grading of recommendation differ somewhat from those proposed by Grading of Recommendations Assessment, Development and Evaluation GRADE Working Group as supporting evidence is generally not from therapeutic studies but from diagnostic studies for which a Thornbury hierarchy may be more relevant.

Table 1: Levels of evidence

Type of study	Therapeutic studies- investigating the results of treatment	Prognostic studies – investigating the effect of a patient characteristic on the outcome of disease		Diagnostic studies – investigating a diagnostic test	Economic and decision analyses – developing an economic or decision model
Level I	High-quality randomised controlled trial with statistically significant difference or no statistically significant difference but narrow confidence intervals	High-quality prospective study (all patients were enrolled at the same point in their disease with ≥80% follow-up of enrolled patients) -Systematic review of level-I studies		Testing of previously developed diagnostic criteria in series of consecutive patients (with universally applied reference gold standard) -Systematic review of level-I studies	Sensible costs and alternatives; values obtained from many studies; multiway sensitivity analyses - Systematic review of level-I studies
	-Systematic review of level-I randomised controlled trials (and study result were homogeneous)				
Level II	Lesser-quality randomised controlled trial (e.g., <80% follow-up, no blinding, or impact randomisation) -Prospective comparative study -Systematic review of level-	Retrospective study Untreated controls from a randomised controlled trial -Lesser-quality prospective study (e.g., patients enrolled at different points in their disease or <80% follow-up) -Systematic review of level-II studies		Development of diagnostic criteria on basis of consecutive patients (with universally applied reference gold standard) -Systematic review of level-II studies	Sensible costs and alternatives; values obtained from limited studies; multiway sensitivity analyses -Systematic review of level-II studies
Level III	Case-control study -Retrospective comparative study -Systematic review of level-III studies	Case-control study		Study of non-consecutive patients (without consistently applied reference gold standard) -Systematic review of level-III studies	Analyses based on limited alternatives and costs; imperfect estimates -Systematic review of level-III studies
Level IV	Case series	Case series		-Case–control study -Poor reference standard	No sensitivity analyses
Level V	Expert opinion	Expert opinion		Expert opinion	Expert opinion

a. A combination of result from two or more earlier studies.

b. Studies provided consistent results.

c. The study was started before the first patient enrolled.

d. Patients treated one way compared with patients treated another way at the same institution.

e. The study was started after the first patient enrolled.

f. Patients identified for the study on the basis of their outcome, called cases, are compared with those who did not have the outcome, called controls.

g. Patients treated one way with no comparison group of patients treated another way.

This table has been adapted, with permission, from the Oxford Centre for Evidence-Based Medicine (http://www.cebm.net/index.aspx?o=1025) and from the *Journal of Bone and Joint Surgery (http://www.jbjs.org/).*

These guidelines are designed to assist the referrers in selecting the most appropriate investigation for a given diagnostic or imaging problem.

The guidelines are divided into 12 sections:

Breast Disease	B
Cancer	CA
Chest and Cardiovascular system	CC
ENT/Head and Neck	E
Gastrointestinal system	G
Interventional Radiology	I
Musculoskeletal system	M
Neurological system	N
Obstetrics and Gynaecology	OG
Paediatrics	P
Trauma	T
Urogenital and Adrenal	U

Each section sets out the clinical scenario and lists relevant investigation with an indication of the associated radiation dose. For each investigation, there is a recommendation on its appropriateness (together with the grade). Finally, an explanatory comment is included when required to clarify the circumstances in which the investigation should be used.

The recommendations used are:

1. **Indicated**
   Investigations most likely to contribute to the clinical diagnosis and management.

2. **Specialised investigation**
   Specialised investigations are frequently complex, time-consuming and/or resource-intensive and will usually only be undertaken after discussion with the radiologist or according to locally agreed protocols.

3. **Indicated only in specific circumstances**
   Non-routine investigations, usually only undertaken if a clinician provides strong evidence or if the radiologist believes the examination represents an appropriate means of furthering the diagnosis and management of the patient. With certain clinical problems that may resolve with time, it may be correct to defer the investigation.

4. **Not indicated**
   Investigations for which the proposed rationale is no longer appropriate.

3. JUSTIFYING AND OPTIMIZING RADIATION DOSE

The use of radiological investigations is an accepted part of medical practice justified in term of clear clinical benefits to the patient, which should far outweigh the small radiation risks.

Although the doses from diagnostic radiology examinations are generally low, the magnitude of the practice can potentially cause a significant radiation impact. Because ionising radiation can cause damage to DNA, exposure can increase a person's lifetime risk of developing cancer. Hence, even low radiation doses are not entirely without risk and the need to keep radiation dose as low as reasonably achievable (ALARA), both for patients and staff occupationally exposed to radiation, remains of paramount importance.

Managing the risks of radiological examinations depends on two principles of radiation protection: appropriate justification for ordering and performing each investigation, and optimisation of the radiation dose. Optimisation of radiation dose is of greatest concern for examinations performed on paediatric patients. This is because paediatric patients are more sensitive to radiation and their younger age means that the potential detriment to this group is greater.

The use of ionising radiation is subject to the Atomic Energy Licensing Act 1984 (Act 304). The requirements to ensure that all exposures to ionising radiation are justified and that doses are optimised are detailed out in the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 (BSRP 2010). Organisations and individuals using ionising radiation must comply with these regulations.

One important means of reducing the radiation dose is to avoid undertaking procedures unnecessarily (especially repeat examinations). BSRP 2010 also introduces the concept of diagnostic guidance levels/diagnostic references levels (DRLs).

The DRLs is recommended for use as a guide for medical exposure to avoid unnecessarily high doses to the patient. In 2013, the Ministry of Health Malaysia (MOH) prepared the "Malaysian Diagnostic Reference Level in Medical Imaging (Radiology)". The aim of this document is to serve as a guide for all public hospitals and private centres in carrying out radiological investigations.

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 on its relative sensitivity to radiation-induced cancer or severe hereditary effects. It thus provides a single dose estimate related to the total radiation risk, based on the dose distribution within the body (Table 2).

Typical effective doses for some common diagnostic radiology procedures range over a factor of about 1,000 from the equivalent of 1–2 days of background radiation (e.g., 0.015 mSv for a chest radiograph) to several years (e.g., for CT of

Table 2: Typical effective doses from diagnostic medical exposure

Diagnostic Procedure	Typical Effective Dose (mSv)	Equivalent Number of Chest X-Rays	Approx. Equivalent Period of Natural Background Radiation
Radiographic examination			
Limbs and joints (except hip)	<0.01	<1	<2 days
Chest (single PA)	0.015	1	2.5 days
Skull	0.07	5	12 days
Thoracic spine	0.4	30	2 months
Lumbar spine	0.6	40	3 months
Mammography (2-view)	0.5	35	3 months
Pelvic	0.3	20	1.5 months
Abdominal	0.4	30	2 months
IVU	2.1	140	11.5 months
Barium swallow	1.5	100	8 months
Barium meal	2	130	11 months
Barium enema	2.2	150	1 year
CT head	1.4	90	7.5 months
CT chest	6.6	440	3 years
CT KUB (for renal stone)	5.5	370	2.5 years
CT abdomen	5.6	370	2.5 years
Ct abdomen and pelvic	6.7	450	3 years
CT colonography	10	670	4.5 years
CT chest and abdomen and pelvic	10	670	4.5 years

Table 2: Typical effective doses from diagnostic medical exposure

Diagnostic Procedure	Typical Effective Dose (mSv)	Equivalent Number of Chest X-Rays	Approx. Equivalent Period of Natural Background Radiation
Radionuclide studies			
Lung ventilation			
(Tc-99m DTPA aerosol)	0.4	30	9 weeks
Lung perfusion			
(Tc-99m)	1	70	6 months
Renal (Tc-99m)	0.7	50	4 months
Thyroid (Tc-99m)	1	70	6 months
Bone (Tc-99m)	3	200	1.4 years
Dynamic cardiac			
(Tc-99m)	6	400	2.7 years
PET-CT head (F-18 FDG)	7	460	3.2 years
PET-CT body (F-18 FDG)	18	1200	8.1 years

the abdomen). The doses for examinations listed above are based on results done in the UK. Low-dose examinations of the limbs and chest are among the most common radiological procedures, but relatively infrequent high-dose examination such as body CT makes the major contribution to the collective population dose. The doses from some CT examinations are particularly high and the use of CT is still rising. CT contributes at least half of the collective dose from all X-ray equipment and practice. **It is thus particularly important that request for CT is thoroughly justified, taking into account the age and sex of a patient, and those techniques that minimise dose while retaining essential diagnostic information are adopted.** Indeed, it is estimated that the additional lifetime risk of developing fatal cancer attributable to the chest, abdominal and pelvic CT examination in an adult may be as high as one in 2,000. However, the overall risk of cancer in the general population is nearly one in three; the excess risk of a

single CT examination is very small by comparison and should be more than offset by the clinical gain. 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 3).

Table 3: Band classification of the typical doses of ionising radiation from common imaging procedures.

Symbol	Typical Effective Dose (mSv)	Examples	Lifetime Additional Risk of Fatal Cancer/Exam
None	0	US; MRI	0
☢	<1	CXR; XR limb, pelvis, lumbar spines; mammography	<1: 20,000
☢☢	1–5	IVU; NM (e.g. bone); CT head and neck	1: 20,000–4,000
☢☢☢	5.1–10	CT chest or abdomen; NM (e.g. cardiac)	1: 4,000–2,000
☢☢☢☢	≥10	Extensive CT studies, some NM studies (e.g.; some PET-CT)	≥1: 2,000

(key: US= ultrasound; MRI=magnetic resonance imaging; CXR=chest X-ray; XR=X-ray; IVU=intravenous urography; NM=nuclear medicine; CT=computed tomography; PET-CT=positron emission tomography co-registered with CT.)

Cancer risks from radiation vary considerably with age and sex, with higher risks in infants and females. Cancer risks indicated in this table is averaged for adults.

4. COMMUNICATION WITH THE RADIOLOGY SERVICE

Referral for an imaging examination is a request for a clinical opinion usually from a specialist in radiology or nuclear medicine. The opinion should be presented in the form of a report to assist in the diagnosis and future management of a clinical problem.

Requests should be completed accurately and legibly to avoid any misinterpretation. Electronic requesting where available may be valuable in this regard. The referrer's details (full name and MMC Number and NSR Number) must be included. Reasons for the request should be clearly stated and sufficient clinical detail should be supplied to enable the imaging specialist to understand the particular diagnostic or clinical problems to be resolved by the radiological investigation.

In some cases, the best investigation for resolving the problem may be an alternative procedure.

If there is doubt as to whether an investigation is required or which investigation is preferable, an appropriate specialist in radiology or radionuclide imaging should be consulted, and imaging providers must be prepared to discuss the investigation with referrers. Regular clinical-radiological meetings especially in the multidisciplinary team (MDT) setting provide a useful format for such discussion and are considered good practice.

Referrers have a duty of care to ensure that results are followed up. The specialist reporting the imaging investigation must ensure that the report is communicated in a timely fashion consistent with the degree of urgency. Both the referrers and the reporting specialist need to have a system in place so that results are not misplaced. Electronic requesting and reporting systems, where available, are helpful in this context. Patients should be informed as to how and when they will receive the results of their radiological examination.

5. PREGNANCY AND PROTECTION OF THE FOETUS

Irradiation of the foetus should be avoided whenever possible. This includes situations in which the woman herself does not suspect pregnancy. The prime responsibility for identifying such patients lies with the referring clinician, but the radiology staff must also check the pregnancy status of patients before performing the examination (because some time may have elapsed since the clinician completed the request form). Woman of reproductive age presenting for an examination in which the primary beam irradiates the pelvic area (essentially, any ionising irradiation between the diaphragm and the knees), directly or by scatter, or for a procedure involving radioisotopes, should be asked whether they are or may be pregnant. If a patient cannot exclude the possibility of pregnancy, she should be asked if her period is overdue.

If the patient can exclude the possibility of pregnancy, the examination can proceed. The examination can also go ahead where pregnancy cannot be excluded, but the period is not overdue and the investigation carries a relatively low dose to the uterus. However, where pregnancy cannot be excluded, the period is not overdue but the examination carries a high dose, the procedure outlined in the following paragraph should be followed. 'High dose' in this context is defined as any examination falling in the highest dose group resulting in fetal doses of more than about 10 mGy. Typically, the only investigation in this category will be pelvic or abdominal CT, complex fluoroscopy and few nuclear medicine procedures. If the patient is definitely pregnant, or if pregnancy cannot be excluded and the period is 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 may increase the risk to the foetus as well as to the mother. This consideration is especially relevant in the emergency situation. In all cases, if the radiologist and referring clinician agree that irradiation of the pregnant or possible pregnant uterus is clinically justified or is not clinically justified, this decision should be recorded and the patient must be kept fully informed. If it is decided that the irradiation is justified, the radiologist must 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, even at higher doses, is unlikely to justify the greater risks of invasive foetal diagnostic procedures (for example, amniocentesis) or those of termination of the pregnancy. When such inadvertent exposure has occurred, a medical physicist should make an individual risk assessment. The radiologist or referring clinician should discuss the results with the patient.

6. IMAGING TECHNIQUES

COMPUTED TOMOGRAPHY (CT)

Over the last decade, use of computed tomography (CT) has continued to increase steadily. Advances in hardware and software technology have opened up new applications, such as cardiac CT. CT images are reformatted from a volume dataset produced by a rapidly rotating radiograph tube and detectors to produce high-quality images with a resolution of less than 1 mm. CT protocols are optimised according to clinical indication to reduce dose while still providing diagnostic information.

The major drawback of CT is the high radiation dose because CT procedures involve repeated or extended exposure. For example, the effective dose from a CT head is roughly equivalent to the effective dose from 100 chest X-rays (Table 2). However, if the procedure is conducted appropriately, the medical benefits it can provide generally outweigh the risks. Driven by growing indications and improved technology, CT use has increased at a rate of 10% per annum and although only accounting for 11% of procedures utilising ionising radiation, is responsible for 54% of collective dose from all procedures. The use of iterative reconstruction techniques can reduce the dose in CT. The dose may be optimised by use of automatic exposure control devices and low-dose protocols where appropriate. It is essential when requesting CT, appropriate clinical information and a record of previous imaging are available to enable justification of the investigation and optimisation of technique; particularly for children and young adults, alternative imaging with ultrasound or MRI should be considered wherever possible.

Despite these considerations, the benefits of CT generally outweigh any potential risks, and it has a number of major applications:

- Acute trauma: especially to the head and torso
- Oncology: diagnosis, staging and response assessments
- Thoracic imaging: particularly for thromboembolism
- Acute neurological syndromes: especially in stroke management
- Urogenital: for renal colic and haematuria
- Gastrointestinal: CT colonography as an alternative to colonoscopy
- CT-guided biopsies.

Although the use of targeted CT for selective screening in national programmes has benefit, the use of whole-body CT for ‘screening’ of self-presenting asymptomatic subjects is not justified.

INTERVENTIONAL RADIOLOGY (INCLUDING ANGIOGRAPHY AND MINIMAL ACCESS THERAPY)

Image-guided therapies are used to treat the non-vascular and vascular condition. Non-vascular intervention/interventional oncology includes drainage of urinary or biliary systems, drainage of abscess or fluid collections, biopsy of masses or lymph nodes and tumour ablation. Vascular interventional radiology includes procedures for revascularisation (angioplasty/stenting), treating aneurysms (stent grafting), blocking blood vessels (embolisation), to manage haemorrhage (eg, GI bleeding/ post-traumatic haemorrhage) and treating vascular tumours/malformation.

Almost all specialities within a hospital use the interventional radiology (IR) services. The provision of therapies by IR must be considered in terms of clinical appropriateness, local expertise and patient choice. Close collaboration with clinical colleagues and a system for patient information and consent are essential. While the development of management algorithms is encouraged, clinicians are urged to discuss cases with the radiology department. Radiologists, clinicians and patients should agree on treatment, expected risks and outcomes. The interventional radiologist will often oversee the imaging investigation of conditions they manage. In some departments, biopsy and drainage are performed by an interventional radiologist, while in other departments diagnostic radiologists will assume this role. It would be helpful to know:

- Who does what in your hospital?
- Which services are available locally?

Not every hospital will be able to offer every treatment. Consideration should be given to which services are desired and how they should be commissioned, developed and provided. It is also important that the provision of IR service is equitable. Where IR services are not available, there should be formal arrangements with other hospitals that allow patient access to interventional services.

MAGNETIC RESONANCE IMAGING (MRI)

Increasing indication for the use of magnetic resonance imaging (MRI) has led to a substantial increase in the number of MRI units. Since ionising radiation is not used, MRI should be considered in preferences to CT when both investigations could yield similar information. All requests for MRI should be approved by a radiologist or accepted through agreed protocols.

Further points to note

The safety of MRI during the first trimester of pregnancy is uncertain. However, it may well be safer than some of the alternative options. All imaging of pregnant women should be discussed with the radiology department. Contraindication to the use of MRI includes metallic foreign bodies in the orbits, aneurysm clips, pacemakers and cochlear implants. MRI should not be used within six weeks

of implants of any device. Furthermore, MRI will give reduced image quality close to prostheses. Possible contraindications should be discussed with the imaging department well in advance of the proposed investigation. Many recently developed implanted devices are now MRI compatible.

NUCLEAR MEDICINE AND RADIONUCLIDE IMAGING

Nuclear medicine (NM) provides a functional approach to imaging of pathology by combining a physiological agent attached to an isotope – commonly Technetium-99m (TC-99m). Radiation dose is similar to and often less than for comparable anatomical studies (Table 2). Hybrid imaging combines anatomy derived from CT images with functional imaging from the radioisotope and is imaged by dedicated single photon emission computed tomography (SPECT) scanners.

Defining the precise clinical problem and question to be answered on the request form will assist radiologists and nuclear medicine physicians in the selection of the most appropriate procedure. Example of NM procedures includes evaluation of renal scarring and pelvic-ureteric obstruction, cardiac ischaemia, bone metastases and imaging for parkinsonian syndromes.

PET-CT

Hybrid imaging with positron emission tomography (PET) co-registered with CT (PET-CT) combines pathophysiological information with anatomical localisation. PET makes use of short half-life radiopharmaceuticals that decay with positron emission and annihilation producing simultaneous gamma rays at 180 degrees to each other, thus improving signal-to-noise ratio and localisation. Low-dose CT data, obtained during the same examination, are co-registered with positron activity.

The main application of PET-CT is in the staging, follow-up and surveillance of patients with cancer using the glucose analogue 2-(18) fluoro-2-deoxy-D-glucose (FDG). FDG PET-CT identifies the increased glucose metabolism seen in malignant cells compared with non-malignant cells. PET-CT imaging also offers a unique approach to the investigation of brain metabolism and myocardial function. Amino acid turnover can be assessed with carbon-labelled methionine and cellular proliferation with fluorine-labelled thymidine.

PET can only be offered by centres with good access to cyclotron-generated radiopharmaceuticals. The effective radiation dose of an FDG PET-CT body scan (from the base of the skull to pubic symphysis) varies according to CT technique but is approximately 18 mSv. This is associated with small but real risk of developing a second malignancy. This risk needs to be balanced against the benefits of the PET-CT examination.

ULTRASOUND

The absence of ionising radiation, the comparatively low cost of equipment and its portability make the ultrasound (US) the first-choice investigation for a range of clinical conditions. The practice of US extends outside the traditional operators with focused use by clinicians to supplement clinical examination. However, US remains highly operator-dependent and requires skills that take time to acquire. Imaging must be undertaken by trained, experienced operators but even then, perfect images may not be obtained for every patient. Image acquisition may be difficult and images suboptimal in clinically obese patients, in patients with extensive bowel gas and in those who are unable to co-operate.

Technological advances including transient elastography and 3-D imaging have served to extend clinical applications of US and have been reflected in a sustained increase in demand for US imaging. In addition, the central role of US in image-guided biopsy and other interventional techniques has contributed to its growth. The use of image guidance for many procedures is mandatory for safe clinical practice; e.g., line placement and pleural fluid aspiration. Although the increase in US imaging is mainly driven by improved patient care, its growth must still be justified against health economic criteria.

Despite avoiding ionising radiation, US examination should only be requested taking into account the appropriateness of this modality for the clinical condition, the potential health benefit and the suitability of the patient for sonography.

RADIOGRAPHY AND FLUOROSCOPY

Radiography remains the first-line imaging investigation for many conditions, particularly for chest and musculoskeletal problems, especially in cases of suspected fractures. The inherent low dose and relatively low cost mean that for many clinical questions, radiography is the ideal investigation to provide a definitive answer. Radiographic images have the advantage of showing easily recognisable anatomy enabling initial interpretation by appropriately trained clinicians.

Using X-ray image intensification, fluoroscopy enables the production of the real-time video image that is used in a number of clinical applications including diagnostic contrast studies, guidance for intervention and for orthopaedic/urological operations. Fluoroscopy is associated with a higher radiation dose compared to radiography. However, use by appropriately trained operators will avoid high radiation dose, which can result from prolonged fluoroscopic screening.

CONTRAST AGENTS

Intravascular iodinated contrast agents have been used safely in contrast studies, CT and interventional radiology for many years with very few serious reactions (0.004%).

Patients with impaired renal function are at greater risk of an adverse reaction to iodinated contrast agents. Hence the need to inform the radiology department of patient's latest renal profile. Patients with renal impairment (with a serum creatinine level of ≥130 micromol/l as a guide) or for conditions associated with renal impairment, for example, diabetes, congestive heart failure or use of nephrotoxic drugs must be made known to the radiology department or radiologist.

The role of N-acetylcysteine in protecting the kidneys in high-risk patients is not well established but has been applied in some practices.

Gadolinium-based intravenous contrast agents used in MRI are well tolerated and have a good safety record over 25 years. Recent research reveals gadolinium retention in the brain in patients who underwent multiple MRI examinations.

FDA issued a safety alert in 2015 (Prince M, *et al. AJR Am J Roentgenol*. 2011;196: W138–W143; Jung JW, *et al. Radiology* 2012;264:414–422; Dillman JR, *et al. AJR Am J Roentgenol*. 2007;189:1533–1538; *Hunt CH, et al.* AJR Am J Roentgenol.2009;193:1124-1127; Kanda T, *et al. Radiology*. 2014;270:834–841; Mc Donald RJ, *et al. Radiology*. 2015;275:772–782; Kanda T, *et al. Radiology*. 2015;276:228–232; Radbruch A, *et al. Radiology*. 2015;275:783–791; FDA website:http://www.fda.gov/Drugs/DrugSafety/ucm455386.htm)

In cases whereby estimated GFR ≤30 ml/min, contrast for MRI examinations is contraindicated.

Intravenous contrast agents approved for US use are micro-bubbles that are well tolerated.

Oral or enteral contrast agents such as barium sulphate and water-soluble iodinated agents are rarely associated with adverse reactions. Nausea, vomiting and constipation may be reported particularly by those who are dehydrated.

COST OF INVESTIGATIONS

The cost for MRI and CT examinations is usually higher than for the US or plain radiography. The cost of NM investigations depends largely on the radiopharmaceutical used and the complexity of the study. Actual costs of various investigations have not been included for a number of reasons. Costs will vary significantly among providers (public and private) and depend upon techniques employed, consumables, equipment and staff. More importantly, the cost of an examination in isolation does not take into account the diagnostic/therapeutic impact of the study, that is, the effect on other investigations or patient management. Performing the best test first may obviate other unnecessary investigations, guide appropriate management, reduce hospital stay and help to avoid futile interventions, leading to better outcomes.

7. ABBREVIATIONS

Abbreviation	Definition
ACTH	Adrenocorticotropic hormone
AXR	Abdominal radiograph
Ba	Barium
BRCA	Breast cancer susceptibility gene
CAD	Coronary artery disease
CECT	Contrast-enhanced computed tomography
CNS	Central nervous system
CSF	Cerebrospinal fluid
CT	Computed tomography
CTA	Computed tomographic angiography
CTM	Computed tomographic myelography
CTPA	Computed tomography pulmonary angiogram
CVS	Cardiovascular system
CXR	Chest radiograph
DEXA	Dual energy X-ray absorptiometry
DMSA	Dimercaptosuccinic acid
DTPA	Diethylenetriamine penta-acetic acid
DVT	Deep vein thrombosis
ECG	Electrocardiogram
EDTA	Ethylenediamine tetra-acetic acid
EEG	Electroencephalogram
ERCP	Endoscopic retrograde cholangiopancreatography
FDG	F-18-fluorodeoxyglucose
FDG-PET	Positron emission tomography using F-18-fluorodeoxyglucose
FNA	Fine-needle aspiration
FNAC	Fine-needle aspiration cytology
Fp-CIT	Fluoropropyl beta-carbomethoxy-3 beta (4-iodophenyltropane)
GA	General anaesthesia
GCS	Glasgow coma scale
GFR	Glomerular filtration rate
GI	Gastrointestinal
HDU	High dependency unit
HIDA	Hydroxy iminodiacetic acid
HMPAO	Hexamethylpropyleneamine oxime
HRCT	High-resolution computed tomography
HRT	Hormone replacement therapy

IDA	Iminodiacetic acid
IN	Indium
ITU	Intensive therapy unit
IUCD	Intrauterine contraceptive device
IV	Intravenous
IVU	Intravenous urography
LUTS	Lower urinary tract symptoms
MAG3	Mercaptoacetyltriglycine
MDCT	Multidetector computed tomography
MDT	Multidisciplinary team
MIBG	Metaiodobenzylguanidine
MRA	Magnetic resonance angiography
MRCP	Magnetic resonance Cholangiopancreatography
MRI	Magnetic resonance imaging
MRU	Magnetic resonance urography
NM	Nuclear medicine
NRPB	National Radiological Protection Board (now Health Protection Agency, Radiation Protection Division
NSTEMI	Non-ST elevation myocardial infarction
OGD	Oesophagogastroduodenoscopy
OPG	Orthopantomograph
PET-CT	Positron emission tomography co-registered with CT
PSA	Prostate-specific antigen
PUJ	Pelvi-ureteric junction
PUO	Pyrexia of unknown origin
PV LOSS	Vaginal bleeding
RBC	Red blood cell
SPECT	Single photon emission computed tomography
SRS	Somatostatin-receptor scintigraphy
STEMI	ST-elevation myocardial infarction
SXR	Skull radiograph
TAUS	Transabdominal ultrasound
TIA	Transient ischaemic attack
TOE	Transoesophageal echocardiography
TVUS	Transvaginal ultrasound
US	Ultrasound
UTI	Urinary tract infection
VQ	Ventilation-perfusion
XR	Radiograph

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Ministry of Health Malaysia

COLLEGE OF RADIOLOGY
Academy of Medicine of Malaysia

GUIDELINES FOR CLINICAL PRACTICE IN RADIOLOGY

SECOND EDITION
2017

KEY TO GUIDELINES

The pages of each section are composed of five columns:

- Clinical/diagnostic problem indicates the situation for requesting an examination/procedure
- Investigation lists some possible imaging techniques with the band of radiation exposure involved
- The symbol for various levels of effective dose (see table below)
- Recommendation (grade) gives the recommendation (and the grade of available evidence) on whether or not the investigation is appropriate
- The comment provides explanatory notes

Cancer risks from radiation vary considerably with age and sex, with higher risks in infants and females. Cancer risks indicated in this table is averaged for adults.

Symbol	Typical effective dose (mSv)
None	0
☢	<1
☢☢	1–5
☢☢☢	5.1–10
☢☢☢☢	≥10

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Asymptomatic Patients				
Breast screening: Women less than 40 years old with no increased risk			Not indicated [B]	Screening programme is conducted only for the high-risk group ≥40-year-old women. (Refer to Clinical practise Guideline on Management of breast cancer 2nd Edition- November 2010 MOH//P/PAK/212.10(GU)) There is no evidence to support screening of women <40 years old who are not at an increased risk from breast cancer. US upon request is performed with the understanding that there is no evidence yet in its effectiveness in screening.
Breast screening: Women 40–49 years old	Mammography	☢	Indicated in high-risk cases [A]	Women seeking screening at this age should be made aware of the risks and benefits. Screening in this younger age range should be with mammography preferably with digital mammography with/without tomosynthesis.
	US	None	Indicated only in specific circumstances [A]	US is a useful adjunct to mammography in women with dense breasts and in those with implants.
Breast screening: Women ≥50 years old	Mammography	☢	Indicated [A]	Evidence supports screening to be done biennially (2 yearly).
	US	None	Indicated only in specific circumstances [B]	US is a useful adjunct to mammography in women with dense breasts and in those with implants. In certain circumstances, it may complement the mammography findings.
Breast screening: Women with high risk of developing breast cancer ≥40 years • 1st degree relative • Genetic carriers	Mammography	☢	Indicated [B]	In women with high risk of breast cancer, annual screening preferably using digital mammography with tomosynthesis, is recommended from the age of 40 years and above. Additionally, referral to a specialist breast clinic and preferably for genetic risk assessment and counselling will be helpful.
	MRI	None	Indicated in specific circumstances [B]	Annual MRI screening may be considered after discussion with a radiologist and surgeon.
	US	None	Indicated only in specific circumstances [B]	US is a useful adjunct to mammography in women with dense breasts and in those with implants, particularly in those unable to undergo MRI. It may be complementary to other investigations.
Breast screening: Women ≥40 years having HRT or being considered for HRT	Mammography	☢	Indicated only in specific circumstances [C]	HRT has been shown to increase density and benign changes in some women, adversely affecting screening performance. Users of HRT have an increased risk of interval cancer. Baseline mammogram may be considered before start of HRT, even though there is no scientific evidence. Biennial (2 yearly) mammograms are recommended in the absence of other risk factors.

Continued...

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Breast screening: Women less than 40 years old having HRT or being considered for HRT	US	None	Indicated only in specific circumstances [C]	US may be useful in dense breasts, implants.
Breast screening: Women 40 years old and above who have had augmentation mammoplasty	Mammography	☢	Indicated [B]	Sensitivity for cancer detection is lower than in the non-augmented breast. Digital mammography, tomosynthesis or contrast-enhanced mammography maybe helpful.
	US	None	Indicated only in specific circumstances [B]	US is a useful adjunct to mammography in women with implants.
	MRI	None	Indicated only in specific circumstances [B]	MRI is a useful adjunct to mammography and ultrasound.
Symptomatic Patients				
Symptomatic patients	Mammography	☢	Indicated only in specific circumstances [B]	Mammography is recommended in women 40 years old and above with persisting breast symptoms.
	US	None	Indicated only in specific circumstances [C]	US is recommended as the first modality of choice in women less than 40 years and complimentary to mammogram in women 40 years and above.
Cyclical mastalgia	Mammography	☢	Not indicated [B]	The usual screening guidelines apply according to the age of the patient.
	US	None	Indicated only in specific circumstances [C]	
Breast inflammation	US	None	Indicated in specific circumstances [C]	US is useful for the diagnosis of abscess, mastitis, etc, and for guiding percutaneous drainage and for follow-up.
	Mammography	☢	Indicated only in specific circumstances [C]	Mammography and MRI may be helpful as part of triple assessment if there is clinical suspicion of malignancy and if the inflammation does not recede with antibiotics.
	MRI	None	Indicated only in specific circumstances [C]	

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Assessment of integrity of breast implants	US and MRI	None and None	Specialised investigation [B]	Imaging of implants is indicated if there are focal signs and symptoms or for the demonstration of implant rupture. US is a useful initial investigation to demonstrate a significant leak. MRI is the gold standard.
	Mammography	☢	Indicated in specific circumstances [C]	MRI is recommended when mammography is not indicated or unable to be performed.
Breast cancer: Diagnosis (suspected or confirmed)	Mammography	☢	Indicated [B]	Mammography is appropriate for women 35 years old and above. Referral to surgical breast clinic is indicated. Mammography, preferably digital mammography, tomosynthesis and contrast-enhanced mammography are recommended.
	US	None	Indicated [B]	For women, less than 40 years old, US is the imaging investigation of first choice. For women with symptoms, ultrasound should be performed even if mammogram is negative.
	MRI	None	Specialised investigation [B]	MRI is a useful tool for further imaging in the detection of occult lesions, e.g., in patients with axillary nodal metastases of unknown origin.
Clinical suspicion of carcinoma in patients with augmentation mammoplasty (implants)	Mammography	☢	Indicated [B]	When breast cancer is suspected, mammography is useful. However, it may be more difficult to visualise the whole breast on mammography.
	MRI	None	Indicated only in specific circumstances [B]	MRI is useful as an adjunct to mammography.
	US	None	Indicated only in specific circumstances [C]	As a complementary tool

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Brain and Spinal Cord				
Brain and spinal cord tumours: Diagnosis	MRI	None	Indicated [B]	MRI is the investigation of choice since CT may miss small tumours and is suboptimal in the posterior fossa and spine. Contrast-enhanced MRI/ CT is required to demonstrate brain metastases.
	CT	☢☢	Indicated [B]	
Brain and spinal cord tumours: Staging and planning	MRI	None	Specialised investigation [C]	Referral should be made to a centre with neurosurgical service where imaging protocols are dictated by navigation equipment. Functional MR techniques can be helpful in pre-surgical planning.
	CT	☢☢	Specialised investigation [C]	
	Angiography	☢☢☢	Indicated only in specific circumstances [C]	CT angiography, MR angiography or catheter angiography assessment of tumour may be indicated in cases of vascular tumours, e.g., meningiomas, and should only be performed in a neuroscience centre.
Brain and spinal cord tumours: Follow-up	MRI	None	Indicated [B]	Pre- and post-contrast MRI is recommended. CT may be considered as an alternative. Depending on the tumour type, and in particular in paediatric posterior fossa tumours, contrast-enhanced sagittal imaging of the spine must also be considered. Techniques such as spectroscopy and perfusion imaging may be helpful if available. Serial follow-up imaging should use identical planes and sequences and if at all possible, should be performed on the same imaging system. Frequency of follow-up will depend on the histological type of the tumour, the site of the tumour, the previous treatment and the local policies established by the regional tumour-site-specific group or MDT.
	CT	☢☢	Indicated [B]	
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT may help to distinguish recurrent brain tumour from radiation necrosis. FDG shows increased uptake relative to normal cortex with high- and intermediate-grade tumours. Alternatively, advanced MRI techniques (MR perfusion, MR spectroscopy, DWI/DTI) may be utilised.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Mouth and Pharynx				
Cancer of mouth and pharynx: diagnosis	MRI/ CT	None / ☢☢	Indicated [B]	Diagnosis is commonly by clinical examination, supported by MRI or CT when there is high suspicion of occult disease.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	When MRI/CT is inconclusive, PET-CT is helpful to identify the occult primary presenting with metastatic neck nodes or when clinical suspicion is high.
Cancer of mouth and pharynx: staging	MRI / CT/ US	None / ☢☢/ None	Indicated [B]	Imaging is not commonly needed for diagnosis. Staging with CT or MRI should include cervical node groups. MRI if well tolerated is generally more accurate than CT. US with fine-needle aspiration cytology (FNAC) may improve N staging. Chest examination for metastatic disease by plain radiography or (preferably) CT, but clinical effectiveness of M staging is unproven.
	PET-CT	☢☢☢☢	Specialised investigation [B]	Used to identify recurrent local and distant disease in previously treated patients.
Parotid				
Parotid cancer: diagnosis	US	None	Indicated [B]	US can characterise salivary gland masses and is the modality of choice for guiding FNAC or core biopsy. There are technical difficulties in visualisation of, and guiding biopsy from, the deep lobe of the parotid.
	MRI/ CT	None/ ☢☢	Specialised investigation [B]	MRI is preferred for the assessment of parotid masses, and is a useful adjunct to US in delineating parotid deep lobe masses. CT shows calcification and demonstrates features of inflammatory disease although dental artefact is sometimes limiting. Imaging does not obviate the need for tissue diagnosis.
	PET-CT	☢☢☢☢	Not indicated [B]	PET-CT is poor at differentiating benign from malignant lesions.
Parotid cancer: staging	US	None	Indicated [B]	For some small salivary gland tumours, in experienced hands, US of salivary glands and local nodes may be the only investigation that is required for staging. However, the majority of malignant tumours require more extensive staging. US (with FNAC) is helpful to assess equivocal nodal spread.
	MRI/ CT	None/ ☢☢	Indicated [B]	MRI should be used in preference to CT for locoregional staging of salivary gland tumours, particularly with large or deep parotid masses. MRI is the investigation of choice for assessing peri-neural spread and intracranial involvement
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT can be used to detect regional lymphadenopathy and distant metastases.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Larynx				
Cancer of larynx: diagnosis	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [B]	Clinical assessment, endoscopy and biopsy for diagnosis. CT/MRI are usually for staging but when clinical diagnosis is equivocal, imaging prior to biopsy is preferable.
Cancer of larynx: staging	MRI/ CT	None/ ☢☢	Indicated [B]	MRI and CT are indicated for T and N staging. CT thorax is the investigation of choice for detecting metastatic and synchronous primary lung tumours.
	US (including US-FNAC)	None	Specialised investigation [B]	US is used for locoregional nodal staging enabling guided FNAC or core biopsy of suspicious nodes. In centres with appropriate expertise, US can be useful as a supplementary investigation in T staging of laryngeal tumours.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT is of value in staging at the time of diagnosis or suspected recurrence, particularly when other imaging techniques are equivocal. It should be considered prior to primary or salvage surgery.
Thyroid				
Thyroid cancer: diagnosis	US	None	Indicated [B]	Used in combination with or to guide FNAC
Thyroid cancer: staging	US/ MRI/ CT	None/ None/ ☢☢	Indicated [B]	To assess large primary tumours, detect distant metastases, and for medullary thyroid carcinoma in multiple endocrine neoplasia syndromes.
	NM (131-Iodine)	☢☢☢☢	Indicated [B]	Whole-body 131-I scintigraphy is useful for the detection of residual/ recurrent differentiated thyroid cancer after thyroidectomy. Scintigraphy following 131-I ablation treatment will show treated extra-thyroid deposits.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT is valuable in suspected recurrent thyroid cancer with raised thyroglobulin but negative whole-body iodine scan.
Lung				
Lung cancer: Diagnosis Continued...	CXR	☢	Indicated [A]	Lung cancer can have variety of clinical presentations. CXR is indicated when the patient is symptomatic. Some cancers are not identifiable on chest radiograph even when sputum cytology is positive for malignant cells.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Lung cancer: Diagnosis	CT	☢☢☢	Indicated [A]	CT has a higher sensitivity than chest radiograph for detection of small-volume lung tumours or early-stage disease. However, CT has not yet been proven to be of benefit in the context of population screening for lung cancer.
Lung cancer: Staging	CT	☢☢☢	Indicated [A]	CT has an overall accuracy of 80% in detection of mediastinal lymph node enlargement. Lymph node biopsy will still be required in some cases to confirm nodal involvement before thoracotomy. CT remains a frontline investigation which provides rapid assessment of chest wall invasion, and hepatic and adrenal status, in addition to assessing nodal size.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [A]	PET-CT improves the diagnostic accuracy of preoperative staging compared with CT alone in patients with lung cancer. It is indicated in patients prior to attempt at surgical resection or other treatments with radical intent.
	MRI	None	Indicated only in specific circumstances [C]	In most patients with lung cancer, MRI does not offer any clear benefit over CT. However, it is occasionally of use in diagnosing the extent of superior sulcus (Pancoast) tumours and assessing the extent of tumours where there is distal atelectasis.
	US	None	Indicated only in specific circumstances [B]	Endoscopic US may allow cytological sampling of mediastinal nodes by transesophageal or transbronchial route.
Breast: Staging of Carcinoma				
Breast cancer staging: Locoregional	Mammography/ US breast and axilla	☢/ None	Indicated [B]	The staging strategy is usually decided by the multidisciplinary team (MDT). Local and regional staging is by mammography and US of both breast and axilla with guided biopsy if required.
	MRI breast	None	Indicated only in specific circumstances [B]	MRI breast is reserved for specific circumstances, e.g., multifocal tumours, in young women considered for lumpectomy or breast conserving surgery.
	NM (sentinel node localisation)	☢	Indicated only in specific circumstances [C]	Sentinel node imaging is used perioperatively to identify the sentinel lymph nodes to reduce unnecessary axillary dissection.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Breast cancer staging: Distant metastases	US liver/ CXR/ NM (bone scan)/ CT thorax/ abdomen	None/ ☢/ ☢☢/ ☢☢☢/ ☢☢☢	Specialised investigation [B]	Staging for metastases is reserved for patients with high pretest probability (often Stage III disease and higher) or those who have symptoms suggestive of distant spread. The choice of US/CXR/NM or CT will be guided by the local MDT.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT can be used when conventional methods mentioned above are not conclusive.
Breast cancer follow-up (surveillance)	Mammography/ Ultrasound	☢/ None	Indicated [A]	Mammography and US should be used for routine surveillance for local recurrence.
	MRI	None	Indicated only in specific circumstances [B]	MRI maybe used for follow-up of the conserved breast in selected cases.
	Bone Density Evaluation (BMD)	☢	Indicated only in specific circumstances [B]	Bone densitometry is suggested for selected patients, e.g., patients on aromatase inhibitor treatment.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT is selectively used for problem-solving when assessing possible metastatic disease equivocal on routine imaging modalities.
Oesophageal				
Oesophageal cancer: diagnosis	Ba swallow	☢☢	Indicated only in specific circumstances [B]	Although endoscopy is usually the first investigation, barium studies are helpful, especially for high dysphagia.
Oesophageal cancer: staging	CT	☢☢☢	Indicated [B]	Many patients present with advanced disease, which is unresectable or unsuitable for radical radiotherapy. CT can be used as the initial investigation since locally advanced or metastatic disease may preclude surgery. CT may also help in planning neoadjuvant or palliative treatment.
	Endoscopic US	None	Indicated [B]	Endoscopic US (EUS) is the preferred technique for staging the primary tumour and locoregional nodes when the tumour is thought to be resectable, and distant metastases have been excluded. EUS-guided FNA of locoregional lymph nodes is possible and will increase sensitivity and specificity of staging.
	PET-CT	☢☢☢☢	Indicated [B]	There is evidence that PET-CT is more sensitive than CT alone for detection of distant metastases at diagnosis, and in the detection of residual or recurrent disease after surgical or other treatment. Accurate staging affects not only the surgical approach but also the use of other treatment, such as chemotherapy and radiotherapy, in the neo-adjuvant settling

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Stomach				
Stomach cancer: Diagnosis	Endoscopy	None	Indicated [B]	Endoscopy is the best investigation for diagnosis of gastric cancer and enables immediate biopsy.
	Double-contrast barium meal	☢☢	Indicated only in specific circumstances [B]	For diagnosis of gastric malignancy when endoscopy cannot be performed.
	CT	☢☢☢	Indicated only in specific circumstances [B]	Alternative investigation for the diagnosis of gastric cancer where endoscopy cannot be performed. Useful in confirming submucosal abnormalities.
Stomach cancer: Staging	CT	☢☢☢	Indicated [B]	Best initial staging investigation if active treatment is planned. Endoscopic ultrasound is useful for local early T and N staging before surgery. Laparoscopy is the most sensitive investigation for detecting small peritoneal deposits.
	Endoscopic US	None	Indicated [B]	
Liver: Primary lesion				
Primary liver lesion: Diagnosis	US	None	Indicated [B]	The initial investigation for a clinically suspected hepatic mass and indicated for follow-up imaging in the medium to long term to detect primary hepatic tumours in patients with chronic liver disease. This also applies to focal liver lesions detected as 'incidental findings' during investigations of abdominal pain.
	CT/ MRI	☢☢☢ / None	Specialised investigation [B]	CT/MRI may be used for further characterisation of focal hepatic lesion detected on US. MRI with a liver-specific contrast agent may result in a more specific imaging diagnosis.
Primary liver lesion: Staging	MRI	None	Indicated [B]	MRI is probably the optimal investigation for establishing extent of primary hepatic lesions and bile duct tumours prior to surgical resection. Liver-specific contrast agents may improve accuracy when there is a background of chronic liver disease.
	CT	☢☢☢	Indicated [B]	CT delineates extent of liver tumours and can be used when MRI is contraindicated. Multiphase contrast-enhanced technique should be used as an adjunct to MRI for local staging, and for detection of distant disease.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Liver: Secondary lesions				
Secondary liver lesion: Diagnosis	US	None	Indicated [B]	In patients with known primary tumours in other organs, US is effective in the detection of liver metastases greater than 2 cm in diameter. It can also be used to characterise some benign or incidental lesions and can be used to guide biopsy when clinically indicated. The use of ultrasound contrast agents increases sensitivity for detection of metastases, but the whole liver is not always assessable with US and it should not be relied upon to exclude metastases, and CT/MRI should be used instead.
	CT	☢☢☢	Indicated [B]	CT is more sensitive than US for the detection of small liver metastases and is indicated when US findings are negative and clinical suspicion is high. CT is essential for accurate staging of metastases in patients being considered for liver resection.
	MRI	None	Specialised investigation [B]	Most frequently used to characterise lesions considered equivocal on US and/or CT. Contrast-enhanced MRI techniques are highly sensitive and are recommended when hepatic resection of metastases is being considered.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT (F-18 FDG) is indicated when surgical resection of liver metastases is being considered and is highly sensitive in detecting disease outside the liver. It may also be used for further characterisation of the lesions considered equivocal on other investigations.
Pancreas				
Pancreatic cancer: Diagnosis	US (including endoscopic US)/ CT	None/ ☢☢☢	Indicated [B]	Choice of diagnostic technique depends on local expertise and the patient's habitus. US is usually adequate in slim patients, but CT is more reliable in visualising the whole pancreas, especially in large patients. Endoscopic US is an accurate technique and is useful for guiding fluid aspiration and biopsy.
	MRI/ MRCP	None/ None	Specialised investigation [C]	MRI is useful for clarification of problems. MRCP is useful for investigation of jaundice but needs to be combined with cross-sectional MRI for suspected pancreatic tumour.
	ERCP/ PTC	☢☢	Specialised investigation [C]	ERCP is preferably performed with therapeutic intent (e.g., permanent stent placement) following evaluation and decision making based on cross-sectional imaging. Stent may be placed percutaneously as well.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Pancreatic cancer: Staging	US/ CT/ MRI	None/ ☢☢☢/ None	Indicated [B]	US at the time of diagnosis may detect liver metastases. Multiphase CT imaging to assess potential vascular invasion and staging if radical surgery is considered and prior to stenting. MRI with MRCP is a supplementary investigation.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT (Gallium-68 Dotatoc) may be used in equivocal cases for distant staging, where there is significant possibility of metastatic disease and resection is being considered.
	Endoscopic US	None	Indicated only in specific circumstances [B]	Endoscopic US may be useful when cross-sectional imaging is equivocal and also for guiding FNAC.
Pancreatic islet cell tumours: Preoperative localisation	US (including endoscopic US)/ NM/ CT/ MRI	None/ ☢☢/ ☢☢☢/ None	Specialised investigation [B]	The diagnosis of functioning islet cell tumours is made on clinical and biochemical criteria. Imaging is for preoperative localisation. Imaging approach is the same as for pancreatic carcinoma with non-functioning islet-cell tumours. The choice of non-invasive imaging will depend on local availability and expertise but could include CT and MRI. For carcinoma, staging procedures should include CT and somatostatin-receptor scintigraphy. PET-CT has the potential to be the most sensitive modality.
Colon				
Colon cancer: Diagnosis	Colonoscopy	None	Indicated [A]	Colonoscopy is the investigation of choice for younger patients and allows tissue diagnosis.
	CT colonography	☢☢☢	Indicated [A]	Comparable sensitivity to colonoscopy for detection of polyps and tumours. It is used in some screening programmes where available.
	Barium enema	☢☢	Indicated [B]	Less sensitive alternative investigation which is largely being replaced by colonoscopy and CT colonography.
Colon cancer: Staging Continued...	CT	☢☢☢	Indicated [B]	CT of thorax, abdomen and pelvis is the modality of choice to assess for distant metastases. Local spread of advanced tumours can be detected by CT or CT colonography. CT colonography can also identify synchronous colonic lesions.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT (F-18 FDG) may detect metastases not evident on CT alone, and may be used if treatment of primary tumour and resection or ablation of distant metastases are being considered.
	MRI	None	Indicated only in specific circumstances [C]	Hepatic MRI may be used if liver resection is being considered.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Colon cancer: Staging	US and CXR	None and ☢	Indicated only in specific circumstances [B]	US and CXR are less sensitive alternatives to CT for detection of metastases in the liver and lungs.
Colon cancer: Follow-up	CT/ US/ CXR	☢☢☢ / None/ ☢	Indicated [B]	Postoperative CT or ultrasound at regular intervals for up to 2–5 years is recommended depending on individual risk factors for recurrence and on the suitability of the patient for further treatment.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	When tumour markers rise and CT and other investigations are normal, PET-CT (F-18 FDG) can detect local recurrence and metastatic disease. It may also help to characterise liver and lung lesions before proposed or ablative treatment.
Rectal				
Rectal Cancer: Diagnosis	Procto-sigmoidoscopy	None	Indicated [B]	Diagnosis of rectal cancer is by clinical and endoscopic examination with biopsy.
Rectal cancer: Staging	Pelvic MRI	None	Indicated [B]	The investigation of choice for preoperative local staging of rectal cancer. It will show the relationship of tumour to muscularis propria extension through the rectal wall to the mesorectal fascia and also involvement of local nodes and vessels.
	CT	☢☢☢	Indicated [B]	The investigation of choice for detecting metastatic disease in nodes, liver and lungs.
	Endorectal US	None	Specialised investigation [B]	Endorectal US may be used to assess whether potentially early-stage tumours (T1 or T2) are suitable for local resection using techniques such as transanal endoscopic surgery.
	US and CXR	None and ☢	Indicated only in specific circumstances [B]	Alternative to CT but are less accurate.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [C]	PET-CT (F-18 FDG) may be helpful to detect metastases at the time of diagnosis, if surgical or ablative treatment of metastases is being planned.
Rectal cancer: Follow-up and surveillance Continued...	CT	☢☢☢	Indicated [B]	CT of thorax, abdomen and pelvis may be used for early detection of metastases.
	MRI	None	Specialised investigation [B]	For detection of local recurrence and to establish response to neoadjuvant chemotherapy or radiotherapy before surgery.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Rectal cancer: Follow-up and surveillance	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT (F-18 FDG) is useful in assessing residual masses where MRI or CT is equivocal. It may also be used to help characterise distant lesions detected on CT and in the presence of a rising tumour marker, may detect lesions, e.g., peritoneal metastases that are not apparent on CT.
	Endorectal US	None	Specialised investigation [B]	Endorectal US may be used for the assessment of local recurrence.
	US and CXR	None and ☢	Indicated only in specific circumstances [B]	US and CXR are a less sensitive means than CT for detecting metastases.
Anal				
Anal cancer: diagnosis	Proctoscopy	None	Indicated [C]	Diagnosis of anal cancer is clinical with proctoscopic biopsy.
Anal cancer: Staging	MRI	None	Indicated [C]	Most useful investigation for demonstrating extent of local invasion to sphincter, pelvis floor and adjacent structures.
	CT	☢☢☢	Indicated [B]	Used for detection of hepatic, nodal and pulmonary metastases.
	Endoanal US	None	Specialised investigation [B]	Endoanal US is used in combination with MRI and is useful in staging of small superficial/very early tumours.
	PET-CT	☢☢☢☢	Specialised investigation [C]	PET-CT (F-18 FDG) may characterise locoregional nodes and detect distant metastases especially when CT is equivocal.
	US/ CXR	None/ ☢	Indicated only in specific circumstances [B]	Liver US and CXR are an alternative to CT to detect metastases but are less accurate.
Anal cancer: Follow-up	MRI	None	Indicated [B]	Most local recurrences are detected clinically and confirmed by biopsy. MRI is the imaging modality of choice to restage local recurrence.
	CT	☢☢☢	Indicated [B]	The modality of choice for early detection of metastases to nodes, liver and lungs. This is helpful both for surveillance and restaging local recurrence.
	Endoanal US	None	Specialised investigation [B]	Endoanal US where available is accurate for local restaging of small recurrent tumours.
	PET-CT	☢☢☢☢	Indicated in specific circumstances [B]	May help to characterise equivocal abnormalities on CT, in locoregional nodes or at distant sites.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Renal				
Renal cancer: Diagnosis	US	None	Indicated [B]	Frequently used as the first investigation for symptoms suggestive of renal tumour, US is sensitive in detection of renal masses greater than 2 cm and can differentiate between cystic and solid masses. Contrast agents may help to characterise complex cystic lesions.
	CT	☢☢☢	Indicated [B]	CT is sensitive in detection of renal masses ≥0.75 cm. It is a key investigation in characterising complex cystic renal masses. CT urography is the investigation of choice for detecting urothelial tumours of the renal pelvis and ureters.
	MRI	None	Specialised investigation [B]	Contrast-enhanced MRI is as sensitive as contrast-enhanced CT for detecting and characterising renal masses that are not adequately characterised by CT and US, or if iodinated contrast medium is contraindicated because of diminished renal function or previous adverse reaction to iodinated contrast agents.
	IVU	☢☢	Indicated only in specific circumstances [C]	When CT is unavailable, IVU is an alternative for detecting urothelial tumours.
Renal cancer: Staging	CT/ MRI	☢☢☢/ None	Indicated [B]	CT is the initial investigation of choice unless iodinated contrast medium is contraindicated. CT facilitates detection of pulmonary and other distant metastases at the same investigation. MRI may be used in a problem-solving role, for example, if degree of vascular involvement is unclear on CT alone.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT offers no advantage in T staging but may be helpful if CT/MRI is inconclusive for metastases.
Renal cancer: Follow-up Continued...	CXR	☢	Indicated [B]	For patients considered at low risk for relapse (e.g., T1/T2 renal tumours that have been resected), chest radiograph should be done at regular intervals up to 5 years following surgery.
	CT	☢☢☢	Indicated [B]	CT of thorax and abdomen is the mainstay of follow-up for patients considered at intermediate or high risk. Estimation of risk will depend on a number of factors including histopathological grade, size and stage of primary tumour and whether the tumour was completely resected, treated with local ablative therapy or left *in situ.* CT of thorax and abdomen will reveal the majority of local recurrences and distant metastases. The interval between investigations can be tailored by the MDT on the basis of existing risk factors.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Renal cancer: Follow-up	PET-CT	☢☢☢☢	Indicated only in specific circumstances [C]	PET-CT has a limited role as a problem solving tool.
Urinary Bladder				
Bladder cancer: Diagnosis	US/ CT (including CT urography)	None/ ☢☢☢	Indicated only in specific circumstances [B]	Cystoscopy is the investigation of choice in diagnosis of bladder tumours. Ultrasound and CT can detect larger tumours in patients with symptoms suggestive of bladder tumour. CT urography is more accurate than IVU and is capable of detecting bladder mucosal lesions less than 5 mm. Imaging investigations prior to cystoscopy may help in planning the technical approach in selected patients.
	IVU	☢☢	Not indicated [C]	
Bladder cancer: Staging	CT	☢☢☢	Indicated [B]	CT is most useful for assessing local extramural spread within the pelvis and at the same time distant metastatic disease in the abdomen and thorax. CT urography detects urothelial tumours in the upper tracts and is more accurate than IVU.
	MRI	None	Indicated [B]	MRI is sensitive and specific for assessment of the bladder and local invasion to adjacent organs. Increased tissue contrast compared with CT makes MRI more useful for assessment of local invasion, but MRI is less versatile in staging of distant disease.
	CXR	☢	Indicated [C]	Chest radiograph is used to assess for pulmonary metastatic disease when CT thorax has not been performed.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT has a limited role in staging of bladder cancer, but can detect occult metastases and is sometimes used prior to radical cystectomy.
	IVU	☢☢	Not indicated [C]	
Prostate				
Prostate carcinoma: Diagnosis	MRI	None	Indicated only in specific circumstances [B]	MRI is capable of detecting prostatic carcinoma when clinical suspicion is high but transrectal US-guided biopsy is negative. Focal areas of abnormal signal can be targeted for biopsy or repeat biopsy under ultrasound guidance.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Prostate carcinoma: Staging	MRI	None	Indicated [B]	There is a wide range of treatment options for early- and late-stage prostate carcinoma, and no clear consensus exists on optimal treatment. MRI with pelvis phased-array or endorectal coils is the most sensitive and specific method for assessment of disease that may be organ-confined and is being considered for radical treatment. MRI can demonstrate pelvic and abdominal lymph node disease. MRI is the preferred investigation for staging local disease, but some information may be available from transrectal ultrasound performed for diagnostic purposes.
	NM (bone scan)	☢☢	Indicated [B]	Isotope bone scan is used in assessment of metastases in patients considered to be at risk. A range of parameters, e.g., PSA greater than 20, Gleason grade 4 as dominant pattern, local stage T3 or T4 clinically, or bone symptoms, would allow stratification into a high-risk group where bone scintigraphy is likely to be positive. PET-CT has no established place in staging of prostate carcinoma.
	CT	☢☢☢	Indicated only in specific circumstances [C]	CT is of no value for local staging of prostatic disease. It may be widely used for abdominal or pelvic nodal staging or if widely disseminated disease is suspected clinically.
Testicle				
Testicular cancer: Diagnosis	US	None	Indicated [B]	US is used in suspected testicular malignancy to determine if a lesion is present and if a tissue diagnosis is required. Presumed inflammatory or benign conditions should be followed up to ensure resolution or stability.
	MRI	None	Indicated only in specific circumstances [B]	MRI also has a role in assisting the characterisation of indeterminate masses. The use of MRI in these selected cases is to help avoid unnecessary orchidectomy for masses that are non-malignant.
Testicular cancer: Staging Continued...	CT	☢☢☢	Indicated [B]	CT is the mainstay of staging at initial diagnosis and should include the chest and abdomen. Inclusion of the pelvis is controversial and subject to the presence of risk factors (e.g., abdominal nodal disease, anatomical urogenital anomalies and previous scrotal surgery) and local protocols. Thoracic CT is more sensitive than CXR in detection of pulmonary metastases.
	MRI	None	Specialised investigation [B]	MRI is capable of detecting abdominal nodal disease with similar accuracy to CT.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Testicular cancer: Staging	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT may be used to help characterise indeterminate lesions on CT.
Testicular cancer: Surveillance and follow-up	CT	☢☢☢	Indicated [B]	Following resection, regular surveillance CT of the chest and abdomen is undertaken for up to 2 years. If risk factors for pelvic nodal disease have been excluded, pelvis CT may be omitted. When metastasis is present at the time of diagnosis (Stage II–IV), CT is used to confirm satisfactory response to treatment. The appearance of residual masses on CT may assist in decisions on whether to undertake surgery.
	MRI	None	Indicated only in specific circumstances [B]	MRI will demonstrate abdominal nodal masses (but not chest disease), and has the advantage of no radiation burden.
	CXR	☢	Indicated only in specific circumstances [B]	Chest radiograph is used in short- and long-term follow-up of Stage I non-seminomatous germ cell tumour and will demonstrate the majority of pulmonary metastases, although thoracic CT is undoubtedly more sensitive.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	When a marker rises after treatment, FDG-PET may be helpful in identifying the site of relapse. In the presence of a residual mass, FDG uptake may be useful in indicating the presence of a persistent or recurrent tumour.
Ovarian				
Ovarian cancer: Diagnosis	US	None	Indicated [B]	Most ovarian lesions are identified initially on clinical examination or US. A combination of transabdominal US (which may detect evidence of spread) and transvaginal US, supplemented by colour Doppler, is recommended.
	MRI	None	Specialised investigation [B]	MRI of the abdomen and pelvis is useful for problem-solving, particularly adnexal lesions that are indeterminate on US. It is more accurate than US in establishing the presence of benign features in complex masses.
Ovarian cancer: Staging	CT	☢☢☢	Indicated [B]	CT of the abdomen and pelvis has a role in identifying patients who may benefit from chemotherapy or are being considered for cytoreductive surgery.

Continued...

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Ovarian cancer: Staging	MRI	None	Specialised investigation [B]	MRI of the abdomen and pelvis is useful when enhanced CT is contraindicated, when the patient is pregnant or for problem-solving.
	PET-CT	☢☢☢☢	Specialised investigation [C]	PET-CT is indicated in difficult management situations, and in the assessment of distant and local spread.
Ovarian cancer: Follow-up	CT	☢☢☢	Indicated [B]	Clinical examination and serum CA125 measurement are used to detect recurrent disease. CT of the abdomen and pelvis is used to assess treatment responses. CT can establish the extent of disease recurrence, but a normal imaging appearance does not exclude recurrence.
	MRI	None	Specialised investigation [B]	MRI of the abdomen and pelvis is useful for surgical planning and problem-solving.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT is useful when concentration of CA125 is increasing but CT and/or MRI are normal or inconclusive.
Uterine Cervix				
Cancer of the uterine cervix: Diagnosis	MRI	None	Indicated only in specific circumstances [B]	Usually a clinical diagnosis. MRI may assist in complex cases.
Cancer of the uterine cervix: Staging	MRI	None	Indicated [A]	MRI is indicated for patients with clinical Stage IB or greater and is the most accurate means of determining local stage. The abdominal lymph nodes and ureters may also be evaluated.
	CT	☢☢☢	Indicated [B]	CT may be used for staging of disease in the thorax and abdomen.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT is a sensitive imaging technique for detecting pelvic lymph node spread in the presence of locally advanced cervical carcinoma, and should be considered in selective cases where CT/MRI is equivocal or negative, and radical treatment is being considered.
Cancer of the uterine cervix: Recurrence	MRI	None	Specialised investigation [B]	MRI provides better information in the abdomen and pelvis than CT. Biopsy (e.g., of nodal mass) is easier with CT.
	CT	☢☢☢	Specialised investigation [C]	CT is the investigation of choice for detection of thoracic metastases.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT may be helpful in identifying the extent of recurrent disease and in differentiating post-radiation or surgical change from recurrent disease. It is more sensitive for the detection of distant recurrent disease than either MRI or CT.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Uterine Body				
Cancer of the uterine body: Diagnosis	US/ MRI	None/ None	Indicated [B]	US is indicated for postmenopausal bleeding to exclude significant endometrial pathology. The diagnosis is usually made at hysteroscopy or dilatation and curettage. MRI may assist in complex cases.
Cancer of the uterine body: Staging	MRI	None	Indicated [A]	MRI is the optimum technique for combined local and pelvis nodal staging of endometrial carcinoma.
	PET-CT	☢☢☢☢	Specialised investigation [C]	There is little evidence to support the use of PET-CT as a routine staging procedure. In specific circumstance such as before exenterative surgery or in the presence of very high-grade uterine carcinoma or sarcoma, it may be useful in detecting distant metastatic disease.
	CT	☢☢☢	Not indicated [A]	CT is of limited value for local staging and therefore is unlikely to affect surgical management.
Lymphoma				
Lymphoma: Diagnosis	US/ CT	None/ ☢☢☢	Indicated [B]	US/CT-guided core biopsy or FNA can be used where expertise is available particularly for patients with comorbidity.
Lymphoma: Staging	CT	☢☢☢	Indicated [B]	CT of the, abdomen and pelvis is the routine staging procedure at the time of diagnosis. Head and neck CT may also be indicated.
	PET-CT	☢☢☢☢	Indicated [B]	PET-CT (F-18 FDG) is very sensitive and specific and ideally should be used for staging of Hodgkin's lymphoma (HL) and high-grade non-Hodgkin's lymphoma (NHL).
	US/ MRI	None/ None	Indicated only in specific circumstances [B]	US/MRI may be useful in staging specific organs. MRI is indicated for suspected CNS disease and may establish the extent of bone marrow involvement. US is useful for imaging of the neck, thyroid, testis and peripheral soft tissue masses.
Lymphoma: Response assessment and surveillance Continued...	CXR	☢	Indicated [B]	Initial assessment of response in thoracic disease by a CXR is appropriate. It may also be used for long-term follow-up after completion of treatment, e.g., after mantle radiotherapy.
	CT	☢☢☢	Indicated [B]	Nodal size on CT is used as a measure of response during treatment. A residual mass may be visible on CT at completion of treatment. If complete remission is established, repeat imaging should be directed by clinical presentation and likelihood of relapse.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Lymphoma: Response assessment and surveillance	PET-CT	☢☢☢☢	Specialised investigation [B]	There is evidence that PET-CT (F-18 FDG) can be used for early interval assessment of Hodgkin's and high-grade non-Hodgkin's lymphoma during therapy to predict outcome. It is also useful in the assessment of residual masses.
	MRI	None	Indicated only in specific circumstances [B]	Useful for assessment of CNS disease.
Musculoskeletal tumours				
Musculoskeletal tumours: Diagnosis	XR	☢	Indicated [B]	Plain XR is the initial investigation for suspected bony tumour and is useful in establishing the need for biopsy.
	MRI	None	Indicated [B]	MRI is a sensitive technique for assessment of marrow involvement, skip lesions and soft tissue spread of bony tumours. It is also useful for assessment of bony involvement by presumed soft tissue lesions.
	US	None	Indicated [B]	May be used as image-guided biopsy for certain musculoskeletal lesions.
	NM (bone scan)	☢☢	Indicated [B]	Bone scan is useful in the identification of osteoblastic skip lesions in bone and in multifocal or metastatic bone tumour.
	CT	☢☢☢	Indicated [B]	CT is used to assess calcification associated with bony and soft tissue tumours. It may assist in pre-biopsy evaluation.
	PET-CT	☢☢☢☢	Specialised investigation [C]	PET-CT has a role in establishing the grade of malignancy and in directing biopsy.
Musculoskeletal tumours: Staging	MRI/ CT	None/ ☢☢☢	Specialised investigation [C]	MRI is best for the assessment of local spread and extent. CT chest is used to detect lung metastases.
	NM (bone scan)	☢☢	Specialised investigation [C]	Indicated for tumours known to have potential for skip lesions and distant bony metastasis, e.g., osteosarcoma.
	PET-CT	☢☢☢☢	Specialised investigation [C]	PET-CT is sensitive in the detection of metastases.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Metastases from Unknown Primary Tumour				
Metastases from unknown primary tumour: Diagnosis	CXR	☢	Indicated [B]	Occult lung primary is common.
	CT	☢☢☢	Specialised investigation [B]	CT of the abdomen and pelvis is the most helpful initial investigation in determining the primary site and may enable effective treatment and palliation. Guided biopsy of lesions detected is possible and histological techniques may suggest a primary site.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT (F-18 FDG) is a useful method for detecting primary tumours where initial imaging is non-contributory and is widely used in head and neck and thoracic malignancy.
	US	None	Indicated only in specific circumstances [B]	US is indicated in cases in which thyroid or testicular cancer is suspected from the pattern of metastatic disease.
	Mammography	☢	Indicated only in specific circumstances [C]	Even in the presence of metastases, diagnosis of an occult breast primary is worthwhile, since treatment decisions may be affected by pathology.
	MRI	None	Indicated only in specific circumstances [B]	MRI of the breast may show primary breast carcinoma with axillary lymph node metastases despite normal mammogram and US. MRI is sometimes used for suspected head and neck malignancy.
Melanoma				
Melanoma: Diagnosis	Excision biopsy	None	Indicated [C]	Diagnosis of melanoma is by excision biopsy.
Melanoma: Staging Continued...	US	None	Indicated [B]	Used to detect enlarged or abnormal lymph nodes in regional drainage basin and to guide fine-needle aspiration of any suspicious nodes. It is also used to characterise indeterminate liver lesions on CT.
	Sentinel lymph node lymphoscintigraphy	☢	Maybe indicated	May be and may not be offered in patients with clinically negative nodal basin and primary melanoma greater than 1 mm in depth.
	CT	☢☢☢	Indicated [B]	CT to detect disseminated metastasis is undertaken following positive sentinel lymph node biopsy or when clinical symptoms and signs are present that indicate a likelihood of distant metastases.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Melanoma: Staging	MRI	None	Specialised investigation [B]	Helpful for detection of symptomatic and asymptomatic metastases in high-risk melanoma (e.g., brain involvement) particularly when surgery is contemplated for solitary or oligometastatic disease.
	PET-CT	☢☢☢☢	Specialised investigation [B]	PET-CT should be considered when surgery is being planned for apparently solitary or oligometastatic disease.
Melanoma: Follow-up	CT	☢☢☢	Indicated [B]	If there is clinical evidence of regional nodal recurrence of distant metastases, CT is the most effective investigation in detecting multiple sites of disease. CT is generally used for re-evaluation of metastatic disease on chemotherapy trials.
	MRI	None	Specialised investigation [C]	MRI is helpful to assess distant metastases where clinically indicated.
	PET-CT	☢☢☢☢	Specialised investigation [C]	PET-CT (F-18 FDG) should be considered when surgery is being contemplated for apparently solitary or oligometastatic disease.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute chest pain: ST elevation myocardial infarction (STEMI) and subsequent assessment	CXR	☢	Indicated [B]	Should not delay acute revascularisation. Only useful when associated pulmonary oedema or infection is suspected.
	Catheter coronary angiography and intervention	☢☢☢	Indicated [A]	Coronary angiography followed by primary percutaneous intervention is indicated in centres with access to primary angioplasty service or rescue angioplasty following thrombolysis depending on the time of presentation.
	Echocardiography	None	Indicated only in specific circumstances [B]	Echocardiography is indicated only after initial angiography/ percutaneous coronary intervention/thrombolysis to assess any mechanical complications of myocardial infarction and ventricular function before discharge. It can also be used to exclude Type A aortic dissection with or without contrast-enhanced CT.
	CT chest	☢☢☢	Indicated only in specific circumstances [B]	CT of the chest is indicated when coronary arteries are normal and alternative diagnosis such as aortic dissection, pulmonary embolism and pericarditis have to be excluded.
	NM (myocardial perfusion imaging)	☢☢	Indicated only in specific circumstances [A]	NM is indicated for risk assessment in haemodynamically stable patients after successful thrombolysis before discharge. Also, it can be helpful to assess the significance of moderate stenosis after coronary angiography.
	MRI heart	None	Indicated only in specific circumstances [B]	MRI can be used post-revascularisation in haemodynamically stable patients to assess ventricular function, degree of infarction and its transmural extent, and thus to predict improvement in function. It can be used to investigate alternative causes of chest pain (myocarditis, pericarditis, etc.) in patients with normal coronary arteries but increased troponin concentrations.
Acute coronary syndrome (suspected non-STEMI/unstable angina) Continued...	Echo-cardiography	None	Specialised investigation [A]	Echocardiography is used to assist in the diagnosis of ongoing ischaemia (particularly dobutamine stress echocardiography), in the assessment of left ventricular function for prognosis and in the identification of other underlying abnormalities such as aortic stenosis or hypertrophic cardiomyopathy.
	NM (myocardial perfusion imaging)	☢☢	Specialised investigation [A]	Gated SPECT scintigraphy is indicated for diagnosis and prognosis in patients with intermediate probability and low or negative cardiac enzymes. It is also indicated for assessment of lesions on coronary angiography.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute coronary syndrome (suspected non-STEMI/unstable angina)	CT (including CT coronary angiography)	☢☢☢	Specialised investigation [B]	CTA, where available, may be helpful in patients with low or intermediate probability to exclude any significant CAD due to its high negative predictive value. It is also useful in the identification of other causes such as aortic dissection, pulmonary embolism, pericarditis and pulmonary infection. Absence of coronary artery calcification by itself has been shown to be of good prognostic value in patients with normal serial ECG and enzymes.
	MRI	None	Specialised investigation [B]	ECG-gated MRI of the heart with rest perfusion and/or pharmacological stress, ventricular function and delayed enhancement imaging can be used to assess the significant CAD and other causes of chest pain in patients with low to intermediate probability and who are haemodynamically stable. Cardiac MR imaging can evaluate with accuracy a variety of prognostic indicators of myocardial damage, including regional myocardial dysfunction, infarct distribution, infarct size, myocardium at risk, microvascular obstruction and intramyocardial haemorrhage in both acute setting and later follow-up examinations.
	Catheter coronary angiography	☢☢☢	Specialised investigation [A]	Catheter coronary angiography is indicated in patients who have recurrent symptoms or ischaemia despite adequate medical therapy or are at high risk.
Acute aortic syndrome/ suspected aortic dissection	CXR	☢	Indicated [B]	CXR is used mainly to exclude other causes and is rarely diagnostic.
	Trans-oesophageal ultrasound (TOE)	None	Indicated [B]	TOE and CT are equally accurate, but the choice will depend on availability and expertise. CT angiography (with ECG-gating where possible) can be used to diagnose or exclude acute coronary syndromes. Initial unenhanced images may be helpful in the detection of acute intramural haematoma. TOE is useful for exclusion of type A dissections and intramural haematomas and to establish the involvement of aortic root and acute aortic regurgitation. Transthoracic echocardiography can identify type A dissection but cannot reliably exclude other causes of acute aortic syndrome.
	CT	☢☢☢	Indicated [A]	
	MRI	None	Specialised investigation [B]	MRI may be difficult to perform in the acute situation. However, it is useful for sequential follow-up and for aortic valve function assessment.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Suspected pulmonary embolism (PE) Wells' criteria: • Symptoms of DVT: 3 pt • No alternate diagnosis: 3 pt • Heart rate >100/min: 1.5 pt • Immobilisation or surgery: 1.5 pt • Previous DVT or PE: 1.5 pt • Haemoptysis: 1 pt • Malignancy: 1 pt Score of ≤6 need D-dimer first	CXR	☢	Indicated [B]	CXR should be the preliminary investigation to demonstrate consolidation and pleural effusion, but a normal CXR does not exclude a pulmonary embolus.
	CT pulmonary angiography (CTPA)	☢☢☢	Indicated [A]	Investigation of choice in patients with high clinical suspicion or those with moderate to low pre-test probability but positive D-dimer assay particularly in those with existing pulmonary abnormalities on CXR. Allows diagnosis of alternative causes of chest pain, assessment of right ventricle and main pulmonary artery.
	NM (ventilation-perfusion scintigraphy)	☢☢	Indicated [B]	VQ scintigraphy is an alternative to CTPA in patients without pre-existing pulmonary disease and with normal CXR. In view of the lower radiation dose, VQ scintigraphy should be considered as first choice in young patients, particularly during pregnancy. A normal perfusion scintigram excludes clinically significant pulmonary emboli. VQ scintigraphy is also helpful in patients with suspected chronic pulmonary thromboembolism.
	MRA	None	Indicated only in specific circumstances [B]	MR pulmonary angiography may be considered when CTPA is contraindicated, and when ventilation-perfusion scintigraphy is unlikely to be helpful in the presence of an abnormal CXR.
Pericardial disease (suspected pericarditis, thickening, tumour or pericardial effusion) Continued...	Echocardiography	None	Indicated [B]	Echocardiography is the first-line investigation for suspected pericardial effusion, cardiac tamponade and constriction. It is useful for guiding pericardiocentesis. Echocardiography is also widely used imaging technique for the detection of pericardial thickening.
	CXR	☢	Indicated [B]	CXR may reveal a massive pericardial effusion, calcification in the pericardium, associated lesions in the lung and pleural effusion. Normal CXR does not exclude the diagnosis.
	CT	☢☢☢	Specialised investigation [B]	CT will show pericardial thickening, presence of calcification and associated pericardial and pleural effusions. CT may also suggest the cause. The degree of confidence is high for detecting pericardial disease on contrast-enhanced CT scanning. Tissue characterisation is limited. ECG gating improves image quality and precision. A limitation of CT imaging of the pericardium is the occasional difficulty in differentiating a small effusion from pericardial thickening.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Pericardial disease (suspected pericarditis, thickening, tumour or pericardial effusion)	MRI	None	Specialised investigation [B]	Where available, cardiac MRI will show pericardial thickening, associated pericardial and pleural effusions and functional sequelae of pericardial disease, but will not show calcification. With late enhancement, MRI can show underlying associated myocarditis. CMR may not always provide a definitive pathological diagnosis but it can aid in limiting differential considerations and be of help in treatment planning for surgical cases. CMR can play an important adjunct role when there is clinical uncertainty or a need for more comprehensive anatomic and physiologic evaluation.
Chronic stable angina Continued...	CXR	☢	Indicated [B]	CXR is useful in the assessment of heart size, ventricular aneurysms, status of pulmonary vasculature (such as congestion), aortic aneurysms and calcification in the pericardium. It may also show any non-cardiac cause of chest pain such as pneumonia and other lung disease.
	Echocardiography	None	Indicated [B]	Rest echocardiography is indicated if there is a murmur to suggest valvular abnormality or obstructive hypertrophic cardiomyopathy. Stress echocardiography (like other non-invasive stress imaging procedures) is used in patients with intermediate pretest probability for significant coronary artery disease or in the presence of stenosis of uncertain significance on anatomical imaging.
	CT	☢☢☢	Specialised investigation [B]	CT coronary calcification has a role in risk stratification and by itself in the assessment of chest pain with low pretest probability where the absence of calcification would represent a low probability of significant coronary artery disease. In the presence of calcified plaques and in those with intermediate pretest probability, CT coronary angiography is a better test. Presence of moderate stenosis (50%–75%) could be followed by stress imaging. Wherever possible, use of a low radiation technique is recommended.
	MRI with vasodilator or inotropic stress	None	Specialised investigation [B]	Stress perfusion MRI with pharmacological agents is recommended in patients with intermediate pretest probability of CAD or in the presence of stenosis of uncertain significance on anatomical imaging. Adenosine or Dobutamine stress cardiac MRI can be superior to stress echocardiography, especially in patients with a poor acoustic window.
	NM (myocardial perfusion with stress)	☢☢	Specialised investigation [A]	Stress nuclear myocardial perfusion with exercise or pharmacological agents is recommended in patients with intermediate pretest probability of CAD or in the presence of stenosis of uncertain significance on anatomical imaging.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Chronic stable angina	Coronary angiography	☢☢☢	Specialised investigation [B]	Coronary angiography remains the gold standard for diagnosis of CAD. It is best used as the initial test in patients with a high probability of angina and those with abnormal, equivocal or inconclusive non-invasive tests.
Suspected valvular heart disease	Echocardiography	None	Indicated [B]	Echocardiography is the current standard for detection and quantification of valvular heart disease. When the acoustic window is suboptimal, or in cases of suspected infective endocarditis, transoesophageal echocardiography (TOE) may help.
	CXR	☢	Indicated [B]	CXR is useful as a baseline to identify any valvular calcification, cardiomegaly and pulmonary vascular congestion or oedema.
	MRI	None	Specialised investigation [B]	MRI is complementary to echocardiography when transthoracic acoustic windows are limited and a trans-oesophageal approach is unfeasible. It is also helpful when the results from echocardiography and catheterisation conflict. MRI is valuable for assessment of the severity of regurgitant lesions and for quantification of the effects of valvular lesions on ventricular volumes, function and myocardial mass. Most prosthetic heart valves are safe for MRI unless severely dehisced.
	CT	☢☢☢	Specialised investigation [B]	ECG-gated CT of the heart can assess the aortic valve area in patients with suspected aortic valve stenosis. Calcification in the aortic valve has also been shown to be related to the severity of stenosis in degenerative valve disease.
Suspected heart failure and/or myocarditis Continued...	Echocardiography	None	Indicated [A]	Echocardiography is the first-line investigation for establishing diagnosis and possible cause of heart failure/cardiomyopathy. Low-dose dobutamine stress can be used to assess hibernation where ischaemic cardiomyopathy is suspected.
	CXR	☢	Indicated [B]	CXR is a useful investigation for assessment of cardiac size, any pulmonary congestion and associated pulmonary disease. Normal CXR does not exclude a failing heart. CXR forms a useful baseline.
	MRI	None	Specialised investigation [B]	MRI is complementary to echocardiography in most instances, but is superior in quantifying specific causes such as amyloidosis, iron overload and sarcoidosis. MRI has become the accepted technique to assess hibernation when combined with delayed enhancement and/or adenosine stress. It is also the technique of choice to show myocarditis. The technique used to study myocardial hibernation will depend on local availability and expertise.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Suspected heart failure and/or myocarditis	NM (cardiac scintigraphy)	☢☢☢	Specialised investigation [B]	Multiple-gated acquisition (radionuclide angiography) or gated rest SPECT techniques using Tc-99m agents can quantify ejection fraction. They are similar to MRI for this purpose but can have limitations in certain circumstances. Rest perfusion techniques using Tc-99m agents with nitrates and rest-redistribution techniques with Thallium-201 are used to assess hibernation. FDG-PET for metabolism with ammonia for perfusion can also be used to identify hibernation where available.
	CT	☢☢☢	Specialised investigation [B]	ECG-gated CT can be used to quantify ventricular function in the same study performed for assessing coronary arteries. There is increasing evidence that this technique correlates closely with 3D echocardiography, MRI and gated SPECT. Its role in assessing various cardiomyopathies is evolving.
Congenital heart disease	Echocardiography	None	Indicated [A]	Echocardiography is the technique of choice for the diagnosis and evaluation of congenital heart disease. It can be supplemented with MRI and/or CT if required.
	CXR	☢	Indicated [B]	CXR can suggest diagnosis and help in the assessment of pulmonary vascularity and cardiac situs.
	MRI	None	Indicated [B]	MRI is an alternative to echocardiography in newborn babies and young children and is used mainly if vascular rings or complex congenital heart disease is suspected. In adults, MRI is used for postoperative follow-up, for abnormalities involving aorta and pulmonary arteries and for shunt quantification. Most prosthetic heart valves are safe for MRI and compatibility can be checked against databases. MRI is contraindicated with some older ball-cage-socket type valves and with suspected valve dehiscence.
	CT	☢☢☢	Specialised investigation [B]	CT can be used in defining complex cardiac morphology where MRI is not possible. It is also useful in defining abnormalities of the aorta, pulmonary vasculature and particularly coronary arteries. Limited functional information is currently available from CT.
	Cardiac catheterisation	☢☢☢	Indicated only in specific circumstances [C]	Diagnostic catheterisation should be used when there is still uncertainty as to a diagnosis, following cross-sectional imaging; when measurement of pressure is essential; or when echocardiography suggests that a lesion may require treatment, and a diagnostic/query proceed catheter is performed.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Assessment of asymptomatic patients for cardiovascular risk	US (carotid intima-medial thickness)	None	Indicated only in specific circumstances [B]	Both US and CT can be useful for the assessment of cardiovascular risk in patients with unclear or intermediate risk on traditional risk assessment. There is no evidence to show that routine screening of asymptomatic people leads to improved clinical outcome. There may be a case to refine risk prediction in patients at intermediate cardiovascular risk in whom pharmacological risk modification will be considered.
	CT (coronary calcification)	☢☢☢	Indicated only in specific circumstances [B]	
Abdominal aortic aneurysm	US	None	Indicated [A]	US is useful in diagnosis, determination of maximal diameter, screening and surveillance. CT is preferable for suspected leak but should not delay urgent surgery.
	CT/ MRI	☢☢☢☢/ None	Indicated [A]	CECT or MRI is used for renal and iliac vessels. There is increasing demand for detailed anatomical information because of consideration of endovascular stenting.
Suspected deep vein thrombosis (DVT) Wells' criteria: • Active cancer: 1 pt • Paralysis/ immobilisation: 1 pt • Bedridden/ surgery: 1 pt • Venous tenderness: 1 pt • Entire leg swollen: 1 pt • Calf swelling ≥3 cm: 1 pt	US	None	Indicated [A]	DVT can be ruled out in a patient who is judged clinically unlikely to have DVT and who has a negative D-dimer test. Ultrasound testing can be safely omitted in such patients. US is more sensitive with colour flow Doppler. Most clinically significant thrombi are detected. US may show other lesions. Pelvic vein DVT may not be reliably diagnosed on US and in suspected cases MRI, CT or venography would be useful. MR and CT venography are alternatives to US with similar accuracy but less availability.
	Venography	☢☢	Indicated only in specific circumstances[B]	DVT can be ruled out in a patient who is judged clinically unlikely to have DVT and who has a negative D-dimer test. Ultrasound testing can be safely omitted in such patients. US is more sensitive with colour flow Doppler. Most clinically significant thrombi are detected. US may show other lesions. Pelvic vein DVT may not be reliably diagnosed on US and in suspected cases MRI, CT or venography would be useful. MR and CT venography are alternatives to US with similar accuracy but less availability.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
• Unilateral pitting oedema: 1 pt • Collateral veins: 1 pt • Previously proven DVT: 1 pt • Alternative diagnosis: -2 pt Score >2 for US Score ≤2 need D-dimer first				
Ischaemic leg	Primary angioplasty plus selective stenting	☢☢☢	Indicated [A]	There are several endovascular interventional techniques for the treatment of the range of peripheral vascular disease from intermittent claudication to critical limb ischaemia. These include angioplasty (with or without stenting) of stenotic or occlusive disease in the iliac, superficial femoral/popliteal and crural arteries. Appropriate treatment decisions are made after consultation with vascular surgeons and interventional radiologists.
Ischaemic upper limb	MRA	None	Specialised investigation [B]	Local policy on imaging/intervention needs to be determined in consultation with vascular surgeons and intervention radiologists, especially with regard to therapeutic interventions. Non-invasive techniques should be used initially with catheter angiography reserved for endovascular intervention. The choice of Doppler US, MRA or CTA will depend on availability and expertise.
Non-specific chest pain	CXR	☢	Indicated only in specific circumstances [C]	Most musculoskeletal causes of non-specific chest pain show no abnormality on CXR but its main purpose is to exclude serious alternative pathology: e.g., pneumothorax.
Pre-employment or screening medicals	CXR	☢	Indicated only in specific circumstances [B]	CXR is 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).
Routine preoperative Indicated	CXR	☢	Indicated only in specific circumstances [C]	Screening preoperative CXR is indicated in patients undergoing cardiothoracic surgery. For non-cardiothoracic surgery, routine preoperative CXR is not indicated in patients aged <60 years old but may be helpful in patients aged 60 and over with significant cardiorespiratory disease.
Upper respiratory tract infection	CXR	☢	Not indicated [C]	There is no documented evidence of the effect of CXR on the management or outcome of upper respiratory tract infection.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute exacerbation of asthma	CXR	☢	Indicated only in specific circumstances [B]	Patients presenting with asthma but without pyrexia or leucocytosis do not require CXR, except when the asthma is life-threatening or does not respond adequately to treatment.
Acute exacerbation of COPD	CXR	☢	Indicated only in specific circumstances [B]	Patients with an exacerbation of COPD requiring referral to hospital should have a CXR.
Pneumonia	CXR	☢	Indicated [C]	CXR is of limited value in predicting the causative pathogen, but is useful to determine the extent of pneumonia and to detect complications.
Pneumonia: Follow-up	CXR	☢	Indicated only in specific circumstances [B]	CXR need not be repeated before a satisfactory clinical recovery from community-acquired pneumonia. CXR should be arranged after 6–12 weeks for all patients who have persistent symptoms or physical signs or who are at a higher risk of underlying malignancy (especially smokers and patients ≥50 years), whether or not they are admitted to hospital.
	CT	☢☢☢	Indicated only in specific circumstances [C]	CT or specialist referral may be needed in case of pneumonia not resolving by 6–12 weeks.
Pleural effusion suspected	CXR	☢	Indicated [C]	Erect or lateral decubitus CXR may detect small quantities of pleural fluid.
	US	None	Indicated [B]	US confirms the presence and characteristics of pleural fluid and is superior to CT in the detection of loculation and internal septation. US may detect pleural malignancy and should be used to guide thoracocentesis.
	CT	☢☢☢	Indicated only in specific circumstances [B]	CT may help in the detection of pleural fluid. CT guided drainage may be for following difficult cases or collection of air within. CT may also identify and characterise underlying pleural disease.
Haemoptysis (including massive haemoptysis) Continued...	CXR	☢	Indicated [B]	All patients presenting with haemoptysis should have a CXR. If CXR is normal and the haemoptysis was significant and occurred without a concurrent chest infection, referral for further investigation should be considered.
	CT	☢☢☢	Specialised investigation [B]	CT (including CT angiography) may be used in conjunction with bronchoscopy to investigate patients with haemoptysis. CT may detect underlying malignant and non-malignant disease (e.g., bronchiectasis) not identified on CXR or bronchoscopy and may usefully localise the area of lung affected if intervention is subsequently required. It is not sensitive in detecting mucosal and submucosal disease.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Haemoptysis (including massive haemoptysis)	Bronchial angiography +/- embolisation	☢☢☢	Indicated only in specific circumstances [B]	Catheter bronchial angiography (with or without embolisation) may be life-saving in some patients with massive haemoptysis.
ICU/HDU patient	CXR	☢	Indicated [B]	A CXR is helpful when there has been a change in symptoms or insertion or removal of a device. The value of the routine daily CXR is unproven. US or CT are useful adjuncts to CXR for problem solving in critically ill patients.
	US	None	Indicated only in specific circumstances [B]	
	CT	☢☢☢	Indicated only in specific circumstances [C]	
Suspected diffuse/ infiltrative lung disease	CT	☢☢☢	Specialised investigation [B]	Although CXR is often used for initial assessment, there is evidence to indicate that HRCT may be used: a) to confirm suspected diffuse/ infiltrative lung disease and b) in some instances, to provide histo-specific characterisation. Valuable information about disease reversibility and prognosis may be provided by HRCT. A multidisciplinary approach should be used for diagnosis.
Cardiac tumour	Echocardiography	None	Indicated [A]	First-line imaging modality as it is non-invasive, cost-effective, quick and widely available.
	CXR	☢	Not Indicated	Not an effective method for screening for cardiac neoplasms or for evaluating the extent of a tumour.
	MRI	None	Indicated [B]	CMR has superior tissue contrast resolution and offers multiplanar anatomical evaluation in terms of size, extents and anatomical relationship of masses to neighbouring structures, thus paracardiac, metastatic and infiltrative processes can be masses.
	CT	☢☢☢	Indicated [B]	The degree of confidence is high for detecting cardiac tumours on contrast-enhanced CT scanning. Tissue characterisation is limited. ECG gating improves image quality and precision.
	NM and Angiography	☢☢☢	Not indicated	Limited use.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Conductive hearing loss and other middle ear symptoms	CT	☢☢	Specialised investigation [B]	CT is the best method for assessing disease extent within the middle ear/mastoid and involvement of osseous structures such as the bony labyrinth. Cone beam CT radiation is an efficient alternative.
	MRI	None	Indicated only in specific circumstances [B]	MRI enables a more specific diagnosis of middle ear disease (especially for postoperative cholesteatoma recurrence) and assesses disease extension within the skull base and brain.
Sensorineural hearing loss and other inner ear symptoms	MRI	None	Specialised investigation [A]	MRI is more sensitive than CT for diagnosis of vestibular schwannoma; however, CT may be useful in the diagnosis of otosclerosis and bony inner ear deformities.
	CT	☢☢	Indicated only in specific circumstances [C]	
Sinus disease	Low-dose CT sinus (non-contrasted)	☢☢	Specialised investigation [B]	When maximum medical treatment for sinusitis is ineffective, low-dose CT is useful to show the presence and distribution of disease and also sinonasal anatomy before functional endoscopic sinus surgery.
	Contrast-enhanced CT sinus	☢☢	Specialised investigation [B]	Higher dose contrast-enhanced CT is a specialised investigation indicated when there are complications such as orbital cellulitis or if malignancy is suspected. Cone beam CT is a radiation-efficient alternative.
	MRI sinus	None	Indicated only in specific circumstances [B]	MRI is used as an alternative to CT to assess sinonasal soft tissues. When there are complications of inflammatory sinus disease or suspected malignancy, MRI is helpful in addition to CT.
	XR sinus	☢	Not indicated [C]	Acute sinusitis can be diagnosed and treated clinically. If it persists past 10 days on treatment, CT is recommended when the results could alter management. Signs on XR sinus are often non-specific and are encountered in asymptomatic people.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Thyroid nodules	US	None	Indicated [B]	US is the best investigation for differentiating between thyroid and extrathyroid masses, for guiding aspiration or biopsy (especially in difficult-to-palpate or small thyroid nodules), and for the detection of associated lymphadenopathy in thyroid malignancy. While US can be specific for malignancy, sensitivity is lower. With generalised thyroid enlargement or multinodular goitre, US readily shows retrosternal extension; real-time studies show the effect of neck extension, etc. CT or MRI is needed to demonstrate retrosternal extent and tracheal compromise. Triple assessment (clinical, US, FNAC) has largely replaced NM as the initial assessment procedure.
	US- guided FNAC/ FNAC	None	Indicated [B]	Thyroid nodules are extremely common; most are benign. Clinically guided FNAC (without imaging) is the most cost-effective initial investigation but US-guided FNAC has a higher diagnostic rate.
	NM (pertechnetate/ I-123)	☢☢	Indicated only in specific circumstances [B]	In patients with nodules and non-diagnostic cytology, NM can help reduce unnecessary surgery.
Thyrotoxicosis	US/ NM (pertechnetate/ I-123)	None/ ☢☢	Specialized investigation [B]	US with colour Doppler in experienced hands or NM can differentiate between Grave's disease, toxic nodular goitre, and subacute thyroiditis. NM provides functional information about nodules.
Ectopic thyroid tissue (e.g. lingual thyroid)	US/ NM (pertechnetate/ I-123)	None/ ☢☢	Indicated [B]	US is the first line investigation in both adults and children. It allows the evaluation of most thyroglossal duct remnants and can confirm the presence of normal thyroid tissue as well as identify possible malignancy. NM should be reversed for those cases in which a normal thyroid has not been shown. Ectopic thyroid tissue may require cross-sectional imaging. e.g. MRI
Primary hyperparathyroidism	US/ NM (sestamibi)/ CT/ MRI	None/ ☢☢/ ☢☢/ None	Specialized investigation [B]	Diagnosis is made on clinical/biochemical grounds. Imaging with sestamibi scintigraphy and US gives excellent localisation to facilitate focused or minimally invasive surgery. Much depends on local availability and expertise. MRI, CT, SPECT-CT or PET-CT may help in difficult cases. Selective venous sampling in expert hands can localise residual or ectopic or recurrent tumours.
	Selective venous sampling	☢☢☢	Indicated only in specific circumstances [B]	
Neck mass of unknown origin	US	None	Indicated [C]	US is the initial investigation for characterising neck masses. May be combined with FNAC.
	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [C]	MRI (preferably) or CT may be helpful if the full extent of the lesion is not established by US. It is also useful for the identification of other lesions, and for staging.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Salivary obstruction	US/ sialogram	None/ ☢☢	Indicated [C]	US or sialography is indicated for intermittent, food-related swelling. XR of the floor of mouth is useful when US has demonstrated sialectasis but not shown a calculus. US or sialography is also helpful to assess suitability for minimally invasive management of salivary calculi rather than gland excision.
	XR	☢	Indicated only in specific circumstances [C]	
Salivary mass	US	None	Indicated [B]	US is the initial investigation of choice for a suspected salivary mass. It can be combined with FNAC if necessary. US is extremely sensitive and has high specificity.
	MRI/ CT	None/ ☢☢	Specialized investigation [B]	Whenever deep lobe involvement or extension into deep spaces is suspected, MRI or CT should be used. MRI may be better than CT for malignant lesions in the assessment of local spread, including perineural extension.
Dry mouth: connective tissue disease	US/ MRI/ Sialogram/ NM (sestamibi)	None/ None/ ☢☢/ ☢☢	Specialized investigation [B]	Imaging not routinely required. US and sialography may be diagnostic but NM provides better functional assessment. MRI/MR sialography may also be used if US is normal. Sialography and MR sialography may be used to grade the severity of Sjogren's syndrome.
Temporomandibular joint dysfunction	MRI	None	Specialized investigation [B]	XRs do not add information because most temporomandibular joint disorders are due to soft tissue dysfunction rather than bony changes (which appear late and are often in the acute phase). MRI is the investigation of choice to identify internal derangement. US can show a joint effusion condylar erosion but is highly operator-dependent. CT may be useful in special circumstances such as post-surgical repair and implants. Cone beam CT is a radiation dose-effective alternative to assess bony changes.
	CT	☢☢	Indicated only in specific circumstances [B]	

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Difficulty in swallowing: High dysphagia	Ba swallow	☢☢	Indicated [B]	Motility disorders may be present despite normal endoscopy–to be examined in prone or supine position. Subtle strictures are best demonstrated by bread or another bolus study.
	Video fluoroscopy	☢☢	Indicated [B]	Video recording of swallow is done where available. A multidisciplinary approach with ENT surgeon would be best.
Difficulty in swallowing: Low dysphagia	Ba swallow	☢☢	Specialised investigation [B]	Endoscopy should be the first-line investigation for recent-onset progressive dysphagia in patients ≥40 years. Barium swallow is useful for high dysphagia and demonstration of webs and pouches. Motility disorders may be present despite normal endoscopy–to be examined in prone or supine position. Subtle strictures are best demonstrated by bread or another bolus study.
Heartburn/chest pain: Hiatus hernia or reflux	Ba swallow/meal	☢☢	Indicated only in specific circumstances [B]	Only indicated when lifestyle changes and empirical therapy are ineffective. Barium studies to assess oesophageal motility before anti-reflux surgery do not reliably predict postoperative dysphagia.
Suspected oesophageal perforation	CXR	☢	Indicated [B]	Abnormal in 80% of cases. Pneumomediastinum is visible in only 60% of cases.
	Contrast swallow	☢☢	Indicated [B]	Non-ionic iodinated contrast medium is the only safe agent. It is sensitive, but if no leak is demonstrated, proceed to immediate barium/CT.
	CT	☢☢☢	Indicated [B]	CT is sensitive for the presence of perforation and for the detection of mediastinal/pleural complications.
Acute GI bleeding: Haematemesis/melaena Continued...	Endoscopy	None	Indicated [A]	Endoscopy enables diagnosis in most cases of upper GI bleeding and can be used to deliver haemostatic therapy.
	CT and CT angiography	☢☢☢	Specialised investigation [B]	As an alternative to or before conventional angiography in cases where initial endoscopy is negative and there is active bleeding. CT angiography is accurate with acute bleeding but less accurate with chronic or slow blood loss.
	NM (labelled red cells)	☢☢	Specialised investigation [B]	Tc-labelled red cells or colloid is used after endoscopy. It is easy to perform but is time consuming. Red cell labelling can detect bleeding rates as slow as 0.1 mL/min, which is more sensitive than angiography. Red cell study is useful for intermittent bleeding, but detection of the most likely site within the bowel is best when actively bleeding.
	Angiography	☢☢☢	Specialised investigation [B]	In cases of uncontrollable bleeding, angiography can often be used to identify the bleeding site or to direct surgery accurately. It can be used to effect treatment by transcatheter embolisation.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute GI bleeding: Haematemesis/ melaena	Abdominal US	None	Indicated only in specific circumstances [B]	To look for signs of chronic liver disease at a later stage. Not routinely done during acute stage.
	AXR	☢	Not indicated [B]	AXR is of no value.
	Ba studies	☢☢	Not indicated [C]	Barium studies preclude angiography and CTA.
Dyspepsia	Ba studies	☢☢	Indicated only in specific circumstances [B]	Endoscopy is the investigation of choice. If endoscopy or barium studies are normal, diagnosis of gallstone disease needs to be considered. Barium meal is indicated for failed or refused endoscopy and may be considered for diagnosis of functional dyspepsia after negative endoscopy.
	US	None	Indicated only in specific circumstances [B]	Diagnosis of gallstone disease in the older age group if endoscopy or barium studies are normal.
Gastric or duodenal ulcer: Follow-up	Ba studies	☢☢	Not indicated [B]	Scarring prevents accurate assessment with barium studies. Endoscopy is recommended to confirm complete healing and to obtain biopsies where necessary.
Suspected anastomotic leaks after recent upper GI surgery	Contrast swallow/ meal	☢☢	Indicated [B]	If water-soluble contrast swallow does not show a leak at the anastomotic site and there is clinical concern, a barium swallow should follow. CT with oral contrast is sensitive for detecting small leaks. In cases of discrepancy between clinical and imaging findings, endoscopy will discriminate.
	CT	☢☢☢	Specialised investigation [B]	
	Endoscopy	None	Indicated only in specific circumstances [B]	
Previous upper GI surgery (not recent): Dyspeptic symptoms	Ba studies	☢☢	Indicated only in specific circumstances [B]	Gastric remnant is best evaluated by endoscopy.
	NM (gastric emptying scintigraphy)	☢☢	Indicated only in specific circumstances [B]	NM gastric emptying studies may be considered when delayed gastric emptying is suspected.
Previous upper GI surgery (not recent): Dysmotility/ obstructive symptoms	Ba studies	☢☢	Indicated [B]	Barium studies demonstrate surgical anatomy and may show dilated afferent loop, narrowed anastomoses, internal hernias, closed loops, etc.
	NM (seek local advice)	☢☢	Specialised investigation [B]	NM is a good method of assessment of gastric emptying, dumping and stasis.
	CT	☢☢☢	Indicated only in specific circumstances [C]	May be helpful in suspected cases of afferent loop obstruction.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Intestinal blood loss: Chronic or recurrent	Endoscopy/ video capsule endoscopy	None	Indicated [B]	The initial investigation is endoscopy of the upper GI tract and colon. Video capsule endoscopy has the highest diagnostic yield, where available, for obscure GI bleeding that persists or recurs after a negative initial endoscopy.
	CT	☢☢☢	Indicated [B]	IV contrast-enhanced CT or CT colonography are useful to look for lesions that may be bleeding (e.g., tumours). CTA may demonstrate bowel angiodysplasia. CT enteroclysis may have a role in small bowel assessment.
	Ba small bowel enema	☢☢	Indicated [B]	Barium meals and enemas have a role if endoscopy is not possible/ feasible. For small discrete lesions, small bowel enema is more sensitive than barium follow-through.
	Ba meal/ Ba enema	☢☢/ ☢☢	Indicated only in specific circumstances [B]	Barium meals and enemas have a role if endoscopy is not possible/ feasible. For small discrete lesions, small bowel enema is more sensitive than barium follow-through. Angiography is sensitive for angiodysplasia and to show tumour neovascularity.
	Angiography	☢☢☢	Specialised investigation [B]	
Acute abdominal pain: Perforation/ obstruction				Although CT has the highest sensitivity for detection of the cause of acute abdominal pain, US and CT scan both have similar specificity. A strategy for imaging should take into account radiation dose and sensitivity, body habitus, availability of equipment and expertise. When AXR suggests bowel obstruction, CT is the investigation of choice.
	AXR+/- CXR erect	☢+/- ☢	Indicated [B]	AXR is useful when bowel obstruction is suspected clinically. Supine AXR may be sufficient to establish diagnosis of obstruction and point to an anatomical level. Consider erect AXR if supine AXR is normal and there is strong clinical suspicion of obstruction. When CXR needs to be supine, a right lateral decubitus AXR is useful to show free gas.
	US	None	Indicated [C]	US is widely used as a survey for abdominal pain. It is sensitive for free fluid in perforation, is useful in the diagnosis of acute appendicitis and may identify bowel disease.
	CT	☢☢☢	Indicated [B]	CT is the investigation of choice in adults when AXR suggests bowel pathology or is equivocal. CT has the highest sensitivity for the detection of the cause of acute abdominalw pain. It is helpful for identifying sealed perforations, suspected bowel ischaemia and for establishing the site and cause of obstruction. It is the investigation of choice in bowel obstruction.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute small bowel obstruction: Confirmation and assessment of level	AXR	☢	Indicated [C]	Useful to establish if bowel obstruction is high or low grade.
	CT	☢☢☢	Indicated [B]	When AXR suggests small bowel obstruction, CT confirms diagnosis, indicates level and may show cause. When AXR is equivocal and low-grade, subacute small bowel obstruction is suspected clinically. CT enteroclysis has a higher site-specific sensitivity and specificity than CT.
	Contrast studies	☢☢	Indicated only in specific circumstances [B]	In suspected small bowel obstruction due to adhesions, a plain radiograph 24 h after 100 mL oral water-soluble contrast medium is a good predictor of resolution without operation.
	US	None	Indicated only in specific circumstances [C]	Helpful in the gasless abdomen and in children to demonstrate intestinal peristalsis in order to differentiate between a functional (adynamic) and obstructive (mechanical) ileus.
Small bowel obstruction: Low grade/intermittent	CT (including CT enterography/ enteroclysis)	☢☢☢	Indicated [B]	CT enteroclysis and conventional enteroclysis are more sensitive than standard unprepared CT and oral contrast studies in detecting both the cause and site of low-grade small bowel obstruction. CT enterocylsis also has the advantage of assessing extra luminal tissues.
	Contrast studies (small bowel meal/barium enteroclysis)	☢☢	Indicated [B]	
	MRI (including MR enterography/ enteroclysis)	None	Indicated only in specific circumstances [B]	MR enterography/enteroclysis is helpful in distinguishing between active inflammatory Crohn's disease and complications of Crohn's disease including low-grade/intermittent small bowel obstruction.
Suspected small bowel disease (Crohn's disease) Continued...	Ba small bowel meal	☢☢	Indicated [B]	Barium studies are in part being replaced by MRI and CT (in adults) and US (particularly in children and young adults). Particular consideration should be given to limiting the cumulative radiation burden of CT examinations in the generally younger Crohn's patient. Video capsule endoscopy has high sensitivity but should only be considered when strictures have been excluded. Labelled white cell scintigraphy shows activity and extent of disease and is complimentary to barium studies. Choice of modality depends greatly on expertise and availability.
	Endoscopy/ video capsule endoscopy	None	Specialised investigation [B]	
	US	None	Specialised investigation [B]	
	MRI	None	Specialised investigation [B]	
	CT	☢☢☢	Specialised investigation [B]	

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Suspected small bowel disease (Crohn's disease)	NM (White cell study)	☢☢☢	Specialised investigation [B]	
	Ba small bowel enema	☢☢	Indicated only in specific circumstances [C]	
Change of bowel habit to loose stools with or without rectal bleeding persistent for 6 weeks: Colorectal neoplasia	CT (CT colonography)	☢☢☢	Indicated [A]	Colonoscopy is the first-line investigation in younger patients, avoiding radiation and enabling biopsy. Fully prepared CT colonography, where available, is the radiological investigation of choice for detecting colorectal cancer and large polyps. It has similar accuracy to colonoscopy. Limited preparation CT colonography, although of slightly lower accuracy, is well tolerated by the older or frail patient. Ba enema is an alternative and is widely used for investigating change in bowel habit in the absence of rectal bleeding.
	Ba enema	☢☢	Indicated [B]	
Large bowel obstruction: Acute	AXR	☢	Indicated [B]	AXR may suggest diagnosis and indicate likely level.
	CT	☢☢☢	Indicated [B]	CT is the investigation of choice after AXR. It will confirm the diagnosis and level of acute large bowel obstruction and can identify the cause.
	Contrast enema	☢☢	Indicated only in specific circumstances [B]	Water-soluble contrast enema is an alternative to CT and is useful if CT is inconclusive. It can confirm diagnosis and level of obstruction, and may indicate cause.
Inflammatory bowel disease of the colon: Acute exacerbation	AXR	☢	Indicated [B]	Useful to diagnose and monitor toxic dilatation.
	Contrast enema	☢☢	Indicated [B]	Unprepared instant enema complements AXR and confirms extent of disease, although it is now becoming replaced by alternative investigations. It is contraindicated in toxic megacolon.
	CT	☢☢☢	Indicated [B]	CT can both identify the extent of colitis and also identify extra-colonic complications such as perforation or abscess. Consideration should be paid to cumulative radiation dose in younger patients.
	NM (white cell study)	☢☢☢	Indicated [B]	Labelled white cell study or PET-CT may show activity and extent of disease.
	MRI	None	Specialised investigation [B]	MRI can both identify the extent of colitis and also identify extra-colonic complications such as perforation or abscess, and avoids radiation. It also has a specific role for assessment of anorectal sepsis and planning of subsequent surgery.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Inflammatory bowel disease of the colon: Long-term follow-up	Ba enema	☢☢	Indicated only in specific circumstances [B]	Colonoscopy is the most reliable investigation for identification of complications including dysplasia, stricture and carcinoma. Ba enema has a limited role to define colonic configuration after surgery and to evaluate for fistulae.
	MRI (including MR colonography)	None	Indicated only in specific circumstances [B]	MR colonography may have a role as an alternative to Ba enema when colonoscopy is not feasible but currently has limited availability. MRI can also exclude pelvic complications and is useful for the follow-up of perianal fistulae.
	CT colonography	☢☢☢	Indicated only in specific circumstances [B]	CT colonography is an alternative to barium enema for differentiating benign from malignant strictures when colonoscopy is not feasible.
Acute abdominal pain warranting hospital admission for consideration of surgery	AXR and CXR erect	☢ and ☢	Indicated [B]	Supine AXR is indicated if obstruction is suspected. Erect CXR can identify perforation and a thoracic cause for pain. It may give extra information if liver pathology is suspected (e.g., air fluid level in liver abscess).
	US	None	Indicated [B]	Used as first investigation when hepatic and biliary or gynaecological pathology is suspected.
	CT	☢☢☢	Indicated [B]	CT is the single best investigation. Imaging strategies should take into account dose.
Palpable mass	US	None	Indicated [B]	US often solves the problem.
	CT	☢☢☢	Indicated [B]	CT is used when US is inconclusive, and to provide more complete assessment of disease extent before definitive treatment.
	MRI	None	Indicated only in specific circumstances [B]	MRI may be helpful for distinguishing malignancy when ultrasound and CT are equivocal.
	AXR	☢	Indicated only in specific circumstances [C]	AXR is rarely of value.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Malabsorption	CT	☢☢☢	Specialised investigation [C]	The diagnosis of malabsorption is clinical and usually requires small bowel biopsy. Barium studies may define a structural cause especially if bacterial overgrowth is suspected; e.g., jejunal diverticulosis. Small bowel meal or enema may identify complications of coeliac disease such as lymphoma, ulceration or adenocarcinoma. CT and MRI may show a structural cause, or associated features, of malabsorption, including lymphoma, chronic pancreatitis and lymphadenopathy. MR-enterography or CT-enteroclysis may be particularly useful to identify the complications of coeliac disease, such as lymphoma. MRCP will demonstrate evidence of chronic pancreatitis, which could also be shown by US (especially endoscopic US). PET-CT may be useful to diagnose lymphoma in refractory coeliac disease. Several NM investigations are available that should establish the presence of malabsorption.
	MRI (including MRCP)	None	Specialised investigation [C]	
	Ba small bowel enema/ Ba small bowel meal	☢☢/ ☢☢	Indicated only in specific circumstances [C]	
Constipation	Intestinal transit studies	☢☢	Specialised investigation [B]	Intestinal transit studies using orally ingested radio-opaque shapes are simple to perform and can confirm if intestinal transit is globally normal or delayed.
	Evacuation proctography	☢☢	Specialised investigation [B]	Evacuation proctography may be useful in patients in whom constipation is secondary to a disorder of evacuation.
	MRI	None	Specialised investigation [B]	Dynamic MRI of the pelvic floor is an alternative to evacuation proctography and provides additional information – e.g., cystocoele and enterocoele – while avoiding radiation.
	AXR	☢	Indicated only in specific circumstances [B]	AXR may be useful in the elderly to show the extent of faecal impaction, but does not diagnose constipation.
Abdominal sepsis: Pyrexia of unknown origin (PUO) Continued...	US	None	Indicated [C]	Seek early radiological advice. US is often used first and may be definitive, particularly when there are localising signs; it is especially good for subphrenic/subhepatic spaces and pelvis.
	CT	☢☢☢	Indicated [C]	Probably the best test overall. Infection and tumour are usually identified or excluded. It also enables biopsy of nodes or tumour and drainage of collections (especially in recently postoperative patients when US is difficult).
	NM (labelled white cell)	☢☢	Indicated [C]	Labelled white cell study or PET-CT may show activity and extent of disease

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Abdominal sepsis: Pyrexia of unknown origin (PUO)	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT (F-18) may be helpful as a second-line examination in some cases of PUO, especially where there is suspected osteomyelitis, vascular graft infection or HIV-associated pyrexia.
Characterisation of a solitary liver lesion identified on US (e.g., hemangioma, metastases etc.)	MRI/ CT	None/ ☢☢☢	Indicated [B]	The choice of MRI or CT depends on clinical context and local provision. MRI is more accurate than CT and will be preferable to evaluate an incidental lesion. If malignancy is suspected, CT is helpful to assess extra-hepatic disease.
	Contrast-enhanced US	None	Specialised investigation [B]	Where available, contrast-enhanced US can be accurate at excluding malignancy and characterising a focal liver lesion.
Known cirrhosis: Complications	US	None	Indicated [B]	Sensitive for ascites and portal vein patency. May show varices in the splenic hilum in portal hypertension. US is of lower sensitivity than CT or MRI for the detection and confirmation of hepatoma.
	MRI	None	Specialised investigation [B]	Contrast-enhanced MRI is more accurate than CT in the assessment of a cirrhotic liver for suspected hepatoma.
	CT	☢☢☢	Specialised investigation [B]	Contrast-enhanced CT is helpful, especially when US is equivocal in the presence of increased concentration of alpha-fetoprotein and in the staging of hepatoma.
Jaundice Continued...	US	None	Indicated [B]	US reliably differentiates between obstructive and non-obstructive jaundice, but bile duct dilatation may be subtle in early obstruction. When US indicates obstructive jaundice, subsequent investigation will depend on the level of obstruction, presence or absence of stones in the gall bladder and ducts, as well as the clinical situation.
	CT	☢☢☢	Specialised investigation [B]	CT is frequently the next investigation for US-proven obstructive jaundice, especially when US shows the obstruction below the hilum. For pancreatic cancer, CT reliably predicts unresectability. In malignant hilar-level obstruction, CT may provide staging information critical to the planning of surgery or palliative therapy.
	MRI, including MRCP	None	Specialised investigation [B]	In hilar-level obstruction, MRCP is the investigation of choice after US. MRCP reliably and non-invasively depicts the pattern and extent of duct involvement, thus facilitating planning of curative surgery or interventional treatment. In malignant hilar-level obstruction, MRI may provide staging information critical to the planning of surgery or palliative treatment. If US shows gallstones, but no definite duct stones, MRCP is indicated before ERCP. Note: CT/MRI/MRCP has the advantage of not causing biliary sepsis caused by contrast injection during ERCP.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Jaundice	ERCP	☢☢	Specialised investigation [B]	If US shows duct stones, proceed to ERCP for confirmation and therapy. ERCP remains the gold standard for intra-hepatic duct changes and sclerosing cholangitis but carries a risk of iatrogenic pancreatitis.
	Endoscopic US	None	Indicated only in specific circumstances [B]	Endoscopic US is the most accurate method for the detection of small duct stones and small papillary or periampullary tumours. It allows biopsy of the pancreas without risk of tumour seeding.
	Percutaneous transhepatic cholangiogram	☢☢☢	Indicated only in specific circumstances [B]	Percutaneous transhepatic cholangiogram may be performed when ERCP is not possible and as an adjunct to percutaneous therapies.
Suspected gall bladder disease or post-cholecystectomy pain	US	None	Indicated [B]	The investigation of choice to show or to exclude gallstones and acute cholecystitis. It is the initial investigation of biliary pain but cannot reliably exclude common duct stones.
	CT	☢☢☢	Specialised investigation [B]	Important in the detection of complications of acute cholecystitis in patients who fail to improve on conventional treatment.
	Endoscopic US	None	Specialised investigation [B]	Endoscopic US is very accurate in the diagnosis of ductal stones and may obviate the need for ERCP and its attendant risks.
	MRCP/ ERCP	None/ ☢☢	Indicated only in specific circumstances [B]	Diagnostic ERCP is no longer justified. MRCP should be used to investigate suspected biliary disease unless earlier investigation suggests that therapeutic ERCP will be required. Sensitivity of MRCP will be limited in the presence of large fluid surrounding the suspected pathology.
	NM (Tc-99m-IDA study)	☢☢	Indicated only in specific circumstances [B]	NM is used as a second line test if US is inconclusive or negative in suspected acute cholecystitis, gall bladder dyskinesia, or sphincter of Oddi dysfunction.
	AXR	☢	Not indicated [C]	AXR shows only about 10% of gallstones.
Postoperative biliary leak Continued...	US	None	Indicated [B]	US is the first investigation of suspected leak – will demonstrate the size and anatomical position of collections and guides aspiration.
	MRCP	None	Specialised investigation [B]	MRCP can demonstrate bile duct anatomy and evidence of a biliary leak. Hepatobiliary contrast agents may help.
	ERCP	☢☢	Indicated only in specific circumstances [B]	ERCP is indicated in therapeutic stent placement across a leaking duct.
	NM (Tc-99m-IDA study)	☢☢	Indicated only in specific circumstances [B]	HIDA scan with add on SPECT-CT examination is a better approach for localisation of the leak.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Postoperative biliary leak	Percutaneous transhepatic cholangiogram	☢☢☢	Indicated only in specific circumstances [C]	PTC may be required for drainage when ERCP is not possible; e.g., after surgery. Stent placement can be done via PTC.
Pancreatitis: Acute	US (including endoscopic US)	None	Indicated [B]	US must take place early to enable identification of patients with gallstones, which suggests a diagnosis of gallstone pancreatitis. Endoscopic US may be useful when standard imaging fails to show a cause of acute pancreatitis. US is also used to monitor fluid collections, avoiding the high radiation dose of CT.
	AXR and CXR	☢ and ☢	Indicated [C]	XRs are rarely contributory in diagnosis, but when acute pancreatitis presents as non-specific acute abdominal pain, AXR may show intestinal obstruction. Erect CXR can detect perforation, and demonstrates pleural and pulmonary pathology.
	CT	☢☢☢	Indicated [B]	Contrast-enhanced CT is helpful at 6–10 days for assessing complications of severe pancreatitis such as necrosis, which is helpful for prognosis. Early CT is only used when the diagnosis of acute pancreatitis is uncertain.
	MRI (including MRCP)	None	Indicated only in specific circumstances [B]	MRCP is helpful to identify gallstone pancreatitis if not identified by US.
Pancreatitis: Chronic	US (including endoscopic US)	None	Indicated [B]	US shows pancreatic parenchymal changes and calcification. Endoscopic US where available has greater resolution, shows ductal changes and enables FNAC.
	AXR	☢	Indicated [B]	AXR may show calcification (calcified duct stones) but is less sensitive than CT.
	CT	☢☢☢	Indicated [B]	CT is the best non-invasive investigation to demonstrate pancreatic calcification, masses, fluid collections and vascular abnormalities but has limited sensitivity for early parenchymal changes.
	MRI (including MRCP)	None	Indicated only in specific circumstances [B]	MRCP shows moderate and severe ductal changes but is of lower resolution than endoscopic US.
Asymptomatic patients aged 50–75 years with a positive faecal occult blood test on screening for bowel cancer	Colonoscopy	None	Indicated [A]	When the screening faecal occult blood test (FOBT) is positive, colonoscopy is the investigation of choice and enables biopsy. FOBT should be done more than once as the sensitivity is low and result is normally altered by diet.
	CT colonography	☢☢☢	Indicated only in specific circumstances [B]	CT colonography, where available, is accurate and well accepted by patients when colonoscopy is incomplete or contraindicated.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
False aneurysm (pseudoaneurysm) of the common femoral artery following diagnostic/ therapeutic arterial puncture	US-guided thrombin injection	None	Indicated [B]	Percutaneous US-guided thrombin injection is a quick, effective and safe treatment for femoral pseudoaneurysms. US-guided compression is an alternative. For larger pseudoaneurysms, endovascular or surgical repair may be required.
	US compression	None	Indicated [B]	
Obstruction of the renal pelvis or ureter	Percutaneous nephrostomy	☢☢	Indicated only in specific circumstances [B]	US and fluoroscopically guided percutaneous nephrostomy is an alternative to retrograde stenting. This procedure is most safely performed within normal working hours. Obstruction with renal sepsis, or in a single kidney or transplant kidney, may require more urgent drainage. Nephrostomy for malignant obstruction needs careful consideration. With malignant obstruction of the lower ureter and bladder, retrograde stenting is more likely to fail; hence, nephrostomy may be preferred.

Interventional Radiology may be able to help in the clinical management of the following problems. The decision will depend on the clinical condition of the patient and local expertise. Discussion with your local interventional radiologist is recommended.

Vascular

- Asymptomatic carotid disease
- Symptomatic carotid disease
- Pulmonary embolus
- Acute massive lower GI haemorrhage
- Chronic or recurrent upper GI haemorrhage
- Chronic mesenteric ischaemia
- Hypertension due to fibromuscular dysplasia
- Hypertension due to atherosclerotic renal artery stenosis
- Abdominal trauma with acute GI bleeding, with or without retroperitoneal or intraperitoneal haemorrhage
- Embolisation for uncontrolled haemorrhage after pelvic fracture
- Vena caval obstruction

Hepatic

- Ascites due to portal hypertension
- High biliary obstruction (intrahepatic ducts or upper half of extrahepatic bile duct)
- Low biliary obstruction (lower half of extrahepatic bile duct or pancreatic duct)
- Actual or suspected acute calculous or acalculous cholecystitis
- Varicocele
- Focal liver lesion(s) requiring biopsy
- Unresectable liver tumours
- Primary hepatoma and liver metastases

Renal

- Renal failure due to atherosclerotic renal artery stenosis
- Flash pulmonary oedema due to atherosclerotic renal artery stenosis
- Renal calculi

Miscellaneous

- Subphrenic abscess
- Pelvic abscess
- Pulmonary mass diagnosis
- Mediastinal mass (non-vascular)
- Percutaneous gastrostomy required for enteral nutrition

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Possible atlanto-axial subluxation (non-traumatic)	XR	☢	Indicated [B]	A single lateral cervical spine XR with the patient in supervised comfortable flexion should show any significant subluxation in patients with rheumatoid arthritis, Down's syndrome, etc.
	MRI	None	Specialised investigation [B]	MRI shows effect on cord when XR is positive or neurological signs are present.
	CT	☢☢	Specialised investigation [C]	CT is used to identify congenital or structural abnormalities predisposing to atlanto-axial subluxation, including diagnosis of post-traumatic rotatory subluxation.
Neck pain, brachialgia, degenerative change	MRI	None	Specialised investigation [B]	Consider MRI and specialist referral when pain affects lifestyle or when there are neurological signs or red flag features (including vascular insufficiency, trauma, malignancy, infection, inflammation and myelopathy). CT myelography may occasionally be required to provide further delineation, or when MRI is unavailable or impossible.
	XR	☢	Indicated only in specific circumstances [B]	Neck pain generally improves or resolves with conservative treatment. Degenerative changes begin in early middle age and are often unrelated to symptoms.
Thoracic spine pain without trauma: Degenerative disease	MRI	None	Specialised investigation [C]	MRI may be indicated if local pain persists or is difficult to manage.
	XR	☢	Indicated only in specific circumstances [C]	Degenerative changes are invariably present from middle age onwards. Imaging is 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.
Chronic lumbar back pain with no clinical or neoplasia (i.e., no red flags)	MRI	None	Indicated only in specific circumstances [C]	MRI is the preferred investigation for the diagnosis of most spinal diseases and is helpful in identifying those patients who may benefit when planning surgical intervention.
	XR	☢	Indicated only in specific circumstances [C]	XR is only indicated if presentation suggests osteoporotic collapse in the elderly.
	CT	☢☢	Indicated only in specific circumstances [C]	CT is used when MR is contraindicated and when further assessment of spondylolysis is required.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute back pain with potentially serious (red flag) features	MRI	None	Indicated [B]	MRI is the imaging investigation of choice and indicated in patients with acute neurological features, and in those with suspected malignancy or infection.
Serious (red flag) features: A) Neurological • Sphincter and gait disturbance • Saddle anaesthesia • Severe or progressive motor loss • Widespread neurological deficit B) Other • Age <20 or ≥55 years • Previous malignancy • Systemic illness • HIV • Weight loss • IV drug use • Steroid use • Structural deformity • Non-mechanical pain (no relief with bed rest) • Fever • Thoracic pain	XR	☢	Indicated only in specific circumstances [C]	Plain radiograph may be required preoperatively. MR is preferable as the first-line investigation in patients with red flag signs, since it has a stronger negative predictive value.
	CT	☢☢	Indicated only in specific circumstances [C]	CT is useful to guide soft tissue and bone biopsy and may identify sequestra in infection.
	NM (bone scan)	☢☢	Indicated only in specific circumstances [B]	NM is non-specific and should be viewed with plain radiographs. It is useful to show the full extent of disease, especially with metastatic deposits.
Acute back pain without potentially serious features (red flags)	MRI/ CT	None/ ☢☢	Specialised investigation [B]	MRI is the preferred investigation (wider field of view visualising the conus, postoperative changes, etc.). Demonstration of disc herniation should be considered after failed conservative management. Clinico-radiological correlation is important because many disc herniations are asymptomatic.
	XR	☢☢	Indicated only in specific circumstances [C]	Acute back pain is usually the result of conditions that cannot be diagnosed on XR (osteoporotic collapse is an exception). Normal XR may be falsely reassuring.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Osteomyelitis	XR	☢	Indicated [C]	XR is the initial investigation but may be normal in early osteomyelitis.
	MRI	None	Indicated [B]	MRI accurately shows osteomyelitis and associated soft tissue abnormality. It is the best imaging technique in suspected osteomyelitis. PET-CT may be an alternative to MRI if chronic osteomyelitis is suspected but metallic artefact limits use with surgical implants.
	US	None	Specialised investigation [C]	US is very sensitive for detecting periosteal elevation in infants when MRI is difficult or requires GA.
	CT	☢☢	Specialised investigation [C]	If MRI is contraindicated and PET-CT unavailable. CT is valuable for showing sequestra and for guiding biopsy.
	NM (seek specialist advice)	☢☢	Specialised investigation [C]	Two- and three-phase skeletal scintigraphy, Tc-99m-HMPAO and In-11-labelled white-cell scans are an alternative to MRI when osteomyelitis is suspected and there are no localising signs or symptoms. Labelled white cells may be used to identify periprosthetic infection.
Soft tissue infections	XR	☢	Indicated [C]	To evaluate for any periosteal reaction or signs of osteomyelitis.
	US	None	Indicated [C]	Presence and location of abscess. May detect periosteal elevation.
	MRI	None	Specialised investigation [B]	MRI is useful in determining an exact extent and location of abscess when planning for surgery. Indicated when plain X-ray is negative, the patient is not responding to therapy and abscess is suspected.
Suspected primary bone tumour	XR	☢	Indicated [B]	XR should be used in cases of unresolving bone pain.
	MRI	None	Indicated [B]	If the XR appearances are suggestive of primary bone tumour, referral to a specialist centre should not be delayed. MRI is the investigation of choice for local staging.
	NM (bone scan)	☢☢	Indicated [B]	If the XR appearances are suggestive of primary bone tumour, the acquisition of skeletal scintigraphy to exclude multiple lesions should not delay referral to a specialist centre.
	US	None	Indicated only in specific circumstances [B]	US is helpful to guide biopsy of certain superficial primary bone tumours in specialised bone tumour centres.
	CT	☢☢	Specialised investigation [B]	CT may improve diagnostic information in some tumours, such as osteoid osteoma, and show intratumoral calcification and ossification. CT-guided biopsy of primary bone tumours should take place in specialised bone tumour centres where histological expertise and knowledge of surgical approach are available.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Skeletal metastases from known primary tumour	MRI	None	Indicated [B]	More sensitive and specific than NM, MRI is the investigation of choice to confirm symptomatic metastases, especially in the axial skeleton.
	NM (bone scan)	☢☢	Indicated [B]	NM is a sensitive test, but correlative imaging is required to increase specificity. NM is useful for assessment of presence and extent of skeletal metastases in patients with known primary cancers. It may also be used to assess response to treatment, although the flare phenomenon may suggest disease progression if used too soon after systemic therapy. It is usually only appropriate to repeat a skeletal scintigram within 6 months if there are new symptoms.
	XR skeletal survey	☢☢	Indicated only in specific circumstances [B]	XRs are indicated only for specific focal symptomatic areas or for correlation with an NM examination.
	CT	☢☢	Indicated only in specific circumstances [B]	CT is an alternative to bone scintigraphy in patients undergoing whole-body CT for staging soft tissue metastatic disease. CT may identify the primary lesion, other metastases and the best site for percutaneous biopsy.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT is useful to evaluate both soft tissue and bone metastases but should not be used solely for the assessment of skeletal lesions as the dose is considerably higher than for bone scintigraphy. It is sensitive and specific for lytic bone metastases. When PET-CT is performed, MRI and bone scintigraphy are unnecessary.
Soft tissue mass	US	None	Indicated [B]	US is useful as an adjunct modality to evaluate cystic and solid masses. It is also useful to monitor benign lesions such as haematomas or small abscesses.
	MRI	None	Indicated [B]	It is useful to demonstrate anatomy and can provide a specific diagnosis in some patients.
	XR	☢	Indicated [B]	XR may show bony abnormalities associated with masses and can show tumour mineralisation. CT may occasionally help in these areas.
	Image-guided biopsy	None to ☢☢	Specialised investigation [B]	Image-guided biopsy, most frequently with US, is useful for deep-seated tumours.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT has a limited role in selected conditions such as neurofibromatosis. Use of PET-CT is restricted due to high radiation dose and lack of availability.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Bone pain	XR	☢	Indicated [C]	XR gives a dedicated view of the symptomatic area.
	MRI	None	Indicated [C]	MRI is appropriate if pain persists with normal XR or apparently normal NM. MRI may also provide further information when XR and/or NM findings are abnormal.
	NM (bone scan)	☢☢	Indicated [C]	NM is used if pain persists with normal XR or equivocal and abnormal XR in specific circumstances (e.g., suspected osteoid osteoma, osteomyelitis, metastases, metabolic bone disease and inflammatory arthropathy). Bone scan is particularly well suited for rib pain.
	CT	☢☢	Specialised investigation [C]	CT is used to define bony anatomy in areas of abnormality on XR/MRI/NM, especially if bone biopsy is indicated.
	US	None	Indicated only in specific circumstances [C]	US may be helpful to assess suspected infection, tumour and some fractures particularly in children.
Myeloma	XR skeletal survey	☢☢	Indicated [C]	Skeletal survey limited to spine, pelvis and proximal femora is sensitive. It is especially useful in non-secretory myeloma or in the presence of diffuse osteopenia. It can also be used for tumour mass assessment and follow-up.
	MRI	None	Specialised investigation [B]	MRI is used for staging and the identification of lesions that may benefit from radiotherapy. Survey can be limited to specific areas for follow-up.
	CT	☢☢	Specialised investigation [B]	CT is useful to evaluate local disease. Low-dose whole-body CT may be an alternative to MRI for staging.
Metabolic bone disease Continued...	XR	☢	Indicated [C]	XR is helpful in the identification of osteoporotic collapse, and differentiation from other unrelated causes. It also identifies characteristic signs of other metabolic bone disease, including osteomalacia and hyperparathyroidism. It is important in correlation with NM abnormalities.
	DEXA	☢	Indicated [A]	DEXA is used for measurement of bone density. Quantitative CT provides objective measurements of bone mineral content in patients where DEXA is difficult to interpret, whether because of deformity of the spine or hypertrophic degenerative change. Quantitative CT is more sensitive than DEXA but has a higher dose. The role of quantitative US is controversial.
	NM (bone scan)	☢☢	Indicated [C]	NM is useful in hypercalcaemia after exclusion of myeloma in the identification of metastases.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Metabolic bone disease	MRI	None	Indicated only in specific circumstances [B]	MRI may distinguish acute from chronic osteoporotic collapse, and also distinguishes between osteoporotic and malignant vertebral collapse.
Suspected osteomalacia with pain	XR	☢	Indicated [B]	Localised XR is used to establish the cause of local pain or an equivocal lesion identified on NM.
	MRI	None	Specialised investigation [C]	MRI is the investigation of choice to establish the cause of local bone pain not shown on XR and to assess equivocal XR findings. MRI distinguishes acute from long-standing fractures and helps to identify malignant causes of collapse. Sagittally reformatted CT can accurately identify occult vertebral fractures when MRI is not feasible.
	NM (bone scan)	☢☢	Specialised investigation [C]	NM can show increased activity and some local complications, such as pseudo-fractures.
Suspected osteoporotic collapse	Lateral thoracic spine XR and Lateral lumbar spine XR	☢ and ☢	Indicated [B]	Lateral XR of the thoracic and lumbar spine is the first investigation in suspected osteoporotic collapse. Collapsed vertebrae are often seen as incidental findings at CT.
	MRI	None	Specialised investigation [C]	MRI distinguishes acute from chronic osteoporotic collapse, and may distinguish between osteoporotic and malignant vertebral collapse.
	DEXA	☢	Specialised investigation [C]	DEXA is reserved for patients with risk factors for osteoporosis and may detect moderate and severe vertebral fractures. In the elderly, fracture on XR is adequate to establish a diagnosis and DEXA is unnecessary unless monitoring of treatment is required.
	CT	☢☢	Indicated only in specific circumstances [C]	Sagittally reformatted CT may identify occult vertebral fractures when MRI is not feasible.
Arthropathy: Presentation Continued...	XR affected joint	☢	Indicated [B]	XR of the affected joint may be helpful to establish cause, although erosions are a relatively late feature.
	XR hands/feet	☢	Indicated [B]	In patients with suspected rheumatoid arthritis, XR of the feet may show erosions even when symptomatic hand(s) appear normal.
	US/ MRI/ NM (bone scan)	None/ None/ ☢☢	Specialised investigation [B]	All can show acute synovitis. US and MRI can show early erosions. MRI can also show articular cartilage. NM is rarely needed but can show distribution. MRI bone marrow oedema is a strong predictor of radiographic progression. US may be helpful both for assessment and monitoring of activity.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Arthropathy: Presentation	XR multiple joints	☢☢	Indicated only in specific circumstances [B]	Radiographs are indicated for symptomatic joints only.
Arthropathy: Follow-up	XR	☢	Specialised investigation [C]	XR may be required by specialists to assist management decisions, e.g., for instituting and modifying drug treatment and referral for joint replacement.
	US/ MRI	None/ None	Indicated only in specific circumstances [B]	US and MRI are more sensitive than XR for identifying synovitis and early erosive change and may be required by specialists to allow the introduction of disease-modifying agents. The choice will depend on local expertise and availability. US or MRI may be required by specialists to assess disease progression.
Painful shoulder (including impingement syndrome and suspected rotator cuff tear)	US	None	Specialised investigation [B]	US is the investigation of choice in the assessment of rotator cuff and surrounding soft tissues. It may be used to guide injection. It is reserved for cases unresponsive to first-line treatment and clinically guided injection. It is indicated preoperatively if the surgeon requires assessment of rotator cuff integrity.
	MRI/MRA	None	Specialised investigation [B]	MRI is useful to assess complex injury and bony abnormality. MRI excludes rare conditions obscured by acromial arch and bone abnormalities when other investigations and treatments do not establish a diagnosis. MRA is useful for suspected rotator cuff pathology/tear, especially as a preoperative tool.
	XR	☢	Indicated only in specific circumstances [C]	XR is used as a preoperative assessment. Impingement is clinically diagnosed. XR is indicated for persistent shoulder pain that is unresponsive to conservative treatment and to exclude other diagnoses unrelated to rotator cuff. It is useful in assessing presence of mature calcific tendinitis and sclerosis, bone quality and subacromial space.
Shoulder instability	XR	☢	Indicated [C]	Plain XRs may show characteristic bony lesions in the humeral head and glenoid.
	MR/ MR arthrography	None/ ☢	Specialised investigation [B]	MR may show the labrum without intra-articular contrast but MR arthrography is the investigation of choice for labral and ligamentous lesions.
	CT/ CT arthrography	☢☢/ ☢☢	Specialised investigation [B]	CT will show the bony glenoid, Hill-Sachs lesions, anteromedial humeral impaction fractures (posterior dislocation) and CT arthrography will show cartilaginous labral tears.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Sacroiliac pain	XR	☢	Indicated [B]	Although XR of the sacroiliac joints is the first-line investigation for seronegative arthropathy, it is not sensitive for early disease.
	MRI/ CT/ NM (bone scan)	None/ ☢☢/ ☢☢	Specialised investigation [B]	MRI will detect inflammation and structural changes and is the investigation of choice for early disease. CT will show erosive changes and ossification. NM is of limited value to confirm suspected sacroiliitis. US in expert hands has been used to show inflammation in periarticular soft tissues and enthuses.
Non-traumatic hip pain including suspected avascular necrosis	XR	☢	Indicated [B]	XR of the pelvis is indicated for persistent pain. It may demonstrate focal bony pathology, erosive joint changes, dysplasia and anatomical features associated with femoroacetabular impingement. XR is abnormal in established avascular necrosis but is frequently normal within first 6–9 months.
	MRI	None	Indicated [B]	MRI is widely accepted as the best investigation for further evaluation of XR negative/equivocal hip pain, including occult fractures and avascular necrosis. MR arthrography may be helpful to diagnose labral tears.
	NM (bone scan)	☢☢	Indicated only in specific circumstances [B]	Bone scan is less specific than MRI for avascular necrosis and other focal lesions but is an alternative when MRI is not possible. A three-phase bone scan or labelled white-cell scan may be helpful to assess suspected infected hip prostheses.
	CT	☢☢☢	Indicated only in specific circumstances [B]	CT is helpful for diagnosis of osteoid osteoma or for identifying subchondral fracture.
Knee pain without trauma, locking or restriction of movement	MRI	None	Specialised investigation [B]	MRI is useful in patients with persistent undiagnosed pain, including suspected avascular necrosis and sepsis.
	US	None	Indicated only in specific circumstances [C]	US is useful for anterior knee pain with suspected tendinopathy or associated bursitis.
	XR	☢	Indicated only in specific circumstances [C]	Symptoms frequently arise from soft tissues, which will not show on XR. Osteoarthritic changes are common. XR is needed when considering surgery. Sudden onset or exacerbation of pain is a good indication for imaging, especially in pain persisting for more than 6 weeks in children and young adults.

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Knee pain with locking	MRI	None	Indicated [B]	MRI is the investigation of choice to identify meniscal tears and loose bodies.
	XR	☢	Indicated [C]	XR will identify radio-opaque loose bodies, a less frequent cause of locking.
Painful prosthesis	XR	☢	Indicated [B]	XR is useful to detect established loosening.
	NM (bone scan, white-cell scan)	☢☢ to ☢☢☢	Indicated [B]	A normal skeletal scintigram excludes most late complications. Increased uptake is seen around a loose prosthesis, but a three-phase study is of limited value in distinguishing between sterile and infected loosening. Labelled white-cell scintigraphy is more accurate than bone scintigraphy for diagnosing prosthetic infection.
	US	None	Specialised investigation [C]	US is accurate for the detection of periprosthetic abscess or superficial infection. Useful to guide aspiration.
	Arthrography (aspiration/ biopsy)	☢☢	Specialised investigation [B]	Aspiration in conjunction with arthrography is useful when findings are equivocal, when there is a high clinical suspicion of infection or when a cause of pain is not established.
	MRI	None	Indicated only in specific circumstances [C]	Sequences that minimise metallic artefact may be helpful in the assessment of periprosthetic soft tissues, especially postoperative muscle defects and bursitis.
	CT	☢☢	Indicated only in specific circumstances [B]	CT will show subtle periprosthetic osteolysis when XR is equivocal.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT may help when other investigations are equivocal and is sensitive but not specific for diagnosing an infected prosthesis.
Hallux valgus	XR	☢	Indicated only in specific circumstances [C]	XR is useful to guide surgery.
Heel pain: Suspected plantar fasciitis	US/ MRI	None/ None	Indicated only in specific circumstances [B]	US and MRI will show thickening of plantar fascia and inflammatory change but should be used selectively. US enables guided injection therapy.

Continued...

Clinical/Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Heel pain: Suspected plantar fasciitis	XR	☢	Not indicated [C]	Calcaneal spurs are common incidental findings. The cause of pain is rarely detectable on XR.
Myelopathy: Tumours, inflammation, infection, infarction, etc.	MRI	None	Indicated [B]	MRI is the initial investigation of choice for all spinal cord lesions, to assess cord compression and to give an indication of postoperative prognosis.
	CT/ CT myelogram (CTM)	☢☢/ ☢☢	Specialised investigation [B]	CT may be needed if better bony detail is required. CT myelography is used only if MRI is unavailable or impossible.
	NM (bone scan)	☢☢	Specialised investigation [B]	NM is still widely used to screen for metastases.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Acute stroke	CT	☢☢	Indicated [B]	The main reason for emergent CT is to differentiate haemorrhagic from ischaemic CVA and to exclude other acute diseases. In patients being considered for thrombolysis, both CTA and CT perfusion techniques significantly aid patient selection. Local availability and expertise will determine which imaging investigation is considered and needed.
	MRI	None	Specialised investigation [B]	MRI should be used in young patients (<45 years) and patients presenting late (≥7 days) when CT is no longer as sensitive in excluding haemorrhage. MRI should also be used in clinically suspected posterior circulation infarction/ischaemia. Diffusion-weighted and perfusion-weighted MR imaging significantly aid patient selection for thrombolysis and outcome prediction.
	US carotid/ neck arteries/ MR angiography/ CT angiography	None/ None/ None/ ☢☢	Indicated only in specific circumstances [B]	Neck artery imaging should be used for: 1. Those patients in whom carotid endarterectomy is considered for secondary prevention. 2. Those patients in whom carotid endarterectomy is considered for secondary prevention. 3. Cases of suspected dissection. Young patients, whether with disabling or non-disabling ischaemic stroke. The choice of which imaging modality to consider should be based on local expertise and availability. Patients with mild stroke are at a high risk of subsequent stroke with the risk greatest early after the index event, and so should undergo neck vessel assessment as soon as possible and certainly within 2 weeks. Patients with symptomatic severe carotid stenosis should ideally be offered revascularisation within 2 weeks of the clinical event. Transcranial Doppler US may be considered in the acute setting as a rapid technique for the assessment of the intracranial vasculature. Local availability and expertise will determine which imaging investigation is considered and needed.
TIA Continued...	MRI/ CT	None/ ☢☢	Indicated [B]	MRI and CT can detect established infarction and haemorrhage and exclude disease processes such as tumour and extra-cerebral haemorrhage.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
TIA	US neck arteries/ MR angiography/ CT angiography	None/ None/ ☢☢	Indicated [B]	Neck arterial imaging to assess suitability for carotid endarterectomy or stenting. Echocardiography (or alternative cardiac imaging) should be considered for those with normal brain imaging to identify a central source of emboli. Local availability and expertise will determine which imaging investigation is considered and needed.
Demyelinating and other white matter disease	MRI	None	Indicated [A]	MRI is the most sensitive and specific investigation for establishing a diagnosis of multiple sclerosis and other demyelinating diseases.
Space-occupying lesion	MRI	None	Indicated [B]	MRI is more sensitive for early tumours and may distinguish between tumour and abscess. It will resolve exact position (useful for surgery), characterise tumours and is particularly helpful for posterior fossa lesions. MRI may miss calcification.
	CT	☢☢	Indicated [B]	CT is often sufficient for excluding intracranial space-occupying lesions and for identifying supratentorial lesions. If the initial CT is not diagnostic, MRI should be performed.
Headache: Sudden onset, severe; subarachnoid haemorrhage Clinical red flags for imaging are: • Focal neurological deficit • Papilloedema • Change in level of consciousness • Memory impairment and loss of consciousness Thunderclap headache	CT	☢☢	Indicated [B]	CT is the investigation of choice at initial presentation.
	MRI	None	Specialised investigation [C]	MRI is better than CT for inflammatory causes. MRI may be useful if subarachnoid haemorrhage has been excluded by CT and lumbar puncture.
	CT angiography	☢☢	Indicated only in specific circumstances [B]	CT/MR angiography should be the initial vascular assessment in patients with proven subarachnoid haemorrhage or primary parenchymal haemorrhage. It is not an investigation for the cause of headache.
	MR angiography/ venography	None	Indicated only in specific circumstances [B]	MR or CT venography is of particular value in the diagnosis of cerebral venous thrombosis.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Headache: Chronic These features significantly increase the odds of finding a significant abnormality on MRI or CT: • Recent onset and rapidly increasing frequency and severity of headache • Headache causing patient to wake from sleep • Associated dizziness, lack of co-ordination, tingling or numbness • Headache precipitated by coughing, sneezing or straining • Patients with malignancy or who are immu-nocompromised • Recent onset headache in patients older than 50	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [B]	Imaging is not usually useful for isolated headache without abnormal neurological features (see clinical problem). Cervical spine XRs or paranasal sinus imaging are usually unhelpful even when neck signs suggest origin from the neck as they do not alter management.
Pituitary and juxtasellar problems Continued...	MRI	None	Specialised investigation [B]	Urgent referral is necessary when vision is deteriorating.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Pituitary and juxtasellar problems	CT	☢☢	Indicated only in specific circumstances [C]	A dedicated pituitary CT is useful if MRI is either contraindicated or not possible. Enhanced multiplanar CT images will show large masses and compression of the optic chiasm. It should not be used if MRI is available. CT may also have a further role in characterisation of masses and assessment of skull base involvement.
Posterior fossa signs (lower cranial nerve palsies; signs of cerebellar or brainstem dysfunction)	MRI	None	Indicated [A]	MRI is the investigation of choice. Diffusion-weighted images are helpful for investigation of brainstem ischaemia.
	CT	☢☢	Indicated only in specific circumstances [C]	CT is an appropriate first-line investigation in some patients and is especially helpful in the acute case to exclude a mass or bleed. CT may be complementary in evaluating base-of-skull tumours.
Hydrocephalus: Suspected shunt malfunction	CT	☢☢	Indicated [B]	CT is an appropriate first-line investigation.
	XR	☢	Indicated only in specific circumstances [B]	When mechanical shunt failure is suspected clinically, a CSF shunt series XR can show the whole system to define fracture or disconnection.
Dementia and memory disorders, Mild Cognitive Impairment (MCI), Dementia with movement disorders (Lewy body D, MSA, CBD etc.)	MRI/ CT	None/ ☢☢	Indicated [B]	Structural imaging should be used in the assessment of people with suspected dementia to exclude other non-neurodegenerative pathologies and to help establish subtype diagnosis. MRI is the imaging modality of choice to assist with early diagnosis and detect cerebral vascular changes i.e., in VAD. Serial MRI with volumetric sequence may be useful for progression of lobar involvement in AD and FTLD. In a small minority of cases, imaging will show an alternative cause such as a tumour, hydrocephalus or subdural collection. The yield for these lesions is higher if imaging is restricted to those with a rapid or atypical presentation, patients with focal signs, history of gait ataxia, incontinence or head injury. MRI may be useful in acute dementias, including limbic encephalitis and conditions such as Prion disease (Creutzfeldt-Jakob).
	NM – Functional cerebral blood flow imaging (seek specialist advice)	☢☢	Indicated only in specific circumstances [B]	FDG-PET and SPECT can be used to distinguish Alzheimer's disease from other forms of dementia, but specialist advice is needed.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
First-onset psychosis	MRI/ CT	None/ ☢☢	Specialised investigation [B]	Structural neuroimaging techniques are not recommended as a routine part of the initial investigations for the management of first-episode psychosis but may be indicated after specialist psychiatric assessment.
Orbital lesions	MRI/ CT	None/ ☢☢	Specialised investigation [B]	CT remains the investigation of choice for trauma, inflammation and endocrine eye disorders. MRI is the preferred/complementary investigation for orbital mass lesions. Occasionally, both CT and MRI are required for full evaluation of orbital pathology.
	US	None	Indicated only in specific circumstances [C]	US can be used for globe and anterior orbital pathology. Local availability and expertise will determine which imaging investigation is considered and needed.
	XR	☢	Not indicated [A]	Suspected orbital lesions require specialist referral.
Acute visual loss and visual field defects	MRI/ CT	None/ ☢☢	Specialised investigation [B]	MRI is preferable for suspected lesions of the optic chiasm and optic pathways, as well as for cerebral cortical insult and visual perception assessment. CT is helpful for orbital lesions.
	Cerebral angiography (MR/CT/ transcatheter)	☢☢☢	Indicated only in specific circumstances [B]	Angiography, preferably indirectly with MRI or CT should be considered when visual or orbital symptoms raise suspicion of aneurysm or carotid cavernous fistula.
	US (neck Doppler)	None	Indicated only in specific circumstances [B]	Carotid US is helpful for patients with a history suggesting amaurosis fugax.
	SXR	☢	Not indicated [B]	Specialists can diagnose many cases without resorting to imaging.
Epilepsy (adult) Continued...	MRI	None	Indicated [B]	MRI is the investigation of choice to look for structural abnormality for focal onset epilepsy. It is of little value in idiopathic generalised epilepsy. Epilepsy protocol MRI is especially valuable in the evaluation of temporal lobe epilepsy and refractory partial epilepsy.

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Epilepsy (adult)	CT	☢☢	Specialised investigation [B]	CT is used for acute assessment of seizure disorder when the clinical presentation is of an acute neurological illness, and also when MRI is not feasible or unavailable, for example, when general anaesthesia is required or in unstable patient. CT may complement MRI in the characterisation of lesions, e.g., calcification.
	NM (seek specialist advice)	☢☢	Specialised investigation [B]	Ictal regional cerebral blood flow SPECT or interictal FDG-PET is useful in the treatment planning of epilepsy surgery when MRI is negative or its results are not in concordance with clinical EEG or neurophysiological evidence.
Screening for intracranial aneurysm in patients with a strong family history (two or more first-degree relatives) of aneurysmal subarachnoid haemorrhage	CTA/ MRA	☢☢/ None	Specialised investigation [B]	Assessment and counselling at neurosciences centres are essential.
	Cerebral angiography	☢☢☢	Indicated only in specific circumstances [C]	
Movement disorders/ Parkinsonism	MRI	None	Specialised investigation [C]	Imaging is not normally required for Parkinson's disease. MRI may be indicated in the differential syndromes but if contraindicated, CT is the alternative.
Suspected cerebral venous sinus thrombosis	MRI (including MR venography)/ CT (including CT venography)	None/ ☢☢	Indicated [B]	Imaging plays a primary role in the diagnosis of cerebral venous sinus thrombosis. MRI or CT can demonstrate venous infarction and other complications but MR or CT venography will usually be required to confirm venous sinus thrombosis. Transcatheter cerebral angiography is rarely necessary unless non-invasive imaging is equivocal or when transcatheter, intrasinus thrombolysis is considered.
	Cerebral angiography	☢☢☢	Indicated only in specific circumstances [C]	
Asymptomatic carotid bruit	US	None	Indicated only in specific circumstances [B]	Doppler US is a reliable and inexpensive investigation of carotid arteries. It is best performed by experienced practitioners operating within a quality assurance programme.

Continued...

Clinical/ Diagnostic problem	Investigation	Dose	Recommendation [Grade]	Comments
Asymptomatic carotid bruit	MR angiography	None	Indicated only in specific circumstances [B]	Contrast-enhanced MR angiography is most accurate if available.
	CT angiography	☢☢	Indicated only in specific circumstances [C]	CT angiography is an alternative to MRA and US.
	Transcatheter angiography	☢☢☢	Indicated only in specific circumstances [C]	Transcatheter angiography may be required if 2 non-invasive tests are equivocal.

Clinical/ Diagnostic problem	Investigations	Dose	Recommendation [Grade]	Comments
Screening in pregnancy	US	None	Indicated [B]	Screening in early pregnancy (9–13 weeks) accurately dates a pregnancy by measuring the crown-rump length, which reduces the intervention rate for infants born at or after full term. US accurately assesses foetal number and chorionicity and improves outcome for multiple pregnancies. Assessment of nuchal translucency thickness from 11–14 weeks has been shown to be effective in screening for Down's syndrome. Screening for structural abnormality at 18–20 weeks has not been shown to alter perinatal mortality except where selective termination of pregnancy is applied in the presence of gross foetal abnormality. The routine use of US in late pregnancy in low-risk or unselected populations is not associated with improvements in overall perinatal mortality. In the specialist care of high-risk pregnancies, the use of US including Doppler is associated with a reduction in perinatal.
Suspected pregnancy	US	None	Indicated only in specific circumstances [C]	Urinary detection of human chorionic gonadotropin (pregnancy test) should be the firstline investigation. Serum assay of human chorionic gonadotropin should be considered if pregnancy is clinically suspected and urinary pregnancy test is negative or difficult to interpret. There is no indication for US except for dating, or when a complication of early pregnancy is suspected.
Suspected pregnancy of unknown location (ectopic pregnancy)	US	None	Indicated [C]	After a positive pregnancy test, TVUS is the most accurate modality for determining the pregnancy mains, the use of quantitative measurements of location. In cases where no intrauterine pregnancy is seen and clinical concern remains, the use of quantitative measurements of serum human chorionic gonadotropin and progesterone together with TVUS improves the diagnosis of ectopic pregnancy.
Possible early intrauterine pregnancy failure	US	None	Indicated [C]	Diagnosis of a non-viable pregnancy can only be confirmed by TVUS if the mean gestation sac diameter is ≥20 mm with no identifiable yolk sac or embryo, or an embryo with a crown-rump length ≥6 mm with no heartbeat. Diagnosis of failed pregnancy can only be confirmed by transabdominal US if the mean gestation sac diameter is ≥25 mm with no identifiable yolk sac or embryo, or embryo with a crown-rump length ≥6 mm with no heartbeat. Repeat TVUS after 1 week is needed (especially when the mean diameter of the gestational sac <20 mm or crown-rump length <6 mm). Where there is doubt about the viability of a pregnancy, delay in evacuation of the uterus is essential for safe practice.

Clinical/ Diagnostic problem	Investigations	Dose	Recommendation [Grade]	Comments
Postmenopausal bleeding to exclude significant endometrial pathology	US	None	Indicated [A]	TVUS is indicated to exclude significant endometrial pathology in postmenopausal bleeding. Endometrial thickening ≥5 mm or abnormal endometrial morphology or non-visualisation requires biopsy. Recurrent postmenopausal bleeding will require histological diagnosis irrespective of US findings.
Suspected pelvic mass	US	None	Indicated [B]	A combination of transabdominal and TVUS is often required. US should confirm a lesion's presence and determine the likely organ of origin. TVUS should be used to define the anatomy further.
	MRI	None	Specialised investigation [B]	MRI is helpful to further characterise pelvic mass seen on US.
	CT	☢☢☢	Specialised investigation [B]	CT is useful for staging a pelvic mass with a high risk of malignancy or when MRI is not possible.
Pelvic pain, including suspected pelvic inflammatory disease and suspected endometriosis	US	None	Indicated [B]	US (including transvaginal and transrectal US) is helpful, especially when clinical examination is difficult or impossible but has poor predictive value when diagnosing pelvic inflammatory disease. In the clinical setting laparoscopy is usually the next step after US.
	MRI	None	Specialised investigation [B]	MRI can be useful to localise the larger foci of endometriosis, to exclude endometriosis at the recto-vaginal septum and diagnosis adenomyosis.
	CT	☢☢☢	Specialised investigation [B]	CT is useful when a non-gynaecological cause for the pain is suspected. Radiation dose issues should be considered particularly with repeat examinations and in younger women.
Lost intrauterine contraceptive device (IUCD)	US	None	Indicated [C]	Most IUCDs are echogenic and can be identified on transabdominal US. Their correct placement is best ascertained with TVUS. Mirena IUD (levonorgestrel device) is plastic and less echogenic and TVUS will be required for assessment in this situation.
	AXR	☢	Indicated only in specific circumstances [C]	AXR is indicated only when IUCD is not seen in the uterus on US.

Clinical/ Diagnostic problem	Investigations	Dose	Recommendation [Grade]	Comments
Recurrent miscarriages (3 or more)	US	None	Indicated [B]	2D US will show the major congenital and acquired uterine problems. Where available, 3D US is reliable reproducible technique which will diagnose congenital uterine malformations.
	MRI	None	Specialised investigation [C]	MRI is helpful for non-invasive, detailed assessment of complex congenital abnormalities identified on initial US. MRI may also be helpful when all other modalities have failed.
	Hystero-salpingography(HSG)/ sono-HSG	☢☢/ None	Specialised investigation [B]	HSG or sono-HSG are only indicated when US has suggested an endometrial cavity lesion or congenital uterine abnormality.
Infertility	US	None	Indicated [B]	TVUS enables pelvic anatomy to be assessed with more accuracy and reliability. US can assess pelvic pathology, such as endometrioma, cyst, polyp, leiomyoma, adnexal and ovarian lesions. It is used for follicle tracking, in assessing endometrial response to hormonal manipulation, facilitating ovum retrieval and embryonic implantation during treatment.
	HSG/ Sono-HSG	☢☢/ None	Specialised investigation [A]	For initial assessment of tubal patency, HSG is recommended. HSG is also useful for the detection and confirmation of congenital and acquired uterine abnormalities.
Suspected cephalopelvic disproportion	MRI/ CT	None/ ☢	Specialised investigation [C]	There are a few maternal predisposing factors for cephalopelvic disproportion in which pelvimetry may be indicated. MRI and CT can both be used for the diagnosis. MRI is preferable as ionising radiation is avoided. CT pelvimetry is the alternative as the dose is considerably lower than XR pelvimetry.
	XR pelvimetry	☢	Not indicated [B]	
Suspected polycystic ovary syndrome	US	None	Indicated [B]	Polycystic ovary syndrome is a clinical and biochemical diagnosis. At least two of these criteria are required: • Oligomenorrhoea and/or anovulation • Clinical and/or biochemical hyperandrogenism with measurement of the Free Androgen Index • Polycystic ovaries with the exclusion of other causes The diagnosis of a polycystic ovary on US requires the demonstration of at least 12 follicles measuring 2–9 mm in diameter and/or an ovarian volume in excess of 10 mL. Sensitivity and specificity may be improved by 3D US.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Chest and Cardiovascular System				
Acute chest infection in children	CXR	☢	Indicated only in specific circumstances [A]	CXR is indicated if symptoms persist despite treatment, or in severely ill children. If CXR is used and shows simple pneumonia, routine follow-up CXR is not required. A lateral CXR should not be performed routinely.
Recurrent productive cough in children or chronic cough greater than 4 weeks	CXR	☢	Indicated only in specific circumstances [C]	In general, children with recurrent productive cough have CXRs that are normal or show peribronchial thickening. In these children, repeat CXR is not indicated unless atelectasis is seen on the initial CXR. Children with suspected cystic fibrosis or immune deficiency require specialist referral.
	CT (HRCT)	☢☢	Indicated only in specific circumstances [C]	When chronic suppurative lung disease (CSLD) is suspected clinically or from CXR, then low-dose HRCT may help.
Inhaled foreign body (suspected) in children	CXR	☢	Indicated [B]	CXR is indicated, although often normal. If there is high clinical suspicion of an inhaled foreign body, bronchoscopy is mandatory. While air trapping is the most common sign seen in patients with inhaled foreign bodies, it is seen infrequently and the routine use of expiratory XR is not warranted.
	CT	☢☢	Indicated only in specific circumstances [B]	With low clinical suspicion of inhaled foreign body and equivocal CXR, low-dose MDCT should be considered to avoid unnecessary bronchoscopy.
Wheeze in children	CXR	☢	Indicated only in specific circumstances [B]	In most children with wheeze, the CXR is either normal or shows features of uncomplicated asthma or bronchiolitis, such as hyperinflation or peribronchial cuffing. In selected cases, such as those with fever or localised crackles, the CXR may be useful in guiding patient management.
Acute stridor in children including chronic stridor more than 2 weeks	Lateral XR soft tissue neck	☢	Indicated only in specific circumstances [B]	Acute stridor is most commonly due to infection (croup or epiglottitis) or an inhaled foreign body. Chest XR and lateral neck XR may be of value in a child with a stable airway in whom an inhaled foreign body or retropharyngeal abscess is possible. Endoscopy is definitive. MRI, CT and upper GI contrast studies may help demonstrate retropharyngeal masses, abscess or a vascular ring.
	CXR	☢	Indicated only in specific circumstances [B]	
	MRI/ CT/ Upper GI contrast studies	None/ ☢☢/ ☢☢	Indicated only in specific circumstances [B]	

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Heart murmur in children	Echocardiography (ECHO)	None	Specialised investigation [B]	Specialist referral is needed. Echocardiography increases the diagnostic yield.
	CXR	☢	Indicated only in specific circumstances [C]	CXR is rarely helpful in asymptomatic children with a murmur but may help distinguish non-cardiac from cardiac disease.
Central Nervous System/Head and Neck				
Congenital disorders of the brain in children	MRI	None	Indicated [B]	MRI is the definitive investigation for all intra-cranial malformations, avoiding ionising radiation.
	US	None	Indicated only in specific circumstances [C]	In an young infant who is unable to undergo MRI, trans-fontanelle US may be an alternative but of limited use.
	CT	☢☢	Indicated only in specific circumstances [C]	CT may be needed to define bone and skull base anomalies and to identify parenchymal calcification.
Congenital disorders of the spine in children	MRI	None	Indicated [B]	MRI is the definitive investigation for all spinal malformations, avoiding ionising radiation.
	XR	☢	Indicated [B]	XR will be required to delineate bony anomalies and alignment in congenital and idiopathic scoliosis.
	US	None	Indicated only in specific circumstances [C]	US can be used in neonates and infants up to 3 months of age with multiple cutaneous markers or anorectal anomalies to identify occult spinal dysraphism.
	CT	☢☢	Indicated only in specific circumstances [C]	CT may be required for surgical planning.
Abnormal head shape in children	US	None	Indicated [B]	US is helpful to exclude ventricular dilatation in young infants with an open anterior fontanelle. High-resolution US may be used to confirm suture patency. In older children in whom sutures are closed or closing, MRI is indicated.

Continued...

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Abnormal head shape in children	MRI	None	Specialised investigation [C]	MRI is required in cases of suspected craniocervical compromise, venous drainage anomalies and associated congenital or parenchymal brain abnormalities.
	SXR	☢	Specialised investigation [C]	Useful to evaluate signs of premature suture fusion (craniosynostosis) particularly if there is microcephaly or significant plagiocephaly.
	CT	☢☢	Indicated only in specific circumstances [C]	CT is helpful for assessing craniosynostosis when the SXR is abnormal.
Epilepsy in children	MRI	None	Specialised investigation [A]	Specialist clinical assessment and EEG investigation should usually be undertaken before MRI, unless there are signs of raised intracranial pressure or an acute neurological deficit. The MRI protocol will be tailored to the clinical presentation and EEG findings.
	PET-CT/ NM (Seek specialist advice)/ Regional cerebral blood flow SPECT	☢☢☢☢/ ☢☢/ ☢☢	Specialised investigation [B]	Useful only in pre-surgical assessment.
	CT	☢☢	Indicated only in specific circumstances [B]	CT is an alternative to MRI for children in whom a general anaesthetic or sedation would be required when there are signs of raised intracranial pressure or neurological deficit. Positive findings are more likely for high clinical risk groups; i.e., those with a predisposing condition and or children under 33 months of age with focal seizures (excluding febrile seizure). Radiation dose should be taken into consideration particularly with repeat examinations.
	SXR	☢	Not indicated [B]	SXR has a poor yield.
Deafness/hearing loss in children	HRCT/ MRI	☢☢/ None	Specialised investigation [A]	Both CT and MRI may be necessary in children with congenital or post-infective deafness.
Hydrocephalus: suspected shunt malfunction in children	MRI	None	Specialised Investigation [B]	A single axial fast MRI sequence can be used and is ideal for the non-acute presentation. Programmable valves may be affected by MRI.
Continued...	CT	☢☢	Specialised investigation [B]	Low-dose CT is helpful in the acute setting.
	US	None	Indicated only in specific circumstances [B]	Cranial ultrasound can be used to assess the degree of ventricular dilatation in young infants in whom the anterior fontanelle is patent.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Hydrocephalus: suspected shunt malfunction in children	XR	☢	Indicated only in specific circumstances [B]	Use of an XR shunt series should be limited to patients with hydrocephalus who specifically have suspected mechanical causes of shunt failure.
Developmental delay: suspected cerebral palsy	MRI	None	Specialised investigation [A]	In children with cerebral palsy, following specialist clinical assessment, MRI can demonstrate the extent of brain abnormality and may be helpful in determining prognosis. In some cases, MRI reveals unexpected brain malformations or other abnormalities that may have implications for genetic counselling.
Headache in children	MRI/ CT	None/ ☢☢	Specialised investigation [B]	Neuroimaging is essential in children who present with acute headache and clinical features suggestive of intracranial pathology. MRI is preferable. Imaging is not helpful for migraine or chronic tension headache.
	SXR	☢	Not indicated [C]	If headache is persistent or associated with clinical signs, refer the patient for specialised investigations.
Suspected sinusitis in children	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [B]	MRI or low-dose CT (with a radiation dose similar to XR) is useful when surgery is being considered or when there are complications.
	XR Sinus	☢	Not indicated [C]	Imaging is not required for acute sinusitis. XR is not helpful in children under the age of 5 years because the sinuses are incompletely developed. Mucosal thickening may be a normal finding in children.
Torticollis without trauma in children	US	None	Indicated [B]	In congenital torticollis, US of neck muscles is a useful diagnostic tool for confirmation of sternocleidomastoid pseudo-tumour in infants. If US is negative, XR and cross-sectional imaging may be indicated to exclude other causes of torticollis.
	XR	☢	Indicated only in specific circumstances [B]	Muscular causes are most common, but when history and examination are atypical, XRs are advised to exclude causes other than congenital torticollis.
	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [B]	Painful torticollis justifies further imaging to exclude causes other than congenital torticollis. MRI and CT can identify non-muscular causes of torticollis but are unhelpful for guiding management of congenital muscular torticollis.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Back pain in children	MRI	None	Indicated [B]	Persistent back pain in children may have an underlying cause and justifies investigation, although few will have underlying pathology. MRI is the investigation of choice particularly to avoid ionising radiation. Back pain with scoliosis or neurological signs merit MRI/CT.
	CT	☢☢	Specialised investigation [B]	
	XR	☢	Indicated only in specific circumstances [C]	Helpful for identifying congenital anomalies.
	NM	☢☢	Indicated only in specific circumstances [B]	Bone scintigraphy particularly with SPECT is an alternative to MRI to diagnose stress injuries and spondylolysis.
Spina bifida occulta in children	US/ MRI	None/ None	Not indicated [C]	A common variation and not in itself significant. Investigation is only indicated if neurological signs are present.
Sacral dimple or other cutaneous stigmata in children (e.g., hairy patch)	US/ MRI	None/ None	Indicated only in specific circumstances [B]	In the newborn child, isolated midline sacral dimples and small pits can be safely ignored. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (≥5 mm), high on the back (≥2.5 cm from the anus), or appear in combination with other lesions. If there are other stigmata of spinal dysraphism or associated congenital abnormalities, US of the neonatal lumbar spine is the investigation of choice. MRI is indicated when US is abnormal/equivocal, when there are neurological signs or when there is a discharging lesion.
Neonatal hypothyroidism	US	None	Indicated [A]	US is the first-line investigation to confirm the presence of a structurally normal thyroid gland in a normal location in the neck but provides no information on the thyroid function.
	NM (pertechnetate/ 123-I)	☢☢	Specialised investigation [A]	NM is the most accurate test for detecting ectopic thyroid.
Gastrointestinal System				
Intussusception in children	US	None	Indicated [A]	US is a sensitive diagnostic test in experienced hands.
Continued...	AXR	☢	Indicated [B]	AXR is not indicated in an uncomplicated intussusception. AXR is only useful to evaluate the degree of small bowel obstruction and to exclude perforation.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Intussusception in children	US-guided hydrostatic reduction/ Fluoroscopy-guided hydrostatic/ pneumatic reduction	None/ ☢☢	Indicated [B]	US-guided or fluoroscopy-guided hydrostatic/pneumatic reduction should be undertaken only where specialised equipment and trained specialist is available, after consultation with a paediatric surgeon or general surgeon with paediatric surgery training.
Ingested foreign body in children	CXR, including neck	☢	Indicated [B]	Oesophageal foreign bodies require early intervention because of their potential to cause respiratory symptoms and oesophageal complications. CXR and lateral neck XR will detect radio-opaque foreign bodies and lung complications. AXR should not be done unnecessarily, especially in asymptomatic patients. AXR needed only for sharp or potentially poisonous foreign bodies: e.g., battery. Some objects may ake up to 2 weeks to pass.
	AXR	☢	Indicated only in specific circumstances [C]	
Blunt abdominal trauma in children	US	None	Specialised investigation [B]	US avoids irradiation and is usually the first investigation, particularly when the injury is not severe. In many cases, a negative ultrasound in a stable child merits observation only.
	CT	☢☢☢	Specialised investigation [B]	CT is the imaging investigation of choice in severe blunt abdominal trauma with major clinical signs and symptoms, and will guide hospital and post-discharge management of the patient.
	AXR	☢	Indicated only in specific circumstances [B]	Clinical assessment of the patient should be used to determine which patients require further evaluation by imaging, AXR is of very limited use after minor trauma unless there are positive physical signs suggestive of intra-abdominal pathology or injury to the spine or bony pelvis.
Projectile vomiting in infants	US	None	Indicated [A]	US can confirm the presence of hypertrophic pyloric stenosis, especially where clinical findings are equivocal. If US shows no evidence of pyloric stenosis, contrast studies may be helpful.
Recurrent vomiting in children Continued...				Recurrent vomiting in children can be caused by a range of conditions including intracranial tumours and some which cannot be diagnosed radiologically. Bile-stained vomiting requires a clinical/surgical opinion.
	AXR	☢	Indicated only in specific circumstances [B]	AXR may identify the level of bowel obstruction.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Recurrent vomiting in children	Upper GI contrast study	☢☢	Indicated only in specific circumstances [B]	An upper GI contrast study is not indicated for the diagnosis of simple gastro-oesophageal reflux. Where significant gastro-oesophageal reflux has been shown on pH studies, an upper GI contrast study may be indicated to exclude a significant structural abnormality such as hiatus hernia or malrotation. If there are other associated clinical symptoms/ signs–e.g., bile-stained vomiting–the case for contrast studies is much stronger.
	NM	☢☢	Indicated only in specific circumstances [B]	Gastric emptying may be measured with Tc-99m-labelled solid or fluid meal, which may be combined with scintigraphic evaluation of gastro-oesophageal reflux.
Persistent neonatal jaundice	US	None	Specialised investigation [A]	Prompt investigation is essential in neonatal jaundice with raised conjugated bilirubin that persists for more than 14 days in term babies or more than 21 days in preterm babies. The absence of dilatation of the intrahepatic bile ducts does not exclude obstructive cholangiopathy, but recognition of specific ultrasound features has a high specificity for biliary atresia.
	NM (Tc-99m-HIDA)	☢☢	Specialised investigation [B]	Hepatobiliary scintigraphy with Tc-99m-labelled IDA derivatives is useful. Demonstration of excretion of activity into bowel helps to exclude biliary atresia, but absence of bowel excretion does not necessarily confirm biliary atresia. If there is delay or difficulty in obtaining HIDA scan, it is advisable to proceed directly to operative cholangiogram.
GI bleeding in children Continued...				Imaging strategy depends on the age of the patient and severity of bleeding diagnostic possibilities and clinical presentation.
	US	None	Specialised investigation [C]	US is used for the diagnosis of portal vein thrombosis, portal hypertension and gastric masses for upper GI bleeding. In lower GI bleeding, US is used for the diagnosis of intussusception, demonstration of duplication cysts and Meckel's diverticulum. US can complement AXR in the diagnosis of necrotising enterocolitis.
	Endoscopy (Including video capsule endoscopy)	None	Specialised investigation [B]	Upper or lower GI endoscopy is often the most useful next investigation after US. Consider small bowel enema, video capsule endoscopy or enteroscopy if the suspected lesion is inaccessible to endoscopy.
	NM (Tc-99m-labelled RBCs)	☢☢	Specialised investigation [C]	NM (using Tc-99m-labelled RBCs) is used for detecting active bleeding sites including Meckel's diverticulum.
	AXR	☢	Indicated only in specific circumstances [C]	AXR is required if necrotising enterocolitis is suspected.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]		Comments
GI bleeding in children	Angiography (including CT angiography)	☢☢☢	Indicated only in specific circumstances [B]		Angiography (CT or transcatheter) is used for investigation of rapid haemorrhage or chronic haemorrhage not found by other means. High radiation doses should be taken into consideration.
Acute abdominal pain in children	US	None	Indicated [B]		There are many causes of acute abdominal pain. US is a useful first investigation but needs to be guided by clinical findings. For negative or equivocal US, a repeat US is advisable rather than CT in a symptomatic patient.
	AXR	☢	Specialised investigation [C]		AXR is rarely of value and is best performed under specialist guidance. Generally AXR is not undertaken before US.
	CT	☢☢☢	Specialised investigation [B]		Although CT is more sensitive than US for the diagnosis of appendicitis, specificities are similar and the strategy for imaging should take into account radiation dose and clinical features.
	MRI	None	Indicated only in specific circumstances [B]		Following abdominal US, when TVUS is not feasible, MRI is occasionally helpful for evaluating pelvic masses in girls.
Constipation in children	AXR	☢	Indicated only in specific circumstances [C]		There is a wide variation in the amount of faecal residue shown on the AXR and good correlation with constipation has not been proven. AXR using colonic markers in a transit study can help specialists in the management of intractable constipation.
	Contrast enema	☢☢	Indicated only in specific circumstances [B]		Non-radiological investigations, such as rectal manometry and biopsy, are preferred. Contrast enema may have a role if these are not feasible.
	US	None	Indicated only in specific circumstances [B]		Transabdominal US can identify rectal size and severity of constipation.
	MRI	None	Indicated only in specific circumstances [C]		When a neurological cause is suspected, MRI is helpful to assess the spine, sacral plexus and pelvic mass. MRI of the pelvic floor and defaecography are used in some specialist centres.
Palpable abdominal/pelvic mass in children	US	None	Indicated [C]		US is indicated in the assessment of all suspected abdominal masses. If the presence of a mass is confirmed, the patient should be referred to a specialist centre for cross-sectional imaging, preferably MRI rather than CT.
Musculoskeletal System					
Non-accidental injury (NAI)/child abuse Continued...	Skeletal survey (including SXR, CXR, oblique XR ribs, AXR, XR spine and limbs)	☢☢	Indicated [A]		The investigation of suspected child abuse may be complex and should be multidisciplinary, involving the child protection team. The skeletal survey should be performed in accordance with published standards. SXR is essential to demonstrate skull fractures even when CT brain is performed.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Non-accidental injury (NAI)/child abuse	CT Brain	☢☢	Indicated [B]	Any child who presents with evidence of physical abuse with encephalopathic features, focal and neurological signs or haemorrhagic retinopathy.
	MRI	None	Specialised investigation [A]	MRI brain is helpful if CT shows evidence of subdural haemorrhage or brain injury. MRI should be considered not only when CT is abnormal, but also in the presence of an apparently normal CT brain if there is neurological deficit as MRI is more sensitive for subarachnoid haemorrhage at 3 to 5 days.
	NM (bone scan)	☢☢	Specialised investigation [A]	Bone scintigraphy can be of value in the investigation of NAI but should only be performed in departments that have expertise in scanning infants. It is useful when the skeletal survey is equivocal or where there are ongoing clinical concerns despite a normal survey, particularly where a follow-up skeletal survey at 2 weeks is not a viable option. The diagnostic yield from a skeletal survey and NM is greater than either investigation alone. If there are any areas of increased activity on the bone scan, then corresponding radiographs should be obtained. Abnormal findings should be correlated with clinical history, physical examination and XR.
Limb injury in children: Opposite side for comparison	Comparison XRs of the joint on the contralateral side	☢	Not Indicated [B]	Seek radiological advice.
Short stature, growth failure	XR for bone age	☢	Indicated [A]	Child aged 1 year and over: left (or non-dominant) hand/wrist only. XR may need supplementing with further specialised investigations. Skeletal survey if dysplasia is suspected. MRI of hypothalamus-pituitary fossa if central hormone failure is a possibility.
Hip pain in children: suspected irritable hip	US	None	Indicated [B]	US will confirm presence of an effusion but will not discriminate sepsis from transient synovitis.
	XR	☢	Specialised investigation [C]	XR, which should include a frog lateral view, is required in slipped upper femoral epiphysis or Perthes' disease is suspected or if symptoms persist. Yield is higher in children over 9 years of age. If symptoms persist, then follow-up should be as for the limping child.
	MRI	None	Indicated only in specific circumstances [B]	When osteomyelitis, septic arthritis or pelvic collections are suspected, MRI is the most sensitive investigation.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Limp (no trauma) in children	US	None	Indicated [B]	US will confirm the presence of an effusion but will not discriminate between sepsis, transient synovitis and inflammatory arthritis.
	MRI	None	Specialised investigation [B]	MRI may help distinguish between transient synovitis and infection and will occasionally show other pelvic pathology.
	XR	☢	Indicated only in specific circumstances [B]	Children with a limp need proper clinical assessment. XR is helpful in a child with fever or unable to weight-bear and to rule out slipped epiphysis in children over the age of 9 years particularly if pain persists.
	NM (bone scan)	☢☢	Indicated only in specific circumstances [B]	XR and US should be used before NM. NM is an alternative to MRI when XR and US are normal but gives poorer anatomical localisation and carries a radiation burden.
Focal bone pain in children	XR	☢	Indicated [B]	XR should be the first-line investigation, although MRI and NM are more sensitive than XR in detecting occult infection or fracture.
	MRI	None	Specialised investigation [B]	MRI is especially useful if the child can localise the site of the pain and will show occult fractures when XR is normal.
	US	None	Specialised investigation [C]	US can detect occult infection.
	NM (bone scan)	☢☢	Indicated only in specific circumstances [B]	XR should be obtained initially. Skeletal scintigraphy is useful if pain is not well localised but there is suspected infection or recent trauma. Radiation dose should be taken into consideration.
	CT	☢☢	Indicated only in specific circumstances [B]	CT is of value in suspected osteoid osteoma.
Clicking hip; suspected developmental dysplasia of the hip (DDH) in infants	US	None	Indicated [A]	Hip US is indicated selectively where there is clinical suspicion of DDH (Barlow or Ortolani positive or clicking) but not for routine screening. For a neonate with clinical suspicion, hip US should be done within 2 weeks. For newborn with risk factors, hip US at 4–6 weeks. XR of hip is only indicated for an infant more than 6 months.
Osgood–Schlatter disease in children	XR	☢	Indicated only in specific circumstances [C]	Although bony radiological changes are visible in Osgood–Schlatter disease, they overlap with normal appearances. Associated soft tissue swelling should be assessed clinically rather than radiographically. Imaging is not needed for diagnosis and is only required to exclude other pathology.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Urogenital System and Adrenal				
Continuous wetting in children	US	None	Indicated [B]	In toilet-trained girls with a history of continuous dribbling/wetting, an ectopic infrasphincteric ureter and cryptic duplex collecting system must be excluded. US of the whole renal tract including the bladder and pelvis is recommended. Imaging of the urinary tract in children with solely night-time enuresis is of limited value.
	XR lumbosacral spine	☢	Indicated [B]	XR of the lumbosacral spine is indicated in children with abnormal neurology or skeletal examination, in addition to those with bladder wall thickening/trabeculation shown on US or neuropathic vesicourethral dysfunction on videourodynamics.
	MRI	None	Specialised investigation [B]	MRI may be of value in the location of the dysplastic kidney or moiety when US has failed. When there are neurological features, MR urography is an alternative to IVU. MRI of the spine will identify anomalies.
	CT	☢☢☢	Specialised investigation [B]	When MRI is not feasible, CT may be of value in the location of the dysplastic kidney or dysplastic occult moiety when US has failed. CT urography is an alternative to MR urography. Radiation dose should be taken into consideration.
	IVU	☢☢	Indicated only in specific circumstances [B]	IVU is used to confirm the ectopic infrasphincteric ureters in girls with a known duplex system on US and/or DMSA imaging.
	NM (DMSA)	☢☢	Indicated only in specific circumstances [B]	DMSA imaging is useful in the detection and location of the dysplastic kidney and upper moiety of a duplex system. It is also useful to rule out renal scarring associated with bladder dysfunction/recurrent UTI.
	Video urodynamics	☢☢	Indicated only in specific circumstances [B]	Video urodynamics is helpful to assess neuropathic vesicourethral dysfunction.
Impalpable testis in children	US	None	Indicated [B]	Good clinical examination in a cooperative child is the best modality to locate undescended testis in inguinal canal in majority of cases. US may not be necessary. US is used in the location of the testis within the inguinal canal.
	MRI/ Laparoscopy	None	Specialised investigation [C]	MRI may be of value after US to locate intra-abdominal testis. Laparoscopy is the best modality.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Foetal renal pelvic dilatation: post-partum investigation for risk stratification	US	None	Indicated [B]	Postnatal imaging should be planned on the basis of antenatal findings. US performed in the first 3 days of life can underestimate the degree of dilatation and usually needs repeating. In low-risk infants, ideally the examination should be performed 4–6 weeks after birth. In high-risk infants (e.g., with foetal bilateral renal pelvic dilatation), US in the first few days of life is indicated. A normal US at 4–6 weeks obviates the need for further investigation. Other imaging investigations, including micturating cystourethrogram and diuretic renography, should be used according to local protocols for risk stratification.
	NM (DMSA/MAG3/ DTPA)	☢☢	Specialised investigation [B]	In cases of persisting significant postnatal renal pelvic dilatation, DMSA and MAG3/DTPA diuretic renography are essential in the estimation of scarring, renal uptake function (differential function) as well as drainage.
	Micturating cysto-urethrogram (MCUG)	☢☢	Specialised investigation [B]	MCUG should only be used selectively to show vesicoureteric reflux in infants with persisting, significant uretero-pelvic-calyceal dilatation according to local protocol.
Proven urinary tract infection in children	US	None	Specialised investigation [C]	The age of the patient affects decisions. Infants and children with atypical UTI should have ultrasound of the urinary tract during the acute infection to identify structural abnormalities of the urinary tract such as obstruction. For infants younger than 6 months with first-time UTI that responds to treatment, ultrasound is indicated. For infants and children aged 6 months and older with first-time UTI that responds to treatment, routine ultrasound is not recommended unless the infant or child has atypical UTI. Infants and children who have had a lower UTI should undergo ultrasound only if they are younger than 6 months or have had recurrent infections. (Follow local protocol.)
	NM (DMSA)	☢☢	Specialised investigation [A]	DMSA should be used 4–6 months following the acute infection to detect renal parenchymal defects in children under 3 years of age with atypical UTI or all children with recurrent UTI.
	Cystography: MCUG/ NM (Seek specialist advise)/ US	☢☢/ ☢☢/ None	Specialised investigation [A]/ [B]/ [C]	Cystography is helpful in children under 6 months of age with atypical or recurrent UTI. Prophylactic antibiotics should be given as per local protocol.
	MR urography	None	Indicated only in specific circumstances [C]	MR urography should be considered as a problem-solving tool but with potential for wider use to assess anatomical and functional details.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Head injury: The following clinical features indicate a risk of significant brain injury: • GSC <13 on initial assessment in the emergency department • GSC <15 at 2 hours after the injury • Suspected open or depressed skull fracture • Any sign of basal skull acturemo tympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign) • More than one episode of vomiting in adults; three or more episodes of vomiting in children • Post-traumatic seizure • Coagulopathy (history of bleeding, clotting disorder, current treatment with warfarin) providing that some loss of consciousness or amnesia has been experienced; patients receiving antiplatelet therapy may be at increased risk of intracranial bleeding, though this is currently unquantified – clinical judgement should be used to assess the need for an urgent scan in these patients • Focal neurological deficit	CT	☢☢	Indicated [B]	Head CT should be available in all hospitals responsible for assessment of patients with head injuries and should take place as soon as possible (in accordance with local guidelines) in all patients meeting the clinical criteria. CT may be delayed in patients who present with amnesia only, or a dangerous mechanism of injury, but none of the other clinical features of significant brain injury. Deterioration in GSC score by just one-point warrants early CT and deterioration in GCS at 24 hours may warrant a repeat study despite an initial negative scan. A new lesion on CT and deterioration in GCS score by just one point warrant a repeat study despite an initial negative scan. A new lesion on CT or suspicious clinical features should lead to discussion with a neurosurgical specialist centre. Appropriate imaging of the cervical spine (where applicable) should be discussed prior to and coordinated with CT head imaging.
	MRI	None	Indicated only in specific circumstances [C]	MRI is a sensitive tool for evaluation of white matter damage in traumatic brain injury, and may have an important prognostic role in outcome measures. There are currently no clear guidelines on the need for MRI and requests should only be made after discussion with neurosurgeons.
	Skull XR	☢	Not indicated [C]	When CT is not available, SXR could be justified for triage. An important exception is in the case of suspected NAI in children, where SXR is routinely indicated as part of a skeletal survey. In children 0–2 years old, CT of the head is mandatory.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Face and Orbits				
Nasal trauma	SXR/ XR facial bones/ XR nasal bones	☢/ ☢/ ☢	Not indicated [B]	XRs are unreliable in the diagnosis of nasal fractures and even when positive do not usually affect patient management. XR or further imaging could be considered only after ENT/maxillofacial assessment, depending on local policy.
Blunt orbital trauma	XR facial bones	☢	Indicated [B]	XR of the facial bones is used especially where a blowout injury is suspected. XRs cannot detect important soft tissue abnormalities, e.g., rectus muscle entrapment.
	CT	☢☢	Specialised investigation [B]	CT should be performed when there is persistent clinical concern for a fracture not demonstrated on plain film and for pre-surgical planning. CT should be the initial investigation if there is a clinically obvious fracture or evidence of major facial trauma as CT will be required for full evaluation and surgical planning.
	MRI	None	Indicated only in specific circumstances [B]	MRI avoids ionising radiation to the eye and should be considered in children. It is of value to show orbital soft tissue herniation, but inferior to CT for demonstrating fracture lines. US can also be used as an alternative where there is local expertise.
Orbital trauma: Penetrating injury	XR orbits	☢	Indicated [B]	XR of the orbits is indicated for suspected radio-opaque (metallic) intra-orbital foreign body.
	CT	☢☢	Specialised investigation [B]	CT is indicated for suspected poorly opaque (small or non-metallic) intra-orbital foreign body particularly in the presence of clinically evident ocular penetration, but where a foreign body is not clinically visible.
	US	None	Specialised investigation [B]	US is useful for anterior intraocular foreign bodies but contraindicated in globe rupture.
	MRI	None	Specialised investigation [B]	MRI is hazardous with metal intra-orbital foreign bodies. When there is a strong clinical suspicion of a non-metallic foreign body (especially wood), MRI may be needed after other imaging investigations have failed to localise or identify the foreign body.
Orbital lesions: Suspected foreign body Continued...	XR orbits	☢	Indicated [A]	A single radiograph is required to exclude a metallic foreign body; eye-moving images are only for confirmation of the intraocular position of a foreign body once shown. Before MRI, a postero-anterior XR is adequate to exclude a significant metallic foreign body. If a foreign body is confirmed, CT may be required.
	US	None	Indicated [A]	US may be indicated for radiolucent foreign bodies or where XR is difficult.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Orbital lesions: Suspected foreign body	CT	☢☢	Specialised investigation [C]	CT is indicated when XR does not show a strongly suspected foreign body that may not be metallic, when multiple foreign bodies are present or when it is not certain whether a foreign body already shown is intraocular.
Middle-third facial injury	XR facial bones	☢	Indicated [B]	Discuss with the maxillofacial surgeon, who may request low-dose CT at an early stage in management of complex injuries.
	CT	☢☢	Specialised investigation [B]	Patient co-operation is essential to obtain views of diagnostic quality. Consider delay if the patient is uncooperative.
Mandibular trauma	OPG/XR mandible	☢	Indicated [B]	Although OPG/XR is adequate for assessing uncomplicated mandibular trauma, MDCT is more accurate particularly for complex injury patterns. OPG is not appropriate in uncooperative or multiple injury patients. Cone beam CT is more accurate than OPG at a lower dose than MDCT.
	CT (including cone beam CT)	☢☢	Specialised investigation [B]	Although OPG/XR is adequate for assessing uncomplicated mandibular trauma, MDCT is more accurate particularly for complex injury patients. Cone beam CT is more accurate than OPG at a lower dose than MDCT.
	MRI	None	Indicated only in specific circumstances [B]	For more severe condylar fractures MRI may be helpful to assess disc and capsular injury.
Cervical Spine				
Cervical spine assessment in CONSCIOUS PATIENT with head and/or facial injury only Consider imaging only if: • Unable to actively rotate neck left and right to 45° • GCS score <15 • Paraesthesia in extremities • Focal neurologic deficit	XR	☢	Indicated only in specific circumstances [A]	Cervical spine imaging should be considered when validated clinical criteria are present. CT is undoubtedly more accurate than three-view cervical spine XR but carries a higher radiation dose. In patients requiring CT brain, it is reasonable to perform CT of the cervical spine at the same time, obviating the need for XR cervical spine. CT is undoubtedly more accurate than three-view cervical spine XR but carries a higher radiation dose.
	CT	☢☢	Indicated only in specific circumstances [B]	

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
• Not possible to test for range of neck movement (safe assessment if: simple rear-end collision, sitting position in the emergency department, ambulatory at any time since injury, delayed onset of neck pain, absence of midline cervical spine tenderness) • Age ≥65 years • Dangerous mechanism of injury (fall >1 m)				
Cervical spine assessment in an UNCONSCIOUS PATIENT with head injury	CT/ XR Cervical spine	☢☢/ ☢	Indicated [B]	CT of the whole cervical spine from skull base to T4 is the preferred examination in patients with high risk of significant cervical injury. CT cervical spine is clearly more accurate than XR cervical spine and should be done at the same time as CT brain when this is indicated. Although XR is acceptable for less severe injuries, an adequate examination is difficult in the unconscious patient.
	MRI	None	Indicated only in specific circumstances [A]	MRI may be helpful to assess ligamentous or vascular injury in patients with high clinical suspicion but a normal CT scan.
Neck injury with pain Consider imaging only if: • Unable to actively rotate neck left and right to 45° • GCS score <15 • Paraesthesia in extremities • Focal neurological deficit	XR cervical spine	☢	Indicated [B]	Cervical spine imaging should be considered when validated clinical criteria are present. CT is undoubtedly more accurate than three-view cervical spine XR but carries a higher radiation dose. In patients requiring CT brain, it is reasonable to perform CT of the cervical spine at the same time, obviating the need for XR cervical spine.
	CT	☢☢	Indicated [B]	
	MRI	None	Specialised investigation [A]	MRI may be helpful to assess ligamentous or vascular injury in patients with high clinical suspicion but a normal CT scan.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
• Not possible to test for range of neck movement (safe assessment if: simple rear-end collision, sitting position in the emergency department, ambulatory at any time since injury, delayed onset of neck pain, absence of midline cervical spine tenderness) • Age ≥65 years • Dangerous mechanism of injury (fall >1 m)				
Neck injury with neurological deficit	MRI	None	Indicated [A]	MRI is the best and safest method of showing intrinsic cord damage, cord compression, ligamentous injuries and vertebral fractures at multiple levels.
	CT	☢☢	Indicated [B]	CT is more accurate than XR and can be used to rapidly assess the bony cervical spine when it is impossible to obtain good-quality radiographs.
	CT myelography	☢☢☢	Indicated only in specific circumstances [B]	CT myelography may be considered if MRI is not practicable but this may only be available in specialist centres.
	XR cervical spine	☢	Indicated only in specific circumstances [B]	XRs are difficult to obtain in a patient with a neurological deficit and a cervical spine injury and have a limited role, mainly confined to intraoperative localisation and postoperative surveillance.
Neck injury with pain but initial XR normal: Suspected ligamentous injury	MRI	None	Indicated [A]	MRI cervical spine is the investigation of choice and shows ligamentous, spinal cord and soft tissue injuries. A normal MRI can conclusively exclude cervical spine injury.
	CT	☢☢	Specialised investigation [B]	CT is more accurate in the detection of occult cervical spine injury than plain radiography.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Neck injury with pain but initial XR normal: Suspected ligamentous injury	XR cervical spine	☢	Specialised investigation [B]	When MRI is not available, flexion/extension views should be achieved by the patient with no assistance and under medical supervision. These views are of value only when the patient is able to move without limitation from muscle spasm. In some cases, this may be 10 days or more after injury.
Thoracic and Lumbar Spine				
Thoracic and lumbar spine trauma without pain or neurological deficit	XR	☢	Not indicated [B]	Physical examination is reliable in this region. When the patient is alert and asymptomatic without neurological signs, the probability of a radiological finding that would alter management is low.
Thoracic and lumbar spine trauma with pain but no neurological deficit or patient not able to be evaluated	XR	☢	Indicated [B]	The threshold to XR is low when there is pain/tenderness after a significant fall, a high-impact road traffic accident and presence of other spinal fracture, or when it is not possible to clinically assess the patient. If XR suggests instability or posterior element fractures, CT or MRI is essential. With multiple injuries requiring CT, reformatted CT images of the thoracic spine obviates the need for XR.
	CT	☢☢☢	Specialised investigation [B]	
Thoracic and lumbar spine trauma with neurologic deficit with or without pain	XR	☢	Indicated [B]	XR is used for surgical planning purposes.
	MRI	None	Indicated [B]	Whole-spine MRI is indicated when there are multilevel or ligamentous injuries and cauda equina injuries.
	CT	☢☢☢	Indicated [B]	Detailed analysis of bone injury is achieved with CT +/- multiplanar reconstructions.
Pelvis and Sacrum				
Pelvic injury with inability to weight-bear	XR pelvis and lateral XR hip	☢ and ☢	Indicated [C]	Physical examination may be unreliable. Check for femoral neck fractures, which may not show on initial XR, even with good lateral views. When XR is normal or equivocal and clinical suspicion high, CT is recommended to show occult proximal femoral fractures as it is readily available. MRI is an alternative especially if the CT is normal and clinical suspicion is high.
	MRI/ CT	None/ ☢☢☢	Indicated only in specific circumstances [B]	

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Pelvic injury with urethral bleeding	Retrograde urethrogram	☢☢	Indicated [C]	Retrograde urethrography is used to show urethral integrity, leak or rupture. In the presence of pelvic trauma, contrast-enhanced CT, including delayed images, to show upper tract, bladder and pelvic injuries are indicated prior to a retrograde study. Cystography or CT cystography should be considered. In the non-acute situation MRI can be used.
	CT	☢☢☢	Indicated [B]	
Trauma to coccyx or coccydynia	MRI	None	Indicated only in specific circumstances [C]	Normal appearances are often misleading and findings do not affect management. Radiation dose is significant. In cases of chronic intractable coccydynia, MRI or dynamic XR (sitting/standing) may be helpful to support the need for surgery.
	XR	☢	Indicated only in specific circumstances [C]	
Upper and Lower Limbs				
Shoulder injury	XR	☢	Indicated [B]	Some dislocations present with subtle findings. As a minimum, 2 orthogonal views are required. US, MRI and CT may have a role in complex cases or soft tissue injury.
Elbow trauma	XR	☢	Indicated [B]	XR is the best initial investigation to show effusion and/or fracture.
	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [B]	MRI/CT can demonstrate occult fracture. CT is helpful in characterising complex fracture. MRI is particularly helpful to assess stress injuries.
Wrist injury: Suspected scaphoid fracture	XR	☢	Indicated [B]	A scaphoid view is needed when a scaphoid fracture is suspected.
	MRI/ CT	None/ ☢☢	Indicated [B]	If doubt persists following XR and senior clinical review, MRI is accurate and cost-effective. CT may be alternative.
Knee trauma: Fall/blunt trauma Consider XR only if: • Age ≥55 years • The patient cannot walk four weight-bearing steps	XR	☢	Indicated [B]	When blunt trauma or a fall is the mechanism of injury, XR is warranted. CT/MRI/US may be needed where further information is required. CT is helpful for intra-articular fractures, MRI for ligamentous/meniscal/occult bony injuries and US for focal injuries of the extensor mechanism and medial collateral ligament.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
• Localised tenderness of the patella • Localised tenderness of the fibular head • Inability to flex to 90°				
Acute ankle injury Consider XR only if: • Inability to weight-bear immediately and in the emergency department • Tenderness over the posterior edge or tip of either malleolus	XR	☢	Indicated [A]	When blunt trauma or a fall is the mechanism of injury, XR is warranted. Soft tissue injuries and occult fractures may be shown by US, MRI or CT if XR is normal. Discuss with the radiologist.
	US/ MRI/ CT	None/ None/ ☢☢	Indicated only in specific circumstances [B]	
Foot injury	XR	☢	Indicated [B]	XR is indicated only if there is true bony tenderness or inability to weight-bear. Demonstration of a forefoot injury rarely affects management. XRs of foot and ankle are not usually needed together; both will not be done unless there is a good reason. If XR is not performed, advise return within 1 week if symptoms are not improved.
	MRI/ CT	None/ ☢☢	Indicated only in specific circumstances [B]	MRI is useful for diagnosing and grading bone stress fractures. For complex mid-foot injuries, CT or MRI is required.
Stress fracture	XR	☢	Indicated [B]	XR is indicated, although is often unrewarding.
	MRI	None	Indicated [B]	MR is the most sensitive and specific investigation to diagnose a bone stress fracture when the XR is normal or equivocal. NM is an alternative for occult stress fractures but should be reserved for patients who are unable to undergo MRI, due to the radiation exposure, particularly for follow-up examinations. CT may be helpful as an alternative to MRI to demonstrate bony changes but is less sensitive.
	NM (bone scan)	☢☢	Specialised investigation [C]	
	CT	☢☢	Indicated only in specific circumstances [C]	

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Imaging of a Foreign Body				
Soft tissue injury: foreign body, e.g., metal, glass, painted wood, thorns	XR	☢	Indicated [B]	All glass is radio-opaque. Remove bloodstained or soiled dressing first where possible.
	US	None	Indicated [B]	US in expert hands is accurate for confirming radiolucent foreign bodies (e.g., wood, plastic and thorns) or where XR is difficult. US may also show adjacent tenosynovitis and is helpful to guide removal of the foreign body.
Ingested foreign bodies	XR	☢	Indicated only in specific circumstances [C]	After a negative direct examination of the oropharynx, a lateral neck soft tissue XR may be helpful to show foreign bodies in the pharynx and larynx. Differentiation from calcified cartilage can be difficult. CXR may show oesophageal and tracheo bronchial opaque foreign bodies as well as the complications, e.g., collapse. A sharp or potentially poisonous foreign body may be localised by AXR. If there is serious concern that the foreign body has not passed, an AXR after 6 days may be helpful. A low threshold for laryngoscopy or endoscopy should be maintained if pain persists after 24 hours.
	AXR	☢	Indicated only in specific circumstances [B]	In patients with persistent symptoms of foreign body ingestion following negative endoscopy, CT may help exclude a retained foreign body or complication.
	CT	☢☢☢	Indicated only in specific circumstances [B]	
Ingested foreign body: Sharp or potentially poisonous, e.g., battery Continued...	XR	☢	Indicated only in specific circumstances [C]	After negative clinical examination of the oropharynx, a lateral neck soft tissue XR may be helpful to show foreign bodies in the pharynx. Differentiation from calcified cartilage can be difficult. CXR may show oesophageal and tracheo-bronchial opaque foreign bodies as well as the complications, e.g., collapse. A sharp or potentially poisonous foreign body may be localised by AXR. If there is serious concern that the foreign body has not passed, an AXR after 6 days may be helpful. A low threshold for laryngoscopy or endoscopy should be maintained if pain persists after 24 hours. The following fish bones are radio-opaque: cod, haddock, cole fish, lemon sole and gurnard. Poorly opaque fish bones include grey mullet, plaice, monkfish and red snapper. Mackerels, trout and salmon bones are radiolucent

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Ingested foreign body: Sharp or potentially poisonous, e.g., battery	AXR	☢	Indicated only in specific circumstances [B]	
	CT	☢☢☢	Indicated only in specific circumstances [B]	In patients with persistent symptoms of foreign body ingestion following negative endoscopy, CT may help exclude retained foreign body or complication.
Chest Trauma				
Chest trauma: Minor	CXR	☢	Indicated only in specific circumstances [C]	To detect complications such as pneumothorax or infection.
Chest trauma: Moderate severity, stable patient	CXR	☢	Indicated [B]	CXR remains an acceptable screening investigation in thoracic trauma to assess for lung, mediastinal and pleural injury, although there should be a low threshold for proceeding to CT scanning if there is any clinical or radiological concern. CXR, particularly when taken supine, cannot reliably rule out pneumothorax.
	CT	☢☢☢	Indicated [B]	CT is highly sensitive for the detection of lungs mediastinal and pleural injuries, particularly if there is any concern on CXR. Depending on presentation, it may be appropriate to proceed directly to CT as the initial investigation.
	US	None	Indicated only in specific circumstances [B]	US may be used at the bedside to exclude a pleural or pericardial effusion and, in expert hands, traumatic pneumothorax.
Penetrating chest injury Continued...	CXR	☢	Indicated [B]	Postero-anterior and/or other views are used to show pneumothorax, lung damage or fluid.
	CT	☢☢☢	Specialised investigation [B]	CT is very sensitive for pneumothorax, lung damage, mediastinal injury and fluid. It may also detect active bleeding and act as a road map for further intervention/management. CT is indicated when there is possible abdominal involvement. Careful case selection is required as some patients will require urgent surgery without CT. Although CT will detect many more occult injuries than CXR, these often do not require specific management.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Penetrating chest injury	US	None	Indicated only in specific circumstances [B]	US can be useful to show pleural and pericardial fluid.
Sternal injury	Lateral XR sternum	☢	Indicated [C]	In addition to CXR, lateral XR of the sternum is required. Also consider thoracic, spinal and aortic injuries.
	US	None	Specialised investigation [B]	In experienced hands, US can reliably detect sternal fractures.
	CT	☢☢☢	Specialised investigation [B]	CT is useful to detect sternal fractures. It is the modality of choice when there are additional suspected injuries of the chest or spine.
Cardiac trauma (Blunt injury)	Echocardiography	None	Indicated [A]	Echocardiography may depict abnormalities that are highly suggestive of cardiac contusion, such as increased myocardial echogenicity and focal systolic hypokinesis, and it is useful in diagnosing other traumatic cardiac injuries that are commonly associated with myocardial contusion, such as traumatic ventricular septal defect and valvular injury. Echocardiography also plays a role in the follow-up of patients with known cardiac trauma for development of aneurysm or intracardiac thrombus. Echocardiography has not been proved to be useful as a primary screening tool in patients with thoracic trauma who are stable, and it is most valuable in patients who are unstable or have complications such as post-traumatic heart failure, pericardial effusion with suspected tamponade or ventricular septal defect.
	CXR	☢	Indicated [B]	For detecting other traumatic injuries such as rib fractures, pneumothorax, haemothorax, lung contusion, clavicular fracture and sternal fracture, which are common in patients with cardiac trauma.
	MRI	None	Indicated only in specific circumstances [C]	MRI plays no role in the evaluation of patients with acute cardiac trauma, mainly because of the complicated logistics of moving patients who are often critically ill, with life support systems or other medical hardware into a magnetic field environment for an extended period of time. However, several studies have reported the utility of delayed enhancement cardiac MR imaging for defining severity and extension of myocardial complications in patients with subacute or chronic cardiac trauma and previous traumatic injury.
	CT	☢☢☢	Indicated [B]	Multidetector CT provides the excellent spatial, contrast and temporal resolution required to evaluate cardiovascular emergencies in trauma patients, and it allows fast and accurate examination of the entire chest, including the heart, pericardium and great vessels.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Cardiac trauma (Penetrating injury)	Echocardiography	None	Indicated [A]	Echocardiography may depict abnormalities such as pericardial effusion and cardiac tamponade. Follow-up echocardiography is recommended before discharge because complications such as traumatic ventricular septal defect are commonly delayed.
	CXR	☢	Indicated [B]	CXR may be useful as part of the global evaluation for associated thoracic findings (e.g., pneumothorax, haemothorax and fractures) and in identifying missile and ballistic fragments, which may help determine the most likely trajectory and the anatomic structures at risk, but it has poor sensitivity for depiction of haemopericardium or mediastinal haematoma. Regardless of these limitations, the presence of an enlarged cardiac silhouette at radiography should always raise the possibility of haemopericardium.
	MRI	None	Not Indicated [C]	MRI plays no role in the evaluation of patients with acute cardiac trauma.
	CT	☢☢☢	Indicated [B]	In patients with penetrating thoracic trauma who are stable, CT is useful for depicting haemopericardium, with sensitivity of 100% and specificity and accuracy of over 96%. ECG-gated CT, with its improved spatial and temporal resolution, has made depiction of post-traumatic complications such as ventricular septal defects and cardiac pseudoaneurysm possible, providing exquisite anatomic detail and helping surgeons better plan interventions.
Abdomen (including renal)				
Blunt abdominal injury	CT	☢☢☢	Indicated [B]	Contrast-enhanced CT is the most accurate investigation for significant blunt abdominal injury. (The high radiation dose should be taken into consideration for multiple exams).
	AXR supine and CXR erect	☢ and ☢	Indicated only in specific circumstances [C]	XRs are not reliable for excluding significant trauma but may be an alternative to CT for detecting gross pneumoperitoneum.
	US	None	Indicated only in specific circumstances [B]	US is less accurate than CT but is helpful for children and as a portable bedside examination. Focused assessment with sonography for trauma (FAST) may be helpful to identify candidates for emergency surgery.

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Penetrating abdominal injury	CT	☢☢☢	Indicated [B]	Contrast-enhanced CT is the most accurate investigation for significant blunt abdominal injury. (The high radiation dose should be taken into consideration for multiple exams.)
	AXR supine and CXR erect	☢ and ☢	Indicated only in specific circumstances [C]	XRs are not reliable for excluding significant trauma but may be an alternative to CT for detecting gross pneumoperitoneum.
	US	None	Indicated only in specific circumstances [B]	US is less accurate than CT but is helpful in children as a portable bedside examination. Focused assessment with sonography for trauma (FAST) may be helpful to identify candidates for emergency surgery.
Renal trauma: Blunt or penetrating injury with haematuria	CT	☢☢☢	Indicated [B]	CT is the best imaging technique in patients with major injury +/- hypotension, +/- macroscopic haematuria. Delayed (excretory phase) CT must be included to assess the collecting system.
	US	None	Indicated only in specific circumstances [B]	US can be useful in the initial triage of patients with suspected blunt renal injury, but a negative US does not exclude renal injury.
Major trauma – an unconscious or confused patient but haemodynamically stable	XR cervical spine/ CXR/ XR pelvis	☢/ ☢/ ☢	Indicated [B]	Stabilisation of the patient's condition and definitive assessment must be the priority. Only the minimum XRs necessary for initial assessment should be performed. XR can be omitted if early CT is superior to XR in assessing the cervical spine. The spine and cord must be suitably protected until cleared. Pelvic XR is only indicated if early CT is not feasible.
	CT	☢☢☢	Indicated [B]	
	US	None	Indicated only in specific circumstances [B]	Focused US can rapidly detect major abdominal trauma but is not as sensitive as CT.
	MRI	None	Indicated only in specific circumstances [B]	MRI is difficult in the confused or unconscious patient but occasionally may help when there are neurological features likely to be due to cervical spine injury.
Major life-threatening trauma	CXR	☢	Indicated [B]	CXR is indicated for immediate diagnosis of pneumothorax and to assess line/endotracheal tube position.

Continued...

Clinical/Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Major life-threatening trauma	CT	☢☢☢	Indicated [B]	CT is the investigation of choice in major trauma. It is especially useful to exclude mediastinal haemorrhage and aortic injury. Whole-body CT detects unsuspected injuries, obviates the need for C-spine and pelvis XR and improves the chance of survival in major trauma.
	XR (C-spine and pelvic)	☢	Indicated only in specific circumstances [B]	Pelvic fractures with instability of the pelvic ring are often associated with major blood loss. When CT can be performed immediately, cervical and pelvic XR are not required.
	US	None	Indicated only in specific circumstances [B]	Focused US can rapidly detect major abdominal trauma but is not as sensitive as CT and should not delay CT when available immediately.
	MRI	None	Indicated only in specific circumstances [B]	MRI may be difficult in a severely injured patient but can be helpful when there are neurological features likely to be due to cervical spine injury.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Hypertension in the young adult or in patients unresponsive to medication: Suspected renovascular hypertension	MRA	None	Specialised investigation [A]	MRA is the best non-invasive method to visualise the main renal arteries directly. MR contrast agents are contraindicated in patients with an eGFR less than 30 mL/min due to the risk of nephrogenic systemic fibrosis.
	CTA	☢☢☢	Specialised investigation [A]	CTA offers better spatial resolution than MRA and can detect calcified plaque. This is at the cost of radiation burden and therefore should only be used with caution when eGFR is less than 60 mL/min.
	US	None	Indicated only in specific circumstances [B]	Doppler US is less accurate than MRA or CTA for functionally significant renal artery stenosis and can be used when both are contraindicated or unavailable.
	NM (MAG3 pre-captopril and post-captopril)	☢☢☢	Indicated only in specific circumstances [B]	Captopril renography is best to check for functionally significant renal artery stenosis and can be used to assess the outcome of revascularisation hypertension.
	DSA angiography	☢☢☢	Indicated only in specific circumstances [B]	DSA angiography is used to show stenosis if surgery or angioplasty is considered as a possible treatment. Pressure measurement across the renal artery stenosis is important to assess the functional significance of the stenosis.
Renal failure Continued...	US	None	Indicated [B]	US is the first investigation in renal failure to measure kidney size and parenchymal thickness and to check for pelvicalyceal dilatation indicating obstruction. US may also be used to guide renal biopsy when histological diagnosis is required.
	AXR	☢	Indicated only in specific circumstances [B]	NM may be required to show calculi not detectable by US.
	NM (MAG3/ DMSA)	☢☢	Indicated only in specific circumstances [B]	NM may be used to assess functional drainage secondary to pelvi-ureteric junction obstruction or relative renal function in renal failure.
	CT	☢☢☢	Indicated only in specific circumstances [B]	Contrast-enhanced CT helps if US is non-diagnostic or does not show the cause of obstruction, but in patients with eGFR of less than 60 mL/min, iodinated contrast should be used with caution. Unenhanced CT is the optimum investigation for characterisation of obstruction caused by calculi.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Renal failure	MRI	None	Indicated only in specific circumstances [C]	MRI is an alternative to contrast-enhanced CT, but MR contrast agents are contraindicated in patients with renal failure and eGFR of less than 30 mL/min due to the risk of nephrogenic systemic fibrosis.
Measurement of renal function	NM-GFR	☢	Indicated [A]	Multiple sample chromium-51 EDTA or Tc-99m-DTPA technique (2–4 samples) is recommended as it has improved precision of measurement and quality control options. Single-sample techniques may be considered for GFR greater than 30 mL/min/1.73 m^2, but this needs local calibration against multiple sample methods.
	NM (DMSA) – Relative function	☢☢	Indicated [A]	Tc-99m-DMSA is the most accurate method for the measurement of relative renal function; Tc-99m-MAG3 study is usually a satisfactory alternative except in patients with severely impaired renal function.
	NM (MAG3) – Renal transit time	☢☢	Specialised investigation [B]	Renal Tc-99m-MAG3 should be used with an established method of deconvolution analysis for parenchymal transit time index for obstructive nephropathy and mean parenchymal transit time for renovascular disorder.
Suspected ureteric colic	CT	☢☢☢	Indicated [A]	MDCT is the most accurate investigation in suspected ureteric colic and a low-radiation-dose CT technique should be used.
	IVU	☢☢	Indicated only in specific circumstances [B]	IVU is only indicated in suspected ureteric colic when CT is impracticable.
	US and AXR	None and ☢	Indicated only in specific circumstances [B]	Combination of US and AXR may be used when both CT and IVU are not indicated, e.g., in pregnancy. US is less accurate than CT or IVU.
	MRU	None	Indicated only in specific circumstances [C]	MRU may be considered as a problem-solving tool in pregnant women with suspected ureteric colic and evidence of hydronephrosis.
Renal calculi in absence of acute colic Continued...	AXR	☢	Indicated [B]	Low-dose unenhanced CT provides the best baseline assessment in patients with renal stone disease. AXR is less accurate but has a lower dose and is still adequate in routine practise to detect and follow-up the majority of renal calculi, which contain calcium. US is less sensitive than unenhanced CT for the detection of renal calculi. Both unenhanced CT and US can detect urate calculi.
	CT	☢☢☢	Indicated [A]	
	US	None	Indicated only in specific circumstances [B]	

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Renal calculi in absence of acute colic				If calculi can be identified on AXR or US, they should be followed up as such to minimise radiation dose from multiple CT examinations. In cases requiring percutaneous nephrolithotomy, CT urography or IVU is useful for planning renal access.
Urinary tract: Suspicion of calculus disease	KUB X-ray	☢	Indicated [B]	KUB X-rays are frequently used as the first investigation for suspected urinary tract calculus. Follow-up KUB X-rays are obtained in patients for observation and in whom the calculus was identified on either CT or initial KUB. Follow-up imaging with KUB-X-ray serves as an indicator of calculus progression. A follow-up KUB X-ray is also considered in those where calculus is not seen on the initial CT or KUB X-ray but was located in the sacroiliac area, limiting its visualisation.
	US	None	Indicated [B]	US is sensitive in detection of renal calculus greater than 0.5 cm and can evaluate hydronephrosis and/or hydroureter. US is generally not adequate and CT is complementary as it is capable in characterising stone size and location. US, in spite of its lower sensitivity as compared to other modalities, is the preferred initial imaging modality for children and pregnant patients with suspected renal colic because of radiation concerns.
	IVU	☢☢	Indicated only in specific circumstances [C]	When CT is unavailable, IVU is an alternative for detecting urothelial calculus disease.
	CT	☢☢☢	Indicated [B]	Non-contrast CT (NCCT) is the preferred initial imaging study and is superior to other imaging modalities. Non-contrast CT is the preferred modality for follow-up imaging of known calculi disease if the calculus is not readily visualised on X-ray. Low-dose CT should be considered if renal ultrasonography is not diagnostic for children in whom ureteral stone is suspected. Contrast-enhanced CT is indicated when CT without contrast does not explain the symptoms or reveal an abnormality that needs further evaluation (e.g., stone versus phleboliths).
	MRI	None	Indicated only in specific circumstances [C]	MRI without contrast usually defines the level of obstruction and, in some cases, provides an estimate of stone size. In pregnant women, MRI without contrast should be considered as second-line imaging in urothelial calculus disease if US is equivocal.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Renal mass	US	None	Indicated [B]	US is sensitive at detecting renal masses greater than 2 cm and accurately distinguishes cystic or solid masses and helps to characterise some masses indeterminate at CT. Contrast-enhanced ultrasound can be useful for further characterisation of small solid or cystic renal masses.
	CT	☢☢☢	Indicated [B]	Pre- and post-contrast-enhanced CT is the first-line investigation for the characterisation of a renal mass.
	MRI	None	Specialised investigation [B]	MRI (including contrast-enhanced) is as sensitive as contrast-enhanced CT for the detection of and characterisation of renal masses. MRI should be used if masses are not adequately characterised by CT and US or if contraindicated because of previous reaction. MR contrast agents should be avoided in patients with renal impairment.
	US/ CT-guided biopsy	None/ ☢☢☢	Indicated only in specific circumstances [B]	Biopsy may have a role in patients with indeterminate lesions or those with malignant appearances that are high risk for nephrectomy.
Urinary tract obstruction: Diagnosis and causes Continued...	US	None	Indicated [B]	US can be used to assess the degree of collecting system dilatation (not always due to obstruction), the Doppler spectral pattern of intrarenal blood flow, the bladder and the presence of ureteric jets.
	CT	☢☢☢	Indicated [B]	Unenhanced low-dose CT is the investigation of choice in suspected ureteric colic. Contrast-enhanced CT with excretory phase (CT urogram) is useful in determining both the intrinsic and extrinsic cause of urinary tract obstruction.
	NM (MAG3)	☢☢	Indicated [A]	Tc-99m-MAG3 with frusemide diuresis pre- or post-isotope injection is used. Quantification of furosemide of renal function. Parenchymal transit time index measurements aid the assessment of obstructive nephropathy and PUJ dysfunction. Differentiation of a non-obstructed dilated system from obstruction is possible.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Urinary tract obstruction: Diagnosis and causes	MRI	None	Indicated only in specific circumstances [B]	MR urography should be considered in paediatric and pregnant patients, as well as patients with contrast allergy. In the presence of collecting system dilatation, it defines the level of calibre change and often provides the diagnosis.
	IVU	☢☢	Indicated only in specific circumstances [B]	IVU may be used to define anatomy before surgery or other intervention if CT is unavailable.
Urinary tract infection in adults	CT	☢☢☢	Specialised investigation [B]	Contrast-enhanced CT may be necessary in severe infection not responsive to treatment. CT detects renal sepsis and changes of pyelonephritis more sensitively than US. Unenhanced CT may be used to detect occult stone disease. CT urogram or IVU may be useful for those with suspected anatomical abnormality.
	US and AXR	None and ☢	Indicated only in specific circumstances [B]	US and AXR or IVU are alternatives to contrast-enhanced CT in non-acute UTI with suspected underlying renal disease (e.g., papillary necrosis, reflux nephropathy)
	IVU	☢☢	Indicated only in specific circumstances [B]	When scarring is suspected following pyelonephritis or when there is renal impairment, NM may be used for the quantitative assessment of cortical scarring and underlying relative tubular renal function.
	NM (DMSA)	☢☢	Indicated only in specific circumstances [C]	
Renal transplant dysfunction	US and Doppler studies	None	Indicated [B]	US will detect hydronephrosis and collections and can assess perfusion. Colour Doppler US, particularly with contrast agents, is helpful in the diagnosis of transplant artery and vein stenosis. Doppler US cannot differentiate acute rejection from acute tubular necrosis and biopsy may be required.
	MRI and MRA	None	Indicated only in specific circumstances [B]	MRA is helpful in the diagnosis of transplant artery stenosis if Doppler US is equivocal or non-diagnostic. Some MR contrast agents are contraindicated in patients with renal failure.
	NM (MAG3)	☢☢	Indicated only in specific circumstances [B]	Tc-99m-MAG3 is useful to determine whether collecting system dilatation seen on US is obstructive but cannot reliably distinguish between acute tubular necrosis and acute rejection in the early postoperative period.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Lower urinary tract symptoms	US	None	Indicated [B]	Bladder US (with measurement of post-void residual volume and urine flow rate) is helpful in LUTS. Renal US to check for upper tract dilatation only if there is a post-void residue. US also indicated for renal insufficiency, haematuria, stones or infection.
Scrotal mass or pain	US	None	Indicated [B]	US with colour Doppler is indicated for testicles or scrotal swelling or when presumed inflammatory pain does not resolve. A painless testicular swelling requires urgent investigation. US allows differentiation of testicular from extra-testicular lesions.
	MRI	None	Indicated only in specific circumstances [B]	MRI also has a role in assisting the characterisation of indeterminate masses. The use of MRI in these selected cases is to help avoid unnecessary orchidectomy for masses that are non-malignant.
Suspected testicular torsion	US	None	Indicated [B]	Frequently a clinical diagnosis, testicular torsion requires urgent management and imaging should not delay intervention when appropriate. Colour Doppler US has a high sensitivity in suspected testicular torsion but there are still false-negative results. US should be reserved for clinically equivocal cases. Intermittent torsion remains a significant diagnostic problem.
Suspected functioning adrenal medullary tumour	MRI/ CT	None/ ☢☢☢	Indicated [B]	MRI and CT are the investigations of choice in patients with biochemical or clinical findings suggestive of catecholamine-secreting tumour. These investigations may distinguish benign from malignant lesions and provide the best anatomical delineation and is rarely indicated in the absence of biochemical evidence of excess catecholamine.
	NM MIBG, SRS (Octreotide scan-111-In)	☢☢	Indicated only in specific circumstances [B]	Both MIBG and SRS can locate functioning tumours and are especially useful with ectopic or metastatic lesions. MIBG or SRS imaging may help determine whether treatment by a radiopharmaceutical would be appropriate.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	PET-CT with specialised radiopharmaceuticals (Ga 68 DOTATOC) and/or F-18 FDG where available can provide additional independent information for diagnosis and localisation of benign and malignant pheochromocytomas.
	US	None	Indicated only in specific circumstances [B]	US may be helpful in children but CT/MRI will always be required in patients with abnormal biochemistry who are candidates for surgery.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Adrenal cortical lesions: Cushing's syndrome	MRI/ CT/ NM (iodo-cholesterol) and/ or adrenal venous sampling	None/ ☢☢☢/ ☢☢/ ☢☢☢	Specialised investigation [C]	Local advice on the most appropriate examination should be sought. MRI/CT may be able to identify an adrenal cause for Cushing's syndrome. However, nodular adrenal hyperplasia can occur in a significant proportion of patients with ACTH-independent Cushing's syndrome. In such a situation, CT may be unable to distinguish adrenal adenoma and nodular hyperplasia, and further investigation with scintigraphy and/or adrenal venous sampling may be required.
Adrenal cortical lesions: Primary hyper-aldosteronism (Conn's syndrome)	MRI/ CT	None/ ☢☢☢	Indicated [B]	Both MRI and CT can distinguish between a unilateral adrenal adenoma and bilateral adrenal hyperplasia. Local advice on the most appropriate examination should be sought. CT can be used to reliably diagnose adenomas larger than 1 cm. Adrenal venous sampling should be used when CT findings are equivocal or both adrenal glands are abnormal.
	NM (seek specialist advice)	☢☢	Specialised investigation [B]	Radio-labelled cholesterol imaging, where available, may be used if initial MRI/CT is inconclusive or negative in patients with biochemically established Conn's syndrome. NM is a non-invasive alternative to adrenal venous sampling for distinguishing unilateral from bilateral disease in Conn's syndrome.
	Adrenal venous sampling	☢☢☢	Indicated only in specific circumstances [B]	Adrenal venous sampling may be required where other imaging techniques are inconclusive. Patients being considered for adrenalectomy or those that do not respond to medical management for CT/MRI diagnosed bilateral adrenal hyperplasia may be considered for adrenal venous sampling.
Testicular microlithiasis	US	None	Indicated only in specific circumstances [B]	The yield for detection of testicular tumour in the presence of asymptomatic microlithiasis is low. Although there is no evidence to support the causal nature of such tumours, the incidence of tumour is higher in symptomatic patients with microlithiasis compared with those without. Regular self-examination should be encouraged in all patients with microlithiasis and US follow-up reserved for those with additional risk factors like atrophy, previous cancer or maldescent.
Screening of patients with von Hippel–Lindau disease for renal manifestations	US	None	Indicated [B]	US is a good investigation for screening this cohort of patients for any abnormality in the kidneys such as cysts or tumours. It will not reliably detect lesions less than 2–3 cm in size.

Continued...

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Screening of patients with von Hippel–Lindau disease for renal manifestations)	MRI	None	Indicated only in specific circumstances [B]	MRI (including contrast-enhanced studies) can be used to characterise the abnormal cysts/tumours. It offers a radiation-free investigation to monitor the changes in the kidneys and should be used in preference to CT for long-term follow-up.
	CT	☢☢☢	Indicated only in specific circumstances [B]	CT is required to stage the patient in the presence of tumour or to characterise the renal abnormality if MRI is equivocal, contraindicated or unavailable.
Male infertility	Scrotal and transrectal US	None	Indicated [C]	Scrotal US is used to measure testicular volume, to assess testicular texture, detect varicoceles and exclude testicular pathology. Transrectal US is used to detect any causes of mechanical obstruction involving the seminal vesicles, ejaculatory ducts or vas deferens.
	MRI	None	Indicated only in specific circumstances [C]	MRI may classify transrectal US findings in specific cases.
Incidentally detected non-functioning adrenal mass	MRI/ CT	None/ ☢☢☢	Indicated [B]	Management of an incidentally detected adrenal mass depends on the clinical setting. Biochemical evaluation is advised since some incidental lesions will show sub-clinical secretory activity on biochemical screening. Adrenal masses may be characterised by MRI or CT. MRI has the advantage of avoiding ionising radiation and iodinated contrast.
	PET-CT	☢☢☢☢	Indicated only in specific circumstances [B]	
	US	None	Not indicated [C]	There is no clear size threshold but small (less than 2 cm), non-functioning lesions are almost always benign and usually need no follow-up. In patients with large lesions (greater than 4 cm) and in those with known primary malignancy, biopsy or PET-CT may be considered to distinguish benign from malignant lesions.
Urinary tract: Haematuria Continued...	KUB X-ray	☢	Indicated [B]	KUB X-ray may be performed with ultrasonography.
	US	None	Indicated [B]	US is used to identify the cause of haematuria, e.g., renal calculus or mass. However, it may miss ureteral and urothelial lesions. In that situation, abdominal X-ray, retrograde pyelography and cystoscopy may be useful adjuncts.

Clinical/ Diagnostic Problem	Investigation	Dose	Recommendation [Grade]	Comments
Urinary tract: Haematuria	IVU	☢☢	Indicated [B]	IVU can be used for detecting filling defect or other abnormality within the urinary tract system. It is also helpful in demonstrating pelvicalyceal system or ureteric injury.
	CT	☢☢☢	Indicated [B]	CT urography is becoming the method of choice for investigating haematuria, replacing IVU.
	Renal angiography	☢☢☢☢	Indicated only in specific circumstances [C]	This procedure is indicated if CT does not explain or reveals an abnormality (e.g., vascular malformations). Rarely, vascular malformations causes haematuria and it requires angiography to confirm the diagnosis.
Asymptomatic men with elevated PSA	Transrectal US (TRUS) and biopsy	None	Indicated [A]	TRUS is used to assess the prostate for evidence of malignancy, measurement of the prostate volume and to guide prostate biopsy in patients with an elevated PSA. US alone will not reliably diagnose or exclude malignancy.
	MRI	None	Indicated only in specific circumstances [C]	MRI may clarify transrectal US findings and can help to localise tumour for biopsy in those patients with previously negative biopsies and a persistently elevated PSA.
Urinary tract: Benign prostate hyperplasia	US	None	Indicated [B]	Transabdominal US gives an estimate of prostate size and bladder wall thickness. It can also measure intravesical prostate protrusion. Consider this procedure after the patient voids to measure residual urine. If there is significant residual urine, an evaluation of the upper tracts is indicated. US kidneys should be done if significant residual urine is present or renal insufficiency is suspected to evaluate for hydronephrosis.
	IVU	☢☢	Indicated only in specific circumstances [C]	Recommended if significant residual urine is present. In patients with associated calculi or haematuria, the study may be warranted.
	MRI	None	Indicated [B]	MRI can be utilised to determine the prostate size, urinary bladder wall thickness and hydronephrosis. Contrasted MRI is required to evaluate suspicious prostate lesion.

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The Royal College of Radiologists, UK

We have great pleasure to announce that the College of Radiology (CoR) Malaysia has adopted and adapted the guidelines "iRefer: Making the best use of clinical radiology" from the Royal College of Radiologists (RCR), United Kingdom (Seventh Edition).

We would like to thank Dr. Denis Remedios (RCR) for allowing us to adapt these guidelines.

Good guidelines build the best available evidence into the right decision-making process for the referring clinician to make the right choice. The right radiological investigation will always obtain maximum information with the minimum radiation dose, inform clinical management, reassure the patient and add confidence to the clinician's diagnosis.

The CoR would also like to thank Dr Shantini Arasaratnam and Dr Noraini Abdul Rahim for their effort and significant contributions in the preparation of these guidelines.

A special thanks to Professor Ng Kwan Hoong for his guidance, support and encouragement in accomplishing these guidelines.

The CoR hopes that all clinicians, patients, health professionals as well as support groups and NGOs will find these guidelines helpful in determining the most appropriate imaging investigation(s) or intervention for a clinical problem.

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