NHS
Barts Health
NHS Trust

Radiation safety for staff requesting imaging examinations

Study guide

Radiation Safety for Staff Requesting Imaging Examinations

Radiation Safety, Barts Health NHS Trust

1. Who can refer patients for imaging?

The Barts Health IRMER Employer's Procedures[1] outline who is entitled to refer patients to the imaging department for diagnostic examinations involving exposure to ionising radiation (X-ray or nuclear medicine). Currently, all medical doctors may request any clinically appropriate examination (there are restrictions on FY1/2 and clinical trainees), dentists may request dental examinations and other registered health professionals may request specified examinations after completing an agreement with the imaging department. The procedure by which non-medical referrers (staff who are not medical doctors) can apply for an agreement with imaging can be found in the Barts Health Non-medical Referrers Policy[2]. An agreement is also required for non-medical staff who wish to request ultrasound and/or MRI. Completing this radiation safety training is required as part of obtaining the agreement with imaging.

2. Who should read this document?

This information has been compiled primarily for non-medical referrers to provide a basic background into the risks associated with imaging with ionising radiation and MRI. It will also serve as a refresher for medical staff who may have completed their training some time ago.

3. Objectives

This information aims to make staff referring for imaging aware of:

- the role of the referrer under The Ionising Radiations Regulations (Medical Exposure) Regulations 2017
- ionising radiation, radiation doses and associated risks
- MRI safety and precautions
- Risks associated with nuclear medicine imaging

4. Assessment

Non-medical referrers who wish to apply for an agreement with imaging should complete the simple test available here after reading this booklet. Medical and dental referrers may wish to also complete this test to confirm their understanding of the topics covered.

[1] The current Barts Health IRMER SOPs can be found by searching "IRMER" on WeShare (Barts Health intranet).
[2] The current Barts Health Non-medical imaging referrals policy can be found on WeShare (Barts Health intranet) by searching for "imaging referrals".

5. Legislation and Local Policies

5.1. Radiation Protection Principles

Radiation protection legislation is based on the three concepts below:

Justification

- When a patient is exposed to ionising radiation, there must be a benefit to the patient that is greater than the risk; any exposure should do more good than harm.

Optimisation

- In imaging with ionising radiation, often we can achieve higher quality images by using a larger dose of radiation. An optimised image is one that uses just enough radiation to achieve an image that is suitable for the diagnostic task, but no better than that.
- We don't want the best quality image we can get; we want to use the lowest radiation dose that can produce a useful diagnostic image.
- This is the concept of keeping doses as low as reasonably practicable (ALARP).

Dose limitation

- There are no dose limits for patients. Patient doses must be justified and optimised.
- Dose limits are set for staff and public. Radiation use in the hospital is monitored and controlled to keep staff and public safe.

5.2. The Ionising Radiations Regulations 2017 (IRR17)

IRR17 applies to any use of radiation at work. It is concerned with the protection of staff and the public and states dose limits for these groups that must be observed when ionising radiation is used in the hospital.

5.3. The Ionising Radiations (Medical Exposures) Regulations 2017 (IRMER 2017)

IRMER 2017 is concerned with the protection of patients undergoing medical exposure to ionising radiation. As someone who is referring patients for imaging, you should have a good understanding of these regulations as they set out your responsibilities as the IRMER referrer. The roles defined by IRMER are:

Referrer

- Must be a registered health professional (e.g. GMC, HCPC, NMC).
- Is responsible for providing sufficient clinical information to allow the practitioner to decide whether the imaging exposure is in the patient's best interest (justified).
- Should be aware of the referral policy used by the Trust; the RCR iRefer guidelines[3].

Practitioner

- A registered medical practitioner or other health professional (often radiologist or radiographer).
- Has clinical responsibility for the exposure to ionising radiation.
- Is responsible for making sure the exposure is justified; weighing up the benefits and risks to the patient using information from referrer. This includes considering how patient care would be affected by not having the exposure or by using an alternative type of imaging (e.g. taking a plain film X-ray rather than CT).

Operator

- An operator is anyone who carries out any practical aspect of the exposure. This includes things like pressing the exposure button, checking the patient's identity, checking the

[3] https://www.irefer.org.uk or access through WeShare.

pregnancy or breastfeeding status of the patient, calibrating equipment, optimising the exposure and many other tasks.

Employer

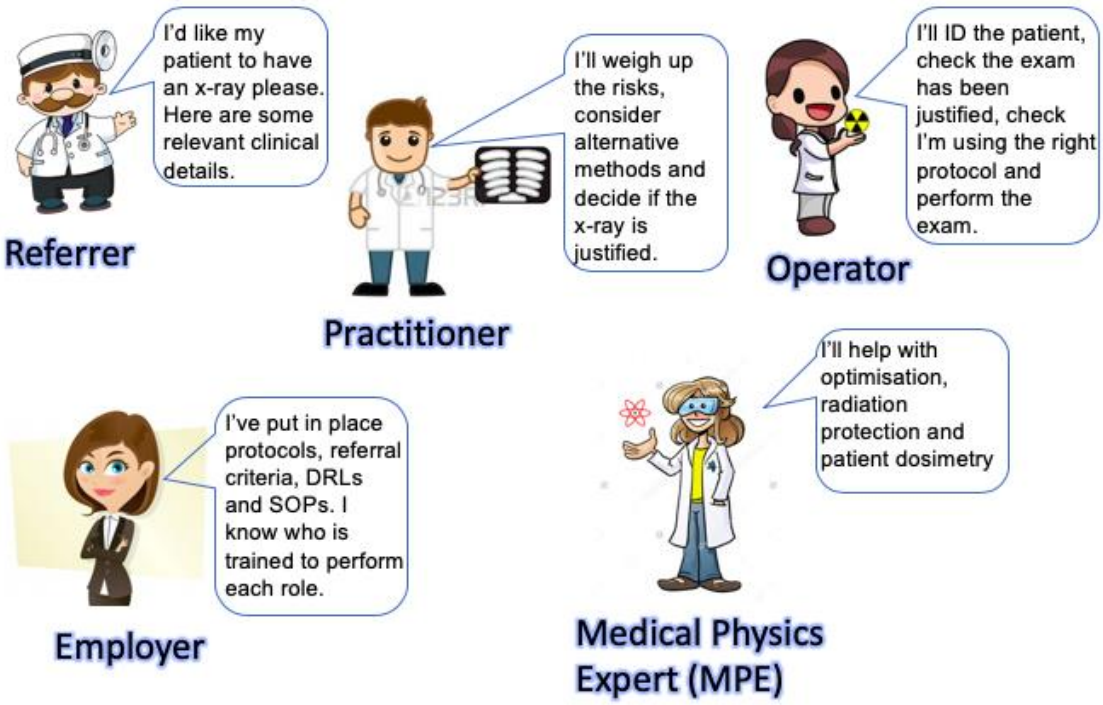
- The employer has legal responsibility for the use of radiation in the hospital. In an NHS Trust, the employer is the CEO of the Trust.
- Responsible for a radiation protection framework including the IRMER SOPs.

Medical Physics Expert

- Medical physicist with experience in diagnostic radiology, nuclear medicine or radiotherapy.
- Helps with optimisation, calculating and auditing patient doses and radiation protection advice.

The Barts Health IRMER SOPs outline how the Trust ensures IRMER compliance and outlines who is entitled to perform each of the roles described above.

The Care Quality Commission (CQC) is the reporting and inspecting body for IRMER.



5.4. Local Policies and Procedures at Barts Health

You should be aware of the following policies, which can all be found on WeShare:

Barts Health Radiation Safety Policy

- General policy regarding the use of ionising radiation at Barts Health.

Non-medical Staff Imaging Referrals Policy

- Policy for staff who are not medical doctors who wish to refer patients for imaging.

Barts Health IRMER Employer's Procedures

- Standard operating procedures that lay out how Barts Health ensures compliance with IRMER.

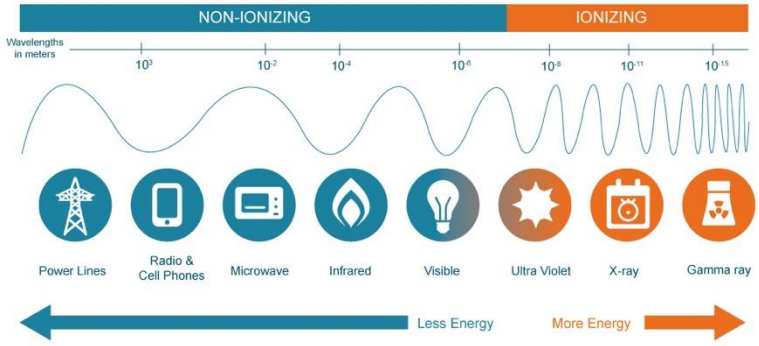
iRefer – Making the best use of clinical radiology

- Publication from the Royal College of Radiology, used as the Trust referral policy. Can be found on WeShare under Launch your application or details at https://www.irefer.org.uk

6. Radiation and Risk

6.1. What is ionising radiation?

Generally, radiation is a form of energy. The energy may be carried by waves or moving particles. Ionising radiation is radiation that has enough energy to break molecules into bits called ions. The electromagnetic spectrum below shows waves with different amounts of energy.

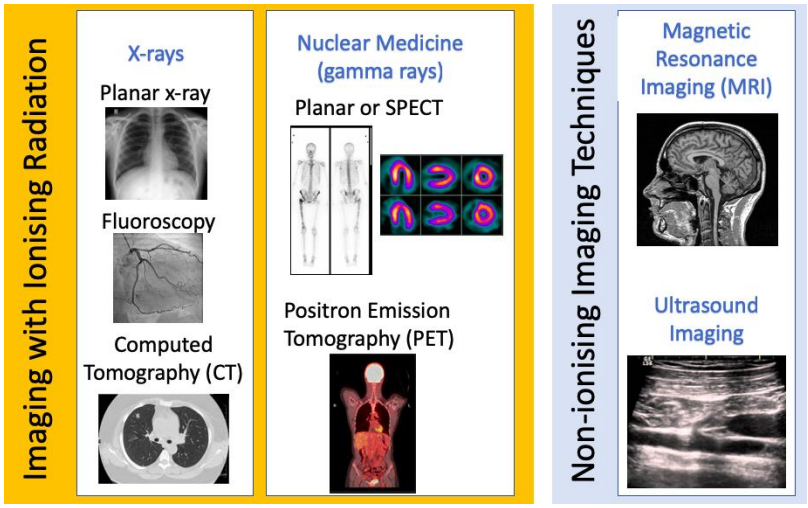


www.mirion.co/introduction-to-radiation-safety/what-is-radiation

X-rays and gamma radiation are examples of ionising radiation that is in the form of a wave. X-rays are used in imaging for plain films, CT and fluoroscopy. Gamma radiation is used in nuclear medicine imaging, for example emitted from 99m-Tc, used in bone scans.

Magnetic resonance imaging (MRI) and ultrasound are examples of imaging techniques that do not use ionising radiation.

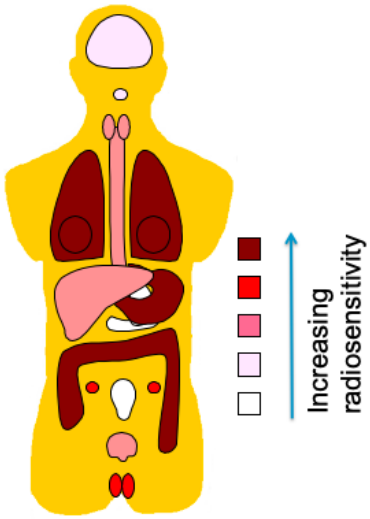
The dose quantities and risks discussed in this section only apply to imaging with ionising radiation. See the MRI Safety section for risks specific to MRI.



6.2. Radiation dose quantities and units

Absorbed Dose, D

Radiation is a form of energy and the transfer of that energy to a material leads to radiation dose. Absorbed dose is a measure of how much energy has been absorbed by a material (e.g. an organ), per unit mass of that material, measured in Gray. The Gray (1 mGy = 1 thousandth of a Gy) is a unit of radiation dose that describes the energy absorbed by a tissue per unit mass. If the energy is concentrated on a small mass of tissue, the absorbed dose is greater. It is a useful measure for describing the dose to an organ, for example the dose to the skin during an interventional procedure.



Effective Dose, E

Some organs in the body are more likely to be damaged by the same absorbed dose of radiation than others. We call this the radio-sensitivity of an organ. Generally, tissues that are actively dividing are more radio-sensitive than tissues that are not actively dividing.

Procedure	Effective Dose (Adult) (mSv)
Chest (PA) X-ray	0.02
Pelvis X-ray	0.7
Abdomen X-ray	1
Barium meal (Fluoroscopy)	3
CT chest	8
CT abdomen/pelvis	10

The effective dose, measured in Sieverts, (1 mSv = 1 thousandth of a Sv) takes in to account the radio-sensitivity of the organs and tissues that were exposed. It is a useful measure for comparing radiation doses from different modalities and techniques and can be related to the risk of some radiation effects- mainly cancer induction (more later).

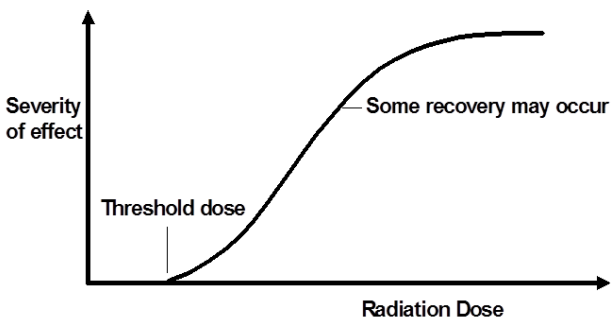
Some examples of effective doses for common X-ray examinations are given on the left. An abdomen X-ray gives roughly 1 mSv, a CT of the abdomen and pelvis would give an effective dose of around 10 mSv.

6.3. Biological effects of radiation and radiation risks

We are aware of the benefits of using ionising radiation within a hospital; to aid the care, management, diagnosis and treatment of our patients. However, we must bear in mind that there are potential risks from ionising radiation. Provided that the use of ionising radiation in the hospital is carefully controlled, the benefit to patients far outweighs the risk of harm.
The effects of radiation can be split into two groups; deterministic and stochastic effects.

Deterministic Effects

Deterministic effects (or tissue effects) are those effects that occur at high radiation doses and have a threshold below which they will not occur. Once the threshold has been exceeded, the severity of the effect increases with increasing radiation dose.



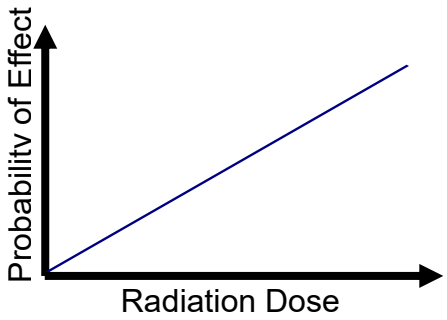
Risk varies with age, sex and organ irradiated. Examples of threshold doses for biological effects to be seen are below:

Tissue Reaction	Time to Develop	Threshold Dose (mGy)
Skin Reddening	1 – 4 Weeks	< 3000 – 6000
Temporary Hair Loss	2 – 3 Weeks	~ 4000
Skin Burns	2 – 3 Weeks	5000 – 10,000
Permanent Sterility	1 – 3 Weeks	~ 3000 – 6000
Eye Cataract	> 20 Years	~ 500

Radiation protection measures and monitoring are undertaken to ensure that radiation doses to staff are kept well below threshold doses for deterministic effects. Patients may occasionally experience some mild deterministic effects from high dose exams using ionising radiation such as complicated interventional radiology. For the overwhelming majority of patients, we would not expect to see any of these effects. For comparison, typical skin doses from X-ray exams would be ~1 mGy for planar X-rays and 10s-100s mGy for fluoroscopy.

6.4. Stochastic Effects

In contrast to deterministic effects, no threshold exists for stochastic effects. The likelihood of these effects taking place is thought to increase linearly with radiation dose. As no threshold exists, even a small dose is thought to present a small risk. This is why the ALARP principle (As Low As Reasonably Practicable) exists. The lowest radiation dose consistent with the aim of the exposure should always be used. This protects both patients and staff.



The main stochastic effect that we usually consider is the development of cancer as a result of the exposure to radiation. There is a long latency period and so effects may not be seen for years or even decades.

The risk of forming cancers is 2 – 5 times greater in children due to their cells being more radiosensitive and there being more time for the effect to be expressed. Particular care is therefore required when referring paediatric patients for imaging with ionising radiation.

The nominal risk coefficient for radiation-induced fatal cancer averaged over all ages and both sexes is:

5% per Sv or **1 in 20,000 per mSv**

For a dose of 0.02 mSv, which is typical of that of a chest X-ray, the cancer risk for an adult is estimated to be:

1 in 1,000,000

Bearing in mind that the baseline risk we all have of developing cancer at some point in our lives is between 1 in 2 and 1 in 3, the lifetime cancer risk due to radiation exposure is grouped into bands:

- Negligible: < 1 in a million
- Minimal: 1 in a million – 1 in 100,000
- Very low: 1 in 100,000 – 1 in 10,000

- Low: 1 in 10,000 – 1 in 1,000

Some examples of the estimated risk from common x-ray examinations are given on the right.

For an abdomen X-ray, with an effective dose of 1 mSv, the risk of inducing cancer is thought be be around 1 in twenty thousand, which is considered to be a very low risk.

Procedure	Effective Dose (Adult) (mSv)	Risk of fatal cancer	Risk band
Chest (PA) X-ray	0.02	1 in a million	Negligible / Minimal
Pelvis X-ray	0.7	1 in 29 thousand	Very low
Abdomen X-ray	1	1 in 20 thousand	Very low
Barium meal (Fluoroscopy)	3	1 in 7 thousand	Low
CT chest	8	1 in 3 thousand	Low
CT abdomen/pelvis	10	1 in 2 thousand	Low

6.5. Background Radiation

Though normal living in the UK, we are all exposed to an average of 2.2 mSv per year. This comes from natural radiation from the ground, space, the air we breathe and the food we eat. Due to the composition of the ground, in some parts of the UK, the background radiation level can be up to 20 mSv per year.

Procedure	Effective Dose (mSv)	BERT
Chest (PA)	0.02	3 days
Pelvis	0.7	4 months
Abdomen	1	6 months
Barium meal	3	16 months
CT chest	8	3.6 years
CT abdomen/pelvis	10	4.5 years

Some common exams are expressed as background equivalent radiation time (BERT) on the left.

Medical X-ray exposures are normally equivalent to somewhere between a few days and a few years of normal exposure to natural background radiation.

6.6. Individuals of Childbearing Potential

For examinations between the knees and diaphragm, before X-raying a patient who may have the potential to become pregnant (aged 12- 55 years), the radiographer will establish whether the patient may be pregnant. For lower dose examinations, such as a planar abdomen X-ray, the examination may proceed so long as the patient is unable to become pregnant (for example hysterectomy) or their last menstrual period (LMP) was within the last 28 days. For higher dose examinations, such as an abdominal CT, the examination may proceed if the patient is unable to become pregnant or their LMP was within the last 10 days. This procedure is outlined in the IRMER SOPs. If you are aware that your patient is pregnant, it is useful to include this on the referral.

Pregnancy is not necessarily a contraindication for X-ray examinations, but the exposure must be justified for both the foetus and the mother.

6.7. Specific Considerations for Nuclear Medicine

For nuclear medicine examinations, the patient is injected with a radioactive tracer. After this injection, the patient themselves becomes a source of radiation. Typically, the patient would have their injection a few hours before their scan and would remain radioactive for several hours after the scan. The patient's urine, blood and other body fluids will also be radioactive for this time. As a referrer, you should be confident that your patient will be able to understand and follow instructions given by the nuclear medicine department to restrict the risk of contaminating or exposing others. If the patient is required to give blood or urine samples, this should ideally not be done on the day of a nuclear medicine exam. It is also important to determine if the patient is continent and whether or not they are self-caring and include this on the referral.

As for X-ray patients, it is useful if the referrer can determine the pregnancy status of individuals of childbearing potential and include this on the referral. Pregnancy status will be established for all nuclear medicine patients who may have the potential to become pregnant. For nuclear medicine patients, it is also important to know if a patient is breastfeeding as a small amount of the radioactive tracer may be present in breastmilk.

7. MRI Safety

Although magnetic resonance imaging (MRI) does not use ionising radiation, there are some features of MRI that referrers should understand in order to help identify patients with possible contraindications to MR imaging. The MHRA have issued MRI safety guidance. The Barts Health MRI safety framework is based on this guidance and can be found on WeShare.

7.1. MRI Risks

An MR scanner uses strong magnetic fields and non-ionising radiofrequency waves to image the body. The magnetic fields are around 100,000 times stronger than the Earth's magnetic field. Some MR imaging requires the use of Gadolinium based contrast agents to improve image quality. The following risks are relevant to referrers:

- Compromised function of medical implants
    - E.g. Pacemaker stops working
- Movement of metallic objects
    - E.g. Movement of aneurysm clip ruptures a blood vessel
- Heating of medical implants
    - E.g. Heating of pacemaker leads causes burns
- Nephrogenic systemic fibrosis after Gadolinium contrast
    - a disease that involves fibrosis of the skin, joints, eyes and internal organs

7.2. What to find out before making a referral for MRI

Referrers must identify patients with medical implants and/or possible contraindications to MRI before referral and should provide the medical information required to enable the accepting clinician to decide if it is safe to MRI scan the patient. There is an MR safety questionnaire that must be completed by all patients before MR imaging. This is available on WeShare and should ideally be discussed with your patient before referral so that details can be included with your request.

Does the patient have any medical implants?

- E.g. pacemaker, aneurysm clips, hip replacements, stents, etc.
- Implants are classed as MR safe, MR conditional (safe with specific parameters) or MR unsafe.

- As much detail as possible about type/manufacturer/model of any implants should be included with the referral.
- Metal implants distort the MR image, so it will not be possible to see the area around the implant.

Does the patient have any metal in their body?

- Any recent surgery or risk of metal fragments?

Does the patient have kidney problems?

- If a contrast agent is to be used, the patients GFR will need to be checked.

Is the patient pregnant?

- MR imaging is considered to be safe during pregnancy, but scans are still assessed on a case by case basis. If you know your patient is pregnant, you should discuss this with the MR accepting clinician before referral, if possible.
- Contrast agents present an increased risk of harm to the foetus and are not used unless absolutely necessary and after a risk benefit analysis.

Is the patient breastfeeding?

- Contrast agent may be present in breastmilk after imaging. The patient may need to stop breastfeeding for 24 hours following the contrast injection.

Is the patient claustrophobic?

- The MR imaging will require the patient to lie inside a 60-70 cm diameter scanner.

Can the patient lie still for at least 30 minutes?

- Most MRI scans will take at least this long. If the patient cannot remain still a useful image cannot be acquired.

Will your patient fit into the 60-70 cm diameter scanner?

8. Some Practical Tips for Imaging Referrals at Barts Health

8.1. Things to consider when making a referral

- Benefit vs Risk – ALARP
    - You should only refer patients for imaging if you feel there will be a benefit to the patient.
- Do I need it? Do I need it now?
    - Will the imaging alter the management of the patient? Is this the best time to have the imaging (e.g. pre/post op)?
- Has it been done already? (Here or elsewhere?)
    - Check for previous imaging; ask the patient and if possible look on PACS/CRS
    - If imaging has been done already, is there a clinical reason to repeat?
    - The Image Exchange Portal (IEP) allows us to view images from other NHS organistaions and some private hospitals. Contact your local imaging department for help with accessing this. IEP can be accessed through WeShare.
- Is this the most suitable investigation?
    - Do you need CT, or would a planar X-ray be suitable? Are you following the iRefer guidelines?
- Could the patient be pregnant or breastfeeding?
    - Justification is required for patient and foetus.
    - Consideration of contrast agents for CT or MRI.

The Society of Radiographers (SoR) has issued 'have you paused and checked?' guidance for referrers. A paused and checked poster is attached at the end of this document. These steps should be followed when making a referral. You can find these posters here:
https://www.sor.org/learning/document-library/have-you-paused-and-checked-irmer-referrers

8.2. How to make a referral for imaging

All referrals to imaging should be made electronically either using Millennium CRS (Clinical Records System) or TQuest (if from outside the Trust). Paper request forms should only be used during system down time as a contingency. You should ensure you have had training on the relevant system. Millennium training can be found on WeShare. Speak to your manager for TQuest training.

Your request will be sent from CRS/TQuest to the RIS (Radiology Information System), the system used by imaging to manage and justify referrals. It is important to note that if your referral was made for the wrong hospital or department, it may not be visible to radiographers in the department you intended. Additionally, if you cancel a referral on CRS/TQuest, please also call the imaging department as the referral may not immediately be cancelled on RIS.

If you are a Barts Health employee, you will have access to Sectra PACS (Picture Archiving and Communication System). This is where you can view images and reports following the examination. For referrals made from outside Barts Health, a report will be sent to the referrer.

8.3. What to include on your referral

To allow the practitioner to decide whether your request is justified, you must include the relevant clinical information, the clinical question you would like to be answered and your name and contact number. The clinical information will determine the projections or examination that will be carried out. If your clinical question is not clear, the radiographer may contact you for clarification. Please avoid abbreviations on your referral as they may not mean the same thing to you and the radiographer.

8.4. What to do if you have a question about a referral

If you are not sure what the best examination for your patient would be, please contact the imaging department. One of the radiographers will be happy to help you. It is better to ask before making your referral than to have your request rejected. The Barts Health Switchboard will be able to connect you to the relevant department.