Science

Cambridge Advanced National (AAQ)

Course Companion

Cambridge Advanced National in Applied Science

F186 Medical Physics

Endorsed for Cambridge OCR qualifications

CAMBRIDGE OCR

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Contents

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- Image of person undergoing radiotherapy

Teacher's Introduction

This course companion has been written specifically for the Cambridge OCR Level 3 Alternative Academic Qualification Cambridge Advanced Nationals in Applied Science qualification (first teaching from September 2025).

The theory notes, examples and questions cover the essential knowledge and understanding prescribed in the optional Unit F186 specification for the Extended Certificate qualification.

About Unit F186: Medical Physics

Unit F186 is centre-assessed using four practical activities that learners carry out independently.
Centre assessments are OCR-moderated.

Unit F186 is an optional unit and will draw on learning from Unit F180 and Unit F181.

Each of the five topic areas has been given its own section in the resource.
These are as follows:

Topic Area 1: Application of non-ionising diagnosis techniques
Topic Area 2: Application of ionising diagnosis techniques
Topic Area 3: Application of ionising therapy techniques
Topic Area 4: Application of non-ionising therapy techniques
Topic Area 5: Planning for diagnosis and therapy

Remember!

Always check the exam board website for new information, including changes to the specification and sample assessment material.

Within each section there are student notes covering the specification content and structure. These notes include descriptions of theory, supported with examples and diagrams where appropriate. Questions are interspersed throughout the guide to assess and develop understanding and practice the key skills required for the assessment.

In addition, two additional practice scenarios are given so that students can apply what they have learned. Prompts are given in the formative discussion questions throughout the resource.

October 2025

Endorsement statement
The teaching content of this resource is endorsed by Cambridge OCR for use with specification Cambridge OCR Level 3 Alternative Academic Qualification Cambridge Advanced National in Applied Science, Certificate (H051) and Extended Certificate (H151). All references to assessment, including assessment preparation and practice questions of any format/style are the publisher's interpretation of the specification and are not endorsed by Cambridge OCR.

This resource was designed for use with the version of the specification available at the time of publication. However, as specifications are updated over time, there may be contradictions between the resource and the specification, therefore please use the information on the latest specification and sample assessment materials at all times to ensure students are fully prepared for their assessments.

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Cambridge OCR recommends that teachers consider using a range of teaching and learning resources based on their own professional judgement for their students' needs. For more information about the endorsement process, please visit the Cambridge OCR website.

Additional practice diagnosis sce

Patient A is a 68-year-old retired man who has been suffering from persistent chest the past three months. He has lost 10 kg in weight within the last two months and is dizziness and irregular heartbeats. He has also recently found blood in his stool. Ar patient's wife after becoming concerned that the chest pains were worsening, and th hospital for further investigation following arrival at the accident and emergency dep

The patient has a history of smoking and drinks alcohol moderately. There is a histo patient's father died in his [illegible] of prostate cancer.

The patient [illegible]viously experienced good health, and being admitted to hospital anxiety to both him and his wife.

The diagnosis technique used will need to identify any cardiovascular irregularities a tumour, including determining whether the tumour is benign or malignant.

You are the consulting physician and are required to create a diagnosis plan for pati healthcare professionals.

Additional practice treatment sce

Patient B is a 25-year-old woman who is a graphic desi[illegible] marketing agency. and often works long hours. The patient exercis[illegible] and eats a reasonably h and consumes a lot of caffeine.

After experienc[illegible] issues, migraines and mild confusion, the patient w an MRI bra[illegible] wi[illegible] contrast revealed a benign, low-grade temporal lobe tumour or metastasi[illegible] the tumour is non-aggressive but is affecting speech and memory

Topic Area 1: Application of non-ioni diagnosis techniques

Medical physics refers to an area of applied physics which involves the use of phy in medicine and healthcare. This includes the use of physics principles in medical of medical conditions by creating images of the inside the body. Radiation ther primarily cancer, by delivering controlled doses of radiation to destroy or damage physics uses both ionising and non-ionising radiation for diagnosing and treating r radiation has enough energy to remove electrons from atoms, which can potentia contrast, non-ionising radiation is generally considered safer, as it lacks the energ

Further your knowledge

- **Late 1890s** – First use of X-rays for diagnosing fractures
- **1913** – The Coolidge tube improves the safety and quality of X-ray imaging
- **1940s** – Scientists discovered the medical applications of radioactive isotopes
- **1950s** – First use of ultrasound for non-invasive imaging
- **1970s** – Development of CT scans by Hounsfield and Cormack

1.1 Magnetic resonance imaging (MRI)

! Key points covered

- Principle of operation of an MRI machine
- Safety considerations
- Basic structure of a
- Advantages, disadv

Principle of operation of an MRI machine

The human body is mostly made from a combination of water and organic molecules: proteins, carbohydrates and lipids. All of these molecules contain hydrogen atoms – some in very large numbers.

The hydrogen atom is the simplest of all atoms with a nucleus containing only one proton. It is this proton in the hydrogen nucleus that exhibits magnetic **resonance**

Resonance is a familiar concept in everyday life. If you pluck a guitar string it will v producing a sound. This frequency is called the string's natural frequency.

If you play a sound near the guitar that has the same frequency of one of its string on its own. This happens because the sound waves from the external source matc making it absorb energy and resonate.

This is exactly how resonance works – when an object gets energy at just the right more strongly!

The proton in the nucleus of a hydrogen atom behaves in a similar way when in a a natural frequency is dependent on the atoms and chemical groups to which it is

When placed in a strong magnetic field, the protons in hydrogen nuclei orient the magnets. When the magnetic field is reversed over and over again at high freque reorient itself rapidly.

When a burst of radio waves is sent into the body at a specific frequency (at the r this excites the hydrogen atoms, making them absorb energy and move out of ali

When the radio waves are turned off, the hydrogen atoms return to their original absorbed energy as radio signals (relaxation). These signals are detected by MRI s computer to create detailed images of tissues and organs. The brightness of the ti how quickly the hydrogen atoms realign with the magnetic field (relaxation time).

In terms of the human body, the chemical environment of the hydrogen atoms va tissue (muscle, bone, nerves, etc.) in which it is located. In this way, the MRI scann different tissues.

Projectile and implant screening in MRI is a critical safety assessment performed b scanner. It ensures that ferromagnetic materials cannot be pulled violently into th procedure, or that unsafe implants or devices, e.g. orthopaedic screws and plates, or heating during the procedure or compromise image quality of the scan. MRI m strict metal-free zone and patients will be required to complete a pre-scan safety

Contrast agents in MRI are substances injected into the body to enhance image q of some tissues. Gadolinium is a paramagnetic metal, meaning it interacts with th certain tissues appear brighter or darker in the MRI scan. This makes it easier to d abnormal tissues, especially in the brain, blood vessels, and tumours. Gadolinium therefore in patients with impaired renal function it stays in the body for much lo effects and should not be used.

Safety considerations

MRI is generally considered to be safe for patients who are pregnant after the firs avoided (especially with gadolinium) within the first trimester unless essential.

An MRI scanner produces a loud noise which can exceed 110 dB. Staff and patien prevent damage to their hearing and this may be unsettling for neurodiverse or a

Recall questions

1. How does MRI distinguish between tissues?
2. Why is resonance important for MRI scanners?

Basic structure of an MRI machine

The diagram shows the main components and their relative positions in a magnetic r

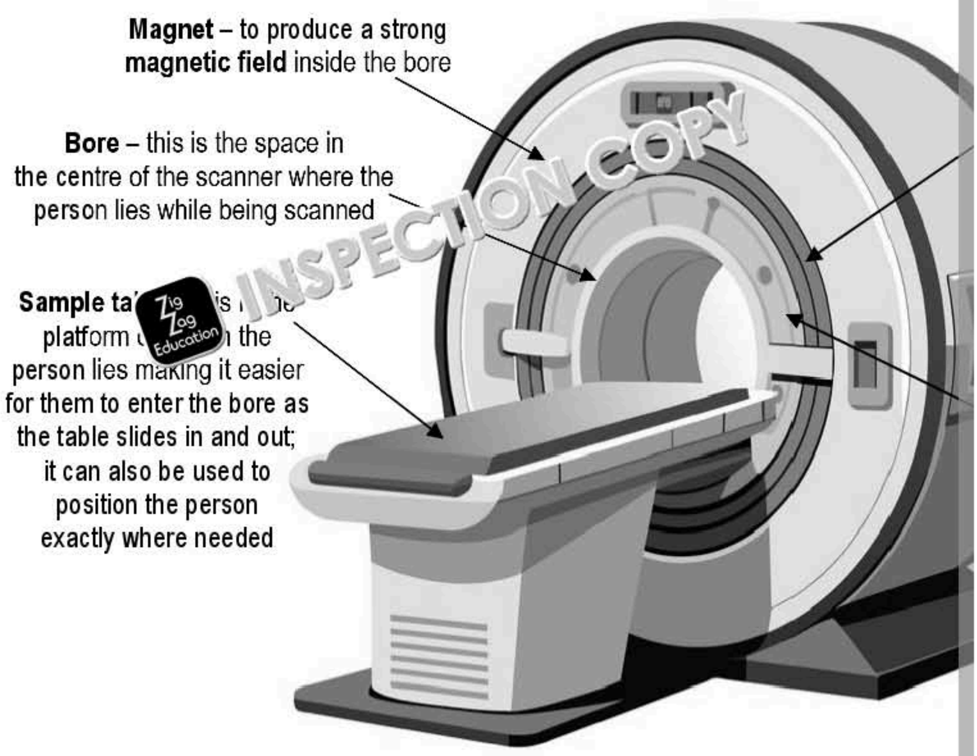


Figure 1.1. MRI machine structure

Advantages, disadvantages and uses of MRI scanning

Advantages	Dis
It is non-invasive. Tissues and organs can be examined in detail without the need for surgery. MRI is much safer than surgery because there is no damage to body tissues and risk of infections. In addition, no anaesthetics are required. MRI scans can be used to examine the skeletal system including joints, the brain and spinal cord, the heart and the rest of the circulatory system, plus other internal organs such as kidneys, uterus, liver and breast tissue. Unlike X-rays, which are ionising, an MRI scan is considered safe.	Very high cost of purch maintenance of the sca The loud noise produce hearing damage and so staff, must wear ear pr Sometimes patients wh procedure can be sedat scanner makes periodic current in the coils is sw be unsettling for some Patients with prosthese joints or cochlear impla undergo MRI scanning presence of metallic su

MRI scanners are operated by medical professionals called radiographers who have training in how to operate the machine in different types of diagnosis situations. The radiographer controls the scanner through a computer interface while seated in a different room. A radiology nurse or technologist will be responsible for the administration of the contrast media and will monitor the patient throughout the

Ad
zze

Interpretation of the images produced by the MRI scan is carried out by a radiolog
person who has specialised in this field. The radiologist then prepares a report tha
directly with the person who had the scan or delivered back to their GP surgery fo

Apply your knowledge

a) Why is MRI suitable for detecting bowel cancer?
b) What other techniques may be used as pa[illegible] of [illegible] broader diagnostic process
bowel cancer?

Formativ[illegible]ussion questions:

Alongside other symptoms, patient A is experiencing blood in his stool.
One of the diagnostic tools available to investigate the cause of the symptoms is

Explain why this diagnostic technique **is or is not** appropriate for the patient's sy

1.2 Diagnostic ultrasound

! ***Key points covered***

- Anatomical ultrasound
- Doppler ultrasound
- General features of ultrasound
- The ultrasound transducer
- Adva[illegible]es and disadvantages

Ultrasound is the term given t[illegible] sound waves that have a frequency higher than th
upper threshold of hu[illegible] hearing. That means frequencies of 20 kHz and above.
All sound w[illegible] re [illegible]ngitudinal, so the particles in the medium oscillate parallel t
the directio[illegible] the sound wave is travelling.

Medical ultrasound relies on the fact that sound waves are reflected from bounda
They are reflected from internal body boundaries such as those between muscle a
and fatty tissue.

The frequencies used in medical ultrasound are usually in the range 1–22 MHz. 1
deep abdominal imaging while 18–22 MHz is used for superficial skin and ocular s
everyday probes sit between 2 MHz and 15 MHz. There are two types of ultrasou
what needs to be imaged. They are anatomical and Doppler ultrasound.

Anatomical ultrasound

Anatomical ultrasound is used to produce ima[illegible]e of structures inside the body. You have [illegible] [illegible] seen pictures of anatomical ultrasound ima[illegible] of u[illegible]born babies. Here, it gives sufficient detai[illegible] [illegible] for defects in the central nervous sy[illegible] hea[illegible] and other organ systems of the foetus. Ana[illegible]l ultrasound can also be used in children and adults to assess swelling around joints due to injury or arthritis. Another use is for checking for possible organ damage after disease or surgery.

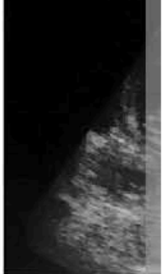


***Figure 1.2.** Anatomic*

Anatomical ultrasound works by detecting reflections of the sound waves off boundaries between tissues. The time taken for an ultrasound wave to pass in towards the boundary and back again can be used to build up an image by calculating the distance that the wave has travelled. To do this, the software uses the equation

$$\text{distance (m)} = \text{speed (ms}^{-1}) \times \text{time (s)}$$

The distance from this result is then halved because the ultrasound wave has travelled to and away from the tissue boundary before being detected again and the total time for this is measured.

Further your
The speed of so
media; it is faste
The speed also
temperature, bu
likely to be arou
relatively consta

Doppler ultrasound

Doppler ultrasound is used to measure the speed and direction of blood flow in a particular vessel. It makes use of the **Doppler effect**.

An ultrasound signal is sent towards or away from moving blood. The sound waves reflect off the moving blood cells and return with an apparent change of wavelength. The greater the change in wavelength, the higher the speed of the blood. By changing the direction that the ultrasound waves are transmitted and received, the direction of blood flow can be worked out.

Further your knowledge: t
The Doppler effect is again somet
daily life. When you are standing
motorcycle or ambulance siren pa
in pitch. The sound seems to be h
approaching and lower pitch when
be confused with the loudness of t

The Doppler effect is beyond the
caused by an apparent change o
comes from, or is reflected off a m
the f... also (grey box) spee
the Doppler effect by reflecting a

Because this technique measures blood flow, it can be used to diagnose conditions such as deep vein thrombosis (DVT) and arterial occlusion (narrowing of arteries). It can also be done on an unborn baby and the placenta for pregnancies that are deemed to be high-risk for conditions such as intrauterine growth restriction.

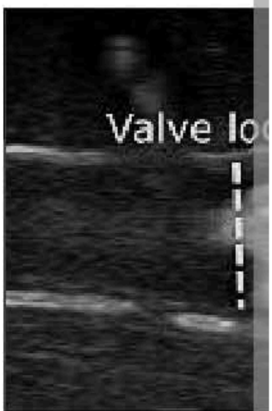


Figure 1.3. Ultrasonography

Recall questions

1. Explain the difference between anatomical ultrasound a

General features of ultrasound

Ultrasound is considered safe to use because it is merely a sound wave. It produces no ionisation and does not start any unwanted chemical reactions in cells. Any heating effects caused by making particles vibrate inside the body are very small.

Two properties of the ultrasound waves affect the image produced and these must be adjusted by the **sonographer** carrying out the scan. The properties are **frequency** and **gain**.

Frequency affects both **resolution** and **penetration**. The higher the frequency of ultrasound (lower wavelength), the higher the resolution, but the lower the penetration. Choice of frequency must be made carefully or chosen as a compromise between depth and resolution.

When gain is increased, this increases the amplitude of the wave. However, this too comes with compromise. When a signal is **amplified**, everything including background and unwanted signals are amplified – not just the signal that we want. Gain is applied to the ultrasound signal that has been reflected back from the tissues and adjusted to get appropriate contrast in the image between body fluids (which are usually adjusted black on an image) and solid tissues (which are usually adjusted to be white or greyscale).

Recall questions

1. Describe the use of ultrasound in medical diagnostics.

The ultrasound transducer

Ultrasound in medicine is produced and detected by a device called a transducer. the electronic equipment that controls frequency and gain and produces the imag

The transducer contains a vibrating element to create the longitudinal wave that transducer can be placed on the skin of the person being scanned, but to avoid being reflected back from the air gap between the transducer and skin, a gel must

How the right transducer is chosen:

- Higher frequency transducers (shorter wavelength): better resolution but les shallow tissues).
- Lower frequency transducers (longer wavelength): deeper penetration but lo deeper organs).
- Probe size and shape: this determines how well it fits in the scanning area (e. endocavitary for internal exams).

Gel is placed between the transducer and the skin to reduce the air gap and ensur the ultrasound waves from the transducer into the tissues. Most ultrasound gels ultrasound frequencies and are seen as 'general purpose' for that reason. Howeve properties for use on people's skin. Gels need to be thick enough so they don't ru following the scan. They should be colourless and also not to stain skin as well as bei

Ultrasound gels are chosen according to their:

- Viscosity (thickness): thicker gels are used for longer examinations where mo
- Conductivity: high-conductivity gels enhance the ultrasound transmission fo
- Skin sensitivity: hypoallergenic gels or those free from irritants are used for s
- Procedure type: some gels are designed for external scans, while others are sa

Recall questions

1. Describe the properties of ultrasound waves that can af

Advantages and disadvantages of ultrasound for imaging

Ultrasound has several advantages and disadvantages for imaging in medical appl
summarised as follows.

Advantages

- Safety: ultrasound uses sound waves, not ionising radiation, making it sa
  children, as well as patients who are pregnant.
- Painless: there's no discomfort involved in an ultrasound scan.
- Real-time imaging: ultrasound provides immediate images, allowing for
  other medical procedures.
- Versatile: can be used to examine various parts of the body, including or
- Cost-effective and widely available: ultrasound is less expensive than other
- Portable: ultrasound machines can be easily moved to different location
  bedside examinations.
- Ultrasound is generally a quiet, mobile technology which is accessible fo
  with disabilities.

Disadvantages

- Operator-dependent: the quality of the images can vary depending on th
  In the UK, sonographers need formal CASE accreditation.
- Limited penetration: ultrasound waves can be blocked by bone or air, m
  certain organs or structures.
- Not ideal for deep tissues: ultrasound may not provide clear images of structures located deep within the body.
- Cannot visualise certain tissues: some tissues, like bone and lung tissue, are difficult to visualise with ultrasound.
- Potential for **artefacts**: echoes from surrounding tissues can sometimes interfere with image quality, creating artefacts.
- The more invasive techniques such as transvaginal ultrasound are intima
  many patients find difficult to tolerate and which require sensitive comm
  potential discomfort and feelings of exposure.

An accredited sonographer or clinical scientist will perform the scan and adjust the
obstetrician will interpret the images and issue a report to the consultant doctor w

Formative discussion questions:
Patient A has been experiencing blood in their stool. Although ultrasound would n
diagnostic technique for bowel cancer, it may be used for an initial assessment o

Summarise how ultrasound might be used in this scenario.

1.3 Endoscopy

! Key points covered

- Structure of a modern endoscope
- Types of endoscopies
- Advantages and disadvantages
- Staff inv‹lved and risks to patie

Endoscopy is a medical procedure that inv... usi... a long, thin tube with a camer of your body. This tube is called ar... It's inserted through a natural openi through a small incision. ... use fibre optics which is a technique where lig received th... flex... Fibre-optic cables are also used in applications like l

Structure of a modern endoscope

The diagram (Figure 1.4) shows the general structure of an endoscope.

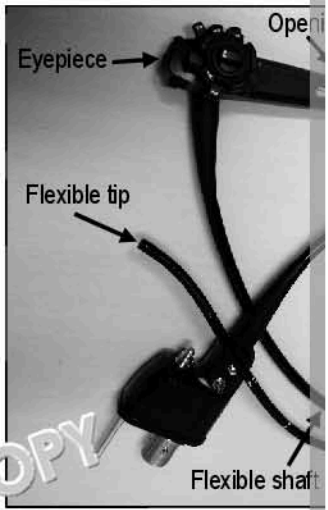


Figure 1.4

When you look at an object in everyday life, you are looking at the light that is reflected from it. However, as there is no source of light inside the body, we must introduce one if we are to produce visual images. Therefore, the endoscope contains two basic parts: a flexible fibre-optic cable to shine light onto the tissue and another with a camera chip at the end to capture the internal images.

The other end of the imaging cable can be connected to an imaging system so ... the image can be viewed direct... dis..ayed on a screen.

The individu...es within these two cables are usually configured in different w The one that shines the light onto the tissue can be **non-coherent**. As long as light transmitted from one end to the other, it doesn't matter what order the fibres go Non-coherent cables are cheaper and easier to manufacture. The imaging cable m have glass fibre optics or electronic sensors which convert the image to an electri signal which is sent by micro-cable to the processor to display the image.

Types of endoscopies

Most types of endoscopies are carried out through existing openings in the body a

- bronchoscopy – the imaging cable is inserted through the mouth and directe and into the bronchi (the widest airways in the lungs)
- colonoscopy – the imaging cable is inserted through ... anus and rectum an (large intestine)
- gastroscopy – the imaging cable is in... in... the mouth and down the thr upper digestive tract
- cystoscopy – the im... ...is inserted through the urethra (tube that car outsid... ...directed into the bladder

Other types ...endoscopies must be carried out through an incision (cut) made es inserting the imaging cable. These include:

- laparoscopy – the incision is made in the abdomen (belly) so that organs in th
- mediastinoscopy – the incision is made just above the sternum (breast bone) lungs that includes lymph nodes can be examined

Another type of endoscope is the capsule endoscope. This is a tiny light source an
a capsule that is small enough to be swallowed. When swallowed, the capsule enc
digestive system, sending images back to a receiver outside the body. As the entir
almost four metres long, capsule endoscopy is a better way to image all of it – par
which is difficult to reach by traditional endoscopy.

Apply your knowledge

For each of the four types of endoscopy, create an imaginary patient who would
endoscopy for diagnostic purposes.

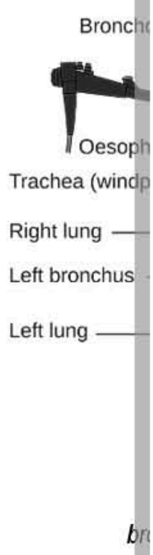
Staff involved and risks to patients

The medical staff that carry out endoscopy will be specialists in the region being i

Professional	Role
Gastroenterologist	Performs the endoscopy, diagnoses conditions. Takes biopsies or removes polyps.
Endoscopy nurse	Prepares the patient before the procedure. Assists the doctor and provides post-procedure
Pathologist	A doctor who analyses biopsy samples from the present during the procedure.
Endoscopy technician	Handles and maintains the endoscopic equipm
Sedation nurse / anaesthetist	Administers sedation to the patient and monito

People having an endoscopy must prepare before the procedure. Examination of
colonoscopy will require fasting before endoscopy and treatment with a strong la
tract is unobstructed. Patients undergoing bronchoscopy will also need to fast al
smoking in order to improve lung function in preparation for the procedure, and a
for a cystos

It is important that the patient fully understands what the procedure involves and that the risks have been fully explained and consent obtained. It may be that additional services such as translation are required if there is a language barrier or the patient is visually or hearing impaired.



Additional research

There is more information on the ranges of effective doses at the following websites:
zzed.uk/F186-bronchoscopy
zzed.uk/F186-cystoscopy

Your turn

Create a patient leaflet for the three types of imaging you have studied so far, expl
simple terms what each one is for, how it works, and the possible risks to the patie

Advantages and disadvantages of endoscopy for imaging

Endoscopy has several advantages and disadvantages for imaging in medical appli
These can be summarised as follows.

Advantages

- Minimally invasive: there is minimal trauma to the body because endosc or natural openings, although colonoscopies or laparoscopies are invas perforation risk.
- Quick recovery: since there is less tissue damage, patients usually reco
- Provides a clear and direct view of internal organs, aiding in precise dia
- Low risk of infection: small incisions reduce the chances of infections a scarring.

Disadvantages

- Although rare, complications such as bleeding, infections, or perforatio
- Discomfort: some patients may experience mild pain, bloating, or disc
- Anaesthesia risks: some types of endoscopy require sedation or anaest
- Not all conditions can be diagnosed or treated through endoscopy, and procedures are needed.
- The procedure can be costly, especially if advanced technology or spec
- Not always conclusive: in some cases, endoscopy may not provide a de further tests or procedures.
- Capsule endoscopy does not allow biopsy tissue to be collected and re decontamination.
- There may be positioning challenges for patients with mobility issues.

Formative discussion questions:
Patient A has been experiencing blood in his stool.

As part of the diagnostic tools available the doctor may order the patient to under
Analyse the advantages and disadvantages of this technique for confirming the d

1.4 Electrocardiogram (ECG)

! ***Key points covered***

- Structure of the heart
- Control of the cardiac cycle
- Principles of operation of the ECG
- Interpreting the ECG trace
- ECG and CT scans
- Advantages and disadvantages
- Staff involved

The heart is the organ that pumps blood around the body. It is mainly made from muscle tissue, but this muscle differs in a significant way from the skeletal muscle that moves us around.

It is called cardiac **muscle** and is described as being **myogenic**. In order to understand how the heart, and electrocardiogram (ECG), works we need to look at the structure of the heart and in more detail about how its beat is started and regulated.

Structure of the heart

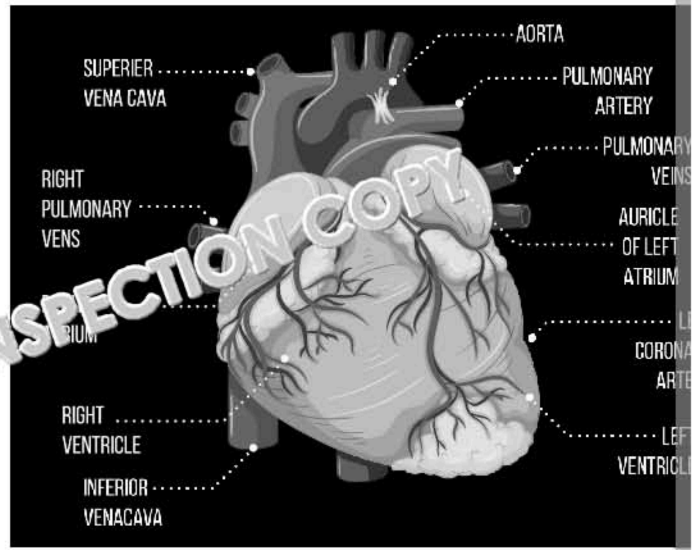


***Figure 1.6** Diagram showing the structure of the heart*

The heart is composed of two pairs of chambers – the left and right atria at the to
the left and right ventricles at the bottom. During the **cardiac cycle**, blood enters
heart from veins into the atria. The atria then contract together, pushing blood do
into the ventricles. The ventricles then contract to push blood out through arterie
around the body. The key timings of the cardiac cycle are:

- atria must contract together and from the top down
- atria must contract while the ventricles are relaxed
- there must be a slight delay to allow ventricles to fill before they contract
- ventricles must contract together and from the bottom up
- atria must be relaxed when ventricles are contracting
- the cycle must repeat for the entire life of the person

Control of the cardiac cycle

The cardiac cycle is continuous so has no start and end points, but we can conside
node (SAN). This structure is located in the wall of the right atrium. The SAN emits
spread down across the walls of the atria. As the wave of electrical activity spread
the atrial walls contracts. This forces blood down and into the ventricles.

When the wave of electrical activity reaches the base of the atria, it encounters a
stops it continuing down to the ventricles. However, in the wall of the heart just b
is a patch of conducting tissue called the atrioventricular node (AVN).

The AVN is often described as a relay station because it picks up the electrical imp
the heart. From here, the electrical pulse spreads up and across the walls of the v
out of them. The AVN also introduces the necessary delay between the contractio

After the ventricles have contracted, the cycle begins again with the SAN emitting

Recall questions

1. Create an annotated diagram which shows what happe
complete cardiac cycle.

Principles of operation of the ECG

An ECG works by detecting the electrical impulses emitted by the heart through the cardiac cycle. A standard 12-lead ECG uses 10 electrodes connected to the skin at various positions on the body: four are positioned on the limbs and six are on the chest, as shown. Hence, the ECG is non-invasive.

The electrodes measure the potential difference between the skin and a reference voltage which does not change. Body tissues contain cells that are surrounded by tissue fluid. Tissue fluid is an aqueous solution containing many substances, some of which are ions. Therefore, tissue fluid acts as an electrolyte, conducting the electrical impulses from the heart to the skin at the surface.

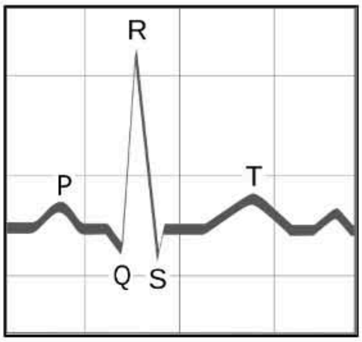


Figure 1.8 A typical ECG trace

The changes in potential difference are display
The ECG waveform consists of deflections that
phases of the cardiac cycle. A positive deflectic
impulses move towards a positive electrode ar
upwards, above the baseline. A negative deflec
move away from a positive electrode and the t
towards the baseline.

The result looks like a graph with potential diff
the *x*-axis. This pattern is called an ECG trace. A
pattern looks like this, where the letters P–T re

Interpreting the ECG trace

An ECG trace reveals a lot about the activity of the heart.
The **P wave** represents the impulse emitted from the SAN to start atrial contractic
The **QRS wave** represent the electrical activity that causes the ventricles to contr

Heart rate, which is the number of beats per minute, can be worked out from the

- noting the time in seconds for one complete cycle (or several complete cycle
- heart rate = 60 / time for one complete cycle to get beats per minute

There are systematic differences in the ECG traces, generally, for male and female pati
female patients generally have a longer QT interval. It is important therefore for healt
patient's sex when interpreting their trace. For transgender and non-binary patients, h
approach this sensitively, respecting gender identity whilst explaining that sex is clinica

The ECG trace changes dramatically just after someone has acute myocardial infarctio
the trace starts to look more like that of a healthy person long after AMI, it will still sho

For example, this image shows an ECG trace of a person after three minutes of AN
trace, the ST section is much higher because there is a blockage in a coronary arte


Figure 1.9 An ECG trace of a person after three minutes of AMI (hea

The next example shows the ECG trace of a person with sinus arrhythmia, which i
impulses arising from the SAN. You can see an irregular heart beat with different t
condition, the shorter time interval coincides with inhalation and the longer inter

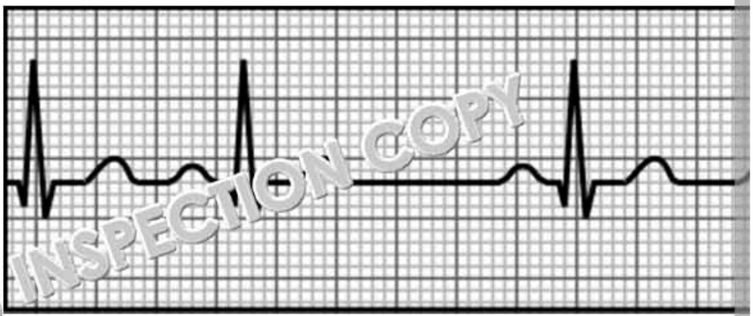


Figure 1.10** An ECG trace of a person with **sinus arrhythmia

Compared to normal heart function which would show a regular pattern, with a P
irregular heart rhythms can be visualised on an ECG trace, such as:

Condition	
Atrial fibrillation	No P waves and the R–R intervals would be irreg quivering instead of beating properly
Ventricular tachycardia	QRS complexes would be wide and fast due to fa
Ventricular fibrillation	Whole ECG totally disorganised with no clear wa
Heart block	Long PR interval because there is a slow signal be the ventricles

ECG and CT scans

ECG can be used in conjunction with CT scans of the cardiovascular system.
ECG enhances CT scans through a technique called **ECG gating**.

The benefits of this are:

- Reduced motion artefacts: by capturing images during the same phase of the diastole, when the heart is relaxed), ECG gating minimises the blurring cause This leads to clearer and more accurate images of the coronary arteries and h
- Improved image quality: with reduced motion artefacts, the overall image qu allowing for improved visualisation of even small coronary lesions.
- Increased diagnostic accuracy: by providing a clearer picture of the coronary CT scans help doctors more accurately diagnose coronary artery disease (CAD of blockages.

Applications of ECG-gated CT scans

- Coronary artery disease (CAD) evaluation: detecting and assessing the severit artery blockages.
- Cardiac calcium scoring: measuring the amount of calcium build-up in the co factor for heart disease.
- Congenital heart defects: evaluating the structure and function of the heart i heart conditions.
- Heart failure assessment: assessing the heart's pumping function and structu heart failure.

Advantages and disadvantages of ECG

ECG is a low-risk procedure. People having this diagnosis have no risk of electric s
are just passive measuring devices. Some people may develop a slight rash where
onto skin, similar to that where an adhesive plaster was attached.

Advantages and disadvantages of ECG can be summarised as follows.

Advantages of ECG

- Non-invasive: ECG doesn't require any surgical procedures.
- Quick and painless: the test takes only a few minutes to perform.
- Widely available: ECG is a standard diagnostic tool found in most healt
- Cost-effective: compared to other diagnostic tests, ECG is relatively ine
- Accurate in detecting heart rhythm abnormalities: ECG is excellent at i
- Can provide evidence of heart damage: ECG can show signs of previous h heart injuries.
- Helps in monitoring heart conditions: ECG can be used to track the pro heart diseases.

Disadvantages of ECG

- Provides a snapshot in time: ECG only records heart activity at the mor detect irregular heartbeats that occur infrequently.
- Limited in detecting certain heart conditions: while ECG is good at dete may not accurately identify other heart issues such as heart failure or
- Interpretation can be subjective: ECG results require interpretation by and there can be variations in how different experts read the results.
- Affected by external factors: factors such as muscle movement, electr electrical interference can affect ECG results.
- ECG does not specifically diagnose ischaemia and the results can be dis the patient's [illegible]

Apply your knowledge

Create a risk assessment for using this diagnostic technique.

a) What are the identified hazards, and what level of risk is involved?
b) What is the level of risk for each hazard?
c) What are the control measures that can be put in place to reduce the risks?

Staff involved

The healthcare professionals involved in administering an ECG may be different d under which the ECG is required; for example, in an emergency situation a param technician would be carrying out the procedure.

Healthcare professional	Role
Paramedic	Performs ECGs in emergencies, e.g. during heart a thr... in ECG patterns
Cardiac nurse	Performs ECGs in hospitals and monitors continu
Cardiologist	Expert interpretation of ECGs to diagnose heart c
Cardiac physiologist	Performs and analyses complex ECG tests such as
ECG healthcare assistant	Routine patient preparation and data handling

Your turn

Create a mind map of all of the different healthcare professionals you have come a and the different roles they perform. You could add information about the educati training required for each role as well.

Formative discussion questions:
Look at the diagnostic scenario which suggests that Patient A would benefit from

Topic Area 2: Application of ionising diagnosis techniques

2.1.1 Plain X-ray image

! ***Key points covered***

- Medical applicatio[illegible] [illegible]-rays
- X-ray [illegible]ru[illegible]
- Produ[illegible] X-rays
- Improv[illegible] X-ray images
- Effective radiation dose
- Safety considerations and prof
- Advantages and disadvantages

Medical applications of X-rays

There are many applications of X-ray imaging in medicine. These include:

- Bone fractures: identifying breaks or cracks in bones.
- Dental issues: examining teeth for cavities, infections or abnormalities.
- Lung conditions: detecting pneumonia, tuberculosis or other lung diseases.
- Heart problems: assessing the size and shape of the heart, identifying blocka in blood vessels.
- Digestive system: examining the oesophagus, stomach and intestines for obstructions or inflammation.
- Breast cancer screening: mammography to detect early-stage breast cancer.
- Guided procedures: assisting in procedures such as an[illegible]grams, biopsies, an orthopaedic surgeries.

Recall questions 1. M[illegible] a list of all the uses of medical x-rays.

X-ray tub[illegible]ucture

X-rays are emitted when fast-moving electrons collide with a metal surface wher electrons in the metal.

Figure 2.2 shows the main components of a typical X-ray tube.

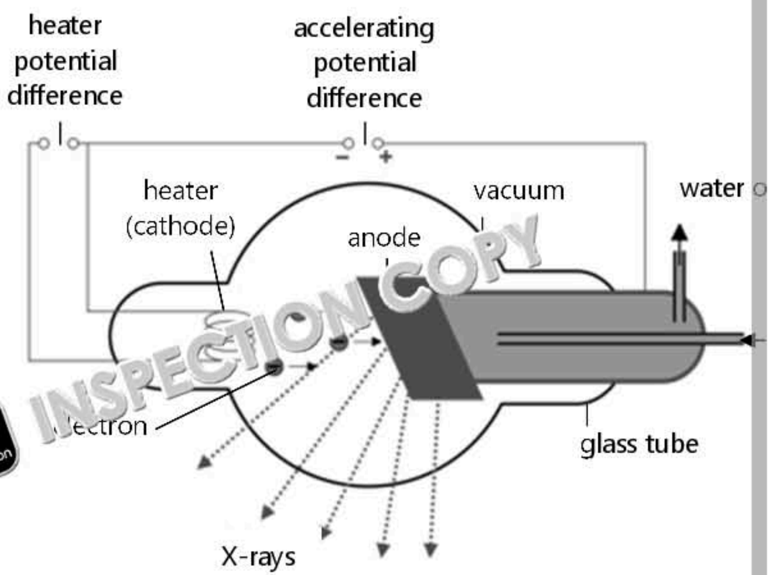


***Figure 2.2.** A typical X-ray tube.*

Production of X-rays

There are two key parameters to be considered when producing medical X-rays from an X-ray tube. One of these is the peak potential difference between the **cathode** and **anode** in the tube, and the other is the current between the two.

As the peak potential difference is measured in kV, it is usually referred to as kVp. The current controls the number of X-rays produced and is usually measured in mA. Higher current will increase image brightness and produce a clearer image of thic abdomen, but will also increase the radiation dose and therefore will often be low

The kVp setting influences the acceleration of the electrons towards the anode and arrival at the anode. The higher the kVp the higher the electron energy and, theref Higher energy X-rays are more penetrating of dense materials and can produce be as they are able to penetrate the lungs and ribs, and for obese patients to ensure X Lower kVp settings are often suitable for X-ray images of hands and feet to improv more X-rays at lower energy, and for paediatric imaging to reduce the dose of radi

The exposure time, measured in seconds, determines how long X-rays are produc of less than 0.1 seconds are used to reduce motion blur from breathing when pro movement of young children. Longer exposure times are often necessary when th for the lower X-ray production, e.g. when producing images of the hands and feet

When X-rays pass through matter, they interact with the particles in the matter producing two main effects: **attenuation** and **scattering**.

Attenuation is a decrease in intensity of the X-rays which can be caused by X-ray photons being absorbed or scattered.

Scattering, as the name suggests, is a random change in direction of the X-ray pho due to interaction with electrons in the matter through which it is passing. Scattering contributes to a decrease in intensity because the number of X-ray pho emerging from the matter in the direction expected is reduced.

Collimators and **filters** can be used to improve the quality of the X-ray beam.

A collimator is a device used to restrict the size and shape of an X-ray beam. A collimator is a series of lead shutters that can be adjusted to match the size of the area being imaged.

This has the advantages of:

- Reducing patient exposure: by limiting the X-ray beam to the area of interest it minimises unnecessary radiation exposure to the patient.
- Improving image quality: by reducing scatter radiation, it enhances image contrast and clarity.
- Protecting staff: helps to protect healthcare workers from unnecessary radia

An X-ray filter is a sheet of material, usually aluminium, copper or tin, placed in th It is designed to absorb low-energy X-rays that contribute little to image formatio

Functions of a filter:

- Reduces patient dose: by removing low-energy X-rays, it decreases the p
- Improves image quality: by increasing the energy of the X-ray beam it improv and penetration.
- Protects the patient: reduces the skin dose, which is particularly important fo

Recall questions

1. Write an explanation in your own words of how x-ray i

Improving X-ray images

Image contrast enhancement is a method to make diagnosis from an X-ray image easier. This is where software is programmed to exaggerate the difference between light and dark areas on the image.

Patient positioning is crucial in minimising artefact on X-ray images. Incorrect positioning can lead to various image distortions, obscuring anatomical structures, and hindering accurate diagnosis.

General positioning principles are:

- The X-ray beam should be perpendicular to the part being imaged to minimise distortion.
- The body part of interest should be parallel to the image receptor to avoid magnification.
- Use positioning aids, sandbags, or restraints to prevent movement.
- Ensure patient comfort to reduce anxiety and potential movement.

Further your kn

Various types of artefa
incorrect positioning:

- **Motion artefact:** during exposure. instruction, immo exposure times. images, superim
- **Magnification a** being imaged is image receptor. interest as close
- **Rotation artefac** of the body part distorted shapes Corrected by ca
- **Overlapping str** structures. Addre patient positioni

Some examples of positioning include:

- Chest X-ray: erect posture, arms raised, chin extended to avoid obscuring lun
- Abdominal X-ray: supine position, knees flexed to reduce bowel gas.
- Limb X-ray: part aligned parallel to the image receptor, avoiding rotation.

Your turn

Create a training poster for a medical imaging facility outlining the steps to be tak x-ray image quality

Effective radiation dose

Effective dose is a measure of the overall risk of developing radiation-induced ca radiation, such as X-rays. It takes into account the different sensitivities of various

To calculate effective dose, two factors are considered:

1. **Equivalent dose**: this measures the biological effect of different types of radi
2. **Tissue weighting factor**: this reflects the sensitivity of different organs and ti

By multiplying the equivalent dose by the tissue weighting factor for each irradiated organ and summing these products, the effective dose is obtained.

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Effective dose (Sv) = Absorbed dose × Tissue weighting factor

Effective dose is measured in **sieverts (Sv)** or more commonly in millisieverts (mSv).

[illegible]	Weighting factor
Brain	0.01
Liver	0.04
Testes	0.08
Lungs	0.12

The effective dose from an X-ray examination varies depending on the type of exam and the specific technique used. Generally, the effective dose from diagnostic X-rays is relatively low.

For example:

- Chest X-ray: 0.05–0.24 mSv
- Dental X-ray (depending on the type of dental X-ray): 0.001–0.03 mSv
- Mammogram: 0.1–0.6 mSv
- Abdominal X-ray: [illegible] mSv

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It is important to note that these are average values and the actual dose can vary.

The current advice on maximum dose per person is 1 mSv per year averaged over
Healthcare professionals, however, have a limit of 20 mSv per year, averaged ove

Safety considerations and professionals involved

Staff, called **radiographers**, protect themselves from X-rays by going out of the room or by standing behind a lead screen when an X-ray image is being taken. Staff also wear film badges which are sent off for development at regular intervals. If the film is seen to go too dark, then their exposure is deemed to have been too high.

Fig

Patients can be protected by wearing protective covers to prevent X-rays from penetrating sensitive tissues that are not part of the diagnostic procedure. These covers are usually in the form of aprons that contain lead panels.

Understanding effective dose helps healthcare providers and patients make informed decisions about the benefits and risks of medical imaging procedures. By minimising radiation exposure while maintaining diagnostic quality,the principle of 'as low as reasonably achievable' (ALARA) is applied.

X-ray images are interpreted by doctors who specialise in radiology and are traine
nuclear medicine images, called radiologists. Orthopaedic surgeons analyse bone
dislocations, and dentists and oral surgeons will interpret dental X-rays to view wi
and jaw fractures.

Advantages and disadvantages of X-ray imaging

The advantages and disadvantages of medical X-ray imaging can be summarised a

Advantages

- Rapid and accessible: X-rays are quick to administer and the results are
- Relatively inexpensive: compared to other imaging techniques, X-rays a
- Wide range of applications: X-rays can be used to diagnose a variety of fractures, pneumonia, and dental issues.
- Non-invasive: X-rays do not require surgery or incisions.
- Effective for diagnosing certain conditions: X-rays are excellent at visua some organs.

Disadvantages

- Radiation exposure: X-rays use ionising radiation, which can increase t repeated exposure.
- X-ray imaging cannot provide detailed images of soft tissues such as th and ligaments. A better alternative for imaging these areas would be M a suspected brain tumour or spinal cord injury would require an MRI ra
- Potential for false positives or negatives: X-ray images can sometimes l to incorrect diagnoses.
- Not suitable for pregnant patients due to the level of exposure to radia
- Allergic reactions: some contrast agents used in X-ray procedures can c
- X-rays often fail to identify small tumours and cannot distinguish betw cancers. For example, if a patient had unexplained weight loss and fati would be more likely to identify early-stage cancer.
- Blood clots and vascular blockages also cannot be detected by X-ray. A or pulmonary embolism would require a CT angiogram to visualise blo

Formative discussion questions:

A patient has been suffering from persistent chest pain and shortness of breath for the p along with unexplained weight loss and blood in his stool. Lung cancer is suspected; the would be [illegible]e to locate the tumour. What would be the expected findings on the X-r

2.1.2 Computerised tomography (CT) scans and contrast

Key points covered

- Structure and function of a CT scanner
- Radiopaque media
- Effective radiation dose
- Safety considerations and professionals involved
- Advantages and disadvantages of CT scans

A CT scan, or computed tomography scan, is a medical imaging technique that produces detailed cross-sectional images of the body. Unlike X-rays, which produce a flat, 2D image, CT scans create a 3D image by combining multiple X-ray images taken from different angles.

CT scans can be used to provide detailed images of organs and tissues in cancer diagnosis, and for a patient with head trauma to check the brain for bleeding and swelling.

Figure 2.4

Structure and function of a CT scanner

Figure 2.5 shows the basic structure of a CT scanner.

***Figure 2.5**. The basic structure of a CT scanner.*

The gantry is a ring that slowly rotates around the part of the patient to be scann
opposite the multiple row detector as the gantry rotates. The multiple row detect
detectors as opposed to just one. This increases the imaging angle at each positio

To scan larger areas of the body, the table can either move through the gantry as
move along the table.

Although CT is a fast procedure, the environment and noise may be stressful for n
and children. Medical professionals should give clear, simple instructions, sometim
through or practice run before the actual procedure in order to put the patient at

Radiopaque media

A contrast medium is a substance used in medical imaging to improve the visibility
internal structures. In the context of CT scans, it's typically an iodine-based liquid
injected into a vein, or a barium compound that is eaten and swallowed with food

The contrast medium travels through the bloodstream and accumulates in specifi
through the digestive tract accumulating in various locations.

This accumulation increases the density of these areas, making them appear whit
contrast helps radiologists differentiate between different types of tissues and ide
clearly. At the end of the procedure the iodine is filtered by the kidneys and excre
patient has impaired renal function this can take longer. Barium compounds pass
and are excreted in faeces.

An angiogram is a specialised imaging test which involves injecting a contrast mediu
blood vessels such as arteries and veins visible in a CT scan in order to detect blockag
An angiogram can be used to image blood flow through the heart, brain, kidneys,

Recall questions

1. Why might a contrast medium be used?

Effective radiation dose

The effective radiation dose from a CT scan can be greater than that of a plain X-r
the scan length and number of phases.

CT scan type	Range of effective dos
Head	1–2
Chest	5–7
Abdomen and pelvis	8–10
Cardiac angiogram	5–15
Pulmonary angiogram	4–7

Safety considerations and professionals involved

Radiographers are the people who operate CT scanners, and the safety procedure
those when taking plain X-ray images.

While CT scans with contrast media are generally safe, there are potential risks. It
risks are relatively uncommon, and the benefits of the scan often outweigh them.
history of allergies or with kidney problems are at greater risk than other people.

The most common risks with contrast media are:

- Allergic reactions (hypersensitivity) to the media: this can range from mild itchi
- Kidney damage: contrast media can potentially harm the kidneys, especially i
kidney problems.

Less common risks are:

- Thyroid problems: in rare cases, contrast media can affect the thyroid gland.
- Other side effects: these can include nausea, vomiting, headache, and a warr

Advantages and disadvantages of CT scans

The advantages and disadvantages of CT scans can be summarised as follows.

Advantages

- Provides highly detailed cross-sectional images of the body.
- Relatively quick procedure compared to other imaging techniques.
- Can be used to diagnose various conditions, including injuries, infectio
- Can quickly identify life-threatening conditions such as internal bleedi
- Can be used to guide biopsies, surgeries, and other medical procedure

Disadvantages

- CT scans expose patients to significant radiation and are not suitable fo
as during pregnancy. Children and young adults should also avoid freque
with suspected appendicitis should be evaluated with an ultrasound be
- If a contrast medium is used, there's a risk of allergic reactions or kidne
- Compared to MRI (topic area 1.1), CT scans provide less detailed image
- Can be expensive and not all medical facilities have a CT scanner for th
- Some patients may experience anxiety, claustrophobia or discomfort d
- Because CT scans show anatomy rather than functions such as blood fl
function in conditions such as epilepsy and dementia. A PET scan woul
diagnostic test for a patient with suspected Alzheimer's disease.

Apply your knowledge

Research some medical scenarios in which the speed of a CT scan would be imp
In each case, state what images would be produced from the scan, and what the

CT and MRI are often combined in medical diagnosis because they provide compl different tissues and structures.

CT scans will provide images of bones and dense structures. It is quick, widely available and good at visualising bone, **calcification** and heavy bleeding, so it would be chosen first in a trauma or stroke.

MRI scans will provide information about soft tiss... such as muscle, nerves, ligaments, cartilage, marrow and tumours. It is used in cases when soft-tissue inju characterisation is needed after the CT. It does not use ionising radiation, but cann metal implants.

However, both scans can often be combined. For example, with a suspected spina show bone fractures, while an MRI will assess nerve or spinal cord damage. Using more complete picture than either scan alone.

Formative discussion questions:

Along with the primary symptoms of chest pain and shortness of breath, patient A is also blood in his stool. In order to investigate this the doctor ordered a CT scan of the bowel.

Explain why this diagnostic test is appropriate for the patient's symptoms.

2.2.1 Radiopharmaceuticals

! ***Key points covered***

- The gamma camera
- Radioactive tracers
- Health and safety in respect of radioactive tracer
- Advantages and disadvantages of radioactive tra

Radiopharmaceuticals are specialised drugs that contain radioactive elements called radioisotopes. These drugs are used in both diagnostic and therapeutic applications in medicine.

Radiopharmaceuticals are designed to accumulate in specific organs or tissues. The emitted radiation can be detected by imaging equipment, providing valuable information about the function and structure of these organs. This helps in diagnosing diseases such as cancer, heart disease, and neurological disorders.

Examples of radiopha
- Technetium-99m: imaging various o heart, brain, bone
- Fluorine-18: key c radiopharmaceuti detect cancer and
- Iodine-131: used i of thyroid conditio

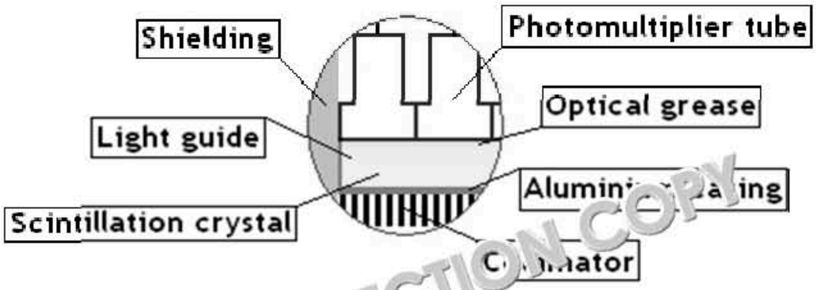
Radiopharmaceuticals are carefully regulated to ensure patient safety. The radiati controlled, and the drugs are administered by trained medical professionals.

The gamma camera

Because gamma rays are composed of photons and are not relatively large, charg they are detected in a different way.

A gamma camera is designed to be able to produce an image from a gamma-emit as technetium-99m. It is comprised of:

- A collimator, which focuses gamma rays onto the crystal.
- **Scintillation crystals** that convert gamma ray photons into photons of visible
- **Photomultiplier tubes** that convert light into electrical signals.



Figure

A compute... used to process the output from the photomultip... tubes and produce an image.

Radioactive tracers

A radioactive tracer is a molecule that has a **radionuclide** incorporated into it. The tracer is designed to be introduced into the body by injection, inhalation or ingestion. The tracer enters certain organs or tissues and is detectable by the radiation that it emits. Radionuclides used in medical imaging become non-radioa and are eliminated from the body through natural biological processes; for examp such as technetium-99 are excreted in urine. Patients are often advised to drink p clearance of the radionuclide.

There are many different radioactive tracers available for medical use. The selecti done by a nuclear medicine specialist. This is a critical decision that depends on se

- The tracer should preferentially accumulate in the target organ or tissue. The the body should be understood to avoid interference from other organs.
- Different tracers are suitable for each type of imaging based on the nature of The tracer's decay characteristics should produce high-quality images.
- The tracer should be appropriate for the intended use, whether diagnostic or also provide the necessary information for the clinical question.
- Age, weight, allergies and kidney function are all patient factors that influenc and dosage.
- Levels of physical activity, diet and smoking and substance abuse are some o account when deciding on an appropriate tracer to use.
- The tracer's half-life should be suitable for the study duration.
- The tracer should deliver a minimal radiation dose to the patient. Although r half-lives, typical diagnostic imaging tracers result in effective doses of 1–10 a gamma emitter with a half-life of six hours, in comparison to iodine-123, al radionuclide, with a half-life of 13 hours.
- Practical considerations such as availability and cost influence the choice of t

Recall questions

1. What would technetium-99 be used for in a scan of the
2. What might affect the quality of the image?

Health and safety in respect of radioactive tracers and profession

The use of radioactive tracers in medicine is a carefully regulated process with str place. In the UK, an organisation called **ARSAC**, which stands for the Administrati Advisory Committee, gives advice on licence applications from organisations that tracers on people.

Healthcare professionals who handle radioactive materials undergo rigorous trai
protocols to protect themselves from exposure. General safety measures associat

- The amount of radioactive material used in medical procedures is incredibly
- Most radioactive tracers are quickly eliminated from the body through urine
- Healthcare professionals use appropriate shielding to protect themselves an exposure. They must wear personal protective equipment including gloves, g
- Radioactive materials should be stored in lead containers inside locked metal c
- Imaging rooms are well-ventilated to minimise airborne contamination.
- Radioactive waste is handled and disposed of according to strict regulations.
- Healthcare professionals require regular monitoring, and radiation film badges
- Hospitals must have plans in place for handling accidents or spills.

Patients undergoing procedures involving radioactive tracers are carefully monitor detailed information about the procedure, including potential risks and benefits be proceed, which is called **informed consent**. Special additional precautions are take selecting a radioactive tracer with the shortest possible half-life and encouraging fr order to clear the tracer from the body as quickly as possible. Post-procedure guid are given specific instructions on fluid intake, hygiene, and avoiding close contact v

Doctors specialising in nuclear medicine with an ARSAC licence are responsible fo selection and dosage of radionuclide tracers for patients and for interpreting the radiopharmacist will ensure safe and accurate compounding of radioactive tracer working to ARSAC standards before administration and will monitor radioactive d nuclear medicine technologist or specialised radiographer will carry out the intrav staff will monitor the patient after administration.

The risk to the public from radioactive tracers used in medical procedures is extre radiation emitted is minimal and rapidly decreases over time.

Recall questions

1. What are the risks of using tracers such as technetium-9

Advantages and disadvantages of radioactive tracers

The advantages and disadvantages of radioactive tracers can be summarised as fo

Advantages

- High sensitivity: they can detect extremely small amounts of substanc
- Specificity: they can target specific organs or tissues.
- Non-invasive: most procedures involving radioactive tracers are non-in
- Functional information: they provide information about physiological p anatomical structures.
- Early detection: they can detect diseases in their early stages.
- Versatility: they can be used for various medical applications, from dia

Disadvantages

- Radiation exposure: while the amount of radiation is minimal, there is
- Cost: the equipment and radiopharmaceuticals can be expensive.
- Image quality: sometimes image quality can be affected by factors suc physiological noise, such as cardiac motion, breathing, blood flow and gastrointestinal motion.
- Limited availability: not all facilities have access to nuclear medicine im
- Allergic reactions: some patients may experience allergic reactions to t

Recall questions

1. What are the advantages of using this technique in ter patient's experience?

A radionuclide tracer and gamma camera provides functional information rather t bone imaging; for example, a patient with a suspected brain tumour would need a gamma camera scan to visualise the cancer.

Radionuclide imaging takes time for tracer uptake and cannot rapidly detect inter or traumatic injuries. A car accident victim with suspected internal bleeding need radionuclide scan.

Similarly to other diagnostic techniques using ionising radiation, radionuclide imag radiation-sensitive patients such as children and young adults, or those who are p

Formative discussion questions:

Because patient A is suffering from chest pain and shortness of breath, a myocardial per using technetium-99 and gamma camera imaging is ordered to identify heart disease.

What are the advantages and disadvantages of this technique for confirming the diagnos

2.2.2 Positron emission tomography (PET)

Key points covered

- Fluorodeoxyglucose (FDG)
- Locating a tumour using CT and PET scans
- Safety precautions for PET sc
- Advantages and disadvantage

Positron emission tomography or PET is a medical imaging technique that produces a three-dimensional image of molecular processes in the body. PET scans measure metabolic activity, which is a key indicator of tissue function. Because PET scans measure function, they can detect abnormalities earlier than structural imaging techniques like CT or MRI.

Figure

A small amount of a radioactive substance (tracer) is injected into the body. This tracer is designed to accumulate in specific organs or tissues based on their metabolic activity. The radiotracer emits a **positron**, which is the **antiparticle** of an electron. The positron collides with an electron, resulting in the production of two gamma rays that travel in opposite directions. The PET scanner detects these gamma rays and uses their direction to determine their origin. A computer reconstructs a three-dimensional image based on the location of the gamma ray pairs.

positron – identical mass to ar with a positive charge

antiparticle – counterpart to a same mass but opposite charg

Fluorodeoxyglucose (FDG)

Fluorodeoxyglucose (FDG) is the most commonly used radioactive tracer in PET s analogue of glucose, meaning it is a molecule very similar to glucose in terms of th radiolabelled with fluorine-18 to make it radioactive. Glucose is the body's prefer means it is taken up in large quantities by cells that are active.

FDG is injected into the bloodstream. Cells with high metabolic activity, such as ca
glucose for respiration. Since FDG is similar to glucose, it's also taken up by these
cannot be fully metabolised, so it accumulates in cells with high glucose uptake. T
radiation emitted by FDG, allowing medical professionals to visualise areas of high

FDG will usually be administered by a nuclear medicine physician.

Locating a tumour using CT and PET scans

PET scans can be often combined with CT scans (PET/CT) to provide both function
For example, the precise location of a tumour requires the PET/CT combination. T
structural images of organs and tissues, allowing a tumour to be located. A PET sc
will visualise tumour cells as bright spots showing physiological information. These
the location and nature of the tumour, improving diagnosis and treatment planni

Safety precautions for PET scans

PET scans are usually carried out by radiologists who also interpret the images.

Generally, the amount of radiation used in a PET scan is relatively low, and the pr
most people. However, as PET scans involve the use of a radioactive tracer, there
to follow.

- Minimal radiation dose: the quantity of radioactive tracer used in a PET scan
- Rapid elimination: the radioactive tracer is quickly eliminated from the body
- Shielding: healthcare professionals use appropriate shielding to protect them radiation exposure.
- Post-procedure guidelines: patients are given specific instructions on fluid int are advised to drink plenty of water to eliminate the tracer and to avoid close anyone who is pregnant for the first few hours afterwards.

Recall questions

1. List the potential hazards of a PET scan on a patient wit low-grade temporal lobe tumour.

Advantages and disadvantages of PET scans

The advantages and disadvantages of PET scans can be summarised as follows.

Advantages

- High sensitivity: PET scans can detect abnormalities in the early stages
- Functional information: provides information about how organs and ti their structure.
- Wide range of applications: used for various diseases, including cancer neurological disorders.
- Accuracy: offers precise localisation of abnormal tissue.

Disadvantages

- Cost: PET scans are often more expensive than other imaging techniqu
- Radiation exposure: while the amount of radiation is relatively low, pa ionising radiation.
- Availability: not all healthcare facilities have access to PET scanners.
- Requires specialised equipment and personnel: PET scans require spec trained technicians.
- Less detailed anatomical information: compared to CT or MRI scans, PE anatomical information.

PET scans focus on function, not anatomical structure, meaning they are not ideal for detecting fractures, organ structure changes, or soft tissue injuries; for example, a patient with a suspected spinal fracture or bone abnormality needs a CT scan or an MRI scan rather than a PET scan.

PET scans take time for tracer uptake, making them too slow for emergencies and unable to detect acute bleeding or fractures. A patient involved in a car accident would require a CT scan rather than a PET scan to identify the extent of their injuries quickly.

Patients are required to lie still for 20-60 minutes for the scan to complete which may be difficult for patients with mobility impairments and children. Healthcare professionals may need to use hoists or sliding sheets to assist the patient onto the scanning bed and may use cushions or supports to reduce pain and stiffness. Using clear, simple explanations helps to reassure patients and sometimes even playing music during the scan helps to distract patients and reduce anxiety.

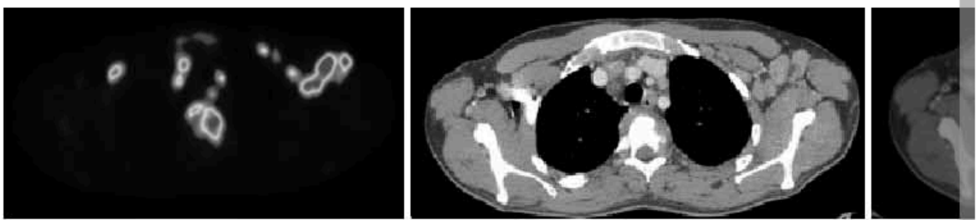


Figure 2.9. *Scans of a patient with cancer metastases – PET scan (left), CT scan (middle) a*

Formative discussion questions:
An MRI brain scan with contrast of patient B has revealed a benign, low-grade temporal l
There areno signs of [illegible] or metastasis on the MRI scan. Why might a doctor also or

Apply your knowledge

Create an overview table of all of the diagnostic techniques you have studied wit and disadvantages. Consider the following headings, as well as any others you v

	Patient safety	Patient comfort	Speed	Versatility	Cost	Availability
Diagnostic technique						

Topic Area 3: Application of ionising therapy techniques

Principle of ionising therapy

Ionising therapy, also known as radiation therapy or radiotherapy, uses ionising ra medical conditions, primarily cancer. It works by damaging the DNA of cancer cell undergoing cell division and eventually leading to their death.

The two main ways of delivering radiotherapy are external radiotherapy and inter External radiotherapy uses a machine outside the body to direct radiation beams radiotherapy involves placing radioactive materials inside the body, either as impl

The use of all forms of ionising radiation therapy must be carefully considered, an pregnant usually require strict pregnancy screening due to the radiation risk to a levels will also impact on radiosensitivity therefore communication by healthcare respectful of gender identity but should be clear the biological sex is important fo

Type of ionising therapy	Penetration	Advantages
X-ray	Moderate to deep	Widely available, precise dosing
Gamma ray	Deep	High penetration
Ultraviolet	Very shallow	Ideal for surface treatment
Proton beam	Precise depth	Highly targeted, spares surrounding tissue
Radionuclide	Variable (depends on radioisotope used)	Can target specific tissues and organs
Brachytherapy	Localised	High dose to tumour, minimal impact on surrounding tissue

3.1 Treatment with external source

! Key points covered

- X-ray radiotherapy
- Gamma Knife radiosurgery
- Ultraviolet skin treatment
- Proton beam therapy
- Safety procedures

There are four external ways of using [illegible] therapy: X-rays, gamma rays, short-w
and proton beams.

X-ray radiotherapy

X-ray radiotherapy is a precise and effective type of cancer treatment that uses high-energy X-rays to kill cancer cells or slow their growth. X-rays are directed at the tumour. Modern radiotherapy techniques allow for precise targeting of the tumour, minimising damage to surrounding healthy cells.

Figure 3.1. *Photograph of a*

X-ray radiotherapy can be used in various stages of cancer in different ways:

- To completely eliminate the cancer.
- To increase the chances of a cure after surgery.
- To shrink a tumour before surgery.
- To relieve symptoms and improve quality of life when a cure is not possible.

While radiotherapy is generally safe and effective, it can cause side effects, such a

- Fatigue
- Skin irritation
- Nausea
- Hair loss (in the treated area)

These side effects are usually temporary and can be managed with appropriate ca

X-ray radiotherapy is usually administered by a therapeutic radiographer. Other m
be involved with delivering the therapy are:

- Radiation oncologist: this is the doctor who prescribes the radiation dose, pla
  the patient throughout the therapy.
- Medical physicist: ensures the equipment is safe and accurate, performs the
  the treatment plans.
- Dosimetrist: works with the oncologist and the physicist to create the treatm
  radiation is delivered

Gamma Knife radiosurgery

Stereotactic Gamma Knife radiosurgery is a highly specialised form of radiation therapy that uses focused beams of gamma rays to treat tumours and other abnormalities. Unlike most X-ray radiotherapy, which delivers radiation in multiple sessions, gamma radiotherapy delivers a concentrated dose of radiation in a single treatment.

Figure 3.2. P
Ga

Gamma radiosurgery uses precise targeting; gamma rays are focused on a specific area with extreme accuracy, minimising damage to surrounding healthy tissue. Gamma rays are in a higher energy region of the electromagnetic spectrum than X-rays.

Gamma radiosurgery is primarily used to treat tumours in the brain and spinal cord, but it can also be used for other parts of the body. It's often preferred for:

- Small tumours
- Tumours in difficult-to-reach locations
- Tumours that are inoperable or where surgery carries significant risks

Advantages

- Targets the tumour with exceptional accuracy, sparing healthy tissue.
- No incisions are required, reducing the risk of infection and complicati
- Often completed in a single session.
- Patients typically experience minimal side effects and can resume norr

Side effects

While gamma radiosurgery generally has fewer side effects than traditional
may experience:

- Headache
- [illegible]
- Fatigue
- Swelling at the treatment site

These side effects are usually mild and temporary but because the full effect can t
may experience side effects during this latency period, which varies depending on
condition treated.

Just like with X-rays, therapeutic radiographers operate the gamma therapy mach
and radiation oncologists will prescribe and oversee the treatment.

Ultraviolet skin treatment

Ultraviolet (UV) skin treatment, sometimes called phototherapy, makes use of lon
high frequency, ultraviolet rays. While the lower frequency end of the UV spectru
frequency part is ionising. UV therapy is normally administered by a dermatologis

UV radiation affects the skin in several ways:

- Reduces inflammation so helps calm and soothe irritated skin.
- Slows skin cell growth so controls conditions such as psoriasis where skin cell
- Helps regulate the immune response involved in some skin conditions.

UV can be used to treat these conditions:

- Psoriasis: a common skin condition causing red, scaly patches.
- Eczema: a condition characterised by itchy, dry and inflamed skin.
- Vitiligo: a skin condition that causes patches of skin to lose their colour.
- Mycosis fungoides: a type of lymphoma affecting the skin.
- Jaundice in newborns: can help break down bilirubin (made from old red blo

However, the side effects from UV treatments are:

- Increased risk of skin cancer: long-term and excessive UV exposure can incre
- UV light can dry out the skin.
- Common side effects are usually mild and can include temporary burning or
- Protective eyewear must be worn during treatment to prevent eye damage.

Your turn

Create a patient information sheet on UV skin treatment suitable for a patient with

Proton beam therapy

Figure
Orsay p

Proton beam therapy is a type of radiation therapy that uses high-energy protons, rather than X-rays or gamma rays, to treat cancer. It's a highly precise treatment that can target tumours with minimal damage to surrounding healthy tissue. Radiation oncologists (cancer specialists) usually administer proton beam therapy.

Protons are directed at the tumour where they release most of their energy, destroying cancer cells. Unlike X-rays or gamma rays, which release energy gradually as they pass through tissue, protons deliver a concentrated dose of radiation directly to the tumour and can be targeted very precisely.

Proton beam therapy is often used for:

- Tumours near sensitive areas: such as the brain, spinal cord, heart and lungs.
- Cancer in children: where preserving healthy tissue is crucial for long-term d
- Recurrent tumours: where previous radiation treatments have damaged surr

Advantages of proton beam therapy include:

- High precision: targets the tumour with exceptional accuracy, minimisi
- Reduced side effects: lower risk of damage to nearby organs and tissu
- Effective for certain cancers: particularly beneficial for tumours located near vital organs.

While proton beam therapy generally has fewer side effects than traditional radiotherapy with X-rays or gamma rays, some patients may experience:

- Fatigue
- [illegible]ita[illegible]
- [illegible]
- Hair loss (in the treated area)

These side effects are usually mild and temporary.

Further your knowledge

The UK government establish beam therapy service in 2009 only two centres in the UK wh Prior to this, patients needing

Proton beam therapy is a specialised treatment that requires advanced technolog treatments, needs experienced healthcare professionals such as therapeutic radi It's not always widely available compared to traditional radiotherapy.

Recall questions

1. Describe proton beam therapy in your own words.

Safety procedures

The principle of ALARA (as low as reasonably achievable) is followed in all aspects therapeutically in order to protect patients and staff.

Pa[illegible]	[illegible]
Precise treatment planning to avoid exposing healthy tissue to radiation, including a pregnancy check	Treatment rooms lined prevent radiation from
Immobilisation devices to keep the patient in exactly the same position for each treatment session	Therapeutic radiograph remotely from a shield
Lead blocks and collimators are sometimes used for shielding	Staff wear dosimeters t exposure over time
Staff watch and talk to the patient during treatment to monitor well-being	Regular calibration of e delivery is accurate and
In vivo dosimetry (real-time measurement of the radiation dose inside the patient)	Controlled area signage

Formative discussion questions:

Patient B has been diagnosed with a benign, low-grade temporal lobe tumour. Why might proton beam therapy be suitable for this tumour?

3.2 Treatment with internal source

! Key points covered

- Internal radionuclide therapy
- Brachytherapy
- Safety procedures

The source of ionising radiation that is us[illegible] ar[illegible] a tumour can be external as
However, ionising sources can als[illegible] [illegible]ered inside the body. The choice betw
sources in radiotherapy d[illegible] clinical and practical factors:

- Tumou[illegible]tio[illegible]ssible tumours may be better treated with internal sou at the [illegible] site whereas deep-seated tumours require external source rad tissues without invasive procedures.
- Cancer type: tumours of the head, neck, brain and lung usually require exter of the complex anatomy involved, whereas tumours of the thyroid are treate internal source.
- Tumour size and spread: large, diffuse tumours require external source radio cover a wider area. Small, localised tumours can be better treated with inter precise, high dose to a small area.
- Patient factors such as suitability for surgery, variability in suitability for impl radiation exposure and general health.
- Equipment and expertise: some facilities may lack the capacity to deliver spe proton therapy.

Internal radionuclide therapy

Internal radionuclide therapy is a type of cancer t[illegible] t that involves systemi substances directly into the body. This targe[illegible] a[illegible]oach allows for a high dose o cancer cells while minimising dam[illegible] [illegible]thy tissues. It's often referred to as r radiotherapy. It is normall[illegible] [illegible]ered by a radiation oncologist.

There are t[illegible] [illegible]na[illegible]y methods of delivering radionuclides:

- Oral or [illegible]venous administration:
  - Radioactive substances are given as a drink or an injection.
  - They travel through the bloodstream and accumulate in specific organs are located.
  - Commonly used for treating thyroid cancer, certain bone cancers, and n
- Targeted therapy:
  - Radioactive substances are attached to molecules that bind to specific r
  - This targeted delivery increases the concentration of radiation in cancer
  - Used for treating specific types of cancer, such as prostate cancer and c

Advantages of internal radionuclide therapy are:

- High precision: delivers radiation directly to canc[illegible] cells.
- Minimal damage to healthy tissues: reduc[illegible] [illegible] effects compared to e
- Effective for various cancer types: c[illegible]n [illegible]e used for both localised and w
- Potential for long-term c[illegible]l: [illegible] provide sustained cancer cell killin

Internal radion[illegible]lid[illegible] [illegible] is used to treat a range of cancers, including:

- Thyroi[illegible]r
- Bone m[illegible]ses
- Neuroendocrine tumours
- Prostate cancer
- Certain lymphomas

Typically, internal radionuclide therapy is used to treat cancers that are localised a to implant the source. The treatment is also usually restricted to tumours that ha sensitive to radiotherapy.

Side effects

Side effects vary depending on the type of radionuclide used and the specif They may include:

- Nausea
- Vomiting
- Fatigue
- Bone marrow supp[illegible]sion
- Mouth sore[illegible]
- [illegible] ac[illegible]

Internal radi[illegible]clide therapy should not be used in pregnancy or if the patient ha because this reduces the patient's ability to clear the radionuclide and could resul

Brachytherapy

Brachytherapy involves placing a sealed radioactive source directly within or very internal radionuclide therapy which is an unsealed, systemically administered sou and is physically confined. Radioactive seeds, wires or capsules are surgically imp tumour. These sources emit radiation, destroying cancer cells. The duration of tre cancer and the radioactive material used.

Low-dose rate (LDR)	Radioactive sources remain in place for several days, de
High-dose rate (HDR)	Radioactive sources are inserted for a short period, deli
Permanent implants	Radioactive seeds are permanent[illegible] placed within the tu

Brachytherapy is effective in treating vari[illegible], including:

- Prostate, breast and cervical [illegible] because these cancers tend to be small, accessible. The radia[illegible] drops sharply just a few millimetres from the s tissues ar[illegible].
- Head a[illegible]k cancers because the radiation 'exit dose' through healthy tiss risk of l[illegible]rm complications.
- Tumours where high dose radiation is needed for effective treatment like pr higher doses to be delivered to the tumour than could be achieved by extern sparing the bladder and rectum.

Advantages of brachytherapy are:

- High precision: delivers radiation directly to the tumour.
- Minimal damage to healthy tissue: reduces side effects compared to e
- Effective for various cancer stages: can be used for early and advanced
- Potential for long-term control: can provide sustained cancer cell killin

Side effects vary depending on the treated area and the type of brachyther effects include:

- Fatigue
- Skin irritation
- Bladder or bowel problems
- Nausea and vomiti[illegible]
- Pain at the t[illegible] site

Brachyther[illegible]uld not be used in pregnancy or if the patient has a severe blee increased ris[illegible]m the implantation surgery. It should also not be used if the tum

Recall questions

1. Describe Brachytherapy in a way that would be suitable
2. Why is Brachytherapy not suitable for deep tumours.

Safety procedures for treatment with internal source

People undergoing internal radionuclide therapy may need to take special precau radiation exposure because the radiation is inside the patient's body. This may in

- Limiting contact with others for a specific period: patients may be treated in limited or allowed for short durations only.
- Patient education: patients are informed of how long they are going to be ra be around others, particularly close contact with tho ho are pregnant or

Alongside this, the principle of ALARA wi ed protect staff administering t could include: minimising time adioactive patients during treatment; barriers where possible; a personal dosimeter; and adhering to strict pro and disposi ad materials.

The cost and availability of treatment with internal radionuclides varies according provider. Brachytherapy involves fewer sessions and less equipment time than tr however, the need for anaesthesia, surgery and hospital admission increases the Often, these procedures are carried out in specialised cancer centres.

Formative discussion questions:

Patient B has been diagnosed with a benign, low-grade temporal lobe tumour.

Explain why treatment with brachytherapy is not suitable for this scenario. What preferable to brachytherapy for this tumour?

Note: If you have already covered proton beam therapy on page 33 you do not n

Topic Area 4: Application of non-ioni
therapy techniques

4.1 Lasers

! Key points covered

- Properties of laser light
- Laser therapies
- Safety considerations

Properties of laser light

Laser light differs from light produced from a light bulb in three main ways:

- Laser light is all of the same wavelength, so appears as a single colour, which is called **monochromatic**.
- Laser light is directional, so it emerges as a narrow, parallel, **collimated** beam rather than spreading out in all directions.
- Laser light is **coherent**, which means that all the light waves in the beam are in unison with each other.

These properties make lasers useful in medicine because the light energy can be concentrated in one spot and allows for precise, minimally invasive procedures ar

The wavelength of a laser determines its interaction with body tissues. Different w different molecules, leading to differences in absorption, scattering and penetrati

- **Absorption**: different tissues and molecules absorb light at specific wavelengths. For example, water absorbs infrared light, while haemoglobin (red pigment in red blood cells) absorbs green light.
- **Scattering**: the way light interacts with tissue also depends on wavelength. Shorter wavelengths scatter more, while longer wavelengths penetrate deeper.
- **Penetration depth**: the depth to which a laser can penetrate tissue is influenced by wavelength. Shorter wavelengths are absorbed closer to the surface, while longer wavelengths can penetrate deeper.

For lasers to be used effectively and safely, clinicians need to understand how ligh Too little absorption by the tissues would result in no effect, while too much abso and tissue damage. Choosing the right penetration is key when treating either sur joints that require more penetrating lasers. Laser systems are designed to minimis remains tight and controlled.

Laser therapies

There are two primary categories of laser therapy:

1. High-intensity laser therapy uses high-powered lasers that deliver a strong be tissues to cut, vaporise, or cauterise tissue (sealing to prevent bleeding). Vap laser turns the water in the cells to steam, causing the cells to break apart. surgery, removal of tumours, and treatment of skin conditions.
2. **Low-level laser therapy (LLLT)** or cold laser therapy employs low-power laser to stimulate healing and reduce pain. It is often used for pain management, w inflammation reduction.

The specific mechanism of action of the laser on tissues depends on the type of la
application. However, some general principles include:

- Thermal effects: high-intensity lasers can produce heat, which can cut, vapor
- Photochemical effects: certain lasers can induce chemical changes in tissue, l
- Biostimulation: low-level lasers stimulate cellular activity, promoting healing

Common applications of laser therapy include:

Surgery:

- Cutting and cauterisin[illegible] tissue with precision
- Removing tum[illegible] and abnormal growths
- Pe[illegible]g delicate procedures such as eye surgery

Using las[illegible]erapy in surgery reduces the risk of infection and promotes faste expensive equipment with specialised training and there is a risk of tissue dam

Dermatology:

- Removing hair, tattoos, and skin lesions
- Treating acne, wrinkles, and skin rejuvenation
- Managing psoriasis and vitiligo

Dermatological laser treatment targets skin layers precisely and promotes growt component of skin. There is, however, risk of hyperpigmentation and treatment

Dentistry:

- Removing tooth decay, soft tissue, and gu[illegible]se
- Whitening teeth

Laser therapy in dentistry i[illegible] ten[illegible] painful than surgical options because it bleeding and swelli[illegible] re can be limited access to these expensive tools

Pain management:

- Relieving muscle and joint pain
- Accelerating wound healing
- Treating chronic pain conditions

Although effective at promoting healing and reducing inflammation, there is li LLLT for pain management.

Orthopaedics:

- Treating sports injuries and arthritis
- Accelerating bone healing

Apply your knowled[illegible]

Create a pa[illegible]nt h[illegible] for one of the applications of lasers you have covered explain w[illegible] treatment proposed would be suitable.

Laser therapy should not be used if cancer is suspected because lasers stimulate c make tumours worse. It should also not be used if the patient has photosensitivity medication, because this could increase the risk of burns, rashes or adverse reacti cause damage to the retina and uncontrolled coagulation disorders.

Lasers are versatile medical tools and are used generally for surgical cutting, vapo stimulating healing and remodelling. The table shows some examples of differen medical applications.

laser type	wavelength / nm	applicat
argon	488, 514	Sealing leaky blood vessels in the ey and removi[illegible]gmented lesions
carbon dioxide	10 600	Cut[illegible]ng [illegible] cauterising soft tissue, e [illegible]rinkles and acne scars) and mole a
erbium-YAG	[illegible]	Cavity preparation without drills, ski wrinkles) and removing pigmented l
neodymi[illegible]G	1064	Treatment of glaucoma, hair and tat acne scarring, prostate tissue remov

The medical professional using the laser in a particular application will be a specia laser eye surgery will be carried out by an ophthalmologist and removal of tooth c

Safety considerations

Light from a laser is never ionising because the photon energies in the laser light a from the electromagnetic spectrum that photon energy is proportional to frequen to wavelength. Even the shortest wavelength laser produces photons with energie ionise atoms.

However, there are safety considerations that should be made with both high- and low-intensity laser therapy because potential risks include:

- Eye damage if proper protective measure[illegible] a[illegible] n[illegible] taken with all laser use. Eye prot[illegible] [illegible]uld be matched to wavelength
- Skin burns or irrita[illegible] ev[illegible] though LLLT doesn't genera[illegible]t, [illegible]ged use on one spot can still cause [illegible]n and mild burns.
- Infectio[illegible] (rare) resulting from skin burns.
- There are mandatory 'laser controlled area' rules, which include a warning light and interlocked doors.

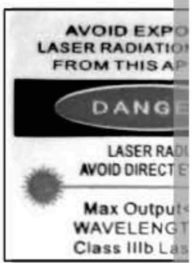


***Figure 4.1**. A ty (ANSI) laser warni*

Plume evacuation refers to the process of removing surgical smoke or laser-gener (known as plume) from the room using specialised suction and filtration systems. patients and staff and is removed using high-efficiency suction and activated carb

Overall, laser therapy is a highly precise, minimally invasive procedure that results less pain and swelling. The disadvantages are, however, that the procedure is ofte availability and is not suitable for all patients or may require multiple sessions.

Recall questions

1. Make a list of the adva[illegible]es [illegible]d disadvantages of lase

Formati[illegible] [illegible]uestions:
Patient B[illegible]en diagnosed with a benign, low-grade temporal lobe tumour.
What are the advantages and disadvantages of using laser therapy to treat the tu you recommend it?

4.2 Photodynamic therapy (PDT)

! Key points covered

- Properties of laser light
- Laser therapies
- Safety considerations

Photodynamic therapy (PDT) is a relativ... ...n... ...edical treatment developme... photosensitising drug to destroy ... ...cells. It is frequently used to treat can... certain skin conditions ar... ...ses.

Photodyna... ...rapy is managed by a multidisciplinary team with specific respo... purpose of t... treatment.

- A dermatologist or specialist medical doctor will select the photosensitising a... choose the light source and exposure time.
- A specialist nurse will prepare the patient and apply the photosensitising age... comfortable and safe throughout the light activation.
- An oncologist or a surgeon may insert fibre-optic probes into internal tumou...
- A medical physicist will ensure the correct light dose and maintain and calibr... ensure the correct dosage.

The principle of PDT operation is:

1. A special drug, called a photosensitiser, is introduced into the body. This dru... cells. These drugs are classed as **phototoxic** bec... they become toxic w...

2. Light activa... ...ecific type of light (usually laser light) is directed at the a...

3. Cell destruction: when the photosensitiser is exposed to light from the laser, ... called a radical that starts chemical reactions that produce compounds calle... **cytotoxic**, which means that they can kill the cells.

Uses of photodynamic therapy include:

- Cancer treatment: PDT is used for various types of cancer, including skin, lung, bladder and oesophageal cancer. Cancer cells often retain photosensitisers longer than normal cells, and light can be applied only to the tumour to reduce side effects.
- Skin conditions: it can target abnormal cells in acti... ...atosis, a **precancero...** skin condition, and other types of abnorm... ...kin ... ...ths. It can also help in ... management by killing bacteria a... ...re... ...g oil gland activity.
- Eye diseases: PDT is used ... trea... ...ge-related macular degeneration (AMD), a common cause o... ...ss in older adults by closing off abnormal blood vessel... ...re... ...a without damaging surrounding retinal tissue.

Photodynamic therapy should not be used on patients who have photosensitivity... they may suffer severe reactions to light activation. Patients with severe liver and... not be prescribed photodynamic therapy because these organs metabolise and cl... impaired function could result in toxicity. Additionally, immunosuppressed patie... response and so an increased risk of infection and should therefore avoid this the...

Advantages of photodynamic therapy

- Minimally invasive: unlike surgery, PDT often requires only local anaes
- Precise: the light can be focused on the target area, minimising damag
- Potential for long-term effects: in some cases, PDT can stimulate the i remaining cancer cells.

Disadvantages of photodynamic therapy

- PDT is only effective where light can reach so deep or large tumours c can't penetrate the tissues.
- Advanced cancers that have metastasised may also be hard to treat wi needed to generate the reactive species, solid tumours with a poor ox [illegible] d [illegible] treatment.
- [illegible]g treatment can be more complex because the therapy require photosensitising agent, waiting for a specific time followed by light tre

Side effects of PDT in comparison to ionising therapies can include:

- Skin sensitivity to light lasting for several weeks after treatment which can ca (like bad sunburn) and eye discomfort in bright light
- Fatigue
- Nausea caused by the photosensitising drug
- Skin redness and tenderness or swelling in the treated area

Apply your knowledge
Create a risk assessment for the use of photodynamic therapy in the treatment of

4.3 Artificial cardiac devices

! *Key points co[illegible]*

- The pacemaker
- The implantable cardioverter

In this section we will describe the structure and operation of artificial devices that can be implanted to treat various heart conditions – artificial cardiac devices.

Further you
In the study of various terms organs or orga usually derived Greek, so do n English words the term cardia Greek *kardiak* heart'. Other e kidneys and *de*

The pacemaker

A pacemaker can be required when a person's heart beats too slowly (bradycardia), too fast (tachycardia) or can stop periodically causing the person to experience dizziness or loss of consciousness. These conditions can be diagnosed by an ECG, which we described earlier in this unit.

A pacemaker is a small, battery-powered medical device implanted in the chest to regulate the heart beat. It consists of two main components:

1. **The pulse generator**. This is the main body of the pacemaker, 4–5 cm in widt thick a[illegible] sometimes be seen beneath the skin of someone who has one computer chip, and electronic circuitry. The computer chip controls the pace pacing rate, mode, and output.
2. **Leads**. These are thin, insulated wires that carry electrical impulses from the p One end of the lead is attached to the pulse generator, and the other end has the cardiac muscle. Most pacemakers have one or two leads, depending on th

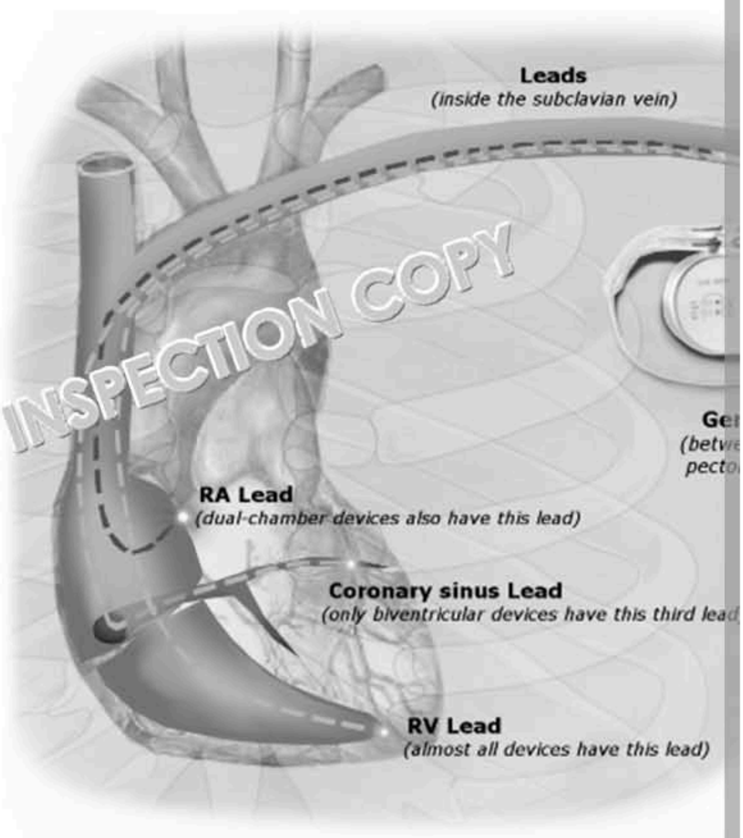


Figure 4.3. *Illustration of implanted cardiac pacemaker showing locations of card*

Further your knowledge
There are different types of pacemaker... e...ple:

- Single-chamber pacema... has one lead connected to either the righ ventricle. It is us... ...pler heart rhythm problems.
- Du... ...mb... pacemaker: With two leads, this type connects to both the ri ven... helps coordinate the pumping action of the heart more effectivel
- Biventricular pacemaker: This uses three leads, with two in the ventricles a It is specifically used for heart failure patients to synchronise the heart's co

The pacemaker essentially takes over the role of the sino-atrial node (SAN), the fu earlier in this unit. A typical pulse amplitude is 2–5 V, although this varies by devic 0.4–1.0 milliseconds.

Modern pacemakers can sense the heart's activity, either from the atria or from t respond to correct any abnormal rhythm. Modern pacemakers use sensing and de when needed, making pacing more efficient and responsive to the patient's natur mode continuously monitors the heart's electrical activit... if it detects a natur pulse will be delivered. In the demand mode the ...ac...m...r only delivers a pulse its own within the set time.

Some more modern pac... ...a... no leads and are much smaller so can be impla

There are s... ...cumstances when a pacemaker should not be used, e.g. if the p or a mechanical tricuspid valve which could be damaged by placing a pacemaker l may also be hypersensitive to the components in a pacemaker such as titanium o needed. Pacemakers are also sensitive to electromagnetic interference. Most de machines, and anti-theft gates, can generate interference that may interfere with leading to inappropriate pacing inhibition, asynchronous pacing, or even device r

The implantable cardioverter defibrillator (ICD)

If someone has a history of sudden cardiac arrest, certain inherited heart conditio they may require an **implantable cardioverter defibrillator (ICD)** to be fitted.

The ICD is an implanted device that continually monitors the heart's activity and d the cardiac muscle to correct potentially fatal changes in activity such as rapid or i stops altogether.

The electric shock delivered from the ICD can be painful to the person but is life-s

The structure of the ICD is similar to that of a pacemaker in that it has a body cont pulse generator and then leads between the body and the heart. However, the bo somewhere between the size of a credit card and a smartphone. It needs to be lar component called a **capacitor** which stores charge from the battery.

A capacitor can be completely discharged much faster than a battery so can delive to the heart in a short time than the battery could.

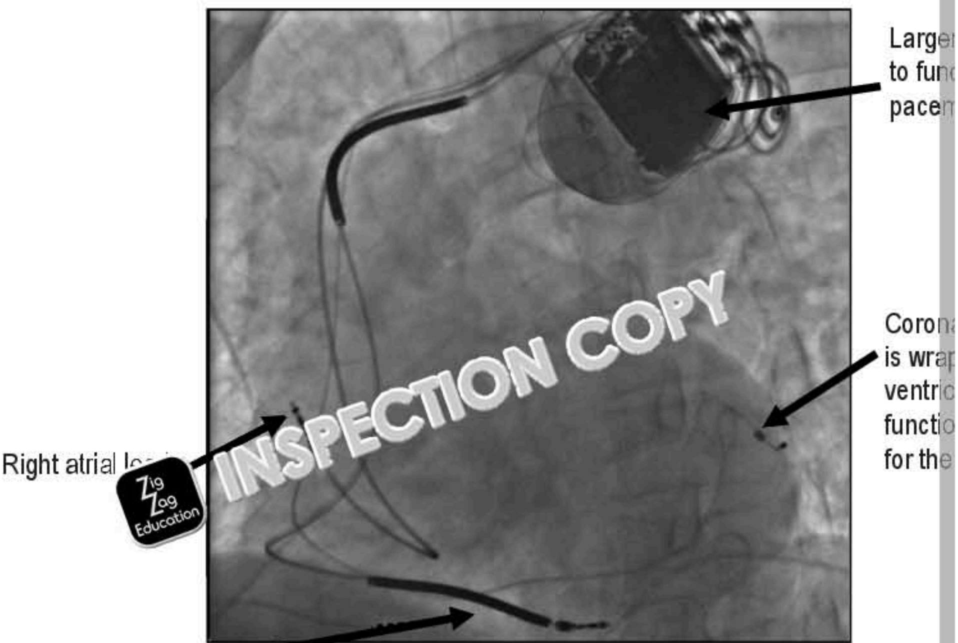


***Figure 4.4.** This image shows a combined ICD and pacemake*

Both pacemakers and ICDs will be implanted under the supervision of a cardiologi

Recall questions

1. What is a pacemaker?
2. How are pacemakers and ICDs different?
3. How do the different types of artificial cardiac device m
4. What conditions are pacemakers and ICDs used for?

Advantages of artificial cardiac devices

- Implantation can improve quality of life by reducing breathlessness, fa reduce the number of hospitalisations by managing chronic conditions
- Most devices are fine-tuned to be able to meet individual patient's nee so are suitable for long-term use (typically, pacemakers last 5–15 years
- Proper heart rhythm control can prevent the risk of stroke from atrial f

Disadvantages of artificial cardiac devices

- Insertion of an artificial device requires surgery which carries risks such
- Leads can break, dislodge or cause blood clots, and as with any mecha devices require maintenance and regular follow-up.
- Devices and surgery may be expensive and may not be accessible in all
- Sometimes ICDs can shock the heart unnecessarily, which can be painf
- Risk of an air leak, when air enters the pleural space during or after pa through accidental puncture of the lung.
- 'Twiddler's syndrome' happens when a patient consciously or unconsc the pacemaker generator in its pocket, causing the leads to dislodge or

It is important that patients with hearing or vision impairment have accessible ins example instructions in braille or vibration alarms rather than sound in order to m

Apply your knowledge

Patients who have been diagnosed with abnormal cardiac rhythms such as brady tachycardia (too fast) can be fitted with a pacemaker. Summarise the use of artifi treatment of abnormal cardiac rhythms.

4.4 Ultrasound therapies

! Key points covered

- High-intensity focused ultrasound (HIFU)
- Low-intensity pulsed ultrasound (LIPUS)
- Shock wave lithotripsy (SWL)
- Ultrasound hyperthermia

Ultrasound, which we have previously described earlier in this unit and also in Uni which uses high-frequency sound waves, beyond the range which humans can he handheld transducer.

In general, ultrasound therapy uses lower frequency and higher intensity than for create heating effects in tissues which stimulates blood flow, reduces pain, and pr than the echoes which create images in diagnostic ultrasound. It can also be used unwanted tissue.

Therapeutic ultrasound machines use larger, more specialised applicators than dia also involve cooling systems and robotic positioning systems for precision. While minimal preparation, patients undergoing therapeutic ultrasound may require se

High-intensity focused ultrasound (HIFU)

High-intensity focused ultrasound (HIFU) is a non-invasive or minimally invasive medical treatment that uses focused ultrasound waves to treat various conditions. A typical operating frequency range of HIFU is 0.8–10 MHz. Unlike diagnostic ultrasound, which uses sound waves to create images, HIFU employs extremely high-intensity sound waves from the transducer to pass through skin, muscle and fat tissue to heat and destroy targeted tissue, e.g. a tumour.

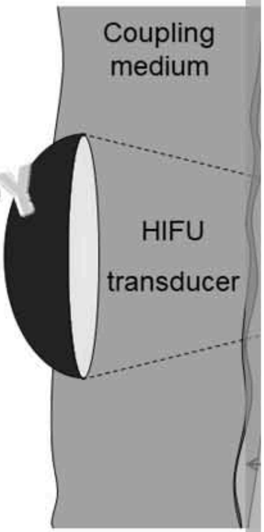


Figure 4.5. Diag

HIFU works on these principles:

- Focused energy: high-intensity ultrasound waves are focused on a specific point within the body.
- Heat generation: the concentration of energy transfer to a small area creates heat at the focal point, causing tissue destruction.
- Precision: the treatment is highly precise, allowing for the destruction of targeted tissue while minimising damage to surrounding healthy tissue.

HIFU has a growing range of applications, including:

- Cancer treatment: it can be used to destroy tumours in various organs, such and kidney.
- Uterine fibroids: HIFU can reduce the size and symptoms of uterine fibroids muscle tissue of the wall of the uterus.
- Skin tightening: HIFU is used in cosmetic procedures to improve skin tone an
- Other applications: research is ongoing to explore HIFU for treating other co Parkinson's disease, and essential tremor.

Its advantages are due to the fact that HIFU is:

- Non-invasive or minimally invasive: often requires no incisions or hosp
- Precise: targets specific tissue with minimal damage to surrounding ar
- Short recovery time: patients typically recover quickly compared to tra

The disadvantage of HIFU is, however, that it is limited to specific locations to well-defined, localised tumours, e.g. prostate cancer, and is not suited to embedded tumours. It also cannot be used near bones, bowel or lung due and risk to nearby structures.

Side effects of HIFU can vary depending on the treated area and individual patien include pain, swelling and bruising.

Benefits	R
Non-invasive, no incisions or stitches, and therefore minimal risk of infection	May not fully destroy larger
With precise targeting, surrounding tissue is spared	It requires precise imaging, breathing can reduce accura
Minimal recovery time and usually an outpatient procedure	May be unintended heat da
Safe for high-risk patients	Post-treatment symptoms ca urinary or bowel issues (whe

Low-intensity pulsed ultrasound (LIPUS)

Low-intensity pulsed ultrasound (LIPUS) is a type of ultrasound therapy that uses
waves to stimulate tissue repair and regeneration, typically in the range of ~1.5 M
focused ultrasound (HIFU), which targets specific tissue for destruction, LIPUS is u
reduce inflammation.

LIPUS works by delivering low-energy sound waves to the affected area. These so
vibrations within the tissue, which can stimulate cellular activity and promote hea
how LIPUS works are still being researched, but it is currently thought to:

- Increase blood flow to the area
- Stimulate cell growth and division
- Reduce inflammation

LIPUS is primarily used to treat bone and soft tissue injuries.

Some common applications include:

- Fracture healing: accelerates bone healing, especially in cases of fractures th
- Osteoporosis (brittle bone disease): may help increase bone density.
- Tendinitis (swelling in tendons) and other soft tissue injuries: can reduce infl tissue repair.

The advantages of LIPUS include:

- Non-invasive and painless treatment
- Can be used in conjunction with other therapies
- Relatively low cost compared to some other treatment options

Furth
NICE w
fracture
for LIP
of bene

Currently, the limitations of LIPUS are:

- The exact mechanisms of action are not fully understood.
- Effectiveness can vary depending on the condition and individual patie
- Not a universal cure for all bone and soft tissue injuries.

Benefits	
Non-invasive and therefore limited risk of infection	Limited effectiveness unle weeks/months
Short treatment time, typically 20 minutes per treatment	Evidence is inconsistent, n significant improvement
Suitable for high-risk patients, people who cannot undergo surgery	Not recommended for use for patients who are pregr

Recall questions

1. What is the difference between HIFU and LIPUS?
2. Give one example of a patient [illegible] type of ultrasound t suitable for treating.

Shock wave lithotripsy (SWL)

Figure 4.6

Shock wave lithotripsy (SWL) is a non-invasive procedure used to treat people who have kidney stones.

It involves breaking down stones into tiny pieces using high-energy ultrasound shock waves. The fragments can then pass out of the body in the urine painlessly.

SWL works by:

- Targeting the stone: using ultrasound, the medical staff precisely locate the kidney stone.
- Delivering shock waves: high-energy shock waves are generated and directed at the stone.
- Breaking the stone: the shock waves create vibrations that break the stone into smaller pieces.

The advantages of SWL are:

- Non-invasive: no surgical incisions are required.
- Less painful than other stone removal methods.
- Shorter recovery time compared to surgery.

The main limitation of SWL is that it may not be suitable for all kidney sto composition of the stone will determine the best treatment option.

Potential side effects of SWL include:

- Pain in the back or side
- Blood in the urine
- Infection
- Kidney injury (rare)

Ultrasound hyperthermia

Ultrasound hyperthermia is a therapeutic technique that uses ultrasound energy specific tissue within the body. Ultrasound hyperthermia typically heats tissue to This controlled heating process can be employed to treat various medical conditi

It works using ultrasound energy. High-frequency sound waves are directed at the ultrasound energy is transferred to thermal energy within the tissue, raising its te temperature can have therapeutic effects, such as:

- Directly killing cancer cells
- Enhancing the effectiveness of other cancer treatments such as chemothera
- Stimulating the immune system to target the cancer

Applications of ultrasound hyperthermia include:

- Cancer treatment: often used in combination with other therapies to improv
- Pain management: can reduce inflammation and pain in certain conditions.
- Wound healing: may accelerate tissue repair and regeneration.

The advantages of ultrasound hyperthermia are:

- Non-invasive or minimally invasive
- Precise targeting of the affected area
- Can be used in combination with other treatments
- Potential to improve treatment outcomes

There are, however, disadvantages to the treatment: it can be difficult to ta
bone or fat is in the way, because ultrasound energy loses intensity in deep
precise temperature control and imaging guidance to prevent overheating a

There are limitations to the use of ultrasound hyperthermia, in particular:

- It requires specialised equipment and expertise, and therefore isn't alway
- There is variable clinical evidence, and some st[illegible]s lack strong eviden
- It is not suitable for all patients or con[illegible]ns [illegible]here is a risk of overhea implants, and it may interfere [illegible] [illegible]rt[illegible]al cardiac devices. It is also co and respiratory condit[illegible] [illegible]se the heat stress could cause them to and if gas-fill[illegible] [illegible]ps are overlying the target.

The manag[illegible] and delivery of therapeutic ultrasound treatments depend on th being treate[illegible] the healthcare setting.

- LIPUS is commonly delivered by physiotherapists who may be working in reh orthopaedic settings.
- Radiation oncologists will oversee HIFU and ultrasound hyperthermia when u cancer treatment.
- Medical physicists will be involved with the planning, calibration and safety m the energy levels and tissue targeting are accurate and safe.

Formative discussion questions:
Patient B has been diagnosed with a benign, low-grade temporal lobe tumour. Ex therapy is a promising approach for the treatment of brain tumours.

Topic Area 5: Planning for diagnosis and therapy

5.1 Diagnosis plan

! Key points covered

- Producing a diagn[illegible]
- Infor[illegible] an[illegible] to patients
- Risk assessment
- Emotional, social and ment

A diagnosis plan outlines the steps necessary to determine the cause of a patient' **symptoms** or condition. It is a systematic and logical approach that involves:

- Collecting patient history: gathering information about the patient's symptoms, medical history, family history and lifestyle.
- Assessing the results of an initial physical examination into the patient's overall health and identifying any physical **signs** or symptoms.
- Ordering diagnostic tests: conducting tests to gather more information about the patient's condition.

There are three key components of a diagnosis plan.

1. Patient information:
   - Demographics – age, sex, ethnicity, etc.
   - Presenting complaints – the main reason the pati[illegible] has presented to t
   - Medical history – previous illnesses, surg[illegible], [illegible]re[illegible]t medications
   - Family history – relevant or relate[illegible] conditions
   - Social history – lifestyle [illegible] diet, level of exercise etc.
2. Potential diagnosis:
   - The[illegible] ma[illegible] [illegible]ggestion of a possible diagnosis based on the patient' t[illegible] the rationale behind the diagnostic tests selected.
3. Diagno[illegible] tests and procedures:
   - Specific tests to rule in or out potential diagnoses, e.g. imaging studies o electrocardiogram. The plan must name the practitioner who will justify
   - Reason for selecting each test.
     1. Summarise why the test was chosen and briefly explain how it is carri
     2. Complete additional resource to justify your choice of test.
     3. Explain why other tests are not suitable.
     4. Write down the advantages and disadvantages of the test you have
   - Expected outcomes of the tests.

When assessing the quality of a diagnosis plan, these factors need to be considere

- Patient-centredness: Involve the patient in the decision-making process, incl obtaining written consent for invasive tests.
- Evidence-based: Is the plan supported by [illegible] [illegible]edical knowledge and gui
- Timeliness: Does the plan outlin[illegible] [illegible]ble time frame for diagnostic tes
- Efficiency: Does the plan [illegible] [illegible]ecessary tests or procedures? Is it cost-eff
- Risk assessment: [illegible] plan identify potential risks and complications?
- Comm[illegible]: Use clear and understandable terms and bear in mind who For exa[illegible] avoid scientific and medical specialist terms if it is to be presen
- Cultural competence: Does the plan consider the patient's cultural backgrou
- Ethical considerations: Does the plan respect patient autonomy and confide

These factors can be assessed in advance both by the person writing the plan and In retrospect it can be assessed through patient satisfaction surveys.

Creating a risk assessment for the diagnosis plan

Risk assessment is a critical component of a well-structured diagnosis plan. It invo harms or adverse events associated with the diagnostic process and implementin (make them less severe).

The types of risks in diagnosis include:

- Diagnostic errors: incorrect diagnosis leading to inappropriate treatment.
- Test-related risks: complications from invasive procedures or exposure to rac
- Delayed diagnosis: prolonged suffering or worsening of the patient's conditic
- Over-diagnosis: unnecessary tests or procedures leading to increased costs a
- Patient anxiety: stress and worry caused by the diagnostic process.

The risk assessment process is carried out in this order:

1. Identify potential risks: consider the patient's medical history, age, comorbid tests being considered.
2. Evaluate the likelihood and severity of risks: determine the probability of eac impact on the patient.
3. Implement risk mitigation strategies: develop plans to reduce the likelihood c
4. Communicate risks to the patient: explain potential risks and benefits of diag in understandable terms.
5. Obtain informed consent: ensure the patient understands the risks and bene diagnostic tests.

Some examples of risk mitigation strategies include:

- Choosing the least invasive test: opting for non-invasive imaging studies over when possible.
- Providing patient education: explaining the purpose and potential side effect
- Monitoring for complications: closely observing patients after invasive proce adverse events.
- Timely follow-up: scheduling follow-up appointments to monitor test results

Emotional, social and mental health impact on the patient

The process of developing and communicating a diagnosis plan can have significar health impacts on both the patient and the healthcare provider.

Uncertainty: the unknown nature of the illness can lead to anxiety and fear.

- Fear of the unknown: uncertainty about the diagnostic process and potential be overwhelming.
- Anger and frustration: patients may feel angry or frustrated with their sympt
- Hope and optimism: conversely, the possibility of finding answers can create
- Relief: once a diagnosis is made, there can be a sense of relief, even if the dia
- Social aspects: a patient may be concerned about how their family, friends ar

Any or all of these issues can give rise to questions from the patient. Healthcare p and be prepared to answer them honestly and with empathy and clarity. It is bett medical terminology that the patient may not fully understand as this could make or overwhelmed. Answers should be clear, concise and easy to understand, and key messa the patient to remember everything. It is often helpful if they have a friend or rela or take notes too. If the patient asks a question that you cannot answer be honest and offer to find out. Overall, the patient should be reassured that they are not al completely alone.

Healthcare professionals should take into account any additional needs the patier adjustments they need to make to the way in which they communicate with the p barrier a translator may be required or if the patient has cognitive impairment it i relative accompany them to assist the patient in making decisions.

The emotional impact of delivering a diagnosis plan on the healthcare provider co
- Empathy and compassion: understanding the patient's emotional state is cru
- Frustration: complex cases or diagnostic challenges can lead to frustration.
- Burnout: dealing with patients under stress can contribute to burnout.
- Satisfaction: successfully guiding a patient through the diagnostic process an can be rewarding.

Strategies for managing emotional impact are:
- Open communication: encourage open and honest communication between healthcare provider.
- Empathy and support: provide emotional support and understanding to the pat
- Involving the patient: involve the patient in the decision-making process to e
- Managing expectations: clearly communicate the diagnostic process and pot
- Self-care: healthcare providers should prioritise self-care to prevent burnout.

By recognising and addressing the emotional aspects of the diagnosis plan, health patient experience and enhance the overall quality of care.

5.2 Therapy plan

! *Key points covered*

- Producing a therapy plan
- Information and advice to patients
- Risk assessment
- Emotional, social a

A therapy plan is a roadmap for treatment, outlining specific goals, interventions, collaborative document created with the patient, ensuring their needs and prefer the medical needs of their condition.

The essential components to be included in a therapy plan are as follows.

1. **Patient information:**
   - Demographics – age, sex, ethnicity, etc.
   - Presenting problems – main reason for presenting
   - History – medical, psychiatric, social
   - Diagnosis – if this has been carried out
   - Treatment history – previous therapies, previous surgeries, current m medical conditions

2. **Assessment and diagnosis:**
   - Summarise the findings of the diagnostic tests and assessments that h
   - Specify the details of the diagnosis or the provisional diagnosis if it is y

3. **Goals:**
   - Specific, measurable, achievable, relevant, and time-bound (SMART)
   - Short-term and long-term goals for the treatment
   - All goals to be patient-centred goals. This mean they reflect the patie desired outcomes and focus on improving quality of life from the pati what the doctor thinks is medically important. Patient capacity and w obtained before any intervention is booked.

4. **Interventions:**
   - The specific therapeutic techniques or methods to be used including and clearly evaluated advantages and disadvantages of each techniq known contraindications. Where ionising radiation is involved the pr exposure (for example, the consultant clinical oncologist) should be i
   - Frequency and duration of sessions, balancing the medical need of th requirements and preferences of the patient who needs to be able to
   - Self-care regimen – regular tasks or lifestyle changes that the patient conjunction with the treatment received in hospital.

5. **Termination and follow-up:**
   - Criteria for ending therapy
   - Plans for follow-up care or support

Other factors that need to be considered in the therapy plan are the cost and avai treatment. Some therapies are widely available, but some more specialised treatr limited number of sites, and this could limit the options open to the patient if they distances for frequent treatment.

Creating a risk assessment for the therapy plan

A risk assessment is a fundamental component of effective therapy planning. It in to the client, the therapist, and others, and developing strategies to mitigate thos for ensuring the safety and well-being of all parties involved.

The key components of a risk assessment are:
- Patient history: previous surgeries or treatments, other medical conditions a
- Treatment-specific risks: risks from the therapy carried out, potential side eff ionising radiation is used) and drug interactions.
- Patient-specific factors such as age and frailty, for example.
- Psychological factors such as emotional readiness for treatment, especially if side effects or could be difficult for the patient to tolerate.

Once the risks have been identified, ways to mitigate them should be incorporate possible. This might involve:
- Using the principle of ALARA if ionising radiation is used, to protect patients a
- Sedating the patient during therapy if appropriate.
- Clear communication within the treatment team and with the patient.

It is crucial to consider ethical implications when conducting risk assessments and devel
- Confidentiality: protecting client information while balancing the need to share parties. All personal data in the plan is stored on NHS-approved encrypted driv
- Duty to warn: determining when there is a duty to warn potential victims of h
- Informed consent: obtaining client consent for treatment, including risk asses

Risk assessment and therapy planning are ongoing processes that require flexibilit considering potential risks and developing appropriate interventions, therapists c therapeutic environment for their patients.

Emotional, social and mental health impact

A therapy plan, while a detailed and patient-centred document, can have a profou
on patients. It's more than just a roadmap to recovery; to the patient and their fa
hope, progress and potential.

Positive emotional impacts include:

- Hope and motivation: a well-crafted plan can instil hope, providing a sense o
  motivate clients to actively participate in their therapy.
- Empowerment: being involved in creating the plan can foster a sense of cont
  may feel more invested in the process.
- Clarity and focus: a clear plan can reduce feelings of overwhelm and confusio
  the steps involved in their healing journey.
- Validation: the therapist's commitment to creating a personalised plan can va
  and struggles.

Potential negative emotional impacts

- Overwhelm: if the plan is too complex or detailed, it might induce feelings of
- Disappointment: if progress isn't as rapid as expected, clients might experience
- Fear of failure: some clients may fear not being able to meet the goals outlin
- Resistance: if the client feels pressured or coerced into the plan, they might c

To maximise the positive impacts and minimise the negative ones, therapists can:

- Involve the client: collaborative plan creation can increase buy-in and reduce
- Set realistic goals: ensure goals are achievable and measurable to prevent dis
- Flexibility: emphasise that the plan is a living document, subject to change as
- Open communication: encourage clients to express their feelings about the p
- Celebrate small wins: acknowledging progress, no matter how small, can boo

A therapy plan presentation should be tailored differently for patients and health
needs, knowledge levels, and priorities are very different. For the patient, the lang
to be simple and without complex medical terminology and the tone should be re
focusing on what the treatment means for them in terms of the impact on their d
It should be a personal presentation with patient-centred goals at its heart and fo

A presentation directed to a team of healthcare professionals requires a different
different information. For clarity, healthcare professionals would expect clinical, t
to be told the details of the treatment plan such as dosages, treatment times, etc.
The information included should be evidence-based, which may mean that charts
should be included. The focus should be the rationale for the treatment, and the g
(e.g. tumour regression) rather than personal. The presenter should be prepared
based on clinical protocol and medical facts rather than offering reassurance and

Creating and delivering a presentation

! Key points covered

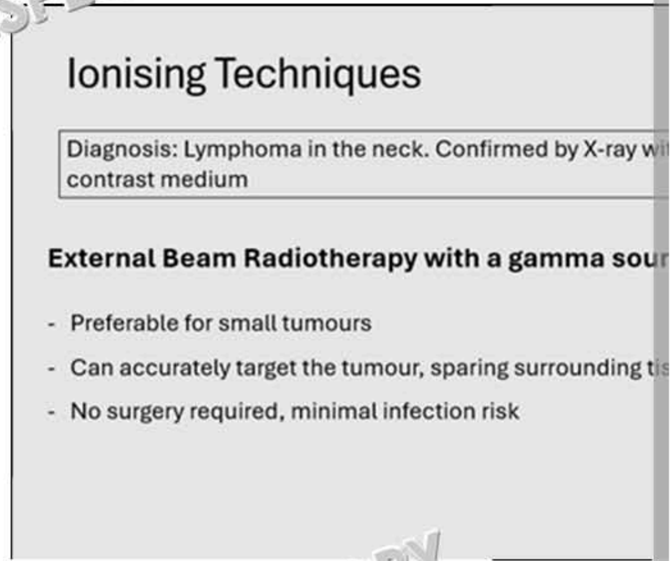
- Communicating a plan
- Information and advice given to patients
- Healthcare profess
- Healthcare profess

A good presentation slide is clear, focused and visually engaging. It supports the
to convey and doesn't overwhelm it.

Slides should be kept simple with one main idea per slide

Stick to one or two text fonts, use bold text to highlight key words where necessary

Organise logically: introduction – main points – conclusion



It is a good idea to create a checklist to help you reflect on both the presentation
will help you to consider the reasons for your design and content of your presenta
tailored your presentation to the target audience.

Preparing for questions

The most important preparation for answering questions on a presentation to eit
professionals is to know the plan inside out so that you have all the information y
an answer. The type of questions and how they should be answered will be differ
delivered to patients or to healthcare professionals.

Patients	Healthca
Be clear on the personal impact of the diagnosis or therapy. *'What will it mean for me?'*	Be ready to explain the clinical decisions
Be ready to break down complex terms into understandable information	Anticipate technical qu *contraindications for th*
Practise calm, supportive answers to emotional responses	Anticipate alternative o explain why you discou
Rehearse answers to common questions such as *'Can I work during treatm*	If appropriate, have res in an answer

Obtaining feedback on the presentation

The feedback on the plan can be provided by fellow students and/or your teacher you need to be able to summarise the key points and use them as the basis for th to your plan and presentation. It is helpful to use a structured feedback sheet wit comments down into clear sections and to ensure that you get information about and the presentation:

1. Clarity of information included – was the diagnosis or therapy clearly explain
2. Use of visual aids – if diagrams or images were used, were they helpful?
3. Suitability for the target audience – was the information tailored for the peo presentation? Was the presenter's empathy and tone appropriate for the au
4. Engagement – did the presentation keep the audience's attention?
5. Questions – were the questions answered completely and correctly?

The audience could give a score out of 5 (a Likert scale) along with comments for The presenter should encourage both positive and constructive points and could questions such as *'Was anything unclear?'* or *'Is there anything I could explain bet*

Summarising the feedback

Once collected, summarise the feedback into a table or a short paragraph. This co each of the criteria you have summarised the average score given by the audience comments on the performance, both positive and constructive. This summary, in appear more than once in the feedback you have collected, can then be used to a weaknesses of the plan and form the basis of any improvements that you think yo making them. You should also consider whether there is any additional informatio order to be able to make the improvements you think are necessary.

Glossary

absorption – light taken in by another material
amplification – increasing the height or strength of a wave, resulting in a more p
anode – the positive terminal in an electric circu...
antiparticle – counterpart to a parti... ...me mass but opposite charge
attenuation – reduction ... ...nsity of radiation
calcificati... ...e... ...ssue or other material in the body becomes hard because
cardiac cyc... ...one complete heartbeat
cardiac muscle – the type of muscle in the heart
cathode – the negative terminal in an electric circuit
coherent – rays of light in the same phase
collimated – the rays of light are parallel to each other producing a narrow, focu
collimator – a device which controls the size and shape of an X-ray beam
ECG gating – with the patient's heart rhythm – synchronising the CT scan
filter – material which removes low-energy X-rays
frequency – the number of waves passing any point per second
gain – in the context of wave signals this means amp... ...o..., or increasing the a
monochromatic – having only one wave...
myogenic – the signals to m... ...the ...uscle contract originate in the muscle itself system. The heart i... ...s own depolarisation.
non-coher... ...es – the orientation of each fibre can be different at one end t
penetration – how deeply light passes through a material before being absorbed
penetration – how far into body tissue can be imaged
phototoxic – becomes toxic when exposed to light
positron – identical mass to an electron but with a positive charge
precancerous – precancerous cells are cells that have grown abnormally but are
radionuclide – unstable atom that emits radiation as it decays
radiopaque medium – accumulates in tissues, improving contrast
resolution – the ability to see objects that are close togeth... ...as separate objects resolution, the more detailed the image
resonance – an object vibrating at maxi... ...nergy because the external force r
scattering – a random cha... ...th... ...direction of a particle due to its interaction
scattering ... h... ...particles in a medium and being redirected in other dire
sign – som... ...g about the patient that is noticeable to someone else, e.g. a lim
sonographer – healthcare professional specialising in ultrasound imaging
symptom – something that the patient themselves perceives that another perso headache or stomach pain