



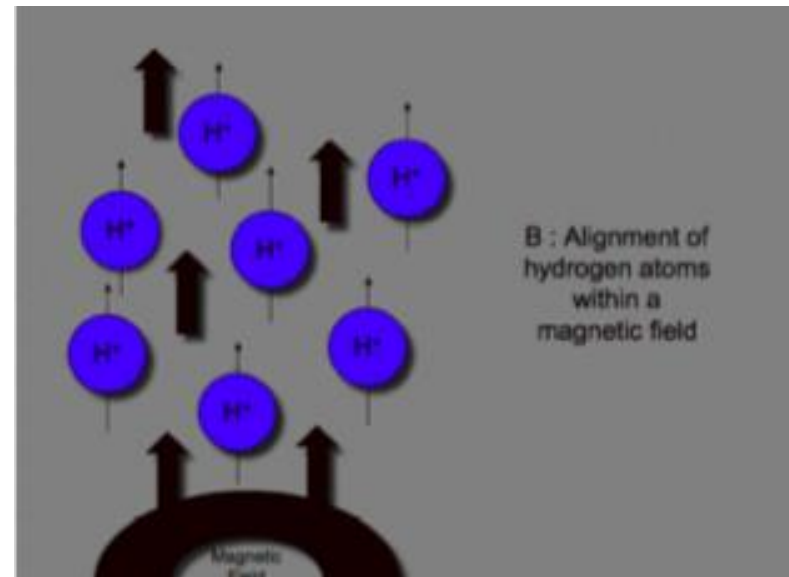
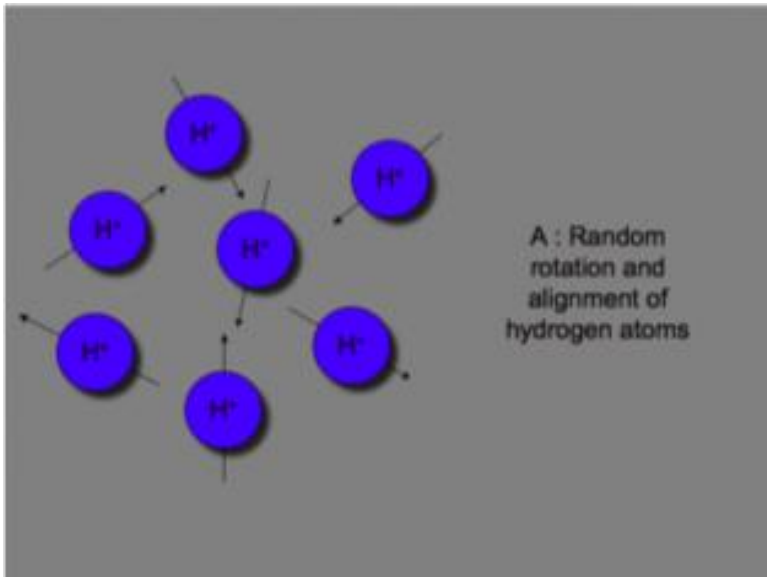
Final FRCA Physics

Laura Conway



- Produces good images of soft tissue
 - Provides greater contrast between different tissue types compared to CT
- Commonly used for CNS, MSK and cardiovascular imaging
- All equipment must be compatible with the MR environment

Alignment of Nuclei



Principles - Physics



- Bursts of radiofrequency energy changes the alignment and a perpendicular electromagnetic field is produced
- When this magnetic field is removed, the energy is slowly released as the nuclei relax back into alignment
- The rate of energy release, and therefore the emitted signal, depends on the type of tissue
- 3 gradient coils – 2 transverse and 1 longitudinal
 - Provides a 3D image
 - The rapid speed at which these turn on and off accounts for the noise

Principles - Physics

- T weighting refers to the relaxation time of different tissues
 - T1 – refers to quicker relaxation times
 - Hydrogen takes a long time to return to original position
 - T1 – fluid is dark (minimal signal)
 - T2 – fluid is white
- Faraday Cage
 - Overall, these signal are very weak so extremely susceptible to interference
 - The cage is radiofrequency shield to reduce this



Principles - Contrast

- Usually Gadolinium
 - Alters the relaxation states of hydrogen nuclei
- S/E; nausea, vomiting, pain on injection and rarely anaphylactoid reactions
- In renal failure, can cause nephrogenic systemic fibrosis



Scanner Design

- Field strength – 0.5-3T
- Superconducting solenoid surrounded by liquid helium
- Fringe field
 - Shape determined by magnet's design
 - $1\text{T} = 10,000\text{ G}$
- Magnetic field is always on in most modern scanners



Safety



- Static Magnetic Field
 - Ferromagnetic objects within 30G contour undergo attractive forces and torque
 - PPM/ICD can dislodge, become inactive or re-programme
 - No one should pass 5G contour without undergoing a safety check for contraindications

Safety Continued

- Time-varying Magnetic Gradient Fields
 - Stimulation of peripheral nerves and muscle cells
- Acoustic Noise
 - Ear protection must be worn
- RF Heating
 - Any conductive material in contact with patient skin can cause rapid and severe burns
- Helium Escape
 - Quench – spontaneous or emergency shut down, liquid helium expands to gas and must be vented rapidly
 - Should vent via quench pipe to outside but if fails the gas will enter the room – open the door!!!



Monitoring & Equipment

- MR Safe
 - No known additional MR-related hazards in **any** MR environment
- MR Conditional
 - No hazard in a **specified** MR environment during **specific** conditions of use
- MR Unsafe
 - Poses a hazard in **all** MR environments
- Monitoring must conform to same standards as the operating theatre



Monitoring & Equipment

- Telemetric
- Battery powered or isolated power source
 - AoA recommend all equipment placed outside of the magnet room
- ECG interference
 - Difficult to detect abnormal changes
 - Locate electrodes close together
 - Fibreoptic transmission
- IABP - Avoid long pressure lines
- Capnography – longer sample line means longer time delay



Sedation & Anaesthesia



- Aims
 - Immobility
 - Patient safety and comfort

Sedation

- Pre-assessment and fasting rules apply
- Monitoring, emergency airway equipment and IV access
- Deep sedation often required to achieve stillness
- Propofol TCI is commonest technique
 - Easily titratable and short recovery times



Anaesthesia

- Indications
 - Paediatrics – neurological disorders, vascular malformations, tumour growth
 - Learning difficulties
 - Severe movement disorders
 - Position limited by pain
 - Claustrophobia
 - Ventilated patients
 - Stereotactic neurosurgical procedures
 - Surgery with intraoperative MRI



Anaesthesia

- Dedicated anaesthetic room outside of 5G contour
 - Standard equipment can then be used/stored
 - Non-ferrous trolley for transfer
- Head or feet first?
 - Head first – completely inaccessible
- LMA or ETT
 - Pilot balloons of cuffed ETT contain a small ferromagnetic spring – tape away from area being scanned
- Maintenance – IV or inhalational
 - MR conditional and safe pumps are available
 - MR compatible anaesthetic machines





Intra-operative MRI

- Near-real time imaging
- Uses an “open” scanner – paired magnets
- Interventions
 - Limited by access
 - Non-ferrous instruments are used and have decreased duration
 - Lower field strength – reduced image quality



Key Points

- MRI based on interactions between a static magnetic field generated by the scanner and the tiny fields that arise from individual atomic nuclei
- Useful for images of soft tissue, providing greater contrast between different types of tissue
- Numerous safety concerns associated with the MRI environment
- Anaesthesia or sedation required to minimise movement and comfort in a claustrophobic environment
- All equipment must be compatible with the MR environment to allow safe anaesthesia and monitoring



Example questions

- You are asked to transfer an intubated intensive care patient for a MRI scan.
 - What is meant by the term MR safe, and MR conditional, in relation to equipment used in the MRI scanner room? 2 marks
 - What precautions can be taken to prevent burns caused by monitoring equipment used in an MRI scanner? 6 marks
 - List other precautions you would take to minimise the risks associated with MRI. 7 marks
 - What are the contraindication to an MRI scan? 5 marks



Example questions

- You are asked to transfer an intubated intensive care patient for a magnetic resonance imaging scan.
 - What is meant by the term “magnetic resonance conditional” in relation to equipment used in the MRI scanner room? 1 mark
 - What precautions should be taken to prevent burns caused by monitoring equipment used in an MRI scanner? 6 marks
 - Describe other precautions you should take while this patient is having an MRI scan. 8 marks
 - What are the relative/absolute contraindications to an MRI scan for any patient? 5 marks





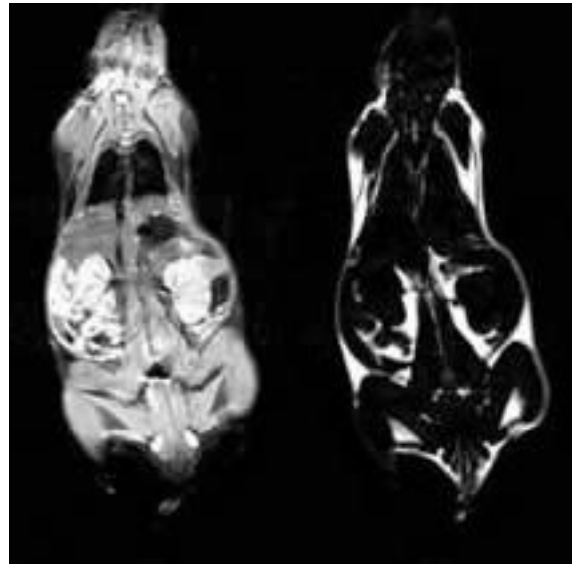
Laura's Weird MRI Quiz

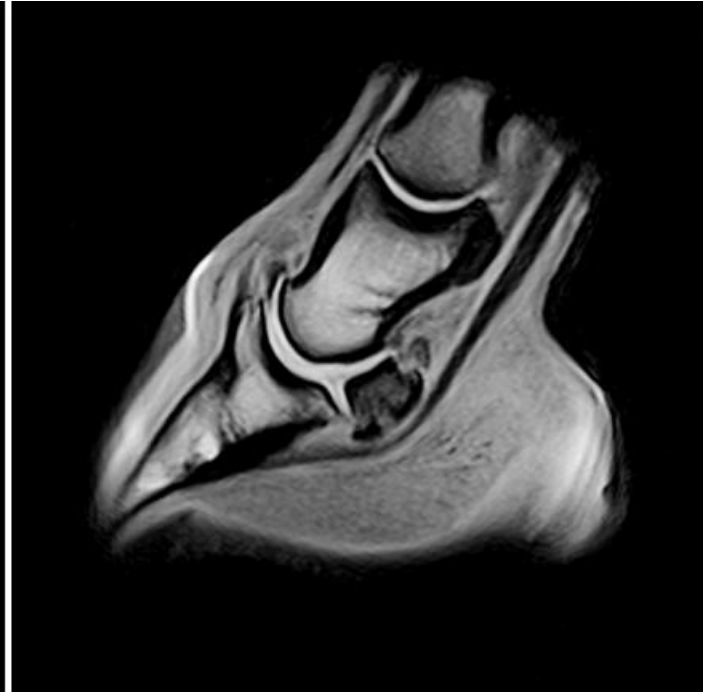
What animal is having an MRI?











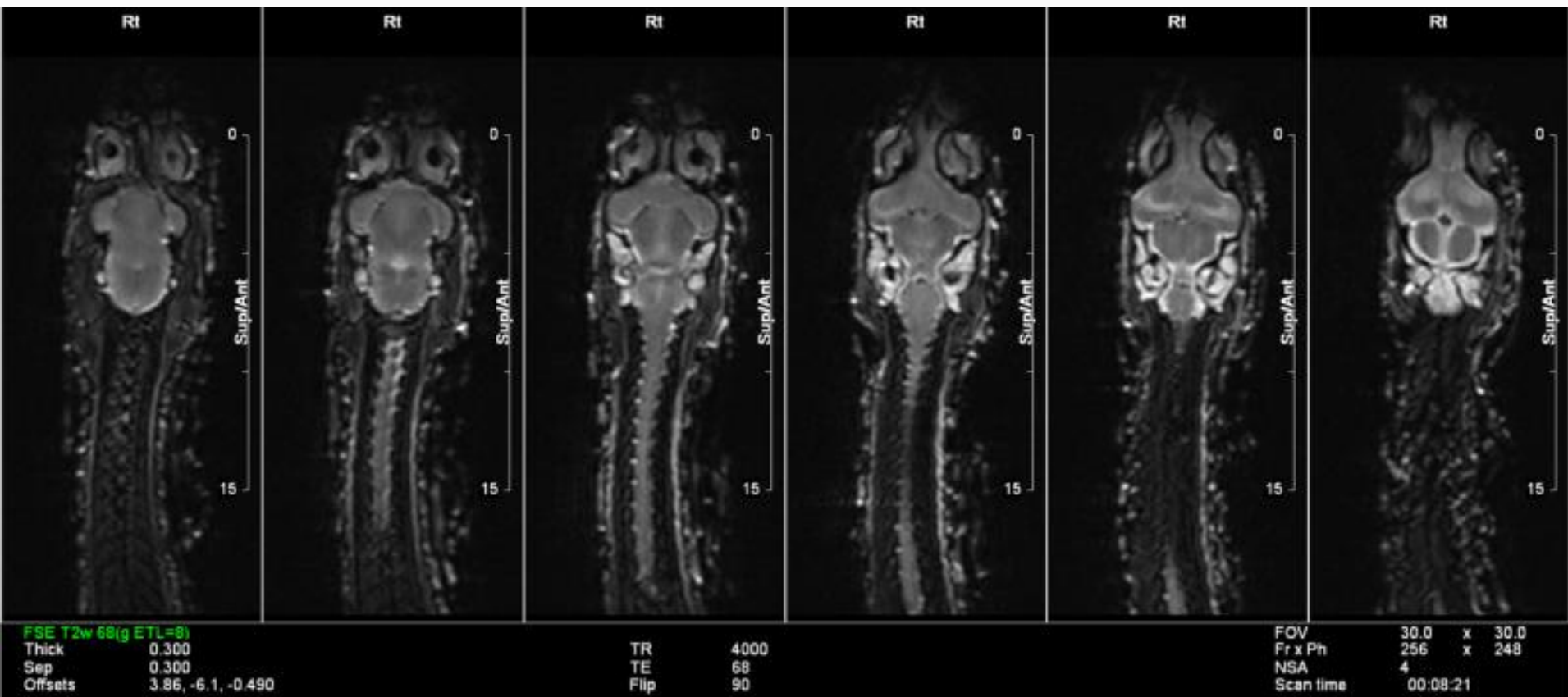


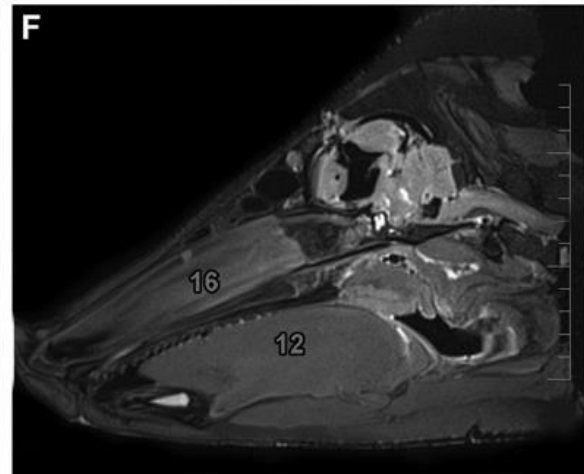
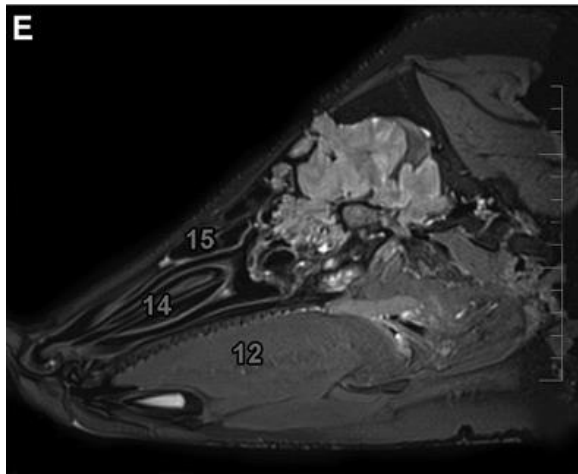
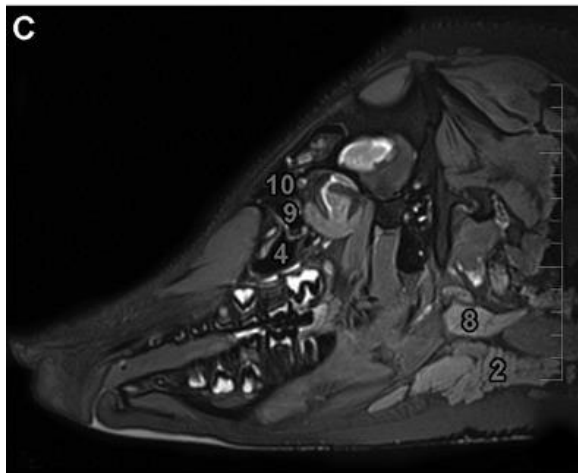
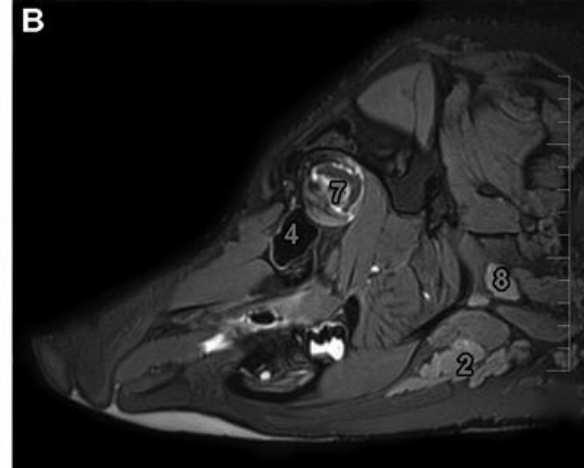
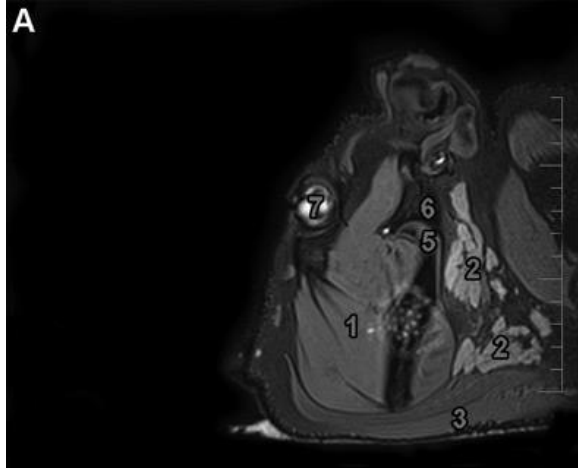
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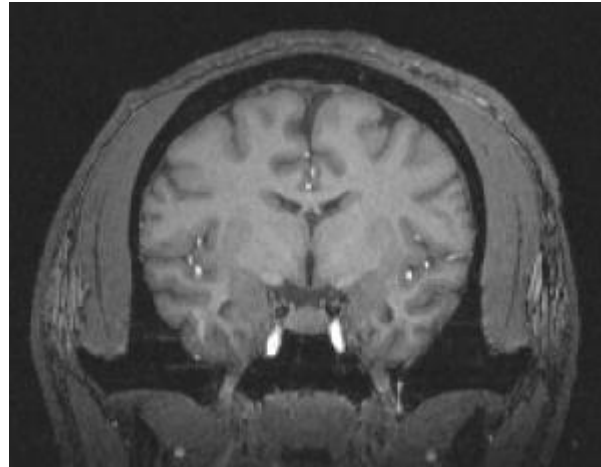
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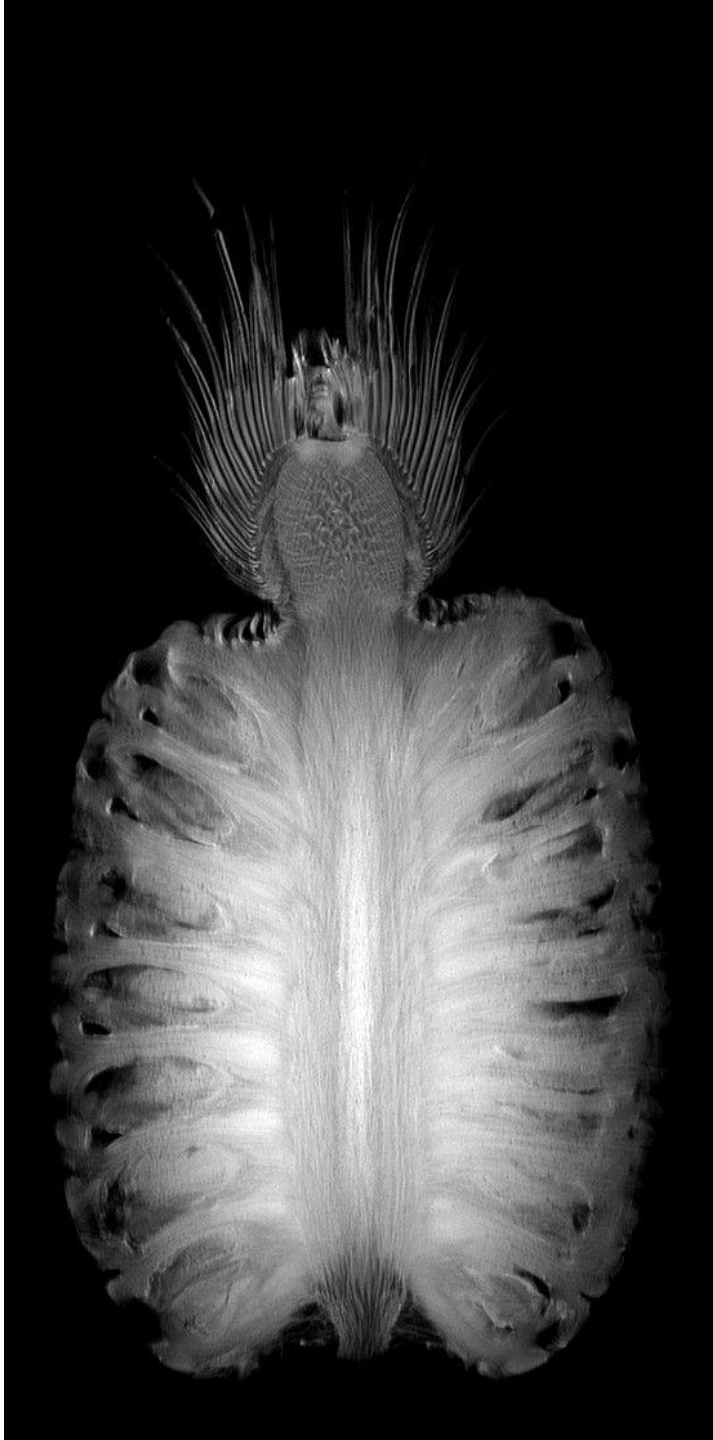


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Diathermy

Diathermy



- Use of an electrical current to cut tissue and coagulate blood via localised heat
- Uses high frequency, alternating current passing between two electrodes
- Heat energy produced is proportional to electrical power dissipated
- Relies on principle of current density
 - $\text{Current Density} = \text{Current}/\text{Area}$

Diathermy Types

- Unipolar

- Probe containing one electrode, large plate placed elsewhere on patient containing the other probe

- Bipolar

- Pair of forceps with each point containing a separate electrode



Diathermy Modes

- Cutting
 - Low-voltage mode producing a high current in the shape of a continuous sine wave
- Coagulate
 - High-voltage mode producing a damped sine wave response
- Blended
 - Mixture of cutting and coagulate on different tissue



Risks

- Burns
 - Incorrectly placed unipolar plate
- Electrocution
 - May injure patient, staff or damage equipment and implants
- Electrical Interference
 - May inhibit pacing or trigger ICDs
- Smoke Production
 - Respiratory irritant, dissemination of viral particles and may be carcinogenic
- Tissue Dissemination
 - Potential source of metastatic seeding



Pacemakers/ICD

- ICDs **must** be turned off
- Avoid diathermy where possible
 - Bipolar safer than monopolar
 - Short bursts, watch for PPM inhibition when in use
- If recently checked and remote from surgical site, malfunction risk is minimal
- British Heart Rhythm Society Guidelines



Electronic Neurosurgical Implants



- Vagal Nerve Stimulators
- Deep Brain Stimulators
- Spinal Cord Stimulators
- Intrathecal Baclofen Pumps

Devices and Diathermy



- No current guidelines for management
- Follow manufacturer's guidelines and consult with device technician before and after surgery
- Not an absolute contraindication
 - Avoid or use bipolar
 - If monopolar required, earth plate as far away from IED and stimulator leads as possible
- Risks
 - Nerve, tissue and device damage
 - Cases of thermal lesioning of brain tissue and death

Example question

- What are the indications for insertion of an implantable cardiac defibrillator? 4 marks
- How might surgical diathermy affect the ICD? 4 marks
- A patient with an ICD is listed for elective surgery; what precautions are necessary pre-operatively, intra-operatively and post-operatively? 9 marks
- How does the management differ if this patient requires emergency surgery? 3 marks



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Questions?

