Understanding Magnetic Resonance Imaging

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Why in News?

Recently, Magnetic Resonance Imaging (MRI) has been a topic of discussion as an indispensable tool for non-invasive exploration inside the human body.

What is Magnetic Resonance Imaging (MRI)?

- **About:**
  - MRI is a **non-invasive diagnostic procedure** used to obtain **images of soft tissues** within the body.
    - Soft tissue is any tissue that hasn't become **harder through calcification.** Calcification of soft tissue is a condition where calcium salts accumulate in soft tissue, causing it to harden.
  - It is widely utilised for imaging various body parts such as the brain, cardiovascular system, spinal cord, joints, muscles, liver, and arteries.
    - Unlike X-rays, which use radiation, MRI scans leverage powerful magnets and radio waves to create detailed images of **soft tissues** within the body.
  - **Professor Paul C. Lauterbur and Peter Mansfield** won the **2003 Nobel Prize in Physiology** or Medicine for their innovative research which resulted in the **invention of MRI.**
- **Working Principle of MRI:**
  - **Hydrogen Atom Utilisation**: An MRI procedure utilises hydrogen atoms present in the body part being scanned.
  - **MRI Machine Components:** The MRI machine consists of four essential components, including a **superconducting magnet**, a radiofrequency pulse emitter, and a detector.
  - **Magnetic Field Application:** The superconducting magnet produces a **strong and stable magnetic field** around the body, causing the hydrogen atoms' spin axes to align either parallel or antiparallel to the field.
  - **Radiofrequency Pulse Emission**: A radiofrequency pulse is emitted into the body part under the scanner, exciting only the small population of unmatched hydrogen atoms.
  - **Signal Detection and Image Formation:** The emitted energy from the excited atoms is detected by a receiver and converted into signals.
    - These signals are then used by a computer to create two- or three-dimensional images of the scanned body part.
- **Importance of MRI:** MRI plays a crucial role in observing and treating cancers like prostate and rectal cancer, as well as tracking neurological conditions including Alzheimer's, dementia, **epilepsy,** and **stroke.**
  - Additionally, researchers use MRI scans to study changes in blood flow, aiding in understanding brain activity, known as functional MRI.
- **Advantages of MRI:**
  - **High Precision**: MRI machines scan specific body portions with gradient magnets.
  - **Safety**: MRI scans pose no long-term harm, and magnetic field effects are well-studied.
  - **Early Disease Detection:** MRI aids early detection of diseases like cancer and multiple sclerosis.

    - **Minimally Invasive Procedure:** MRI is safe and comfortable, unlike surgery, benefiting children and the elderly.
- **Disadvantages of MRI:**
    - **Cost:** MRI machines are expensive to purchase and maintain, leading to high diagnostic costs for patients.
    - **Discomfort and Claustrophobia:** Patients must lie still for extended periods inside the MRI machine, which can be uncomfortable, especially for claustrophobic individuals.
    - **Limited Imaging Capability**: MRI struggles to image certain tissues like bone, air, and some types of implants effectively due to their physical properties.
    - **Strong Magnetic Fields**: The powerful magnetic fields used in MRI can pose potential risks for patients with certain medical implants (e.g., pacemakers) or metallic objects lodged in their bodies.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Q. With reference to 'Near Field Communication (NFC) Technology', which of the following statements is/are correct? **(2015)**

1. It is a contactless communication technology that uses electromagnetic radio fields.

2. NFC is designed for use by devices which can be at a distance of even a metre from each other.

3. NFC can use encryption when sending sensitive information.

Select the correct answer using the code given below:

(a) 1 and 2 only

(b) 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

Ans: (c)

Q. With reference to Visible Light Communication (VLC) technology, which of the following statements are correct? **(2020)**

1. VLC uses electromagnetic spectrum wavelengths 375 to 780 nm.

2. VLC is known as long-range optical wireless communication.

3. VLC can transmit large amounts of data faster than Bluetooth.

4. VLC has no electromagnetic interference.

Select the correct answer using the code given below:

(a) 1, 2 and 3 only

(b) 1, 2 and 4 only

(c) 1, 3 and 4 only

(d) 2, 3 and 4 only

Ans: (c)