TEAM CODE: TY4 intership

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Domain:-Medical Imaging

Objective Description:- To analyze and compare the principles, performance, applications, and challenges of four core medical imaging modalities – MRI, CT Scan, X-Ray, and Sonography – to evaluate their potential in advancing diagnostic accuracy, patient safety, and treatment planning.

Team Member 1: Sumeet Devrukhkar

Sub Domain: MRI

PICO 1

- **Paper Title**: Magnetic Resonance Imaging (MRI) – A Review
- **Authors of Paper**: Govind B. Chavhan, M.D., and colleagues
- **Paper Description**:
    - **Problem Statement**: While MRI is a powerful diagnostic tool, it has limitations like long scan times, high costs, and safety concerns with implants, which need to be evaluated in comparison to other imaging methods.
    - **Intervention**: A comprehensive review of the physics, principles, and clinical applications of MRI, including advancements like functional MRI and diffusion-weighted imaging.
    - **Comparison**: MRI is compared to conventional methods such as CT, ultrasound, and PET. It is superior in soft tissue contrast and functional assessment without radiation exposure, though CT is faster and PET provides metabolic details.
    - **Outcome**: The review concludes that MRI is an indispensable and superior tool for clinical diagnostics, particularly for neurological, musculoskeletal, and cardiovascular imaging, due to its diagnostic accuracy and non-invasiveness.

PICO 2

- **Paper Title**: Vitamin B12 deficiency neurological syndromes: A clinical, MRI, and electrodiagnostic study
- **Authors of Paper**: Jayantee Kalita, Usha Bhatia, and UK Misra
- **Paper Description**:
    - **Problem Statement**: Diagnosing neurological syndromes from Vitamin B12 deficiency is challenging, as clinical features often appear late, potentially leading to irreversible damage if not detected early.

- **Intervention**: The study uses a combined approach of clinical evaluation, MRI, and electrodiagnostic techniques to diagnose these neurological problems. MRI helps specifically by identifying spinal cord abnormalities like hyperintense signals.
- **Comparison**: The study compares MRI findings with clinical observations and electrodiagnostic results, showing that the combination is more effective than any single method.
- **Outcome**: The MRI scans successfully detected characteristic spinal cord changes that correlated with other diagnostic methods, demonstrating that adding MRI to the diagnostic process significantly improves accuracy and supports timely treatment.

PICO 3

- **Paper Title**: Magnetic Resonance Imaging in Interventional Radiology (Diagn Interv Radiol, 18:344)
- **Authors of Paper**: Ayşe Gül Bilen, Mustafa Araz, and colleagues
- **Paper Description**:
  - **Problem Statement**: Conventional imaging methods used in interventional radiology, like CT and ultrasound, have limitations such as radiation exposure and poor soft tissue contrast.
  - **Intervention**: The paper explores the use of MRI as a real-time guiding tool in interventional radiology, leveraging its excellent soft tissue visualization and multiplanar capabilities.
  - **Comparison**: The study compares MRI-guided procedures with those guided by CT and ultrasound. MRI avoids radiation and offers better image contrast, though it requires longer scan times and is more expensive.
  - **Outcome**: The study finds that MRI has significant potential to improve procedural safety and accuracy in interventional radiology, and with future technological advancements, could become an essential tool for minimally invasive therapies.

PICO 4

- **Paper Title**: Study from Journal of Clinical Investigation (JCI0319010)
- **Authors of Paper**: John C. Gore, Ph.D., and colleagues
- **Paper Description**:
  - **Problem Statement**: Non-invasive, accurate tools are needed to understand disease mechanisms at molecular and clinical levels, as traditional histological and biochemical methods are invasive and time-consuming.
  - **Intervention**: The paper applies advanced MRI techniques to visualize functional and structural changes in biological systems in real-time.

- **Comparison**: The study compares MRI results against gold-standard histological and biochemical methods, highlighting MRI's advantage of enabling repeatable and longitudinal studies on the same subjects.
- **Outcome**: The study shows that MRI allows for the non-invasive assessment of disease processes, bridging the gap between laboratory research and clinical applications to enhance diagnostic and therapeutic insights.

PICO 5

- **Paper Title**: Metal Artifact Reduction in MRI – A Review (Journal of Magnetic Resonance Imaging)
- **Authors of Paper**: Gisela G. Koch, Ph.D., and colleagues
- **Paper Description**:
  - **Problem Statement**: Metal implants in patients create severe artifacts in MRI scans, which can obscure critical diagnostic details and reduce the effectiveness of MRI in postoperative evaluations.
  - **Intervention**: The paper reviews advanced artifact reduction techniques such as MAVRIC and SEMAC, along with optimized pulse sequences, designed to significantly improve image quality.
  - **Comparison**: Standard MRI sequences are compared with these new artifact reduction methods. The newer techniques substantially reduce artifacts, making it possible to evaluate patients with implants.
  - **Outcome**: The review concludes that modern metal artifact reduction strategies improve diagnostic confidence and broaden the applicability of MRI in orthopedic and surgical fields, leading to better patient care.

Team Member 2: Krati Jain

Sub Domain:CT Scan

PICO 1

- **Paper Title**: CT (Computed Tomography) — StatPearls (CT Scan)
- **Authors of paper**: P R Patel
- **Paper Description**:
  - **Problem Statement**: CT technology, while crucial for clinical diagnosis, raises concerns about radiation exposure, appropriate clinical indications, and the need to optimize protocols for various clinical problems.
  - **Intervention**: A comprehensive overview of CT principles, scanner technology (helical/spiral scanning), indications, and low-dose strategies to guide clinicians and technologists in appropriate use.

- **Comparison**: The paper compares CT with other imaging modalities like MRI and radiography, and compares different scanner technologies and dose protocols.
- **Outcome**: The paper concludes that CT significantly improves diagnostic accuracy, and low-dose protocols can maintain sensitivity for screening while reducing patient radiation exposure when used correctly.

PICO 2

- **Paper Title**: CT scanning: patterns of use and dose
- **Authors of paper**: F. A. Mettler Jr., P. W. Wiest, J. A. Locken, C. A. Kelsey
- **Paper Description**:
  - **Problem Statement**: CT is a high-dose procedure with rapidly growing use, but there was limited data on usage patterns, patient demographics, and the total radiation dose contribution.
  - **Intervention**: A retrospective review of over 33,700 CT examinations was conducted to document usage patterns, patient demographics, and radiation dose metrics.
  - **Comparison**: The study compares usage patterns across different patient groups and scan types, and compares the dose per examination with published reference values.
  - **Outcome**: The analysis showed that CT contributes a large and growing share of medical radiation exposure, highlighting the need for increased awareness, dose optimization, and tracking of scan indications.

PICO 3

- **Paper Title**: Recent and Future Directions in CT Imaging
- **Authors of paper**: N. J. Pelc
- **Paper Description**:
  - **Problem Statement**: Rapid technological advancements in CT require a synthesis of past trends to guide future developments while addressing concerns about radiation dose and clinical utility.
  - **Intervention**: A technology-focused review of CT developments including detector advances, iterative reconstruction, and spectral imaging, with a discussion of future directions.
  - **Comparison**: The paper compares older CT technologies with modern detector and processing approaches, and contrasts conventional reconstruction with iterative and model-based methods for dose reduction.
  - **Outcome**: The paper concludes that continuous advancements in technology will expand CT's diagnostic capabilities, and iterative reconstruction and protocol optimization will be key to reducing radiation without compromising image quality.

PICO 4

- **Paper Title**: Radiation and Chest CT Scan Examinations: What Do We Know?

- **Authors of paper**: Asha Sarma, Marta E. Heilbrun, Karen E. Conner, et al.
- **Paper Description**:
    - **Problem Statement**: Chest CTs account for a significant portion of CT use and raise public health concerns about cancer risk from radiation. Clinicians need a clear summary of the evidence on dose, risk, and clinical benefits.
    - **Intervention**: A literature review of evidence on chest CT utilization, including quantified radiation doses for common chest CTs and a discussion of balancing diagnostic benefits with theoretical long-term cancer risks.
    - **Comparison**: The paper compares radiation doses across different chest CT protocols and evaluates the estimated radiation-associated risks against the clinical benefits for common chest indications.
    - **Outcome**: The paper emphasizes that while chest CT is clinically valuable, its use must be prudent, and dose-minimization strategies are essential to mitigate population cancer risk. It recommends evidence-based indications and protocol tailoring.

PICO 5

- **Paper Title**: CT Scan Parameters and Radiation Dose: Practical Advice for Radiologists
- **Authors of paper**: S. P. Raman, et al.
- **Paper Description**:
    - **Problem Statement**: Radiologists and technologists need practical guidance on how to manipulate CT scan parameters (tube current, voltage, etc.) to balance image quality and patient radiation dose for specific clinical tasks.
    - **Intervention**: A practical review offering guidance on optimizing eight fundamental CT parameters to reduce radiation dose while preserving diagnostic quality for common clinical indications.
    - **Comparison**: The paper compares different parameter settings and their impact on dose versus image quality, as well as standard versus optimized (low-dose) protocols.
    - **Outcome**: The paper provides actionable recommendations for protocol optimization that can significantly lower radiation dose without compromising diagnostic performance when applied correctly.

Team Member3 : Suman

Khavadia

Sub Domain:X-Ray

PICO 1

- **Paper Title**: Digital Radiography vs. Conventional Film for Medical Imaging
- **Authors of paper**: Y. Bansal, V. Gupta, and P. K. Singh
- **Paper Description**:

- **Problem Statement**: Conventional film-based X-rays require chemical processing, leading to longer wait times, and use higher radiation doses, which limits diagnostic speed and patient safety.
- **Intervention**: Implementation of digital radiography (DR) systems using flat-panel detectors for real-time imaging.
- **Comparison**: DR is compared to traditional film radiography techniques.
- **Outcome**: DR reduces patient radiation exposure by 20–50%, provides faster image acquisition, and improves the diagnostic quality of images for clinical workflows.

PICO 2

- **Paper Title**: Low-Dose Chest X-ray Screening for Early Lung Cancer Detection
- **Authors of paper**: D. R. Aberle.
- **Paper Description**:
  - **Problem Statement**: Lung cancer is often diagnosed in advanced stages because of ineffective early detection, which contributes to high mortality rates.
  - **Intervention**: The use of low-dose chest X-rays for regular screening in high-risk populations, such as smokers.
  - **Comparison**: The screening method is compared to no screening or standard-dose radiography.
  - **Outcome**: Low-dose X-rays enable the earlier detection of lung nodules and lead to a modest improvement in survival rates, although they are less sensitive than low-dose CT scans.

PICO 3

- **Paper Title**: Portable X-ray Devices for Remote and Emergency Medical Care
- **Authors of paper**: Kazuhiko Omori, Youichi Yanagawa
- **Paper Description**:
  - **Problem Statement**: Limited access to radiology services in remote or disaster-stricken areas can delay urgent diagnoses.
  - **Intervention**: The deployment of lightweight, battery-powered portable X-ray devices with wireless image transfer.
  - **Comparison**: This intervention is compared to the alternative of transferring patients to fixed radiology facilities for imaging.
  - **Outcome**: Portable X-ray devices enable rapid on-site diagnosis, reduce the risks associated with patient transport, and improve the efficiency of emergency triage.

PICO 4

- **Paper Title**: Contrast-Enhanced X-ray Angiography for Vascular Assessment
- **Authors of paper**: Carina W Yang, James C Carr

- **Paper Description**:
    - **Problem Statement**: Standard X-rays cannot adequately visualize blood vessels, which hinders the accurate diagnosis of vascular diseases.
    - **Intervention**: The use of iodinated contrast-enhanced X-ray angiography to provide detailed vascular imaging.
    - **Comparison**: This method is compared to non-contrast X-rays or Doppler ultrasound techniques.
    - **Outcome**: The intervention provides superior visualization of blood vessels and improves the detection of stenosis or blockages, with manageable procedural risks.

PICO 5

- **Paper Title**: AI-Assisted X-ray Analysis for Orthopedic Fracture Detection
- **Authors of paper**: Mathias Meetschen, Luca Salhöfer
- **Paper Description**:
    - **Problem Statement**: Manually detecting factures on X-rays is prone to human error and can slow down the workflow in emergency departments.
    - **Intervention**: The application of AI algorithms for the automated detection and annotation of fractures.
    - **Comparison**: The AI-assisted method is compared to radiologists interpreting X-rays without AI assistance.
    - **Outcome**: AI assistance increases the sensitivity of fracture detection and reduces reading time, thereby improving diagnostic accuracy and the speed of clinical decision-making.

Github link: https://github.com/Sumeet416/Research_practices