MEDTEC SCHOOL

Course: _ Advanced Imaging and Diagnostics

Year (1ˢᵗ-2ⁿᵈ-3ʳᵈ-4ᵗʰ-5ᵗʰ-6ᵗʰ): 5th

Period (1ˢᵗ-2ⁿᵈ semester – annual): 1ˢᵗ

Credits: 7

Objectives

The course aims to provide a comprehensive understanding of advanced imaging modalities and their applications in various clinical scenarios. Students will delve into the theoretical and practical aspects of utilizing different modalities for diagnostic imaging. This includes exploring the principles, techniques, and interpretation of studies such as X-rays, CT scans, MRI, ultrasound, and nuclear medicine imaging.

Additionally, the course will cover important topics related to radiotherapy, medical genetics, digital pathology, and the emerging field of artificial intelligence. Students will learn how these areas intersect with and enhance the practice of diagnostic imaging.

Furthermore, the course will introduce students to the fundamentals of electronic and informatics bioengineering, enabling them to grasp the basic principles underlying different imaging modalities. They will also be exposed to various image processing methods used to extract meaningful information from biomedical images.

Overall, this course aims to equip medical students with a solid foundation in the theoretical and practical aspects of advanced imaging modalities, empowering them to effectively utilize these techniques in clinical practice for accurate diagnosis and patient care.

Prerequisites

Anatomy and Physiology.
Mathematics and Statistics.
Biomedical Electronics and instrumentation.

Contents - Lectures

Radiology

- Introduction to Advanced Diagnostic Imaging: clinical domains of different imaging modalities. (1h)

- Contrast Media: how to increase contrast in Radiology; rationale and utilization of contrast media in various imaging modalities. Overview of relative and absolute contraindications. (1h)

- Fundamentals of chest X-Ray semeiotics (atelectasis, pleural effusion, pneumonia, pneumothorax, Pneumomediastinum, pneumopericardium and subcutaneous emphysema). (1h)

- Imaging and management of pulmonary nodules. (1h)

- Cardiovascular Diseases Unveiled: Decoding Pathological Presentations through Advanced Imaging Techniques (2h)

- Gastrointestinal Radiology of Upper GI tract: awareness of clinical role and specific indications of major imaging modalities; differential diagnoses of main pathological conditions and rational to use different diagnostic techniques. (2h)

- Gastrointestinal Radiology of Lower GI tract: awareness of clinical role and specific indications of major imaging modalities; differential diagnoses of main pathological conditions and rational to use different diagnostic techniques. (2h)

- Multimodality evaluation of Focal Liver Lesions. (2h)

- Pancreatic Imaging: Unlocking Insights through Radiological Exploration. (2h)

- Nephrology and Urology: recognition of main pathological affections involging urinary tract, testicle and prostate disease; learning use, advantanges and disadvantages of different imaging modalities. (2h)

- Female Imaging Part 1: Breast. (2h)

- Female Imaging Part 2: Gynecological radiology. (2h)

- Fundamentals of brain imaging: ischemiac stroke and hemorrhages (2h)

- Fundamentals of brain imaging: intracranial masses (2h)

- Choosing wisely: how to prescribe the correct imaging examination (2h)

- Interventional Radiology and Image guided therapy: significance and clinical utilization of main interventional procedures performed by radiologists. (2h)

- Principle of AI in advanced diagnostic imaging. (2h)

NUCLEAR MEDICINE
- Fundamentals of Nuclear Medicine Techniques (2h)

Radiotherapy

- Radiation oncology (Radiotherapy) and clinical indications.

- Radiotherapy for breast cancer and clinical cases.

- Radiotherapy for lung cancer and clinical cases.

- Radiotherapy for gastro-intestinal cancers (colorectal cancer and non-colorectal cancer) and clinical cases.

- Radiotherapy for prostate cancer and clinical cases.

Electronic and informatics bioengineering

- Overview of medical imaging modalities: basic principles, instrumentation and image characteristics of X-ray, CT, magnetic resonance imaging (MRI), nuclear medicine, US.

- Numeric approach to tomographic reconstruction: Radon transform, Sinogram, back-projection and blurring.

- General image characteristics: Spatial resolution, signal-to-noise ratio, contrast-to-noise ratio.

- Image processing methods applied to biomedical images: image enhancement, filtering, segmentation, registration.

- Image analysis. Modelling and rendering of surfaces and volumes.

Pathology

- Digital Pathology (DP) an Historical overview: from telepathology to augmented pathology (1 h)
- Digital pathology and its the instruments (1 h).
- Artificial intelligence (AI), machine learning (ML), and deep learning (DL) (2h)
- AI applications to DP: the research setting (2h).
- AI applications to DP: the clinical setting (2h).

Medical Genetics

Clinical Applications of Medical Genetics

- Genetic Testing and Diagnosis: in the first lecture, we will delve into the clinical applications of genetic testing and diagnosis. We will explore advanced genetic testing techniques, their indications, and their significance in diagnosing and classifying genetic disorders accurately. Additionally, we will discuss the role of genetic testing in determining prognosis and treatment options for patients.
The lecture will include case studies and interactive discussions.

- Rare Disease Diagnosis and Emerging Applications: the second lecture will focus on the diagnosis and management of rare genetic diseases and will explore emerging applications of medical genetics. We will discuss the challenges in diagnosing and managing rare genetic disorders, including the role of medical genetics in identifying the underlying genetic causes. Additionally, we will explore emerging trends, such as gene therapy and precision medicine, and their potential impact on patient outcomes.

Teaching Methods

Lectures: The aim of lectures is to transfer knowledge to students by guiding them through the most relevant aspects and principles. Students are expected to participate in lectures in a proactive manner, asking questions, and taking notes as part of the learning process.

Clinical case discussion: The aim of clinical case discussion is to activate and solidify knowledge acquired during lessons, and to increase student engagement in a collaborative learning setting. Students are encouraged to actively participate to the lectures with questions and comments.

Practical sessions: organized as computer lab, will be proposed to teach how to apply in practice the theoretical concepts learned.

Assessment

Written exam; multiple choice

End of Semester Exam content and evaluation

Content of End of Semester Exam (ESE) (63 questions): Questions will include the whole program of the course.

ESE evaluation: 63 questions, each question 0.5 points
To pass the test you need to answer to at least 36 questions correctly
60 correct answers = 30
61-63 correct answers = 30 cum laude

Texts

- Image analysis. Modelling and rendering of surfaces and volumes. Title: "Radiology Review Manual" by Wolfgang Dähnert

- This textbook is highly regarded and commonly used by medical students at the fifth-year level. It provides comprehensive coverage of various imaging modalities, including radiography, CT, MRI, nuclear medicine, and ultrasound. The book includes detailed discussions on chest X-ray interpretation, cardiovascular imaging, gastrointestinal radiology, liver lesions, pancreatic imaging, nephrology and urology, breast imaging, gynecological radiology, interventional radiology, and principles of AI in diagnostic imaging.

- Additionally, for the radiotherapy component of the course, you may consider the following textbook:

- Title: "Principles and Practice of Radiation Oncology" by Carlos A. Perez, Luther W. Brady, and Edward C. Halperin

- This textbook offers a comprehensive overview of radiation oncology, including the clinical indications and treatment approaches for various cancer types, such as breast, lung, and gastrointestinal cancers. It covers the principles of radiotherapy, treatment planning, and the use of advanced technologies in radiation therapy.

- For the Electronic and Informatics Bioengineering component, the following textbook can be a valuable resource:

- Title: "Medical Imaging Signals and Systems" by Jerry L. Prince and Jonathan M. Links

- This textbook provides an in-depth understanding of the basic principles, instrumentation, and image characteristics of different medical imaging modalities. It covers topics such as tomographic reconstruction, image processing methods (enhancement, filtering, segmentation, and registration), and image analysis. The book also delves into the numerical aspects of medical imaging and provides a solid foundation in bioengineering principles.

- These textbooks should provide comprehensive coverage of the topics discussed in your program and serve as valuable references for fifth-year medical students studying advanced diagnostic imaging, radiotherapy, and electronic and informatics bioengineering.