PDCC Correlative Imaging: Curriculum

Guidelines For Competency-Based Postgraduate Training Programme For PDCC in Correlative Imaging

Preamble:

Medical Imaging has made great technological breakthroughs in the multimodal acquisition, visualization, and analysis with many complementary image modalities to capture human anatomy, physiology, and pathology non-invasively. New functional imaging techniques help elucidate the dynamics of human health and disease at a much higher throughput, enabled by the growth in affordable computing power, memory capacity, processor speed, and communication bandwidth. Recently, exceedingly powerful computer hardware and optimized image processing software may, for the first time, allow high-volume image data processing and manipulation (like multimodal registration) to become clinically feasible on a routine basis in real time.

When it comes to diagnostic imaging, there is a heavy reliance placed on anatomically based techniques, while molecular and functional techniques are often given scan attention. Most clinicians are, therefore, very comfortable using CT, X-rays ultrasound, and MRI because the output is readily understood, particularly if the image is accompanied by judiciously placed arrows demonstrating the abnormalities. Nuclear medicine techniques, apart from bone scanning, which sufficiently resembles the mind-eye perception of a skeleton to pass as an anatomical representation, have often failed to capture the imagination of the clinician. There is a feeling that functional imaging to somehow less valid than radiological techniques because of the lack of fine spatial resolution. Time activity curves, deconvolutional analysis, and compartmental modeling are all based on mathematics and are generally held to be beyond common understanding. The study of combined anatomical, functional, and molecular

Lt Col Varun Bajpai VSM
Executive Registrar
SGPGIMS,Lucknow

imaging, also known as correlative imaging, provided an intuitive integration of information from functional and structural imaging techniques without requiring a detailed understanding of the technologies needed to produce them.

NEED:

Correlative imaging provides a structure where scientists can develop and disseminate information on the medical and physiological application of various imaging modalities as they correlate to nuclear medicine. As the imaging field is involved and developed, the focus has also expanded to include the correlation of nuclear medicine with additional imaging modalities like CT, MRI, and now molecular imaging modalities. It was decided that this new Post-doctoral course (PDCC) would innovate education in CT, MR, and emerging molecular imaging technology. In recent literature, the educational focus has been PET/CT. This PDCC program will also focus on SPECT-CT and MRI correlation as combined PET/MRI imaging looms on the horizon.

Lt Col Varun Bajpai VSM
Executive Registrar
SGPGIMS,Lucknow

Subject Specific Learning Objectives

At the end of the PDCC Correlative imaging, the student should meet the following objectives:

1. Acquisition of knowledge

The learner should comprehensively understand the principles and applications of correlative imaging techniques, mainly focusing on PET/CT, MRI, and PET/MRI. The learner should be able to describe each modality's physics, instrumentation, and technical aspects, including the generation and detection of electromagnetic signals, signal processing, and image reconstruction. The learner should also learn about each technique's strengths and limitations, their respective imaging contrasts, and the underlying molecular and cellular processes they reveal.

2. Acquisition of Skills

Students are expected to develop practical skills, especially in PET/CT, MRI, and PET/MRI correlative imaging modalities. Learners should be able to prepare patients, data collection, and data analysis. Learners should be able to interpret and integrate image data from multiple modalities and apply appropriate image analysis techniques and statistical methods to extract meaningful information. Learners should also develop practical communication skills, such as writing scientific reports and presenting results at conferences and seminars.

3. Teaching and training

The learner has access to state-of-the-art imaging facilities and equipment and experienced and qualified instructors who can provide hands-on training and guidance. The teaching will include didactic lectures, journal clubs, seminar presentations, and inter-departmental meets. The student is expected to take a small prospective project. The student will be encouraged to research and

Lt Col Varun Bajpai VSM
Executive Registrar
SGPGIMS,Lucknow

present papers at national and international conferences.

4. Research

Learners should be able to apply correlative imaging techniques to answer scientific and clinical questions about human physiology, disease pathology, and therapeutic interventions. The student should be able to critically evaluate the scientific literature, identify knowledge gaps, and design and conduct experiments to fill these gaps. Also, learners may contribute to developing new image-processing techniques and image analysis algorithms and collaborate with other researchers to develop and apply correlative image-processing approaches in interdisciplinary research projects.

5. Professionalism, Ethics, and Communication skills

- The student should acquire communication skills of a high order to report/interact with referring doctors, other health professionals, and patient attendants.
- The student should acquire educational skills of a high order to support a teaching role in areas related to the specialty, especially with medical students, junior staff, allied health professionals, and members of the public.
- The student should be able to learn and apply principles of professionalism, ethics, and effective communication in research, nuclear medicine-based services, educational activities, and day-to-day work.

Therefore, the program aims to enable the PDCC correlative imaging students to independently perform Hybrid Nuclear Medicine imaging, teaching, and research. This will help to fulfill the human resources needs of an ever-expanding diagnostic medicine branch.

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Executive Registrar
SGPGIMS,Lucknow

Colour Coding
Global GREEN
Regional BLUE
National ORANGE
Local (State) PINK

Post Graduate Training will consist of Theoretical and Practical Training:

SUBJECT-SPECIFIC COMPETENCES

By the end of the course, the student should have acquired knowledge (cognitive domain), professionalism (affective domain), and skills (psychomotor domain) as given below:

1. Cognitive domain (Knowledge domain)

- Learners should be able to explain the principles and technical aspects of PET/CT, MRI, Ultrasonography and PET/MRI imaging modalities.
- Learners should be able to analyze and interpret image data from multiple modalities.
- Learners should be able to assess the scientific literature on correlative imaging methods critically.
- Learners should be able to design and conduct experiments using correlative imaging techniques.
- Should have knowledge of basic principles of radiation physics and radiation protection subsequent applications.
- Should have knowledge of the safe handling of radionuclides and their disposal at a regional, state, and national level.
- Should be able to conduct clinical research and write a research paper under supervision.
- Should develop a good working relationship with user specialties and handle inter-specialty referrals at a regional, state, and national level.

B. Affective domain:

- Students should understand the importance of correlative imaging techniques in biomedical research.
- Student must commit to ethical research practices, including data integrity and confidentiality. Always adopt ethical principles, maintain proper etiquette in dealings

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with patients, relatives, and other health personnel, and respect the patient's rights, including the right to information and second opinion. Should be able to accept feedback and criticisms with an open mind.

- Learners should develop curiosity and creativity while exploring new imaging methods and techniques.
- Should be able to function as a part of a team, develop an attitude of cooperation with colleagues, and interact with the patient and the clinician or other colleagues to provide the best possible diagnosis or opinion.
- Learners should develop effective communication skills to present research findings clearly and concisely.
- Communicate well with patients and make all efforts to explain the rationale of the diagnostic and treatment approach to patients and their caregivers in their language for ease of understanding.
- Have the skills to participate in seminars, Continued Medical Education programs, panel discussions, and lectures to discuss and review recent scientific data to **further the cause of Nuclear Medicine in the country and increase visibility on national and global platforms.**
- Should be able to pass on such information and knowledge gained to other students and colleagues, especially those working in resource-limited settings, **to improve cancer care in the region, state, and country.**
- Should actively cultivate skills to work in a team, with mutual respect, basic human courtesy, and a supportive attitude towards others, including other clinicians, para-clinical staff, policymakers, and health administrators, to improve Nuclear Medicine **services at a regional, state, and national level.**
- Develop a habit of maintaining honest, detailed, and comprehensive medical records.
- Be aware of ethical principles of clinical research as guided by institutional ethical committees.

C. Psychomotor domain

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At the end of the course, the student should have acquired the following skills:

- Students should develop the technical skills necessary to perform correlative imaging, including preparation, data acquisition, analysis interpretation with clinical findings, and using different image analysis software.
- Learners should develop the ability to troubleshoot and resolve technical and imaging issues.
- Learners should develop the ability to work alone or as part of a team when performing and interpreting imaging.

A) Basic Sciences Experiment:

1. Practical related to Physics, Instrumentation, and quality Control.
2. Preparation of radiopharmaceuticals and their quality control.
3 Practical related to Hybrid Imaging & Fusion Imaging.
7. Practical on qualitative and quantitative aspects of Hybrid Imaging.
8. Practical on the optimized and safe operation of Hybrid imaging Instrumentation

B) Clinical Experiments on:

1. GFR Estimation.
2. Esophageal transit time.
3. Gastric emptying time.
4. Renal transplant evaluation.
5. Determination of Ejection Fraction and RWMA (wall motion).
6. Acquisition, Processing, Post Processing of Hybrid Imaging.

The Correlative Imaging PDCC educational program will aim to:

- Establish an educational program in correlative imaging and its clinical practice to provide a platform for applying correlative imaging in clinical practice and research.

FACULTY ASSOCIATED:

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Dr. S. Gambhir Professor	Prof. Sunil Kumar, Radiology
Dr. P.K. Pradhan, Professor	Dr. Archana Gupta, Radiology
Dr. S. Barai, Professor	Dr. Jafar Niyaj, Radiology
Dr. A Arya Addl Professor	Dr. Heera Lal, Radiology
Dr Manish Ora	Prof. Punita Lal, Radiotherapy
Dr Aftab Hasan Nazar	Dr. Shagun Mishra, Radiotherapy

Eligibility Criteria:

MD or DNB in Nuclear Medicine from a recognized university.

Selection Procedure:

All India open entrance examinations as per the policy of the Institute.

Duration of Course: One year

Syllabus

Topics to be covered during the Nuclear Medicine posting:

- Study of Instrumentation, physics, and functioning of equipment used for correlative imaging.
- Cross-sectional imaging anatomy
- Fusion Imaging
- Positron Emission Tomography: All indications for the use of PET imaging in Oncology, Cardiology,
  Neuro Sciences and psychiatric disorders.
- PET MR imaging (basic instrumentation, protocol, attenuation correction, clinical uses oncological and non-oncological)
- Oncology: Staging, diagnosis, and management of common malignancies. Basic principle of radiotherapy and chemotherapy.
- Radiomics and Artificial Intelligence in Imaging
- Study of various software and computer algorithm used in correlative Imaging in SPECT-CT, PET-CT, 64-SLICE SPECT-CT coronary angiography, and Animal SPECT-CT.
- Study of software used in image acquisitions, storage, and transfer across different imaging consoles.
- Use of oral and intravenous contrast in Nuclear Medicine, including patient preparation and management of contrast-related emergencies.

Topics to be covered during Radiology Posting.

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- Instrumentation, physics, and functioning of various equipment (Ultrasonography, CT and MRI) used for correlative imaging.
- Instrumentation. Imaging Protocols software and clinical applications in the different disease processes.
- Instrumentation, Imaging protocols, software, and clinical application in the different disease processes.
- FDG-PET: instrumentation software and clinical applications in the different disease processes.
- Study of software used in image acquisitions, storage, and transfer across different imaging consoles.

Topics to be covered during Radiotherapy posting:

- Instrumentation, physics, and software used in radiotherapy treatment planning equipment.
- Co-registration of images for radiotherapy treatment planning.
- SPECT, PET, CT, and MRI-based radiotherapy treatment planning.
- Study of agents and modality used for tumor hypoxia imaging and tumor DNA synthesis.

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Needs: Local : Pink, National : Orange, Regional: light blue, International : green

The One-year training program's objectives are to **train a Nuclear Medicine Physician as a skilled Hybrid Imaging physician** in different aspects of theoretical, clinical, and practical spheres of Diagnostic Nuclear Medicine. It will enable them to offer skill-based diagnostic and curative care with the highest professional standards. This training will help to accomplish the local, regional, and national healthcare needs for quality care commensurate with international standards.

Local level	1. **Cancer**: PET/CT imaging can provide valuable information on cancer location, staging, and treatment response. MRI is also used for cancer detection and evaluation, especially for certain tumors, such as brain tumors. Specific focus should be given to cancer subtypes prevalent in the local community and their management. 2. **Neurological** disorders: Hybrid imaging combining PET/CT and MRI can help diagnose and manage neurological disorders like Alzheimer's disease, Parkinson's disease, and multiple sclerosis. This imaging can provide critical information on brain function and blood flow, enabling physicians to develop more effective treatment plans. 3. **Cardiac** disease: Hybrid imaging using PET/CT and MRI can provide valuable information on heart function, blood flow, and anatomy, allowing for more accurate diagnosis and effective management of heart disease, such as coronary artery disease, heart failure, and arrhythmias. 4. **Orthopedic** disorders: Hybrid imaging can help diagnose and manage orthopedic disorders, such as bone tumors, fractures, and joint diseases. MRI is especially useful in evaluating soft tissue injuries and disorders like ligament and tendon tears. 5. **Infection**: Hybrid imaging can be used to detect and monitor infections in the body, such as in bones, joints, or soft tissues. This imaging can provide information on the infection's location, extent, and response to treatment. **6. Overall, a hybrid imaging program that combines PET/PET-CT and MRI can provide valuable information on various diseases and conditions, enabling physicians to develop more effective treatment plans and improve patient outcomes.**
National level	1. **Cancer diagnosis and treatment**: Correlative imaging can provide valuable information on cancer location, staging, and treatment response. With the increasing incidence of cancer in India, there is a need to expand the availability and accessibility of hybrid imaging facilities for early detection and treatment. 2. Cardiovascular disease: It provides valuable information on heart function, blood flow, and anatomy, allowing for more accurate diagnosis and effective management of heart disease, such as coronary artery disease, heart failure, and arrhythmias. There is a need for more hybrid imaging facilities equipped to perform cardiac imaging and image-guided therapy in emerging pandemic of CAD. 3. Neurological disorders: It helps to diagnose and manage neurological disorders like Alzheimer's disease, Parkinson's disease, and multiple sclerosis. This imaging can provide critical information on brain function and blood flow, enabling physicians to develop more effective treatment plans.

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	4. Renal and gastroenterological disorders: Hybrid imaging can help diagnose and manage various inflammatory and infectious disorders affecting the kidneys and gastrointestinal tract. The availability of such facilities needs to be increased to provide better healthcare for patients. 5. Infectious disease: Hybrid imaging can be used to diagnose and monitor infectious diseases such as tuberculosis and other acute and chronic infections prevalent in the Imdia. It could be a beneficial modality to access response to treatment in infectious diseases 6. Bone and joint disorders: Hybrid imaging can help diagnose and treat bone and joint disorders such as osteoporosis and arthritis. 7. Radiation safety: There is a need for radiation safety measures to protect patients and healthcare workers from unnecessary exposure to radiation due to low occupancy factors in India. There is a need for increased awareness and training on radiation safety in hybrid imaging.
Regional level	1. Regional epidemiology: There is a need for regional studies to assess the prevalence and incidence of diseases that can be diagnosed and treated using hybrid imaging techniques. This information can help identify the specific diseases and conditions that require a more comprehensive imaging approach. 2. Regional diseases: Certain regions may have a higher incidence of specific diseases, such as certain types of cancer. Research is needed to understand the diagnostic and therapeutic potential of hybrid imaging techniques for these specific diseases. 3. Availability and accessibility: The availability and accessibility of hybrid imaging facilities can vary widely between regions. There is a need for strategies to improve access to these facilities, especially in underserved regions. 4. Training and education: Training programs for Nuclear Medicine Physicians in correlative imaging techniques should be developed to ensure that they can operate the equipment effectively and safely. 5. Regional collaborations: Collaborations between different regions can lead to sharing knowledge and resources, standardizing protocols, and developing new diagnostic and therapeutic strategies using hybrid imaging techniques
Global level	Correlative imaging can aid in developing new diagnostic and therapeutic strategies and facilitate research collaborations globally. By expanding the availability and accessibility of these techniques, we can enhance healthcare services globally and address the growing burden of complex diseases worldwide.

TRAINING PROGRAMME

Teaching-Learning methods

This should include a judicious mix of demonstrations, symposia, journal clubs, clinical meetings, seminars, small group discussion, bed-side teaching, case-based learning, simulation-based teaching, self-directed learning, integrated learning, interdepartmental meetings and any other collaborative activity

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with the allied departments. Methods with exposure to the applied aspects of the subject relevant to basic/clinical sciences should also be used. **The suggested examples of teaching-learning methods are given below but are not limited to these. The frequency of various below mentioned teachinglearning methods can vary based on the subject's requirements, competencies, work load and overall working schedule in the concerned subject.**

The PDCC student will be attending all the learning session of the department as done by MD students.

A. Lectures: Didactic lectures should be used sparingly. A minimum of 10 lectures in department is suggested. Topics to be selected as per subject requirements

1. Subject related important topics as per specialty requirement
2. Recent advances
3. Research methodology and biostatistics
4. **Salient features of Postgraduate medical curriculum**
5. Teaching and assessment methodology.

B. Journal club: Minimum of once in 1-2 weeks is suggested.
Topics will include presentation and critical appraisal of original research papers published in peer reviewed indexed journals. The presenter(s) shall be assessed by faculty and grades recorded in the logbook.

C. Student Seminar: Minimum of once every 1-2 weeks is suggested. Important topics should be selected as per subject requirements and allotted for in-depth study by a postgraduate student. A teacher should be allocated for each seminar as faculty moderator to help the student prepare the topic well. It should aim at comprehensive evidence-based review of the topic. The student should be graded by the faculty and peers.

D. Laboratory work / Bedside clinics: Minimum - once every 1-2 weeks. Laboratory work/Clinics/bedside teaching should be coordinated and guided by faculty from the department. Various methods like DOAP (Demonstrate, Observe, Assist, Perform), simulations in skill lab, and case-based discussions etc. are to be used. Faculty from the department should participate in moderating the teaching-learning sessions during clinical rounds.

E. Interdepartmental colloquium
Faculty and students must attend monthly meetings between the main Department and other department/s on topics of current/common interest or clinical cases; eg., combined clinical round with Radiology, Pathology etc.

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F. One project work with the associated faculty in correlative imaging.

G. Outside Department posting

The candidate will be posted in Dept of Nuclear Medicine for six months in the Department of radiodiagnosis for four months, and in the Department of Radiotherapy for two months.

Log Book for the entire training period:

Evaluation:

Examination pattern as adopted by the Institute.

Suggested Journals:

1. Radiology
2. Indian Journal of Radiology
3. European Journal of Radiology
4. British Journal of Radiology
5. American Journal of Roentgenology
6. Molecular Imaging and Biology
7. International Journal of biomedical Imaging
8. European Journal of Nuclear Medicine and Molecular Imaging
9. Journal of Nuclear Medicine
10. Magnetic resonance medicine and journal of magnetic resonance Imaging.
11. Journal of the American College of Radiology
12. Radiation Oncology
13. Neuroimage
14. Journal of American College of Cardiology
15. Journal of biomedical Optics
16. Optics letters
17. IEEE Transaction in Medical Imaging

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18. IEEE Transaction in Biomedical Engineering

Suggested Books:

1. Physical Basics of NMR by Rolf Pohmann
2. Molecular Anatomic Imaging: PET-CT and SPECT-CT integrated Modality by Gostov K Von.
3. Netter's Correlative Imaging by Nancy Major.
4. Molecular Imaging: Principle and Applications in Biomedical Research by Markus Redin
5. Molecular Imaging: A Primer by Sam Gambhir
6. Basics of Contrast Mechanisms by Leif Schroder
7. Molecular and cellular MR Imaging
8. Hybrid PET/CT and SPECT/CT Imaging: A teaching files by D Delbeke.
9. Nuclear Cardiology and Correlative Imaging by Jaoa V Vitola.
10. Abdominal Plain Film and Correlative Imaging BY Stephen RB
11. PET IN Oncology by Dresl Stefan
12. Cardiac CT Imaging by Budoff
13. MRI and CT Atlas of Correlative Imaging by Vijay M Rao
14. Computed body Tomography with MRI Correlation by Joseph K T Lee
15. Primer of Sectional Anatomy with MRI and CT Correlation by Charles P Barret.
16. Musculoskeletal ultrasound with MRI and CT correlations by Vikram Dogra
17. Fundamentals of Body CT by W Richard Webb.
18. PET-CT Hybrid Imaging by Schober and Heidal
19. Radiation Protection in Newer Imaging Techniques in IAEA Publication.
20. Medical Radiology Diagnostic Radiology by A L Baert.

Lt Col Varun Bajpai VSM
Executive Registrar
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