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Safety First

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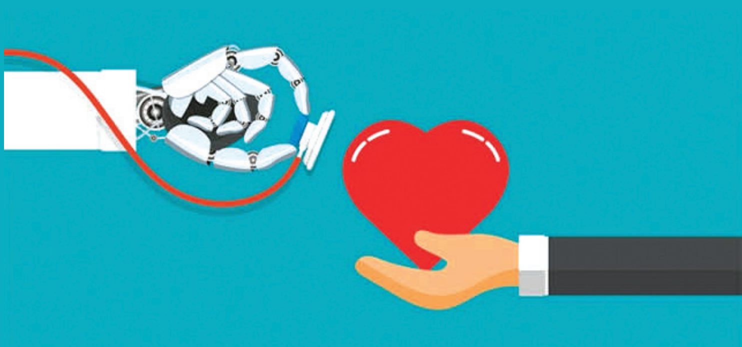
Ridges and Gorges

Recent update from World Health Organization reveals the Cholera out break in some part of the world had already affected millions. Lack of essentials like clean water, proper sanitation etc. are the most suitable reason attributable. On the other hand, healthcare in some part of the world is undergoing a thunderous overhauling assisted by the new power horse namely Artificial Intelligence.

This unpleasant gulf in the inequitable distribution of essentials sustaining the very basic needs that are pivotal in maintaining a healthy life for one and all irrespective of geographic, economic or political divide is the raison d'etre for reemergence and emergence of new diseases world over. This unjust divide is rendering the world even more perilous with unpredictable outcomes, and when such outbreaks swing out of control an epidemic happens spreading all across the globe, washing out men and money irrespective of any advancements to boast of.



In short healthcare is more of a global concern, regional stability in healthcare is in fact short lived, the long-time goal should be a new world health order, accessible for all without any discretion. A dream still in dreams, but you are with the latest rolled out issue of Alara with a fine blend of knowledge and information. Share your knowledge, doubles your wisdom. Be wise to share as you grow. Coexistence is the key for existence.

Editor in Charge

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Demystifying Medical Diagnostic X-Ray Radiation Hazards

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We all know that there are a large number of X-ray diagnostic centres operating in the country. X-rays are ionizing radiations which have a certain hazard potential. So as a member of public, we need to understand what is the hazard potential of X-rays and how much should we be concerned?

First of all, it's important to recognize that medical x-ray equipment for diagnosis encompasses a wide range of devices, spanning from the Cath Lab or Interventional Radiology equipment, to the Dental IOPA equipment (Refer Table overleaf). These equipment pose a varying level of hazard potential to different sets of people (i.e. patients, operators and general public). So, one cannot assume that all these equipment are equally hazardous to all these different sets of people.

Next, we need to understand how workload of the X-ray diagnostic centre affects the hazard potential. Workload has different connotations as far as X-ray equipment operation is considered. It roughly means the exposure parameters used for diagnostic purpose and the actual equipment operating time, generally calculated for a week time. Consequently, centres with heavier workloads pose a higher hazard potential. This isn't solely based on the number of patient but also on diagnosis requirements, which may necessitate the use of higher exposure parameters such as time, kV and mA. To put things in perspective, the time required for each exposure of a typical x-ray examination such as chest x-ray is in millisecond. This means that the "ON" time i.e. when the equipment is really generating radiation, is less than few minutes in a day for the general-purpose x-ray equipment. The situation is not the same for Fluoroscopy equipment where the "ON" time is higher. Cath-Labs or interventional radiology equipment have higher exposureparameters, including operating time and hence are of higher radiation hazard potential.

Another important aspect of these equipment is that they are radiation generating equipment, and do not pose any hazard if they are not being operated. This is in contrast to the radioactive isotopes, which continues to emit radiation even when they are not in use. Consequently, the risk of accidents or incidents with these equipment are minimal.

Now it is important to understand how different groups of people are affected by the radiation exposures. The patients, invariably receive higher radiation dose (primary radiation). Patient exposure has two aspects to it. On one hand, the patients are receiving radiation dose as a MEDICAL EXPOSURE i.e., the benefit in terms of a diagnosis outweighs the risk due to radiation exposure. On the other hand, if the patients receive any excess radiation dose either due to sub-standard design of the equipment or wrong operational parameters, then the radiation received by them is considered undue.

The second set of people receiving radiation dose are the operators of the X-ray equipment. Normally, these operators do not receive the primary radiation. They receive what is known as the scatter radiation i.e. the radiation scattered from patient body, while undergoing the exposure. The scatter radiation (a fraction of the primary radiation) along with leakage radiation from x-ray equipment (also a fraction of primary radiation for good design equipment) contribute to the exposure received by the operator. The definition of "Operator" differs from modality to modality.

The third set of people who are likely to receive radiation are the general public, who are either the relatives, employees or other patients present near the equipment. They are also likely to receive

Different X-ray facilities with increasing radiation hazard potential

Modality	Safety of operator		Safety measures for people around the utility	Safety of patient
	Identified Radiation worker	Minimum Safety accessories required		
Dental–IOPA	a) Dentist b) Dental technician	0.25mm lead (eq) apron	Not Applicable	
Dental OPG/ CBCT	a) Dentist b) Dentaltechnician	0.25mm lead (eq) apron/ Exposure from behind a barrier	X-ray equipment in a dedicated room	
Mobile Radiography	X-ray technologist/ Radiologist if he handles the equipment	0.25mm lead (eq) apron	Ensure minimum occupancy around patient	Identified Quality Tests and Protective Accessories as required
Portable Radiography		0.25mm lead (eq) apron/ exposure from behind abarrier (MPB or brick wall)	X-ray equipment in a dedicated room. No permanent seating around the radiography room	
Fixed Radiography				
Mammography	X-ray technologist	0.25mm lead (eq) apron/ exposure from behind a barrier	X-ray equipment in a dedicated room.	
Fluoroscopy/ C-Arm	a) Doctors/ b) X-ray technologist	0.25mm lead (eq) apron and exposure from behind abarrier, where possible	X-ray equipment in a dedicated room. No permanent seating around the room	
Computed Tomography	CT technologist/ Radiologist	Working from separate control room.		
Intervention Radiology (Cath-Lab)	a) X-raytechnologist b) Doctors / surgeons operating the equipment or in the room c) Nurses assisting them through the process	a) 0.25-0.5 mm lead (eq) apron- sufficient numbers for doctors andnurses b) Ceiling suspended lead(eq) c) Lead(eq) Flaps d) Lead (eq) glasses e) For X-ray technologist, control room outside		

the scatter and leakage radiation leading to some hazard potential. The above table explains the different hazard potential for different facilities.

Why is extra caution required for children?

Children are biologically more vulnerable to the effects of radiation. The biological effects of ionizing radiation in children are higher because of their radio-sensitivity, their life expectancy and the amount of radiation exposures received over a time period. Thus, the lifetime risks are expected to be higher in a child than in an adult.

There are also “unfavourable” conditions in the practice, which they may be subjected to like:

- Using unsuitable Automatic Exposure systems in imported equipment not customized to Indian demography.
- Following adult exposure protocols for children.

HIGHLIGHTS

- All x-ray equipment are not equally hazardous.
- The same type of modality varies in its hazard potential due to its Workload.
- 70-75% of the x-ray equipment in the country are of low hazard potential such as general purpose radiography and dental equipment.
- The fluoroscopy equipment has a very specific purpose and is not used extensively.
- The Cath-Labs are used for life-saving procedures in the Operationtheaters.
- Medical exposures to patients are considered "justified" and AERB does not stipulate dose limits to patients for undergoing medical examinations.
- Operators for all modalities are safe by using minimum radiation safety accessories. The general public around the utility are also safe, if the x-ray equipment is placed in a room with shielding as per AERB guidelines. In most cases a medium sized room with normal brick wall, serves the purpose. Radiation safety of the patient is ensured by giving optimum dose to the patients. This is ensured by proper design and calibration of the equipment and using guidelines to avoid undue exposures.
- The child may receive doses, more than required for a good diagnosis, because of
  - Unsuitable design
  - Operator not using child protocols provided in the equipment owing to unawareness
  - Not considering other options for diagnosis
  - Using sub-standard equipment, which has not been design approved (AERB Type Approved) and not subjecting the equipment to periodic quality control tests.
  - Not using dose-minimizing features of the machine.
  - Radiographs taken by unqualified personnel, who do not fully appreciate the implication of their actions.
  - Not considering alternate means of diagnosis (MRI, USG etc).
  - Not asking for previous x-ray records, for the same ailment.
  - Expecting best quality images, even if there is no additional gain in terms of diagnosis.

Why is there a need for AERB regulations in this practice?

Despite the overall low radiation hazard potential, there is a definite need for fulfilment of AERB requirements towards radiation safety by the stakeholders owing to

(a) Widely spread X-ray equipment in the country

(b) Increasing number of examinations

(c) Increasing number of high dose procedures

AERB ensures that all safety requirements are known to the stakeholders through various means of communications. AERB through its regulatory process of Licensing and Regulatory Inspections ensures ionizing radiation safety in the practice.

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BOOSTING THE CONCEPT OF THERANOSTICS

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Various radio-metals

Radioactive metals such as ^{64}Cu or ^{89}Zr could be used to image drugs with delayed pharmacodynamic characteristics. When radiolabeled with isotopes with lower half-lives, ImmunoPET, especially radiolabeled antibodies or antibody fragments—may exhibit extremely sluggish blood clearance, leading to poor signal-to-noise ratios. Wilson's illness is a prime candidate for ^{64}Cu PET research since it is associated with an overabundance of copper accumulation. An essential subject in tumour imaging is hypoxia. Here, however, the pharmacokinetic is also sluggish, and the clearance is frequently quite lengthy in order to obtain useful signal to noise ratios. For this reason, radio-metals with longer half-lives, such as [^{64}Cu]ATSM,may be a good choice. In medical cyclotrons, ^{64}Cu and ^{89}Zr may both be generated in good quantities.

The invention and deployment of radio metals in "theranostics" is another significant usage for them. In this case, radiotherapy is administered after a diagnostic scan using a tracer labelled with radiometal. Reliability is increased when the same metal is utilised for both the therapeutic treatment and the diagnostic scan. This eliminates the possibility of different metals causing variations in uptake. $^{64}Cu/^{67}Cu$ or $^{86}Y/^{90}Y$ would be the ideal mix. It is important to remember that there may not be an adequate supply of radioisotopes for both therapy and diagnosis, despite the exciting possibilities.

Microfluidics

Using radiopharmaceuticals for molecular imaging has a special advantage in that a wide range of targeted molecules are available to address a variety of diverse problems. The capacity to manufacture these radiopharmaceuticals on demand, however, is the limiting element. This gave rise to the idea of "dose on demand," which uses incredibly adaptable production machinery to quickly manufacture enough radioactivity for a patient's dosage. One limitation of the concept is the requirement to carry out quality control processes on every product prior to its distribution.

The application of microfluidic chemistry, also referred to as "chemistry on a chip," is a key component of the theory. Utilizing extremely quick reaction periods in conjunction with minimal chemical quantities required, microfluidic applications in radiochemistry simplify purification. As a result, research into the potential use of microfluidic devices in PET radiochemistry continues. These efforts are still at the research stage at this time, but with more advancements, they may find wider uses in the production of radiopharmaceuticals.

Prospective viewpoints
Novel radionuclides

Beyond those in Table 1, a wide range of radionuclides have been suggested in the literature as being appropriate for PET, primarily due to one of the following factors: Three key areas are being addressed by the current standard portfolio of radionuclides: (1) access to longer half-lives than ^{18}F; (2) specific chemical properties not covered by the portfolio; and (3) development of theranostic strategies utilising multiple radionuclides of the same element for imaging and therapy. The goal of leveraging data for biodistribution from individual patient PET or SPECT scans to continuously enhance the accuracy of internal radionuclide therapy has led to a significant increase in interest in the field of theranostics in recent years. In keeping with this theme, a few promising radionuclides will be discussed.

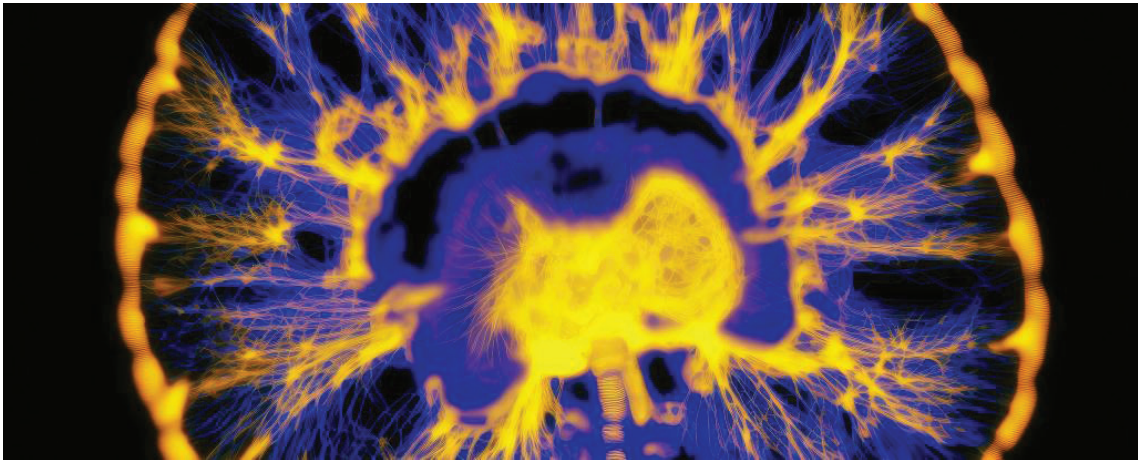
Theranostic pairs that are most promising are likely the positron emitter ^{55}Co (T1/2 = 17.53 h) and the Auger electron emitter ^{58}mCo (T1/2 = 9.1 h), as they have similar half-lives, are stable in vivo, and can be labelled with a wide range of ligands thanks to their compatibility with multiple chelators. Due to their short tissue range and high linear energy transfer (LET), auger electron emitters are generally regarded as a promising method for targeted radionuclide therapy of small tumours. This is especially advantageous if auger electron emitters can be Advancement in production of radiotracers 271 transferred

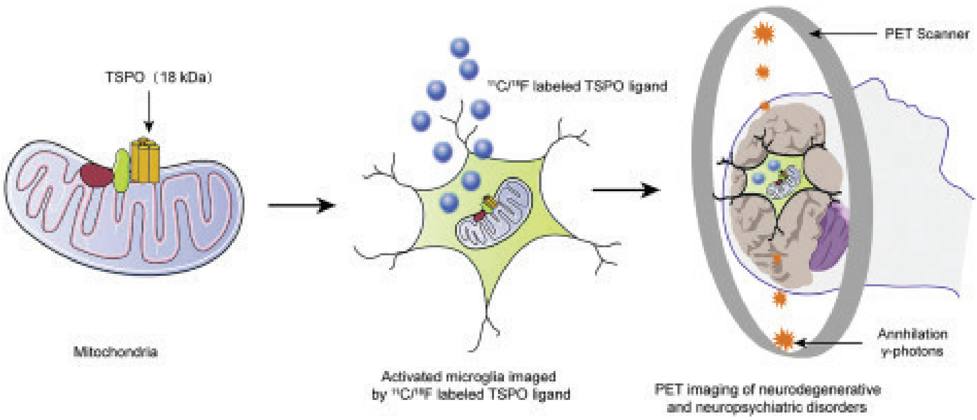
into the DNA of tumour cells.The Auger electron emitter ^{58}mCo was one of the radionuclides that produced the highest theoretical tumor-to-normal tissue dose ratio in a theoretical study of 59 possible therapeutic radionuclides. It was discovered that this ratio is significantly dependent on the subcellular radionuclide distribution. A study using tumor-bearing mice revealed that SSTR2-expressing tumour cells exhibited a significant degree of receptor-specific uptake, indicating the therapeutic effectiveness of peptides labelled with ^{58}mCo for targeted Auger therapy of tiny somatostatin receptor-positive cancers and micrometastases.The radioisotope ^{65}Co has an appealing positron branching ratio of 77 percent for PET imaging; nevertheless, the image quality may be compromised by the production of several prompt gamma rays with energy above 931 keV. Recent research has demonstrated that these gamma rays do not adversely affect image quality on contemporary time-of-flight scanners and that [^{55}Co]Co-DOTATATE can produce improved tumor-to-background ratios when compared to [^{64}Cu]Cu-DOTATATE and [^{68}Ga]Ga-DOTATATE.

The terbium quartet, ^{149}Tb (T1/2 = 4.1 h), ^{152}Tb (T1/2 = 17.5 h), ^{155}Tb (T1/2 = 5.3 d), and ^{161}Tb (T1/2 = 6.9 d), is another intriguing combination of theranostic radionuclides. It covers both PET (^{152}Tb) and SPECT (mainly ^{155}Tb and ^{161}Tb) imaging as well as therapy with a-particles (^{149}Tb) and b-particles (^{161}Tb). Theoretical dose calculations that suggest an additive therapeutic effect from emitted conversion and Auger electrons in the case of ^{161}Tb confirmed the superior performance of [^{161}Tb]TbPSMA-617 compared to [^{177}Lu]Lu-PSMA-617 in a recent study of radionuclide therapy in PSMA-positive PC-3 PIP tumour cells in-vitro and in tumor-bearing mice.The viability of using [161Tb] Tb-DOTATOC for SPECT imaging and potentially therapeutic applications was proven by a first-in-human application in patients with metastatic neuroendocrine neoplasms. Due to radioactive impurities in the product and the requirement for high beam energy, it can be difficult to produce terbium radionuclides in adequate quantities. However, 152Tb has recently been produced via the 152Gd(p,n)152Tb reaction at a low beam energy of 12 MeV.

Innovative and small-sized accelerator technology

The cyclotron's core architecture and operation have not changed since the 1930s, which is somewhat surprising considering how much technology has advanced in other areas of laboratory instrumentation. This could alter in the not-too-distant fu-





ture, and the following will discuss a few such possibilities.

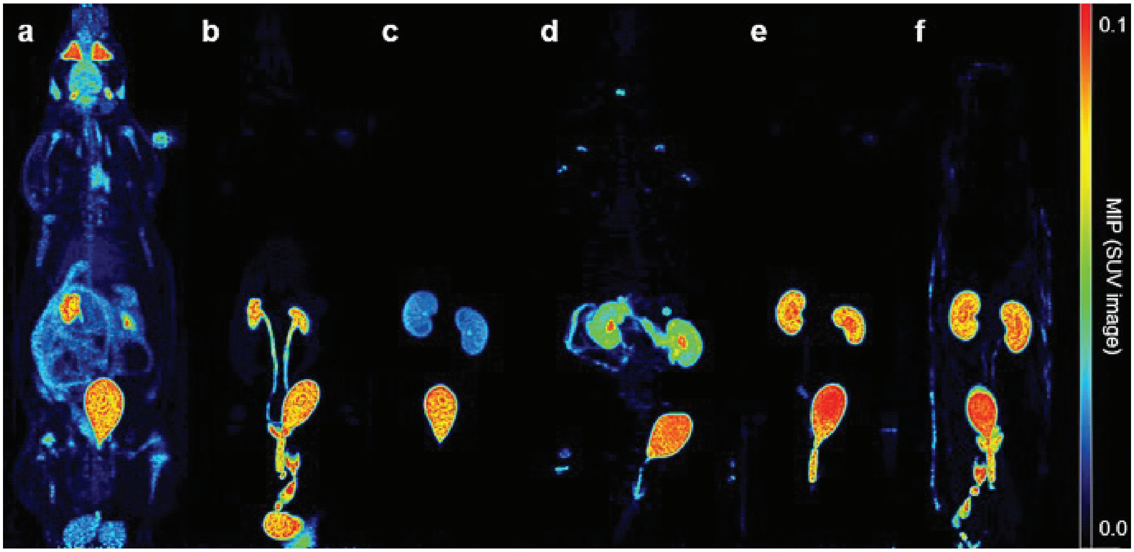
The introduction of super conducting technology for the magnet coil, which has been utilised in MRI scanners and big accelerators for physics research for decades, appears to be the most notable breakthrough. Additionally, Varian Medical Systems launched the technology in 2007 for external beam proton treatment in medical cyclotrons, which resulted in a significant reduction in physical size, weight, and power consumption. The 12.5 MeV ION12SC, currently commercialised by Nucleotron MIT, was the first superconducting cyclotron designed for PET radionuclide synthesis. The iMiTRACE, a compact superconducting 12 MeV proton cyclotron designed for small-scale PET radiotracer manufacturing in conjunction with the iMiLAB radiochemistry robot, was unveiled in 2020 by the French company PMB.

A more appealing strategy could involve swapping out the entire cyclotron for a small linear accelerator, which would eliminate the need for the bulky magnet found in conventional cyclotron designs. In the past, it was challenging to accelerate protons sufficiently over a short distance; nevertheless, protons have been accelerated to 5 MeV of energy along a 2-meter path using contemporary radio frequency quadrupole (RFQ) devices. The ultimate goal of this development is to construct small linear accelerators for proton treatment.

Lastly, it's important to discuss the potential use of powerful laser beams for radionuclide synthesis. The theory is that when a concentrated, pulsed laser beam strikes a solid object, the strong electric field causes charged particles to be released and accelerate to multiMeV energies. The identical nuclear reactions that are carried out in conventional cyclotrons are then driven by the accelerated particles. It has been shown that a variety of radionuclides that are frequently used for PET imaging can be produced; however, only the most potent laser facilities have been able to provide significant yields thus far. Future table-top laser systems may be able to produce radionuclides with more research.

Dose-on-demand

When Ron Nutt founded ABT Molecular Imaging Inc. in 2006, he presented the idea of dose-on-demand for increasing the accessibility of PET tracers. This method provides more manufacturing flexibility and access to a wide variety of tracers, especially at smaller imaging centres, by producing radiopharmaceuticals on a small scale for each patient based on demand. The tiny cyclotron at the heart of the arrangement is linked to chemical synthesis modules through the use of radiochemistry on chip or microfluidic reactors. There are now two



commercial systems available: Nucleotron MIT's ION SC12 and Best ABT Molecular Imaging's BG-75 Biomarker Generator ([^{18}F]FDG and [^{18}F]NaF) ([^{18}F]FDG and [^{13}N]NH_3).

Conclusion

In clinical PET, the radionuclide ^{18}F has earned a unique position as the workhorse. Because of its extremely advantageous physical and chemical properties, ^{18}F is predicted to maintain its leading position going forward. The ability to create an effective coupling to amino acids with chelator molecules has lately led to the rise in popularity of ^{68}Ga, providing an alternative to the chemistry of ^{18}F, which is predominantly dependent on covalent bonds.Major imaging centres' increased 272 S.B. Hansen and D. Bender demand for ^{68}Ga is probably going to push for a switch from generators to cyclotrons as the production method. The most recent generation of total-body PET scanners, which offer more than a ten-fold increase in sensitivity over current PET/CT scanners, is predicted to reinforce and facilitate the increasing usage of radio metals like as ^{64}Cu and ^{89}Zr for imaging of tracers with delayed pharmacodynamic characteristics. The requirement for theranostic pairings will be the primary driver behind the development of further novel radionuclides. The nearly infinite labelling flexibility of a wide range of compounds, including endogenous chemicals, makes the conventional PET radionuclide ^{11}C an invaluable tool for research.

For a number of decades, the fundamental techniques and technologies for producing radionuclides and labelling have remained largely unchanged. Nevertheless, advancements in cyclotron technology and microfluidic reactors may point to a more fundamental shift in the way facilities are set up for the production of PET radiotracers, enabling simpler and less expensive installation. One unique variation is the dose-on-demand method, which still has to prove that it is competitive in day-to-day operations and in a GMP-regulated setting.

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ADVANCEMENT IN THORACIC IMAGING

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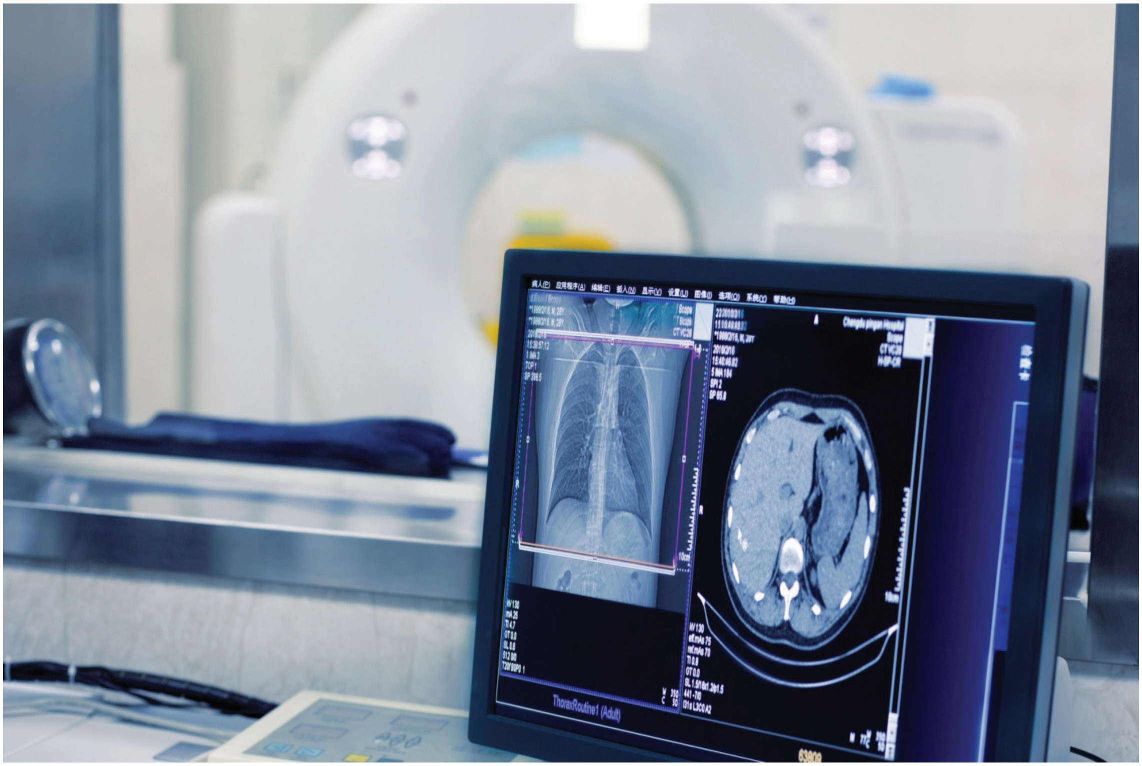
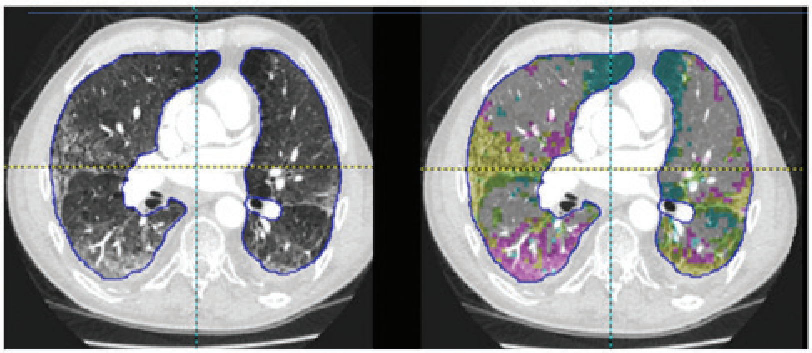


New sophisticated imaging techniques have enabled quantitative and functional thoracic imaging. CT is commonly used in quantitative imaging to assess pulmonary nodules, lung density, airways, and arteries. With the introduction of dual-energy CT (DECT) and functional MR, more functional information may be obtained to assess various lung illnesses.

The use of chest radiography in clinical diagnosis has grown significantly with the development of computed tomography (CT) scans of the thorax, particularly with the introduction of high resolution CT (HRCT), spiral CT, and multidetector spiral CT. Each of these modalities is highly sensitive and specific in detecting various lung pathologies, such as HRCT for diffuse lung illness, spiral CT, and multidetector spiral CT for imaging airways, pulmonary and systemic arteries, and lung nodules. CT thorax with or without contrast enhancement plays a very important role in detecting pulmonary thromboembolism, mediastinal pathology, chest CT incidentalomas, pleural and chest wall pathology, metabolic and storage lung disease. and often cardiac conditions like valvular calcifications, right ventricular dilatation, and right ventricular thrombus.

Demonstration of a quantitative CT (QCT) approach (adaptive multiple features method), acquired using PASS software. Different lung parenchymal disease patterns are identified and highlighted. Blue, emphysema/low attenuation pattern. Yellow, fibrotic changes. Pink, ground glass change.



CT lung cancer screening with quantitative evaluation

Lung cancer is the main cause of cancer death for men and women in India and around the world. The age-standardized rate (ASR) incidence in China and the United States is comparable, but the age-standardized death rate of lung cancer in China is greater than in the United States. The National Lung Screening Trial demonstrated that lung cancer screening with low-dose CT (LDCT) could cut mortality by up to 20% when compared to a chest x-ray. It helps in early detection of lung disease. CT images exhibit excellent concordance with pathological studies in determining the degree and extent of emphysema. CT quantification metrics for emphysema, including emphysema index, air trapping, mean lung density, and total lung volume, have been linked to pulmonary function.

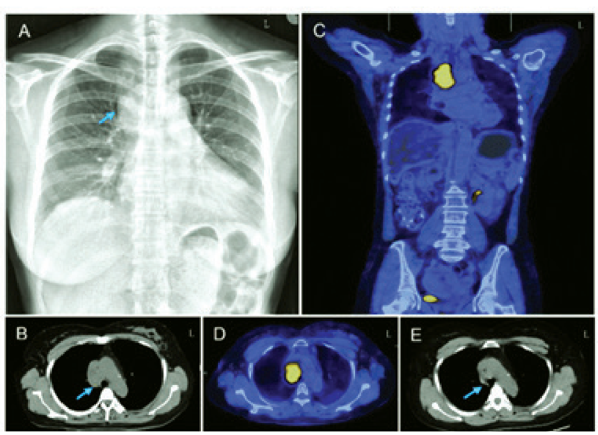
PET/CT in functional imaging

PET/CT combines the functional imaging of PET with the anatomic imaging of CT and is primarily employed in the differential diagnosis of lung nodules, TNM staging, and treatment evaluation. Wang et al. .36 discovered that 18F-FDG PET/CT was more accurate in TNM staging than spiral CT.

This is being pushed by the introduction of deep-learning algorithms, advancements in computing technology, and the exponential rise of medical data created and used for clinical decision making. Currently, AI in thoracic imaging has been used for scanning procedures, imaging diagnosis, and other radiologic care tasks.

AI in thoracic CT

Because of its great resolution, CT is the preferred method for detecting and diagnosing lung diseases. With the popularity of thin-slice chest CT and the increasing number of Chinese patients requiring disease diagnosis, many Chinese radiologists must read tens of thousands of images every day, increasing the risk of



| Thoracic radiograph and PET-CT findings of the patient. (A) Chest X-ray showed a round soft tissue mass (arrow) in the upper-mid mediastinum and infiltrating right lung field. (B) Thoracic CT showed a round soft tissue mass (arrow) located in the upper-mid mediastinum before the arteroae aorta. (C,D) PET-CT scan showed increased uptake of fluorodeoxyglucose signal in this mass axial and coronal plane images. (E) Repeated thorax CT showed the resolution of the mediastinal mass after chemotherapy.

missed diagnosis and inaccurate diagnosis due to radiologists suffering from visual fatigue. In this case, AI-based chest CT processing could assist ease the scarcity of radiologists while also improving diagnostic efficiency. In China, detecting lung nodules is the first stage in evaluating radiomics and AI performance. Effective segmentation of a lung nodule is a critical step in furthering radiomics and AI research, especially for ground glass nodules because of their poor contrast.

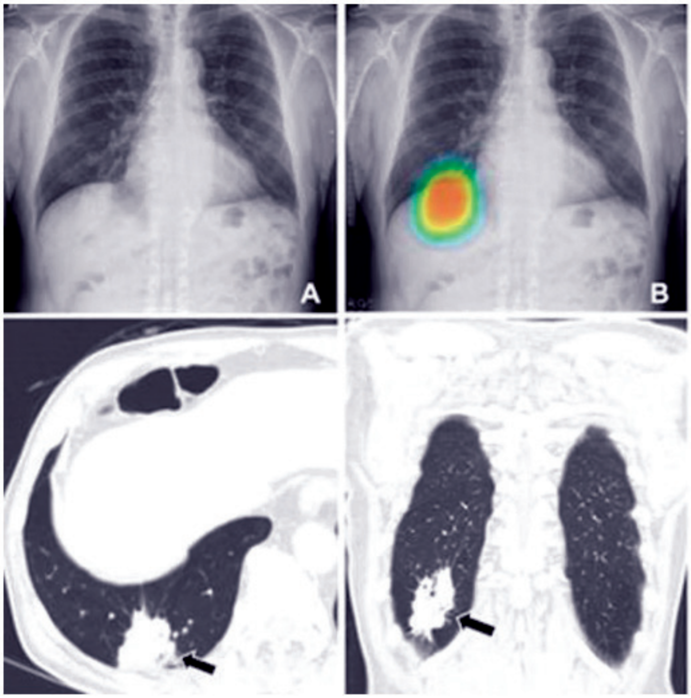
The TBGA has a high lesion identification rate (96.35%), which aided the development of a lung nodule detection product. AI-based lung nodule detection was tested on phantom and clinical instances. Currently, this lung nodule detecting system has been approved by China Food and Drug. Su et al.51 introduced a Faster R-CNN algorithm for detecting lung nodules, which was derived from a standard CNN-based target detection method. The upgraded and optimized Faster R-CNN network detection accuracy achieved 91.2%, outperforming other standard techniques.

Depending on the classification task set to the computer, AI is used to investigate differential diagnosis, histologic categorization of lung cancer, adenocarcinoma subtype (ADC), gene mutation prediction, lymph node metastasis, and prognosis. Several deep learning techniques are utilized to predict the qualities of lung nodules.Xu et al introduced a novel deep learning method named MSCS-Deep LN, which stands for multi-scale cost-sensitive neural networks for lung nodules. MSCS-DeepLN assessed lung nodule malignancy while also addressing the issue of small datasets and category imbalance. A multi-resolution 3D multi-classification deep learning model (Mr-Mc) and a multilayer perceptron machine learning model were constructed for diagnosing multiple pathologic types of pulmonary nodules based on the LIDC-IDRI dataset containing 3D CT images and serum biomarkers.

Radiomics still has some drawbacks. Accurate preoperative assessment of the degree of invasiveness is critical for predicting the prognosis of GGNs and guiding appropriate surgical treatment. Radiomics could extract a huge number of hidden consuming operations.

Accurate preoperative Pneumonia is another popular topic in thoracic artificial intelligence research. A number of COVID-19 investigations have been conducted for segmentation, diagnosis, quantification, severity assessment, and prediction of progression. Wang et al.65 created a fully autonomous deep learning system for COVID-19 diagnosis with an AUC of 0.87 and were successful in classifying patients into high- and low-risk categories. COPD is a multifaceted illness that begins with the remodeling of small airways and small arteries, progressing to the destruction of lung parenchyma and the development of emphysema. The present AI research for COPD is focused on: imaging biomarkers in high risk COPD populations, screening COPD, severity evaluation, and forecasting the progression of the disease.

AI improve lung detection on chest radiography



AI in thoracic MRI

Lung MR is uncommon due to the low spin density of the lung parenchyma. However, MR may give extra functional information. Pulmonary functional MR uses hyperpolarized 129Xe to examine perfusion, ventilation, and pulmonary microstructure in patients with pulmonary embolisms, lung cancer, COPD, and healthy volunteers. Many animal tests have been conducted to assess lung ventilation in a COPD rat model71, as well as other animal models of pulmonary injury.

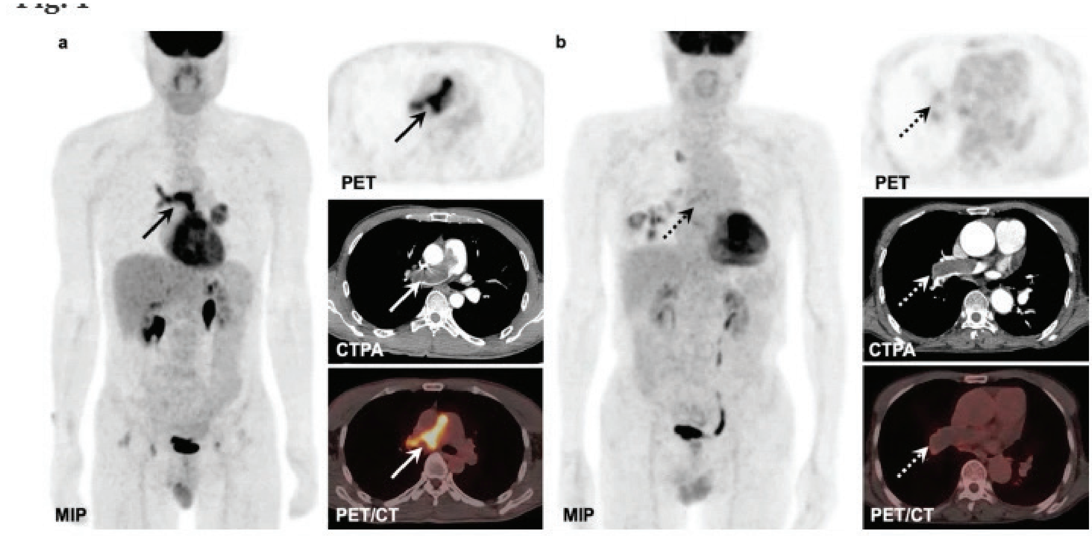
AI in thoracic PET/CT

PET/CT could collect functional metabolic and anatomical data at the same time. PET/CT-based artificial intelligence has been used to differentiate lung cancer, classify subtypes, identify gene mutations, detect lymph node metastases, segment tumors, and assess outcomes. Yang et al77 created and validated a radiomics nomogram that combines radiomic characteristics collected from 18F-fluorodeoxyglucose PET/CT images with clinicopathologic parameters to assess overall survival (OS) in NSCLC patients. They discovered that the rad-score combined with the clinical model had the best C-index for the survival result (0.776 and 0.789 for the training and validation cohorts, respectively), providing viable and practical guidelines for individualized therapy of patients with NSCLC.

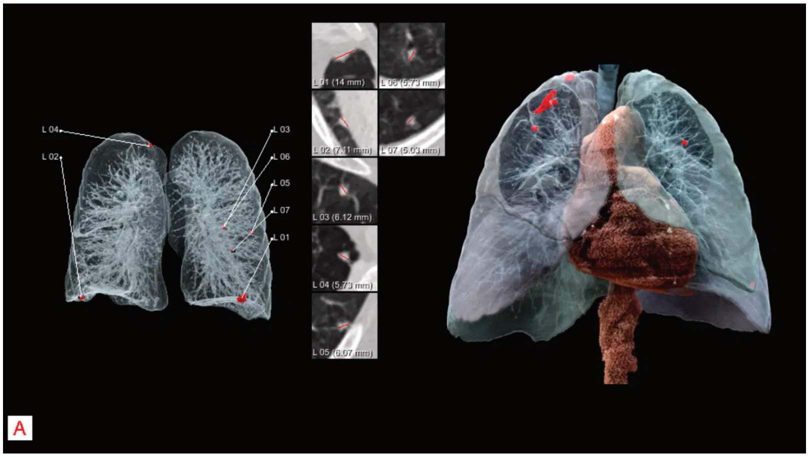
Li et al78 developed a deep learning-based method to automatically fuse multimodality information for tumor segmentation in PET/CT. The method performed well even for tumors with FDG uptake in homogeneity, blurred edges, and complex surrounding soft tissues, with an average dice similarity index of 0.86±0.05, sensitivity of 0.86±0.07, positive predictive value of 0.87±0.10, volume error.

Conclusion

Chest radiography has become more commonly used in clinical diagnosis. CT scans are frequently utilized in quantitative imaging to evaluate pulmonary nodules, lung density, airways, and arteries. With the emergence of dual-energy CT (DECT) and functional MRI, more functional information may be collected to assess various lung disorders. For the primary diagnosis of thorax X-rays are used to screen the lungs for diseases such as T.B. FIBROSIS, pneumonia, and so on. Later, CT and MRI were developed, and new advancements in



a PAS in a 52-year-old man involving PT and RPA (solid arrows) with intense FDG uptake (SUVmax: 10.7) on the MIP, axial PET, and fused PET/CT images, and filling defect on the CTPA image. **b** PTE in a 64-year-old man involving RPA (dotted arrows) with mild FDG uptake (SUVmax: 1.1) on the MIP, axial PET, and fused PET/CT images, and filling defect on the CTPA image technology and AI occurred. With this advancement, disease detection efficiency has increased, allowing diseases to be detected at an early stage and with a greater degree of severity. So, this will also contribute to therapeutic treatment at an early stage after determining the severity of the ailment.. PET/CT combines PET's functional imaging with CT's anatomic imaging and is primarily used to differentiate lung nodules, stage TNM, and evaluate treatment options. the initial step in assessing radiomics and AI performance is the detection of lung nodules. Effective segmentation of a lung nodule is a vital step in furthering radiomics and AI research, especially for ground glass nodules due to their low contrast. TBGA has a high lesion identification rate (96.35%), which helped to develop a product for detecting lung nodules. AI-based lung nodule detection was tested on phantoms and clinical cases. MRI may provide additional functional information. Hyperpolarized 129Xe is used in pulmonary functional MRI to investigate perfusion, ventilation, and pulmonary microstructure in patients with pulmonary emboli, lung cancer, COPD, and healthy volunteers. MRI may provide additional functional information. Hyperpolarized 129Xe is used in pulmonary functional MRI to investigate perfusion, ventilation, and pulmonary microstructure in patients with pulmonary emboli, lung cancer, COPD, and healthy volunteers. PET/CT-based artificial intelligence has been used to differentiate lung cancer, classify subtypes, identify gene mutations, detect lymph node metastases, segment tumors, and assess outcomes.



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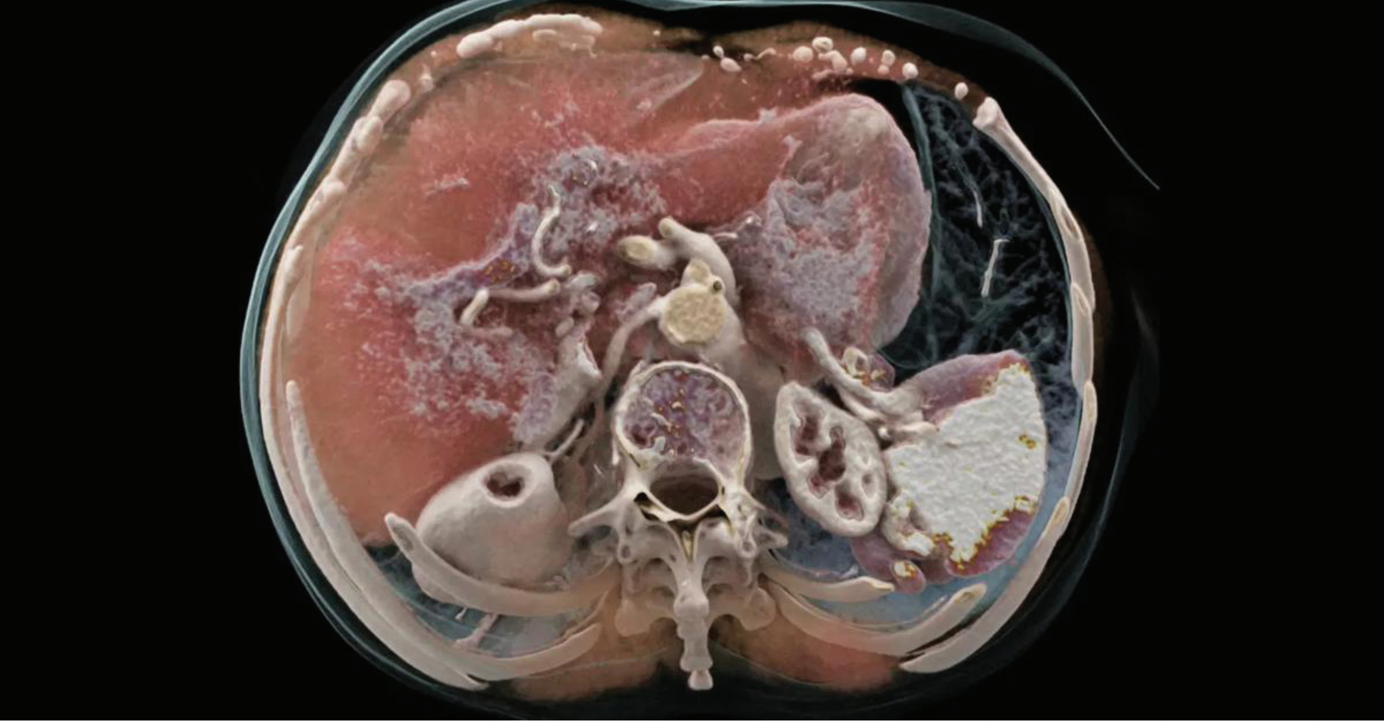

Photon counting CT: Revolutionizing diagnostic imaging

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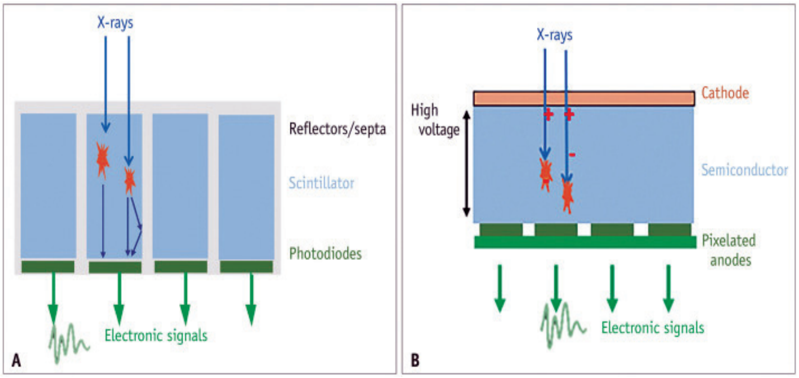
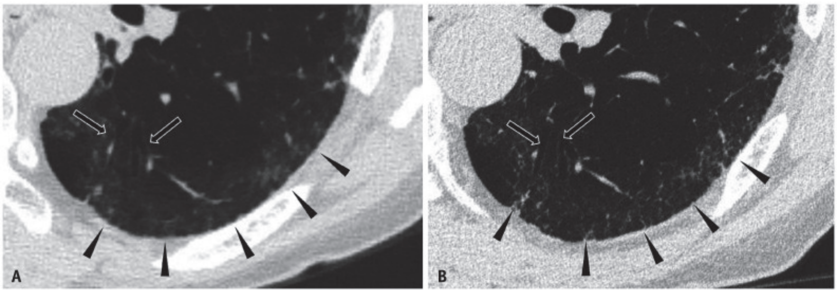
Photon counting computed tomography (PCCT) is an innovative imaging technology that has garnered significant attention in the field of diagnostic radiology. Unlike traditional computed tomography (CT) systems, which use energy-integrating detectors, PCCT employs photon-counting detectors (PCDs) to acquire high-resolution images with enhanced diagnostic capabilities. This article aims to explore the principles, advantages, challenges, and emerging applications of photon counting CT in medical imaging.

Principles of photon counting CT

PCCT operates on the principle of photon counting, wherein individual X-ray photons are de-



A. EIDs use a scintillator to generate visible light when an incident X-ray photon hits them, then the light is recorded by a photodiode with reflective septa in between detector elements to reduce crosstalk.
B. While PCD-CT uses a semiconductor to directly generate positive and negative charges, with negative charges going to pixelated anodes to record each individual photon and its energy.
EID = energy integrating detector, PCD = photon-counting detector



A 74-year-old male clinically diagnosed with idiopathic non-specific interstitial pneumonia was scanned on conventional energy-integrating detector CT (A) and investigational PCD-CT (B) using a clinical routine protocol.

tected and counted based on their energy levels. PCDs consist of semiconductor materials such as silicon or cadmium telluride, which can accurately measure the energy of incoming photons. By discriminating photon energies, PCCT systems can perform spectral imaging, material decomposition, and multi-energy CT acquisitions, providing valuable information about tissue composition and contrast enhancement.

Advantages of Photon Counting CT

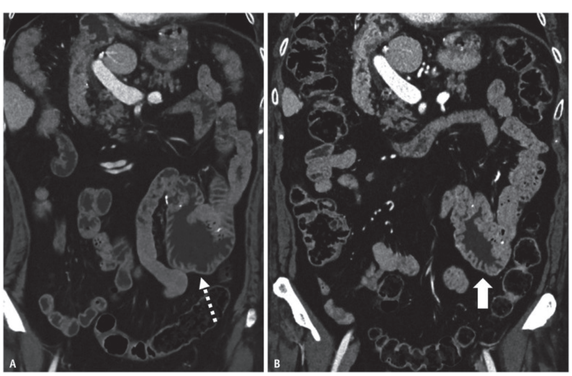
1. Improved Spatial Resolution: PCDs have smaller pixel sizes and higher spatial resolution compared to energy-integrating detectors, enabling detailed visualization of anatomical structures and small lesions.

A, B. PCD-CT demonstrates fine reticulations (arrowheads, B) in the right subpleural right lower lobe, compared to conventional CT, which appears to show ground glass opacities in this region (arrowheads, A). PCD-CT displays traction bronchiectasis more sharply than conventional CT (arrows). PCD = photon-counting detector.

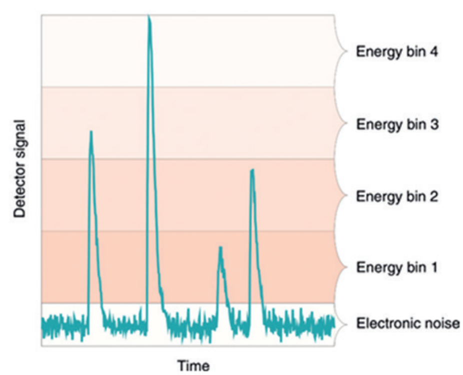
2. Enhanced Contrast Resolution: Spectral imaging capabilities allow for better tissue characterization and contrast enhancement, leading to improved diagnostic accuracy.

A, B. Both studies were taken at a tube voltage of 120 kV. Coronal energy integrating detector-CT (A) shows the jejunojejunostomy (dashed arrow) but photon-counting detector-CT (B) improves the visualization of the contrast and the sharpness of the folds in the jejunojejunostomy (arrow).

3. Dose Efficiency: PCCT systems can achieve dose reductions while maintaining image quality, making them suitable for pediatric imaging and dose-sensitive applications.

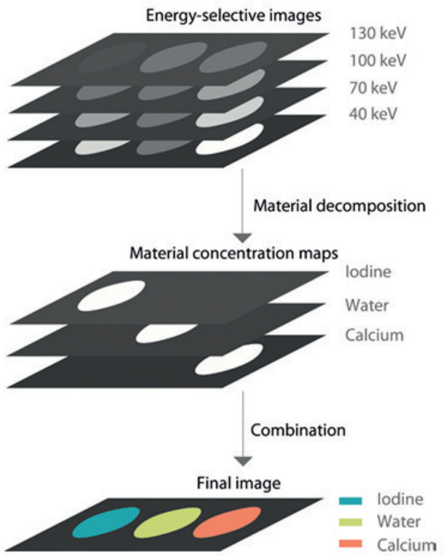


A 70-year-old female with a history of resected intrahepatic cholangiocarcinoma, gastric bypass, and a side-to-side jejunojejunostomy.

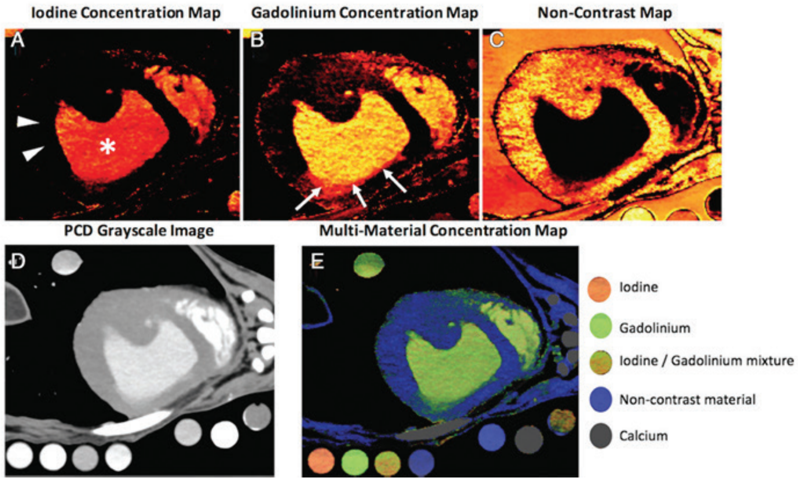


The diagram illustrates the operating principle of a photon counting detector. Each registered photon gives rise to an electrical pulse in the detector readout electronics, with the height of each pulse proportional to the individual photon energy. The detector counts the number of pulses with a height larger than a preset threshold, thereby eliminating electronic noise. By setting more than one threshold, the registered photons can be sorted into several energy bins based on their energy range.

4. Artifact Reduction: Photon-counting technology mitigates beam-hardening artifacts and scatter artifacts, resulting in clearer images with reduced artifacts.



5. Material Decomposition: PCCT enables material decomposition techniques such as virtual non-contrast imaging and iodine mapping, facilitating quantitative analysis of tissue composition. Material decomposition. Energy-selective images are generated from the number of registered counts in each energy bin. From these images, a set of material concentration maps is generated through a data-processing method known as material decomposition. Material concentration maps can then be combined in different ways to form the final image that is shown to the radiologist. This image can, for example, be a color-coded map showing different materials, a virtual monochromatic image, or a virtual non contrast image. Sample results of multi k-edge material decomposition of photon-counting detector (PCD) CT images of canine heart. A, Iodine concentration, B, gadolinium concentration, and, C, non-contrast maps. The iodine material map shows first-pass enhancement of blood pool, whereas gadolinium map shows late enhancement of subendocardial scar tissue (arrows). D, Conventional single-energy image with PCDCT. E, Multi material concentration map obtained by combining the material maps shows that differentiation between infarcted myocardium (arrows in B), remote myocardium (arrowheads in A), and left ventricle blood pool (in A) is possible with high contrast-to-noise ratio compared with conventional single-energy image.

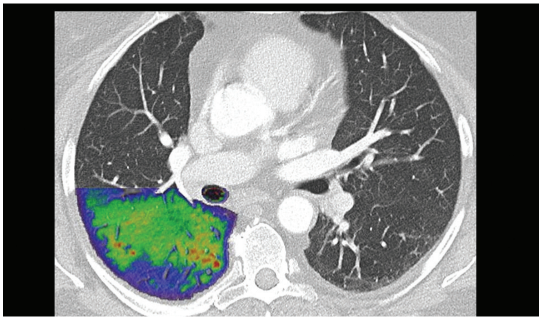


Challenges and limitations

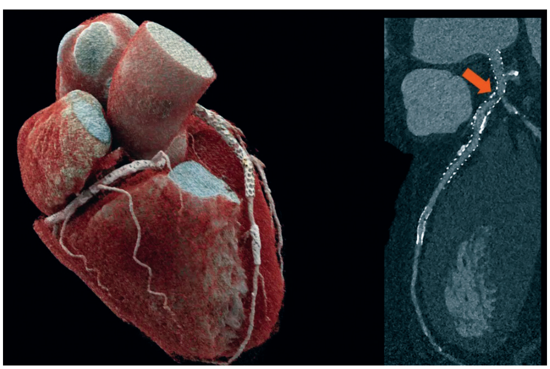
1. Technological Complexity: Implementing photon counting technology requires sophisticated hardware and software solutions, which may increase system complexity and cost.
2. Image Reconstruction: Image reconstruction algorithms for PCCT need to account for photon statistics, energy calibration, and spectral artifacts, posing challenges in algorithm development and optimization.
3. Clinical Validation: Further clinical studies and validation are needed to demonstrate the clinical utility and diagnostic accuracy of PCCT in various medical applications.
4. Radiation Safety: Although PCCT offers dose reduction capabilities, radiation safety remains a concern, particularly in pediatric and high-risk populations.

Emerging applications

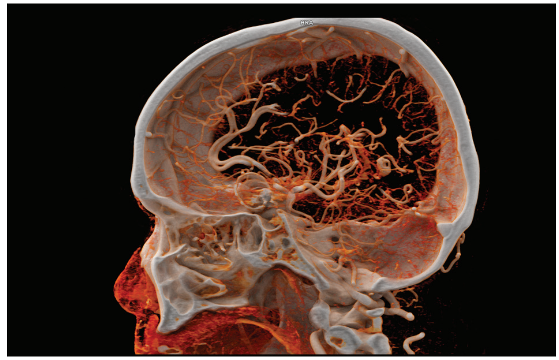
1. Oncology: PCCT enables precise tumor characterization, assessment of tumor vascularity, and monitoring of treatment response in oncology patients.



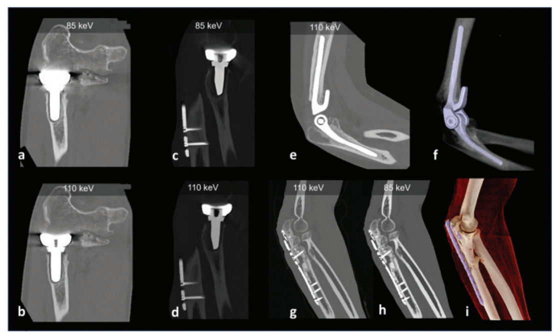
2. Cardiovascular Imaging: PCCT provides detailed visualization of cardiac anatomy, coronary arteries, and myocardial perfusion, offering valuable insights into cardiovascular diseases.



3. Neuroimaging: PCCT facilitates improved visualization of brain structures, vascular lesions, and intracranial hemorrhages, aiding in the diagnosis and management of neurological disorders.



4. Musculoskeletal Imaging: PCCT allows for accurate assessment of bone density, joint pathology, and soft tissue injuries in musculoskeletal imaging.



Conclusion

Photon counting CT represents a groundbreaking advancement in diagnostic imaging technology, offering enhanced spatial resolution, contrast resolution, and dose efficiency compared to conventional CT systems. While challenges such as technological complexity and clinical validation exist, the potential clinical benefits of PCCT are significant, paving the way for its integration into routine clinical practice and improving patient care in various medical specialties. Continued research and development in photon counting CT technology are essential to unlock its full potential and address existing limitations. ●

RAYAT BAHRA UNIVERSITY ICME - The Best among 2023

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With the approval of honourable chancellor sir Sd. Gurvinder Singh Bahra & guidance of worthy Vice Chancellor Prof. (Dr) Parvinder Singh the Department of Radiology & Imaging Technology, University School of Allied Health Sciences (USAHS), Rayat Bahra University organized an International conference on Medical Education (ICME) in collaboration with RAD-AID International (USA) and Association of Medical Radiology and Imaging Technologists, PGIMER, Chandigarh. ICME-2023 was a skill development and refresher course for the radiological technologists and stu-

dents of MRIT on the theme of Emerging Technology and Techniques in Mammography Imaging. The ICME-2023 that was held in the HYBRID mode (Online and Physical mode) on September 23, 2023, in the university's auditorium, Rayat Bahra University brought together experts, researchers, and practitioners in the field of mammography imaging.

Dr. Pankaj Kaul as Chairperson, Dr. Lalit Kumar Gupta served as the Organizing Chairperson, and Aditya Nagrath from PGIMER Chandigarh took on the role of Organizing Secretary The successful execution of this conference was made possible through the support and vision of Honourable Sardar Gurvinder Singh Bahra, the Chancellor and Chairman, Group of Bahra Universities and Hospital, and worthy Vice-Chancellor, Rayat Bahra University, Prof. (Dr.) Parvinder Singh. The Guest of Honor, Prof (Dr.) Ravinder Kaur from the Department of Radiodiagnosis at GMCH Chandigarh, and Dr. SS Gill, the Co-Patron, graced the occasion along with other distinguished guests present on the dais.

The program was streamed worldwide on the social platforms like Zoom and YouTube. Around 250 delegates physically attended and around 300 delegates joined online. The ICME event featured a series of Scientific Sessions, where experts and researchers presented their findings and insights on various aspects of mammography im-

aging. The scientific program was divided into 3 sessions with 2 speakers and 2 chairpersons in each session. Ms. Olive Peart, Program Manager, Mammography Technologists, RAD-AID (USA), Dr. Harnoor Singh, Faculty & Program Director RAD-AID, University of Texas (USA) Dr. Lalit Kumar Gupta, Associate Dean & HOD, Medical Radiology & Imaging Technology USAHS, Rayat Bahra University, and Miss Madhu Mammographer Technologists, PGIMER, Chandigarh were among the distinguished speakers who delivered scientific presentations based on their expertise in mammography imaging.

The event commenced with Miss Varshdeep Kaur, Assistant Professor of Radiology and Imaging Technology, and Mr. Shivam Angiras, Assistant Professor of Radiology and Imaging Technology at USAHS, leading the way. The conference featured an Inaugural Session, Scientific Sessions with presentations by experts, and a Valedictory Function, followed by cultural performances, Nati and Bhangra dances, and a delightful high tea and dinner.

Inaugural Session: The ICME event on Emerging Technology and Techniques in Mammography Imaging began with the Inaugural Session, marked by a sense of enthusiasm and anticipation. Event started with lamp lighting followed by Saraswati Vandana by students of Radiology, Rayat Bahra University and Dr. Harpreet Singh, Assistant Professor, USE Department. Good luck saplings were presented to all the dignitaries on the dais by the

students of Medical Radiology & Imaging Technology. Dr. Pankaj Kaul introduced the dignitaries sitting on the dais. Dr. Lalit Kumar Gupta, the Organizing Chairperson, extended a warm welcome cum Inaugural speech to the esteemed guests, speakers, and participants, setting the tone for the day's proceedings. Dr. SS Gill, Dean Medical Sciences, Rayat Bahra University and Ex-Vice Chancellor, Baba Farid University, gave a speech on the need for mammography and its importance in the rural and the urban areas. The Guest of Honor, Prof. (Dr) Ravinder Kaur, shared valuable insights into the evolving landscape of radiodiagnosis and mammography imaging, emphasizing the need for continuous learning and adaptation in healthcare. Dr. Parvinder Singh, the Vice-Chancellor of RBU, delivered an inspiring address highlighting the importance of advancements in mammography imaging specially in Ultrasound and the role of educational institutions in fostering innovation in the field. The dignitaries on the dais were presented mementos as a token of gratitude and regards.

The scientific program was divided into 3 sessions with 2 speakers and 2 chairpersons in each session. Ms. Olive Peart, Dr. Harnoor Singh, Dr. Lalit Kumar Gupta, and Miss Madhu were among the distinguished speakers who delivered scientific presentations based on their expertise in mammography imaging. These presentations enriched the knowledge-sharing atmosphere of the event and provided attendees with valuable insights to enhance their practices.

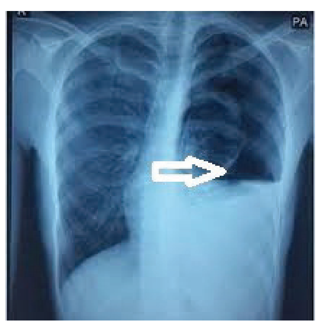
Associations such as ISRT (Indian Society of Radiographers and Technologists), RAD-AID International, and the Association of Radiology Imaging Technologists were honoured with mementoes in recognition of their efforts to advance medical imaging practices.

The associated companies in the field of drugs and chemicals were also awarded for their contributions to healthcare and research. The Valedictory Function marked the formal conclusion of the academic aspect of the event. ●

QUIZ 93

Compiled by : **Prasad P P**

1. Accumulation of septic inflammatory effusion within the pleural cavity is termed as?
2. The tendency to limit the emission of electrons from the cathode filament of X-ray tube is known as?
3. The most common site of avascular necrosis is?
4. Which radiological investigation is considered as the gold standard for detection and evaluation of AVM?
5. The loss of voluntary function of both lower limbs is known as?
6. The contrast washout of more than 60% in the 15min delayed image of an adrenal CT study is suggestive of?
7. In MRI safety aspects, in which zone the magnet is situated?
8. The procedure done to block a blood vessel to stop bleeding or blood flow to an abnormal tissue is known as?
9. In which imaging modality 'comet -tail artifact' is seen?
10. The percentage by which the radiation dose is reduced by a lead apron having a lead equivalence of 0.25mm is?
11. Which reconstruction technique is commonly employed in CT scanners?
12. Which law implies that the radiosensitivity of a biological tissue is directly proportional to the mitotic activity and inversely proportional to the degree of differentiation of its cells?
13. Name the technique used in MRI for perfusion study without injecting contrast media?
14. What is the required flow rate of contrast media injection for hepatic protocol in CT?
15. Name the diagnosis?



Please mail your answers and contact number to **alaraquiz@isrt.org.in** before **15th March 2024**, The subject of mail should be given as **ALARA Q-93**

Answer Key Q-92

1. 37.4Kev
2. Broca's area
3. Clinical and Planning
4. Epistaxis
5. Intermittent injection port
6. Nasopharynx
7. MRI
8. Spectral CT
9. Maze wall
10. Standard uptake value (SUV)
11. Angina pectoris
12. Neonate
13. Adduction
14. Hysterosalpingography
15. Left atrium

Winner : Madhurima Prakash, Hoobly, Karnataka

RADIANCE

Russell H. Varian and Sigurd F. Varian brothers

Russell H. Varian and Sigurd F. Varianbrothers who, with William W. Hansen, invented the klystron radio tube, a powerful microwave generator.During the period 1935–39, Russell and his brother, Sigurd, a largely self-taught engineer and pilot, worked with William W. Hansen of Stanford to develop the klystron. Russell Varian and Hansen developed the theoretical basis of the klystron, a novel application of the principle of amplitude modulation to a beam of electrons. Sigurd Varian built the mechanism. The klystron tube was first used in radar detection and guidance systems and was later applied to electron accelerator technology. Russell Varian also invented a magnetometer that was used for the measurement of the Earth's magnetic field by the Vanguard satellite. In 1948 the brothers formed Varian Associates, a firm that produced microwave devices useful in the linear electron accelerator and in detectors of nuclear magnetic resonance.

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