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My health, my right

The World Health Organization had its birth on 7th April 1948. Formed as a United Nations agency to look after the healthcare concerns of the entire world without any discretion, regional, political, economical or otherwise. World Health Day is observed on 7th April to commemorate the founding day of WHO. Even though WHO is stretching its services far and wide to cater health and healthcare assistance to the entire world, the objective of health for all still remains an enigma owing to many reasons. Most of the countries still not considering access to basic healthcare as a right of an individual. Quality healthcare is still a dream, away from realization to many parts of the world. The theme for World Health Day 2024 is chosen as 'My health, my right in order to underscore the need for establishing constitutional backing so that every country is answerable to its citizens for the inadequacies in the healthcare. Let us hope for a better world with the best healthcare, for health is more than wealth.

Editor in Charge

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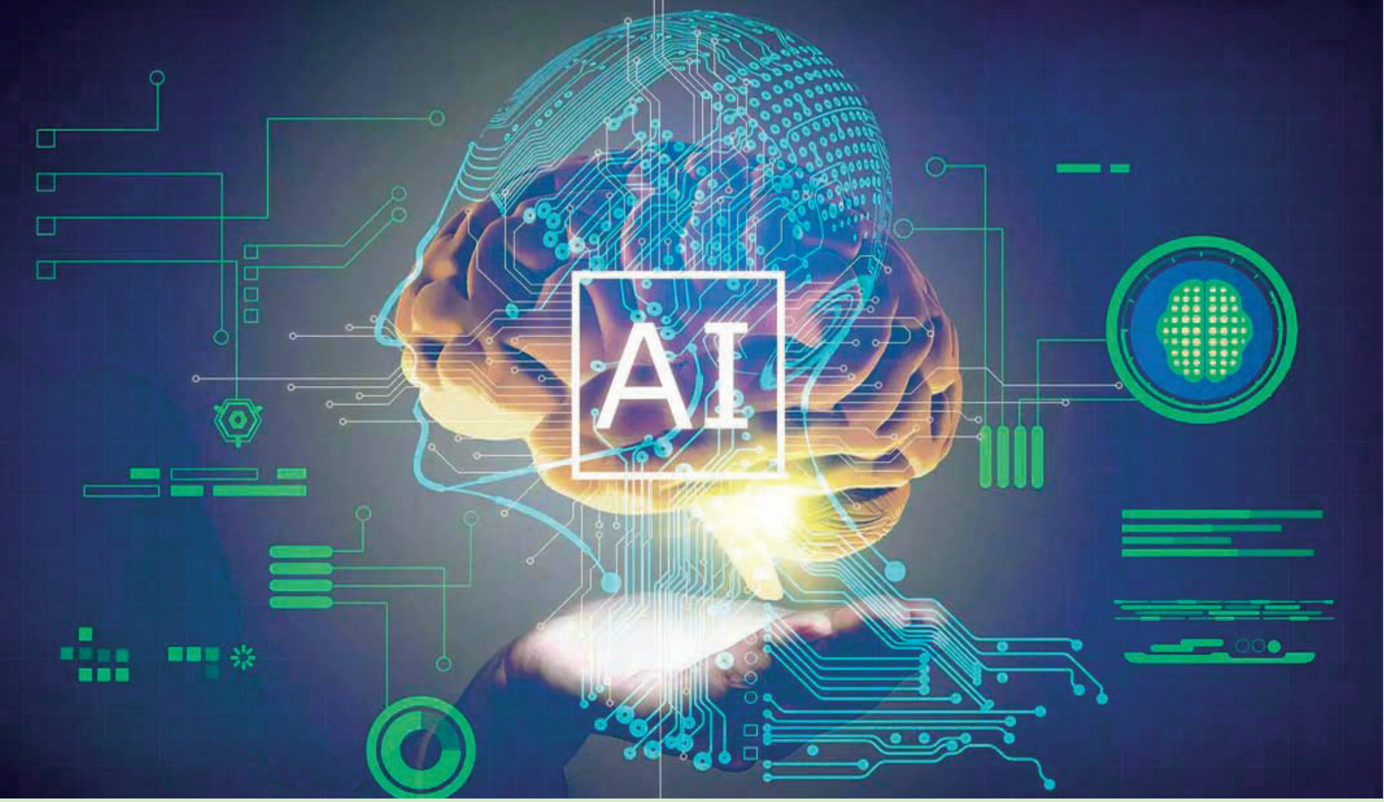

Importance of Artificial Intelligence in Nuclear Medicine Physics and Imaging

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The term AI was coined in 1955 to broadly describe the use of computer algorithms to perform tasks associated with human intelligence, such as learning or problem solving. In recent years, AI has become increasingly prevalent in radiology, driven in part by the fact that since 2015, visual recognition using AI has had a lower error rate than that of humans. This has been made possible by the rapid progress in AI technology, which has been enabled by increasing computational power, novel algorithms, and available data. The healthcare industry has not been immune to these advances, with a growing amount of data being generated by novel imaging procedures and diagnostic imaging procedures, enabling opportunities for personalized and precision medicine. However, this wealth of information is overwhelming for physicians, and sophisticated AI algorithms are needed to exploit it. Specifically in medical imaging, and lowering pipeline, from improving image quality to increasing acquisition speed and particularly in Nuclear Medicine image (NMI), AI can be used to improving image quality to increasing acquisition speed and lowering costs during image acquisition and reconstruction. Additionally, AI can be utilized for image denoising, and registration, and translation between different modalities. Finally, many AI applications for medical image analysis are being developed, including abnormality detection, segmentation, and computer aided diagnosis.

Terminology

This section presents several definitions of machine, specifically in positron emission tomography (PET) and single-photon emission computed tomography (SPECT) imaging, which will be discussed in upcoming sections. Machine learning, being a subset of AI, is not a single algorithm but rather analyzes a set of training data to build a model that carries associations between the variables that are important for a specific outcome. Data extraction and filtration typ-ically require handcrafted features, requiring more human involvement. Regarding the subsets of ML, the first and most crucial is deep learning (DL). In DL, the model may accept raw data, such as images, rather than summary features that rely on human interaction. The human intervention in DL is far more limited in contrast to ML. Deep learning consists of three subfields: Artificial neural networks (ANN), convolutional neural networks (CNN) and generative adver-sarial networks (GAN). Artificial neural networks have linked nodes with weighted paths, where each node has parent nodes that it responds to, an activation function, a ring threshold, and an output value. Artificial neural networks and their communication are comparable to that of neurons. GAN consist of two networks, a generator and a discriminator, which play a zero-sum game to reduce the difference between fake and genuine inputs. Generators produce ficti-tious input data to reduce this difference, while the discriminator sorts the genuine and fake inputs to maximize efficiency. All of this information is simplified so that you may understand the hierarchy and chain of command better in figure 1. The availability of improved hardware, and the fact that ML is an effective tool for analyzing extracted features in radiomics have all led to increased usage of ML in recent years. The field of AI known as ML is utmost significance. For a very long time, traditional ML techniques like naive Bayes, support vector machines, and random forests were used extensively in the medical field. Artificial neural networks, GAN, and other DL technologies have advanced quickly in recent years and have occasionally outper-formed traditional ML. The use of DL in NM includes the diagnosis of disease using PET, SPECT, imaging physics using PET, SPECT, image reconstruction using (PET, SPECT) image denoising (PET, SPECT), image segmentation (PET, SPECT) and image classification (PET, SPECT). The aim of ML and its subsets is to achieve optimal replication while ensuring the best possible to the observed data, leading to improved predictive performance.

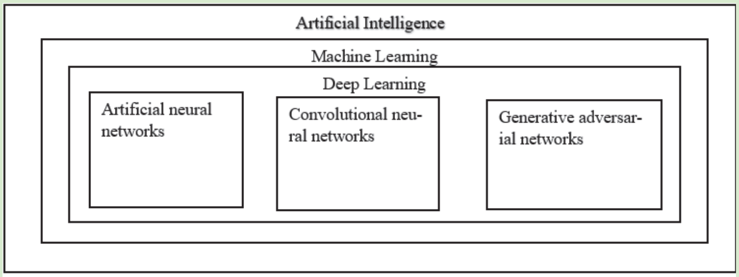


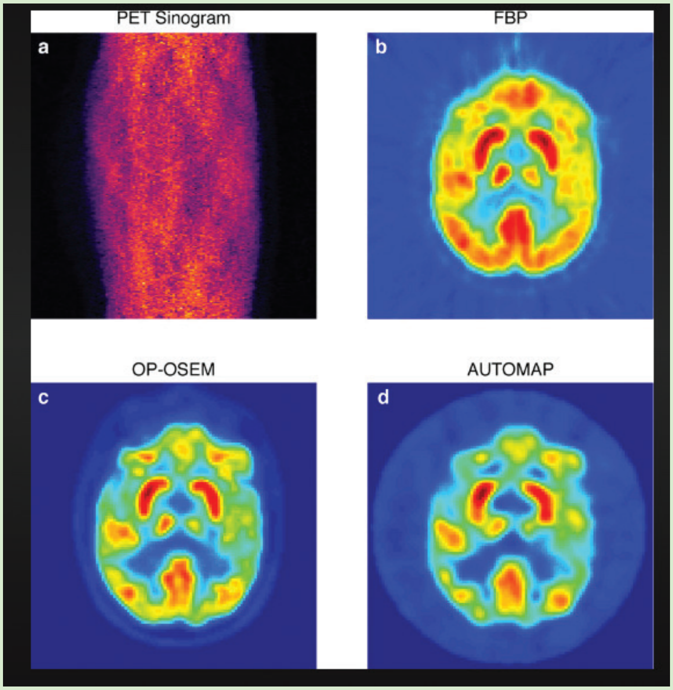
Figure 1. AI subfields

Imaging physics Data correction

This section provides a thorough analysis of the implementation of AI in imaging physics-data correction, particularly in the generation of attenuation maps, correction of scatter events, and detection of photon position. Attenuation maps and scatter correction are currently the focal point of intense research in nuclear medicine for PET and SPECT imaging, with several AI groups contributing to the field.

Attenuation correction (AC)

Obtaining high-resolution PET images is challenging due to photon attenuation, which is the loss of photon flux intensity through a medium. Attenuation correction (AC) is one method used to correct attenuation on an individual basis, which takes place during the data's image processing stage after it has been collected. The majority of suggested AC methods are based on the broader image-to-image translation field using DL, which is a general AI task. These advancements aim to eliminate the need for anatomical image data by directly producing AC images from non-AC PET data, to produce CT equivalent based AC maps from MR images in multimodality PET/MR, and to improve the attenuation maps produced by maximum likelihood reconstruction of activity and attenuation (MLAA) approaches. As a result, it was possible to create and refined continuously valued "pseudo-CT" images solely using the uncorrected 18F-FDG images that served as the basis for the attenuation map. Deep AC's output, an AC F-FDGimage, was found to be quantitatively accurate with typical errors under 1%. The SPECT images from the scatter window and photo peak window served as their inputs, and this method can successfully uncover any attenuation-related hidden information in the emission data. Cycle-consistency networks known as Cycle-GAN are a subset of GAN. A Cycle-GAN is composed of two mirror symmetric GAN and has been used for whole-body PET AC. GAN is re-ferred to as a specific type of GAN that aims to perform image translation when dealing with unpaired data, as is done for MRI-based PET attenuation correction. Residual encoder-decoder networks can produce attenuation and scatter-corrected PET images without the use of attenuation maps, starting from the non-corrected images.



Scatter correction (SC)

A gamma photon may experience Compton or Rayleigh scattering as it travels through a scintillation crystal before being absorbed in a different detector block or pixel through photoelectric absorption. These Compton scattered events are simple to observe for interactions between different crystals or pixels, but it is difficult to identify the first gamma interaction, which can degrade images in PET or SPECT due to incorrectly assigned LOR or counts. As a result, they are frequently thrown away, which reduces their sensitivity. When it comes to SC, the scatter sinograms could be created using the emission and attenuation raw data from PET or SPECT imaging, or they could be created directly using SC images (typically combined with AC) using non-corrected PET images as the network's input data. They then reconstructed PET images using reference and estimated scatter distributions for SC, using the model to forecast scatter estimates for the 14 remaining (validation) bed positions. The total scattering distribution (both single and multiple scattering) was directly derived from the emission and attenuation sinograms using the second network. In this instance, the network structure remained the same. As a training label, a scattering Monte Carlo simulation was used.

Photon position detection Depth of interaction (DOI) The lack of DOI decoding in PET can result in incorrect line-of-response (LOR) assignment for coincident non-perpendicular events, leading to lower accuracy in image reconstruction. As an alternative, a linear method based on scintillation light sharing through a common light guide on the front surface of the crystal was developed for continuous DOI estimation. Compared to the linear approach, the dense neural network and CNN performed similarly, but the accuracy improved by 12% to 26%. Analytically determining which single lies on the LOR under ideal conditions is frequently possible by considering the relationship between the scattering angle and energy deposit. The DL approach seeks

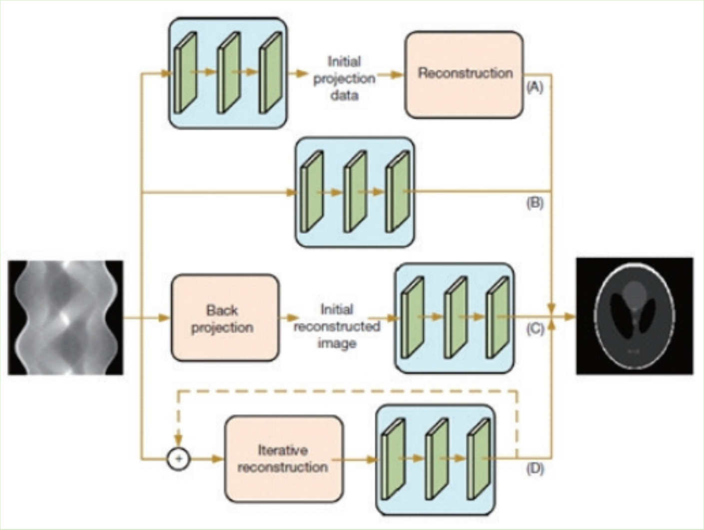


Figure 3. Image reconstruction technique for static nuclear medicine. (A) Artificial intelligence is used in the projection domain to obtain more continuous sinogram data or to complete sinogram data. (B) PET/SPECT images are produced directly from sinogram data using AI technology. (C) AI technology is used to create PET/SPECT image by directly enhancing the back-projection data. (D) Iterative reconstruc-tion methods mixed with AI technologies. SPECT stands for single photon emission computed tomography, and PET is for positron emission tomography.

to address these limitations by naturally accounting for them with realistic training data. Regarding PET detectors, their primary goal is to stop as many of the 511keV gamma rays as possible and produce output signals that can be detected, saved, and analyzed. Monolithic detectors are a distinct category of detectors that provide easier access to DOI data and are not limited by pixel size for spatial resolution. Early studies have demonstrated that neural networks can provide superior spatial resolution with good uniformity and can predict the location of the impinging object for oblique incidences without the need to correct for DOI. Later works added DOI as an additional output, enabling 3D positioning.

Time of flight (TOF)

The positron annihilation position can be determined more precisely along the LOR in time-of-flight (TOF) PET, which utilizes interaction timing data. By incorporating this data during image reconstruction, the qualityof the scan can be significantly improved. In order to predict the TOF difference between two detectors, the study utilized the outputs of two opposing detector pixels, which were digitalized using 100 ps binning and then stacked side by side. Since the crucial timing information is primarily present in the first few arriving scintillation photons, only the signals' brief rising edges were used. This method resulted in a 23% increase in timing resolution compared to constant fraction discrimination and a 20% increase compared to leading edge detection, demonstrating promising results.

Image reconstruction

Artificial intelligence technology can help address important reconstruction issues, such as the transformation between the sinogram and image domains or the displacement of regularization in conventional algorithms, it cannot provide a complete solution to the inverse problem. In direct reconstruction, training occurs between the raw data (represented by sinograms or projections) and the reconstructed images. Newer methods, such as using GAN that were originally proposed for image-to-image translation, make direct AI reconstruction computationally efficient after training is completed. A method for reconstructing images is observedin figure 2. This approach can avoid the inaccurate assumption modeling inherent in conventional methods. AUTOMAP suggests a generalized data-driven approach to inverse problems by learning a mapping from sensor domain to image domain data, which implicitly learns a low dimensional joint manifold of the data from both domains during training. The AUTOMAP authors emphasize that it applies to generalized reconstruction issues and also provide an analysis of PET data.

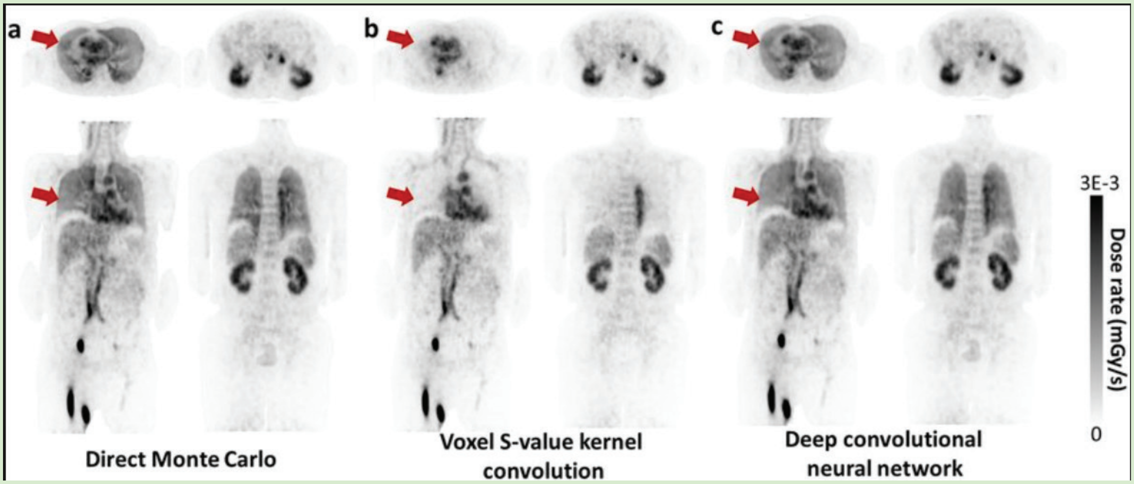


Figure 4. *Dose rate maps estimated by (a) Direct Monte Carlo, (b) VSV kernel convolution, and (c) Deep convolution neural network.*

Deep PET also demonstrated a decrease in computational cost for image reconstruction by pro-ducing images 3 and 108 times faster than the filtered back projection and OSEM methods,respectively. The MLP model was trained using 28 image patches that were reconstructed with the MAP algorithm. The MLP method was able to produce images with less noise than the MAP reconstruction algorithm, resulting in a smaller unachievable region. The reconstructed PET image from the 3U-Net model using PET/MR data had a better signal-to-noise ratio com-pared to those using PET input data alone or PET/MR in a 1U-Net model. Lastly, ResNet, a network architecture based on appending numerous residual blocks one after the other instead of using an encoder-decoder style network with symmetrical skip connections, has potential in image reconstruction. ResNet was modified and applied to denoising PET images.An extensive examination of the application of AI picture reconstruction is observed in figure [3].

Low dose imaging

The use of radioactive tracers in PET imaging has raised concerns due to the potential risk of developing cancer from high levels of radiation exposure. Therefore, it is preferred to lower the dose of radioactive tracer administered to patients in order to reduce radiation exposure. Especially in children and young adults undergoing repeated scans, dosimetry and dose reduction are an issue. A reduction in the use of radiotracers has been made in an effort to lessen this potential risk in PET imaging. Due to the inherent noise in low-dose PET images, it is challenging to derive qualitative and/or quantitative conclusions from the data. Low-dose PET image re-construction presents a challenging problem for iterative reconstruction algorithms due to its poor conditioning. In order to resolve this, effort have been made to create ML techniques that would permit PET/MR imaging with fewer radiotracers while maintaining the diagnostic quality of the image. The use of ML algorithms to tackle this problem simulates a low dose using a portion (roughly 1% to 25%) of PET data that was collected from a full-dose image. Using only the low-dosage data as input, the ML method then forecasts the images of a full dose(dose rate map is seenin figure 4).

DL technique is suggested that uses an encoder-decoder residual deep network with concatenate skip connections to solve this problem. The proposed method can produce better results than the state-of-the-art methods and reconstruct images with comparable quality using just 0.5% of the original regular dose, according to the analysis of ultra-low-dose clinical data. A comparison of this proposed method to state-of-the-art methods using validations on real PET/MRI data from the human brain demonstrates that it can provide competitive estimation quality of the PET images.

In GAN, a discriminator network and a generator network are simultaneously trained with the intention of outperforming the other. In the proposed 3D c-GAN, which are similar to GAN, the model is conditioned on an input low-dose PET image and produces a corresponding output full dose PET image. The training of an AI dosimetry prediction model also needs precise dose estimation.To replace Monte-Carlo simulation for voxel wise dosimetry estimation, DL techniques have been developed. To improve dosimetry estimation from SPECT or PET measurements, preliminary results show that these methods are computationally effective when taking into account individual tissue density distributions as well as the heterogeneity of the radiopharmaceutical concentration.The network structure for low dose imaging is widely shown in figure 5.

In conclusion, the implementation of AI in NM Physics and Imaging is now a reality, and its existing applications are sufficient to demonstrate its utilization, both theoretically and, more importantly, practically. While the full potential of AI in this field is not yet fully understood, the first steps towards realizing it have already been taken. Despite its imperfections, there is no denying that AI will undoubtedly play a significant role in the future of healthcare.

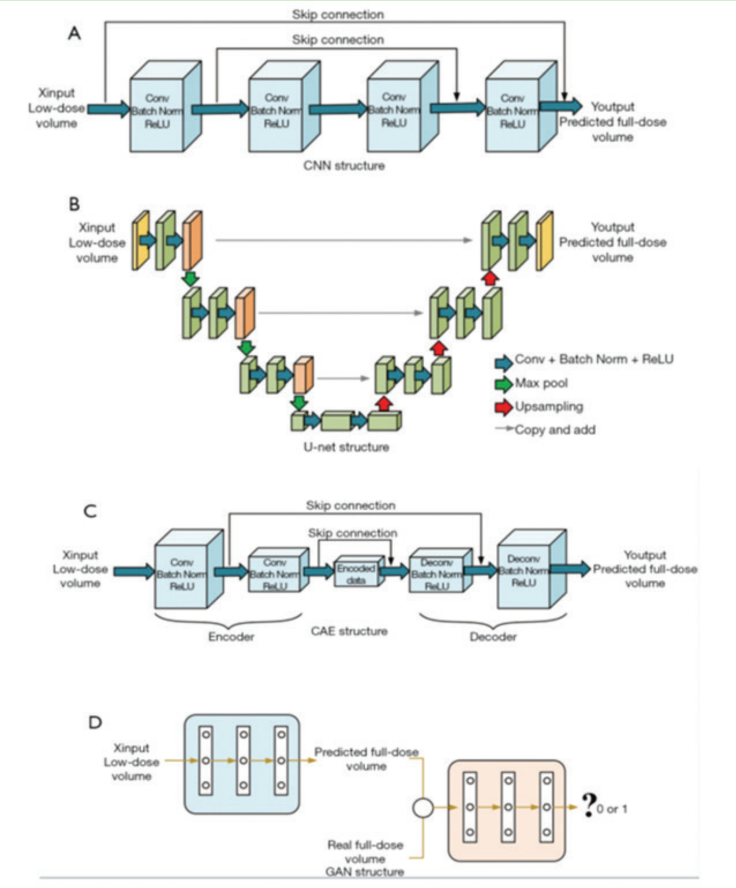


Figure 5. *Low -dose imaging network structure. (A) The CNN structure here was essentially a low -pass fil-ter, and the purpose of convolution was to extract useful from the input. (B) At each stage of the U-net, two overlapping convolutional layers are designed to provide a deeper network. (C) For CAE, to ensure that the network output was the same size, a special design of padding and stride is essential. (D) For GAN, the gener-ator network is used to create a full-dose image, and the discriminator network is used to distinguish predicted full-dose images and actual full-dose images. CNN, convolutional neural network; CAE, convolutional autoencoder; GAN, generative adversarial network.*

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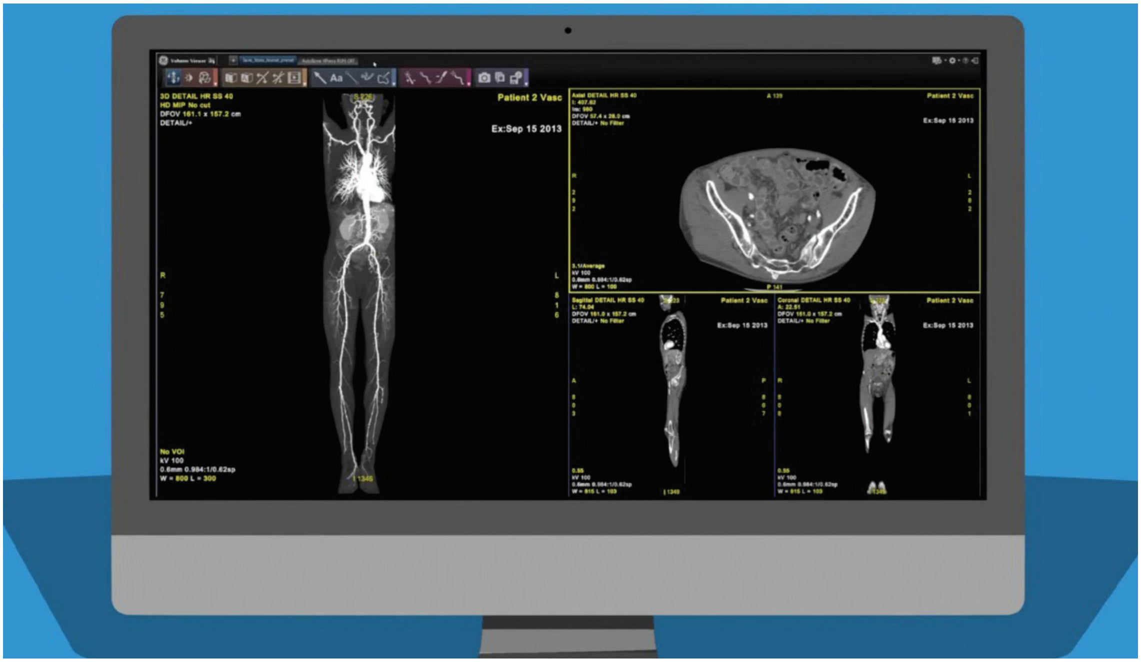

Emerging Trends in 3D Printing
APPLICATIONS FOR ANATOMICAL MODELS IN RADIOLOGY

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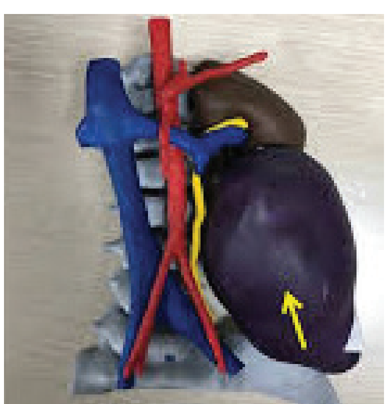
Three-dimensional (3D) printing technology has rapidly evolved and found versatile applications across various industries, including healthcare[1,2]. In radiology, 3D printing has gained significant attention for its potential to create anatomically accurate models from medical imaging data[3]. These models offer enhanced visualization, surgical planning, medical education, and patient communication. This review goes through the recent advancements and emerging trends in 3D printing applications for anatomical models in radiology, exploring its impact on clinical practice and medical training.



Aim: This review aims to explore the evolving landscape of 3D printing technology in creating anatomical models for radiological visualization, education, surgical planning, and patient communication.

Objectives:

- Investigate recent developments in 3D printing materials and techniques applicable to radiology.
- Analyze the applications of 3D-printed anatomical models in preoperative planning and surgical guidance.
- Examine the role of 3D printing in medical education and patient communication.
- Assess the benefits and limitations of 3D-printed models in radiology and clinical practice.
- Identify challenges and potential future directions for integrating 3D printing into routine radiological workflows.

FIGURE: 01 Historical development of radiology 3D Printing5,6.

Introduction:

Three-dimensional printing, also known as additive manufacturing, has emerged as a transformative technology with diverse applications. In the field of radiology, the translation of medical imaging data into physical 3D models has opened up new avenues for visualization and communication[4].

These models offer a tangible representation of complex anatomical structures, aiding medical professionals in surgical planning, medical education, and improving patient understanding.

Materials and Techniques:

Recent advancements in 3D printing materials have contributed to the accuracy and versatility of anatomical models. Materials such as biocompatible plastics, metals, ceramics, and even biomaterials can be used to replicate anatomical structures with high fidelity. Printing techniques, including fused deposition modeling (FDM), stereolithography (SLA), and selective laser sintering (SLS), enable the creation of intricate and detailed models.

Fused Deposition Modeling (FDM): In FDM, a thermoplastic filament is heated to its melting point and extruded through a nozzle. The material is deposited in a precise pattern, layer upon layer, to create the final object. FDM is known for its simplicity, affordability, and ease of use. It is commonly used for rapid prototyping, creating functional parts, and producing anatomical models in radiology due to its ability to produce solid structures with reasonable accuracy.

Stereolithography (SLA): Stereolithography (SLA) is an additive manufacturing process that uses a liquid photopolymer resin as the raw material. A laser or ultraviolet light source is used to selectively solidify the resin layer by layer. The build platform

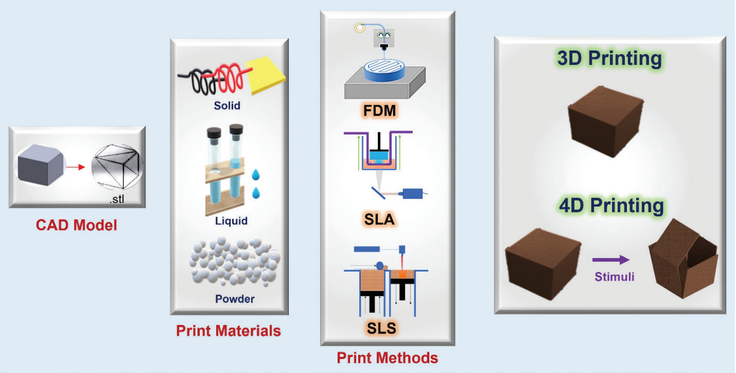


FIGURE: 02 Fused Deposition Modeling (FDM) is a popular additive manufacturing technique that involves the layer-by-layer deposition of material6.

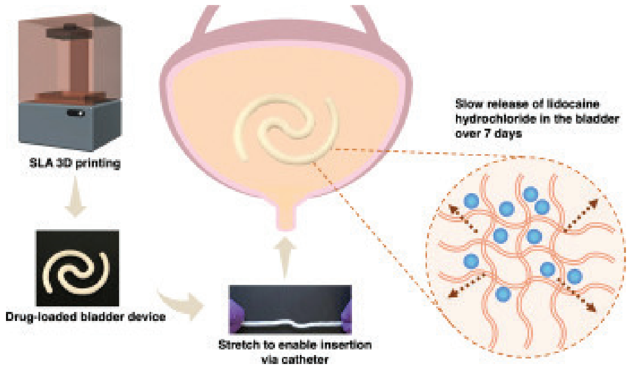


FIGURE: 03 Stereolithography (SLA) is an additive manufacturing process that uses a liquid photopolymer resin as the raw material7.

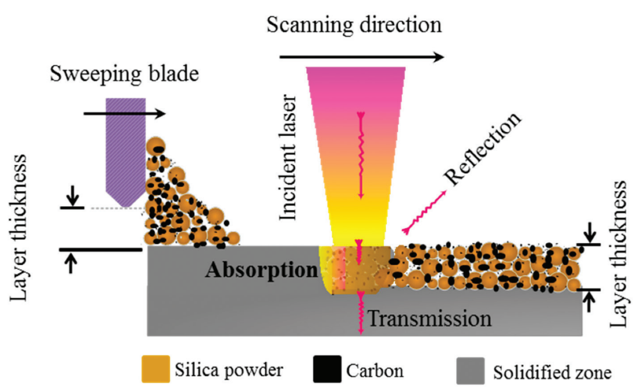


FIGURE: 04 Selective Laser Sintering (SLS) is a powder-based 3D printing technique commonly used with materials like nylon, metal, and ceramics8.

is lowered into the resin tank, and as each layer solidifies, the platform moves up to accommodate the next layer. SLA is known for its high level of detail and precision, making it suitable for creating intricate anatomical models with fine features. It is often used when high surface quality and fine resolution are crucial.

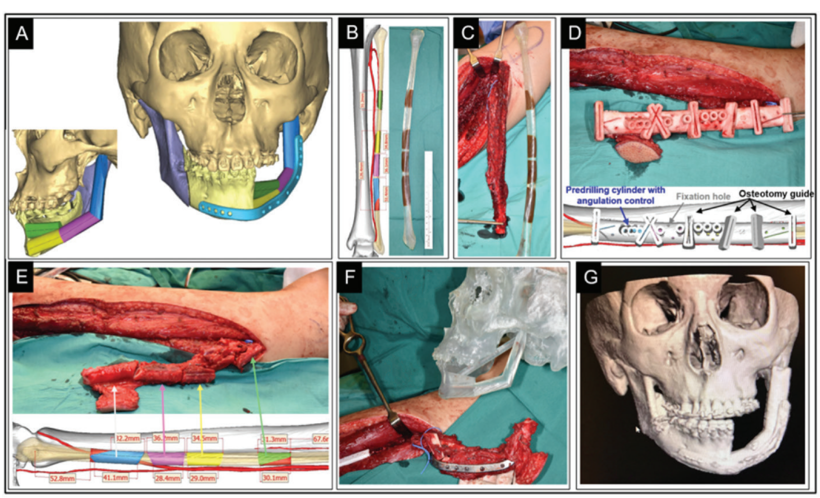
Selective Laser Sintering (SLS): *Selective Laser Sintering (SLS) is a powder-based 3D printing technique commonly used with materials like nylon, metal, and ceramics. In SLS, a high-powered laser selectively fuses or sinters powdered material particles together, layer by layer, to form a solid object. The unsintered powder acts as a support structure during printing, eliminating the need for additional supports. SLS is known for its ability to produce complex geometries and functional parts with good mechanical properties. It is suitable for creating durable and detailed anatomical models.*

Applications:

Surgical Planning: 3D-printed anatomical models enable surgeons to visualize complex cases and plan surgeries with enhanced precision. For example, in orthopedic surgeries, models aid in planning intricate procedures such as joint replacements or deformity corrections.

Medical Education: Anatomical models facilitate hands-on learning experiences for medical students and residents. They provide a tangible and interactive tool for understanding complex anatomical rela-

FIGURE: 05 Illustrates how 3D printing was used to help in reconstructing the jaw after removing a tumor. In the first picture (A), a computer plan for the new jaw is shown. The next picture (B) displays a computer model and a 3D-printed version of the leg bone (fibula) with sections for reconstruction marked. Picture (C) compares the 3D-printed model to the real patient's leg bone. In picture (D), a 3D-printed tool with guides for cutting the bone is seen. Picture (E) shows the patient's real bone alongside a computer model with labeled sections. In picture (F), the reconstructed bone is fixed with a metal plate before cutting the blood vessels. The last picture (G) is a CT scan of the patient three months after the surgery. This figure demonstrates how 3D printing can help in planning and performing complex surgeries9.



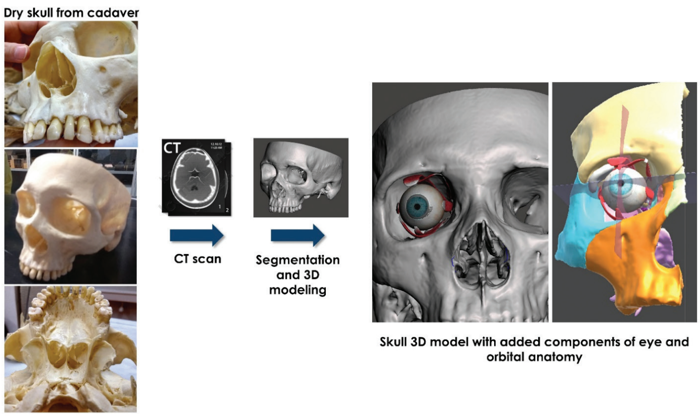


FIGURE: 06 A computer-made model of a skull from a CT scan of a body and the digital parts showing the eyes and facial bones that were added10.

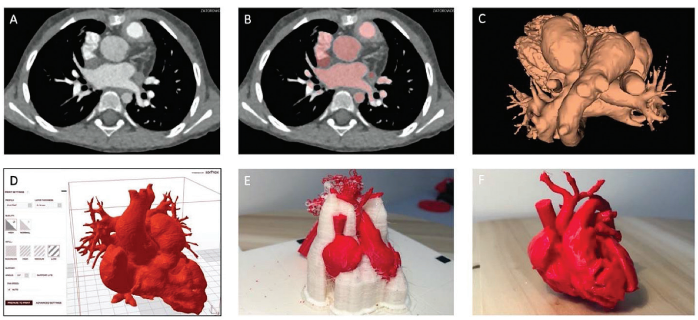


FIGURE: 07 3D printing works in different steps. In the first picture (A), the starting point is a CT scan. Then, in the second picture (B), the CT scan is highlighted in red after separating it. This is used to create a digital model (STL) shown in the third picture (C). In the fourth picture (D), the settings for printing are set up. The fifth picture (E) displays the actual print covered in supportive material. Finally, in the last picture (F), you can see the completed 3D-printed model. This figure illustrates the journey of making something using 3D printing11.

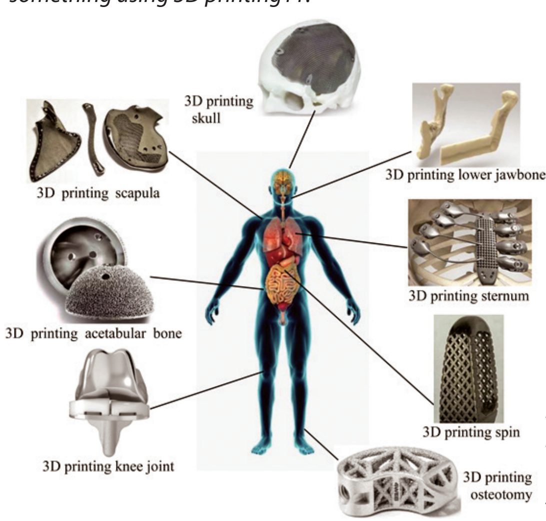


FIGURE: 08 Future prospective of radiology 3D printing12

tionships.

Patient Communication:3D-printed models empower patients to better comprehend their medical conditions and proposed treatments. This enhances patient engagement and informed decision-making.

Research and Innovation: Anatomical models support research endeavors, allowing researchers to simulate and study diseases, treatment outcomes, and novel medical devices.

Benefits and Challenges: While 3D printing offers numerous benefits, challenges include the need for standardized protocols for converting imaging data into printable files, optimizing printing parameters, and integrating 3D printing into existing clinical workflows. Regulatory considerations and the cost-effectiveness of 3D printing are also areas of concern.

Future Directions: The integration of artificial intelligence and machine learning in automating the segmentation of anatomical structures for 3D printing holds promise. Additionally, advancements in multi-material printing could further enhance the realism and functionality of printed models.

Conclusion:3D printing has emerged as a transformative technology in radiology, providing innovative solutions for surgical planning, medical education, and patient communication. As the technology continues to evolve, a collaboration between radiologists, surgeons, and engineers will be essential to fully realize the potential of 3D printing in enhancing patient care and medical training.

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Target Volume Definition & Concepts of Planning Target Volume Margin (PTV) In Radiotherapy

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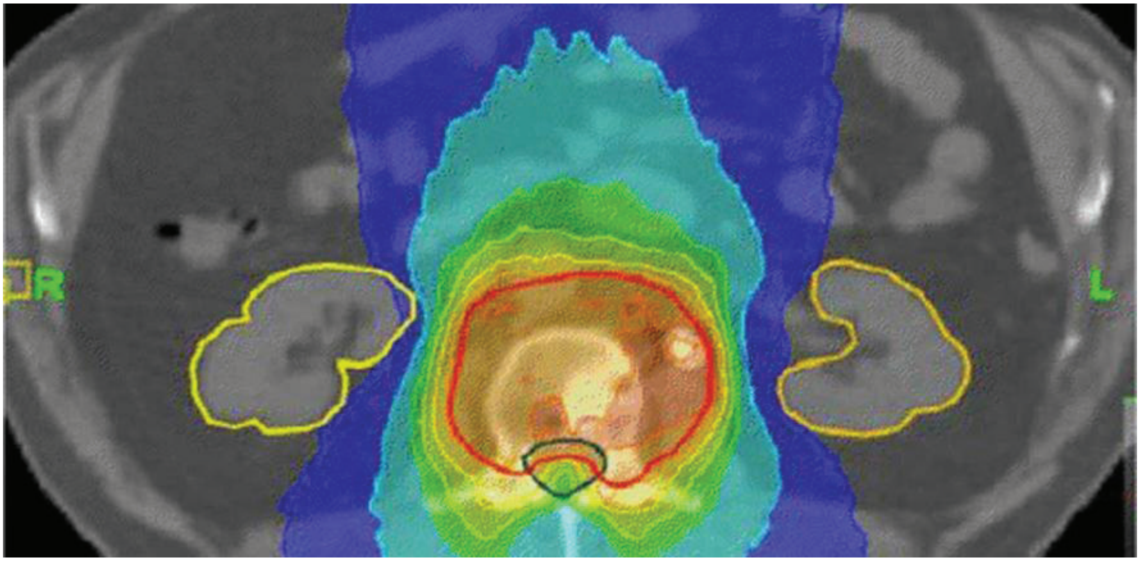


Target Volume delineation is very crucial for the Planning as well as the dose replication. Target Volume Definition and the concept of Planning Target Volume (PTV) are crucial aspects in ensuring accurate and effective treatment delivery while minimizing damage to surrounding healthy tissues. The Planning Target Volume is a concept in radiotherapy involving expanding the Clinical Target Volume to account for uncertainties in treatment setup, patient positioning, and the delivery of Radiation therapy.

The defined volumes are:

- Gross tumor volume or GTV
- Clinical target volume or CTV
- Planning target volume or PTV
- Organ at risk or OAR
- Planning organ-at-risk volume or PRV
- Internal target volume or ITV
- Treated volume or TV
- Remaining volume at risk or RVR

Gross tumor volume or GTV: The GTV is the gross demonstrable extent and location of the tumor. The GTV may consist of a primary tumour & metastatic regional nodes or distant metastasis. TV helps determine the target volume for

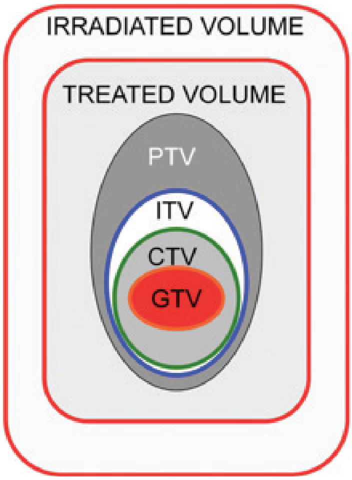


Fig-1 Radiotherapy Target Volumes

radiation treatment. Radiation oncologists use various imaging techniques, such as CT scans, MRI, or PET scans, to identify and outline the GTV. Typically, different GTVs are defined for the primary tumour and the regional node(s). However, in some clinical situations, it might well be that the metastatic node cannot be distinguished from the primary tumour.

Clinical target volume or CTV: The volume of tissue that needs to be irradiated to ensure that the entire tumour and any potential microscopic extensions are effectively treated. CTV includes the GTV and additional margins to encompass the potential spread of cancer cells. CTV contains a demonstrable GTV and/or subclinical malignant disease with a certain probability of occurrence considered relevant for therapy.

Planning target volume or PTV: The PTV is a geometrical concept introduced for treatment planning and evaluation. It is the recommended tool to shape absorbed dose distributions to ensure that the prescribed absorbed dose will be delivered to all parts of the CTV with a clinically acceptable probability, despite geometrical uncertainties such as organ motion and setup variations. TV represents the three-dimensional expansion of the Clinical Target Volume (CTV). The purpose of creating the PTV is to account for uncertainties in treatment setup, patient positioning, and the delivery of radiation therapy

Organ at risk or OAR: The OAR or critical normal structures are tissues that if irradiated could suffer significant morbidity and thus might influence the treatment planning or the absorbed-dose prescription. all non-target tissues could be OARs. However, normal tissues considered OARs typically depend on the location of the CTV and/or the prescribed absorbed dose.

Planning organ-at-risk volume or PRV: Uncertainties and variations in the position of the OAR during treatment must be considered to avoid serious complications. For this reason, margins have to be added to the OARs to compensate for these uncertainties and variations, using similar principles as for the PTV. This leads, in analogy with the PTV, to the concept of PRV.

Internal target volume or ITV: ITV was defined as the CTV plus a margin taking into account uncertainties in size, shape, and position of the CTV within the patient. Such a margin was called the internal margin as opposed to the set-up margin. In ICRU Report 62, it was recommended that internal and external margins be added quadratically, but often in practice, they are instead added linearly, which can lead to an unacceptably large margin. The ITV might be useful only in clinical situations in which uncertainty concerning the CTV location dominates setup

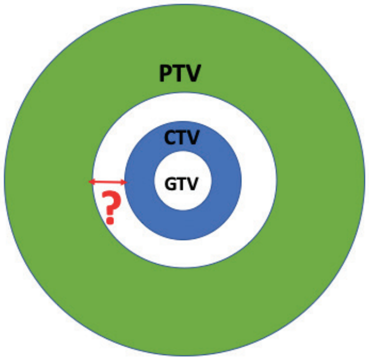
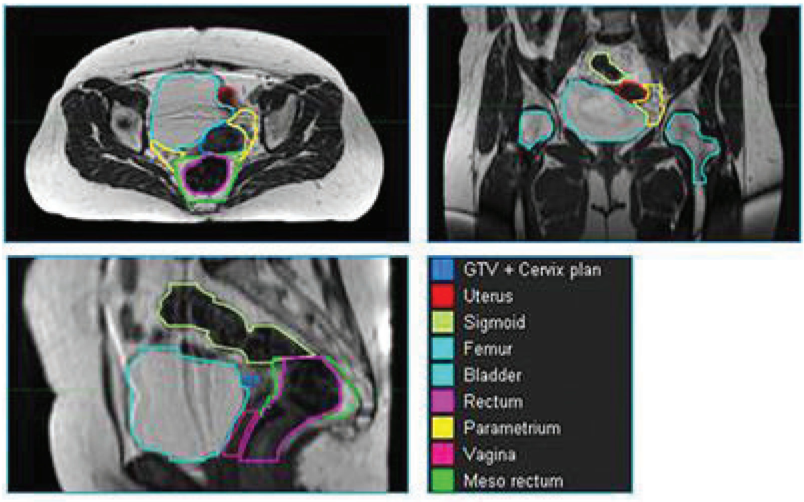


Fig-2 Concepts of PTV Margin



uncertainties and/or when they are independent.

Treated volume or TV: TV is the volume of tissue enclosed within a specific isodose envelope, with the absorbed dose specified by the radiation oncology team as appropriate to achieve tumor eradication or palliation, within the bounds of acceptable complications.

Remaining volume at risk or RVR: The imaged volume within the patient, excluding any delineated OAR and the CTV(s), should be identified as the RVR. The RVR is operationally defined by the difference between the volume enclosed by the external contour of the patient and that of the CTVs and OARs on the slices that have been imaged. The RVR is of importance in evaluating plans as it will be affected by the absorbed dose it receives and, if it is not specifically evaluated,

Concepts of PTV Margin

Margin for Setup Uncertainties: The PTV includes a margin to account for potential variations in patient setup and positioning. This margin helps ensure that the target receives the prescribed radiation dose even if the patient is not in the exact planned position during each treatment session.

Margin for Internal Organ Motion: Internal organs may move slightly during treatment due to factors such as breathing or digestive processes. The PTV margin also considers these internal organ motions, allowing for variations without compromising the treatment's effectiveness.

Margin for Machine and Treatment Delivery Uncertainties: Technical factors in treatment delivery, such as inaccuracies in radiation beam delivery, also contribute to uncertainties. The PTV margin helps compensate for these uncertainties, ensuring that the radiation dose adequately covers the target volume.

What Is PTV Margin: -

PTV encloses the CTV with anisotropic margins to account for possible uncertainties in beam alignment, patient positioning, organ motion and organ deformation. Ideally, the CTV-PTV margin should be determined solely by the magnitudes of the uncertainties involved. Clinician usually also considers doses to abutting healthy tissues when deciding on the size of the CTV-PTV margin.

The PTV concept has been used for more than two decades but is becoming obsolete as the CTV-to-PTV margin creates a static dose cloud that does not properly recapitulate all planning vs. delivery uncertainties. The robust optimization concept has recently emerged to overcome the limitations of the PTV concept. This concept is integrated in the inverse planning process and minimizes deviations to planned dose distribution through the integration of uncertainties in the planning objectives.

PTV is a geometrical concept, introduced for treatment planning and evaluation. It is the recommended tool to shape dose distributions that ensure with a clinically acceptable probability that an adequate dose will actually be delivered to all parts of the CTV & It includes "internal" and "external" variations of the CTV

Rationales	Radixact Tomotherapy	Cyberknife VSI
CTV-PTV Margin	5 mm	1 mm
Daily Pre-Treatment Imaging Modality	MVCT (3.5 MV)	2D Orthogonal X-ray Imaging
Frequency of Imaging	IGRT – Daily Imaging (MVCT) IMRT- Weekly thrice 3DCRT- Weekly Twice	Deals with Live kV-X-ray Intrafraction Imaging System. (5-150 sec)
Selection of Immobilization Devices	All site specific orfits & for Thoracic & Pelvis Cases Vaclok preferably used.	All anatomical Sites with Vaclok Immobilization except the Intracranial Lesions. (U – Frame Thermoplastic Mould)

Sample Protocol for generating PTV Margin

Separate delineation of the ITV is not necessary but motion should be included in the PTV

CTV to PTV margin recipe based on random and systematic errors and beam penumbra,

Priority rules when overlapping PTVs or PTV-PRV,

Dose is prescribed and reported on the PTV.

IMRT can result in hot and cold spots within the PTV.

Why Required Margins: -

The margins, in their simplest form, are simply expansions to the shape of a treatment beam, to ensure that dosimetric planning criteria are met in the presence of inter- and intra-fraction setup variations

The PTV allows for uncertainties in planning or treatment delivery and is designed to ensure that the radiotherapy dose is actually delivered to the CTV. PTV is a geometric concept designed to ensure adequate dose coverage to CTV.

How to Calculate PTV Margins: -

PTV is determined by adding margin to the CTV to account for internal target volume and patient motion, and the field margins are set to confirm the PTV with allowance for the RT beam penumbra and dose build-up effect. Additional sparing of adjoining healthy structures should be accomplished by modifying beam portals, rather than adjusting the PTV.

Systematic Error: Influences all fractions in an Identical way throughout the treatment.

Random Error: Influences fractions randomly

The van Hark formula:

(PTV margin =2.5Σ +0.7σ)

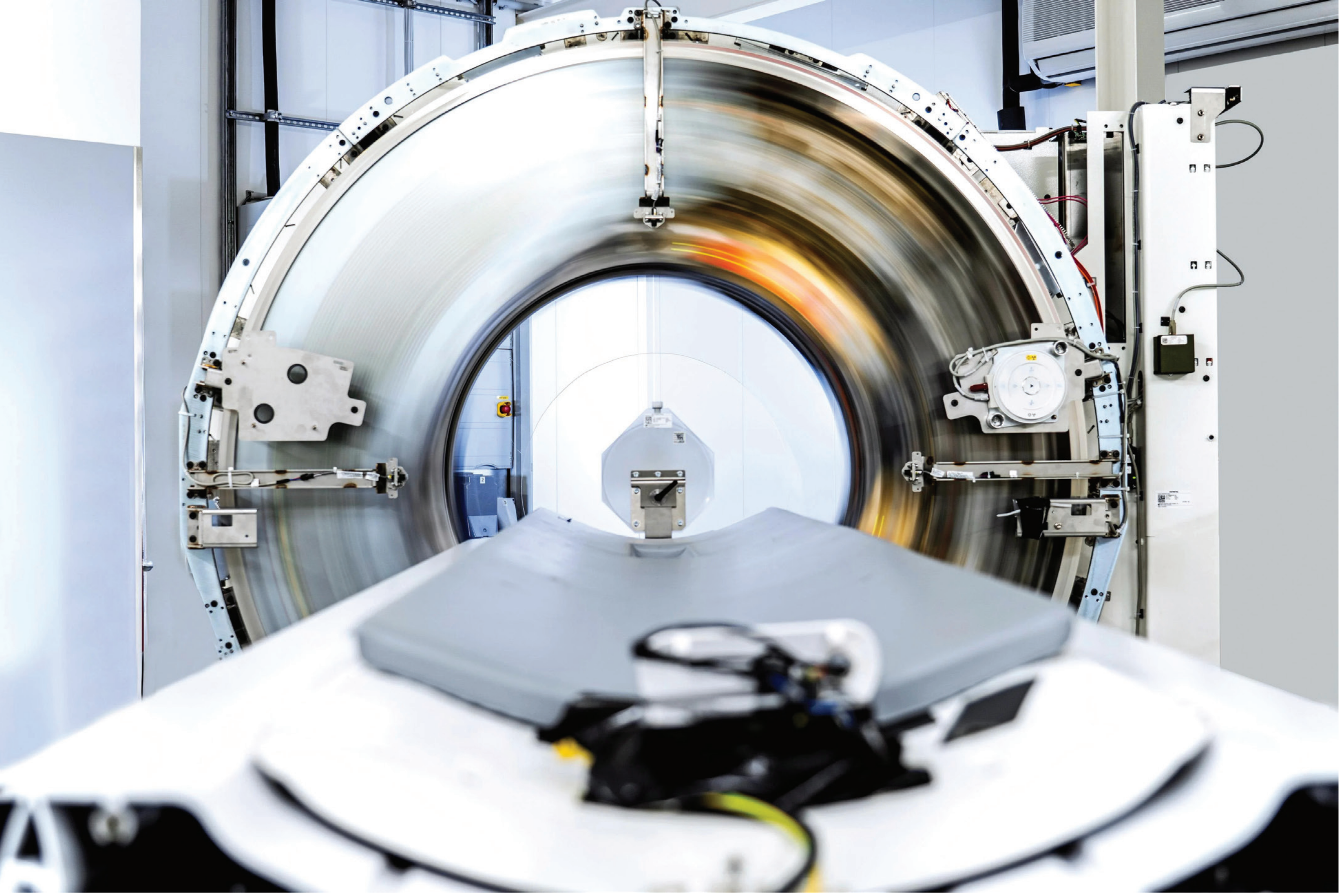
(2.5 X SD of a group of Systematic Error) + (0.7 X SD of Random Error)

Ensures CTV should receive 95% of the Prescribed dose

****SD = Standard deviation***

References:

1) Journal of the ICRU Vol 10 No 1 (2010) Report 83 doi:10.1093/jicru/ndq001 Oxford University Press.
2) Caruana K, Refalo N, Spiteri D, Couto JG, Zarb F, Bezzina P. PTV margin calculation for head and neck patients treated with VMAT: a systematic literature review. Journal of Radiotherapy in Practice.



Photons for the Win: How Light Particles Are Revolutionizing Medical Imaging

Firdous Nazir
M.Sc. Medical Imaging Technology (Jamia Hamdard),Radiographic Technologist, GMC Anantnag.

Move over, X-rays! The future of medical imaging is bathed in the soft glow of photons, the tiny packets of energy that make up light. Forget grainy black and white films and harmful radiation; photon-counting CT scanners are ushering in a new era of precise, detailed, and low-dose scans, transforming the way we diagnose and treat disease.

What is photon-counting CT scanner?

Traditional CT scanners bombard the body with X-rays, capturing snapshots of internal structures. Photon-counting CT, on the other hand, directly detects individual photons as they interact with tissues. This allows for:

- Sharper, higher-resolution images: Think of it like trading in a pixelated photo for a high-definition masterpiece. Photons provide a wealth of information, revealing intricate details invisible to X-rays, from delicate blood vessels to tiny lung nodules.
- Significantly lower radiation doses: Traditional CT scans can deliver a hefty dose of radiation, raising concerns about long-term health risks. Photon-counting CT uses far fewer photons to

achieve the same level of detail, reducing radiation exposure by up to 80% in some cases. This is especially beneficial for children, pregnant women, and patients requiring multiple scans.

- Material differentiation: X-rays struggle to distinguish between different tissues, particularly those with similar densities. Photon-counting CT can differentiate between bone, soft tissue, fat, and even different types of cancer cells, leading to more accurate diagnoses and personalized treatment plans.

The Benefits of Photon Power

The potential benefits of photon-counting CT extend far beyond simply producing prettier pictures. Imagine:

- Early detection of cancers: With their superior resolution, photon-counting scans can spot tiny tumours at their earliest stages, when they are most treatable. This could dramatically improve cancer survival rates.
- Improved diagnosis of complex diseases: From lung diseases to heart conditions, photon-counting CT can provide clearer insights into intricate structures and subtle abnormalities, leading to more accurate diagnoses and better treatment decisions.
- Personalized medicine: By revealing the unique makeup of tissues and tumours, photon-counting CT scan pave the way for personalized treatment plans tailored to each patient's individual needs.

The Future is Bright (Literally)

Photon-counting CT is still in its early stages, but its potential is undeniable. As technology advances and costs decrease, we can expect to see these revolutionary scanners become more widely available, transforming the landscape of medical imaging. So next time you need a scan, ask your doctor if the future is shining through with photon power.

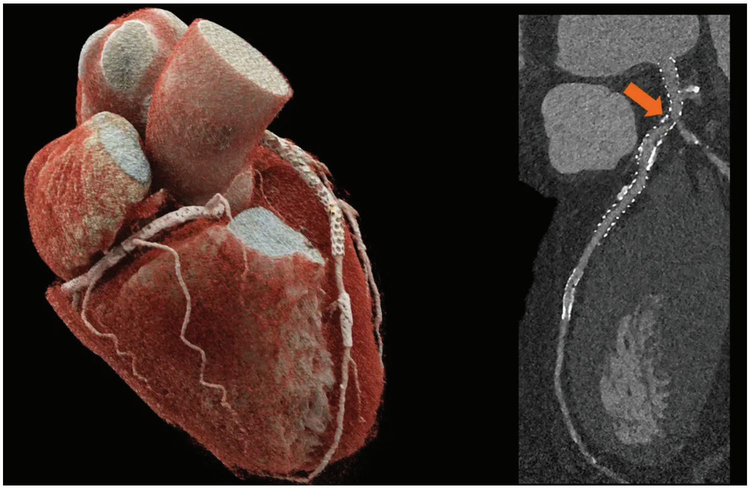
Beyond the Hype: Challenges and Considerations

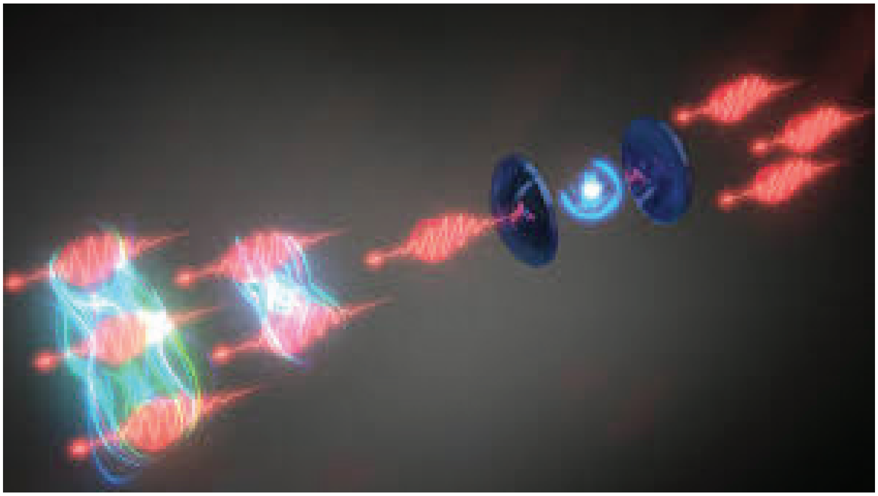
While the promise of photon-counting CT is exciting, it's important to acknowledge some challenges and considerations:

- Cost: Currently, photon-counting CT scanners are significantly more expensive than traditional CT scanners. However, as technology matures and production scales up, costs are expected to decrease.
- Technical complexity: These scanners require more complex technology and sophisticated image processing algorithms. Ensuring accuracy and consistency across different machines and institutions will be crucial.
- Data management: The wealth of data generated by photon-counting CT scans poses challenges for storage, analysis, and interpretation. Robust data management systems and trained professionals will be necessary to harness the full potential of this technology.

Demystifying the Technology:At the heart of this revolution lies the ingenious design of the photon-counting detector. Unlike traditional CT scanners that convert X-rays into light with scintillation crystals, photon-counting detectors directly convert individual X-ray photons into electrical signals. This eliminates the noise and limitations inherent in the scintillation process, resulting in clearer, more detailed images. Imagine capturing every raindrop instead of just the blurry outline of a storm – that's the level of precision we're talking about.

Revolutionizing Scans Across the Spectrum:The applications of photon-counting CT extend far





beyond the realm of oncology. Here's a glimpse into how different specialties harnessing its power:

- Cardiology: Detecting subtle changes in coronary artery plaques to predict heart attacks before they happen.
- Neurology: Visualizing delicate brain structures for improved diagnosis of stroke, epilepsy, and neurodegenerative diseases.
- Pulmonology: Diagnosing lung diseases like emphysema and chronic obstructive pulmonary disease (COPD) with unprecedented accuracy.
- Orthopaedics: Evaluating bone fractures and joint diseases with greater detail, leading to better surgical planning and outcomes.

Personalized Scans, Tailored Treatments:

One of the most exciting aspects of photon-counting CT is its potential for personalized medicine. By revealing the unique composition of tissues and tumours at the molecular level, it allows for scans tailored to each patient's individual biology. Imagine a future where doctors can design treatment plans based on the specific genetic mutations driving a patient's cancer, or predict how they might respond to different medications.

Challenges and the Road Ahead:Like any disruptive technology, photon-counting CT faces its share of challenges. As discussed earlier, cost remains a significant hurdle, along with the need for trained professionals to interpret the vast amount of data generated by these scans. However, ongoing research and development are rapidly addressing these issues.

Conclusion:

Optimistic and Forward-Looking:As the sun sets on the era of blurry X-rays, a dawn of vibrant detail and precise diagnoses breaks with the power of photons. Photon-counting CT is not just a technological marvel, it's a promise whispered in light, a promise of a future where medicine becomes personal, prevention proactive, and hope illuminates every scan. With each photon captured, we step closer to a world where disease trembles before the brilliance of human ingenuity, and the future of medical imaging shines ever brighter.

Reflective and Thought-Provoking:While the potential of photon-counting CT is vast, the path forward is not without shadows. Access, affordability, and ethical considerations loom large, reminding us that the future is not built solely on technology, but on shared principles and responsible human guidance. As we embrace the photons' gift, let us remember that the true revolution lies not in the machinery, but in our collective resolve to harness its power for the good of all. The question remains: will we unlock the full potential of this luminous technology, or will its brilliance blind us to the challenges that lie ahead? The answer, like a developing image, awaits our collective focus.

Action-Oriented and Engaging:The revolution has begun, sparked by a single photon's whisper. But this is not a spectator sport. Let us be the scientists, the clinicians, the policymakers, the advocates who champion the cause of photon-powered medicine. Let us demand equitable access, invest in research, and nurture the ethical framework that guides this technology's journey. Together, we can ensure that the light of the future illuminates not just diagnoses, but the path towards a healthier, more hopeful world. Join the conversation, share your voice, and become a spark in the revolution of medical imaging. ●

Intraoperative MRI

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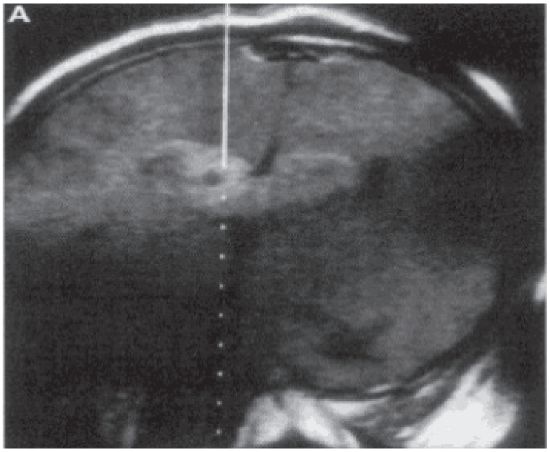
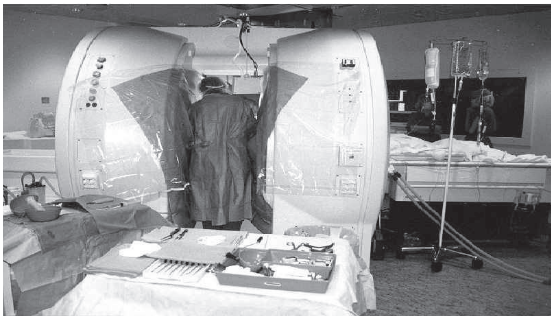
Intraoperative magnetic resonance imaging (iMRI) has significantly improved neurosurgical oncology practice in recent decades. iMRI is the most effective surgical guiding and imaging modality, providing near-real-time monitoring of dynamic changes during surgery. MRI has the benefit of not exposing patients to ionizing radiation, unlike fluoroscopy and CT scans.Using MRI for surgical guidance is a relatively recent concept.

Why iMRI

Surgeons utilize iMRI to help them treat a variety of brain malignancies. Surgery is frequently the initial step in treating a tumour that may be removed without causing neurological injury. Some tumours have well-defined shapes and can be easily removed.Image-guided surgery has made significant advances in neurosurgery



Sagittal in-plane T1-weighted image showing the predicted needle trajectory for biopsy



0.5-T intraoperative MRI system (SIGNA SP, Boston, MA)

and may have broader ramifications. These approaches improve lesion localization accuracy, margin determination, and surgical safety. Using image-based information improves surgeons' ability to treat tumours, vascular abnormalities, and other intracerebral lesions effectively.[(1)(2)(3)]

Localization

MRI is more effective than other imaging modalities for detecting tissue abnormalities and tumour margins. It's great for directing biopsies and tumour resections. MRI is highly sensitive in detecting pathological changes and can fully define tissue damage when contrast is administered. MRI may detect minor physiological, metabolic, or structural changes and offer useful anatomical information by measuring factors including diffusion, perfusion, and flow.

The 0.5-T intraoperative MRI system (SIGNA SP, Boston, MA)

The 0.5-T intraoperative MRI system provides near real-time images, which enable the surgeon to correct or modify the preplanned trajectory of approach during the actual surgery.[(3)]

Instrumentation

The targeting and navigation system encompasses the use of light-emitting diode (LED)-based optical tracking of surgical instruments in combination with the manipulation of the MRI planes. When using flexible instruments such as catheters, guidewires, and flexible endoscopes during intraoperative MRI, other nonoptical tracking methods based on MRI need to be used. Miniature coils and attached to these instruments can be detected by MRI when the instruments are placed deep within the operative field

Direct access to the patient was achieved by the construction of two vertically oriented superconducting magnets with coils in separate but communicating cryostats. Niobium tin is used to get maximum superconducting transition at higher temperatures than the more commonly used Niobium titanium. flexible transmit-receive coils, which can be incorporated into the sterile surgical draping and contoured over the surface of the patient's body in the area to be imaged, permitting access to the region of treatment[(4)(3)])

Celling mounted iMRI

Ceiling Mounted Mobile High Field Intraoperative Magnetic Resonance Imaging

A ceiling-mounted rail system that can move the scanner to the patient. The rail system can be tailored to allow the scanner to be stationed in a separate room for use as a diagnostic scanner, and also move between operating rooms for use in multiple concurrent surgeries[(6)]

Conclusion

Incorporating a mobile high-field strength,or 0.5T vertical system or other ioMRI Systems into neurosurgery can give real-time, high-quality imaging to guide the treatment of brain tumours and disorders. This approach gives instant feedback to determine the effectiveness of the operation. This method helps in modifying the surgical process.

Histotripsy Ultrasound: New Horizon In Cancer Treatment

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Ablation techniques have emerged as promising modalities in targeting and eradicating tumors with minimal collateral damage in the realm of cancer treatment. Histotripsy Ultrasound is one of the emerging techniques that has created a great impact for its non-invasive and remarkable therapeutic potential. Histotripsy is the first non-invasive, non-ionizing, and non-thermal ablation technology guided by real-time imaging. It also offers the potential for repeatable treatments with minimal recovery time and non-invasive alternatives to traditional cancer therapies.Histotripsy can be performed with real-time imaging feedback with enhanced monitoring and precise targeting of the areas. It is a non-invasive focused ultrasound technology.

Construction

❖ Ultrasound Transducer: This is the primary component responsible for generating focused ultrasound waves.

❖ Focusing Lens: concentrate the ultrasound energy at the target site, improving precision and efficacy.

❖ Control System: A control unit is necessary to adjust parameters such as ultrasound frequency, intensity, and treatment duration. duration.

❖ Monitoring and Feedback Mechanisms: Real-time monitoring and feedback mechanisms are often integrated into histotripsy systems to ensure accurate targeting and minimize damage to surrounding healthy tissue.

❖ Safety measures are important to prevent overheating and ensure patient safety during the procedure

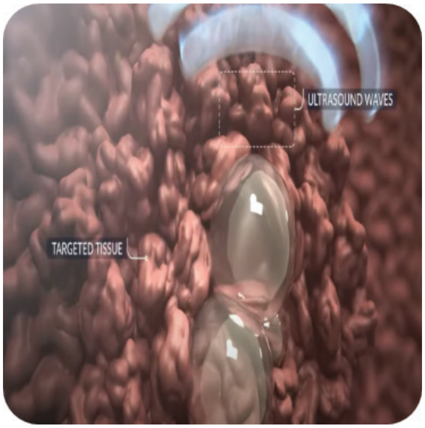
Mechanism

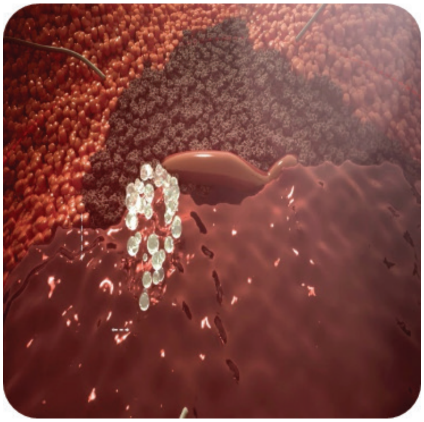
❖ Ultrasound Generation: Histotripsy systems utilize ultrasound transducers, typically made ofpiezoelectric materials, to generate high-intensity ultrasound waves.

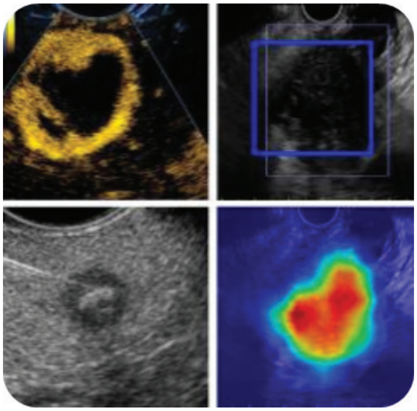
❖ Cavitation: It involves the formation, growth, and collapse of microbubbles within the tissue. When the high-intensity ultrasound waves pass through tissue, they create areas of low pressure where bubbles can form.

❖ Bubble Expansion and Collapse: As the ultrasound waves continue to pass through the tissue, these bubbles grow due to the negative pressure. Eventually, they reach a critical size where they collapse violently, generating shockwaves and mechanical forces.

❖ Tissue Disruption: The rapid and localized collapse of the bubbles produces mechanical forces that can disrupt tissue structures.







❖ Selective Ablation: Histotripsy can selectively target and ablate tissue while sparing surrounding structures. Tissue

❖ Removal and Clearance: Following tissue disruption, the immune system and lymphatic drainage, work to remove the fragmented tissue debris from the treatment site.

Applications

Brain cancer, Liver cancer, Prostate cancer, Renal cancer, Breast cancer, Musculoskeletal cancer, and Pancreatic cancer.

Limitations

However, some challenges include acoustic access, organs containing gas, and risk of the metastasis. Despite these limitations, ongoing research will ensure that Histotripsy will be available widely.

Conclusion

Histotripsy has the potential to revolutionize various medical procedures. As we continue to explore its applications and refine its techniques, histotripsy stands poised to make a profound impact on patient care, ushering in a new era of minimally invasive treatments with improved outcomes and reduced risks. ●

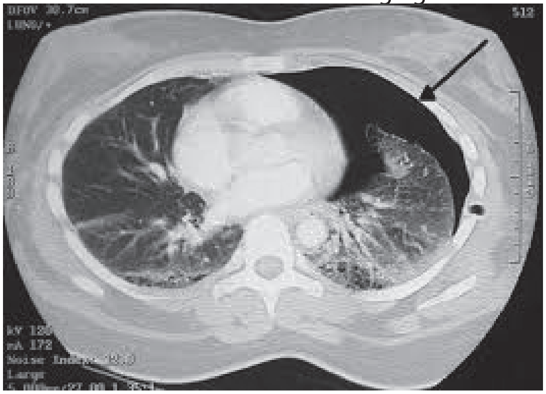
NCNIT 2024

The 3rd national conference of Nitte imaging technology “NCNIT-2024” was held on 2nd & 3rd March 2024, in conjunction with the silver jubilee celebration of KS Hegde Medical Academy. Hosted by the Division of Medical Imaging Technology and Department of Radiology KS Hegde Medical Academy, Nitte (Deemed to be university), in collaboration with the Indian Society of Radiographers and Technologists (ISRT). Over 900+ delegates from 60+ institutions across Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Telangana, Goa, Maharashtra, Delhi, Madhya Pradesh and more participated in the conference. Additionally, we are honored to welcome around 40+ National and International faculties as speakers. Dr. Jaya Prakash Shetty, Vice Dean, KSHEMA was the chief guest, Mr. Vishal Hedge, Pro-Chancellor, Nitte DU presided over the function. Commander Dr. Daniel K J, National Coordinator of ISRT, Prof. S Panneer Selvam, Adjunct Faculty of SRMC Chennai, Dr. U Raghuraj, HOD, Department of Radiodiagnosis, Mr Shashi Kumar Shetty, Co-ordinator Department of Medical Imaging Technology graced the ocassion. Several competitions for delegates were conducted which included Poster presentations with UG & PG categories and Oral presentations with 5 different categories. Proffered papers from the different faculties were invited. Active participation among the delegates was seen throughout the event with around 100+ posters and oral presentations. The program was concluded with a valedictory event with prize distribution to winners of various competitions.

QUIZ 94

Compiled by : **Prasad P P**

1. The two most common sites of AVM are?
2. The presence of blood in the pleural cavity is termed as?
3. Which is the most common artifact encountered in Doppler ultrasound?
4. The largest white matter structure in human brain is?
5. The process of making Bo as homogenous as possible in MRI is known as?
6. In double contrast Barium enema study which is administered along with Barium Sulphate suspension?
7. The programmed application of parameters to get a particular image contrast in MRI is known as?
8. Lower end of spinal cord is known as?
9. To which modality T and Z scores are associated with?
10. The orbitomeatal line is also known as?
11. By which process Technetium 99m decays?
12. Which imaging technique is employed in MR spectroscopy?
13. What is the energy range of orthogonal X-rays?
14. In ultrasonography, Q factor is an indication of?
15. Name the diagnosis in the image given?



Please mail your answers and contact number to **alaraquiz@isrt.org.in** before **15th April 2024**, The subject of mail should be given as **ALARA Q-94**

Answer Key Q-93

1. Pyothorax
2. Space charge effect
3. Femoral head
4. Angiogram
5. Paraplegia
6. Micro adenoma
7. Zone IV
8. Embolization
9. USG
10. 96%
11. Filtered back projection
12. The law of Bergonie and Tribondeau
13. Arterial spin labelling
14. 4ml/sec
15. Hydropneumothorax

Winner : Annie D' Cruz, Salem, Tami Nadu

RADIANCE

John Mugler

Mugler was instrumental in developing innovative pulse sequences that revolutionized magnetic resonance imaging, making it practical to create high-contrast 3D images quickly and with high resolution. Previously, MRI machines produced primarily two-dimensional "slices" for clinical imaging, but Mugler's research allowed for the creation of detailed images that can be viewed from any angle. The increased detail allows doctors to identify subtle abnormalities earlier, leading to better diagnoses and treatment for patients. Mugler's work proved so important that it has been implemented in MRIs in hospitals and research institutions around the world.

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