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NUCLEAR MEDICINE PHYSICISTS ASSOCIATION OF INDIA
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NEWSLETTER

THERANOSTIC CHRONICLES : BRIDGING THERAPY AND DIAGNOSIS

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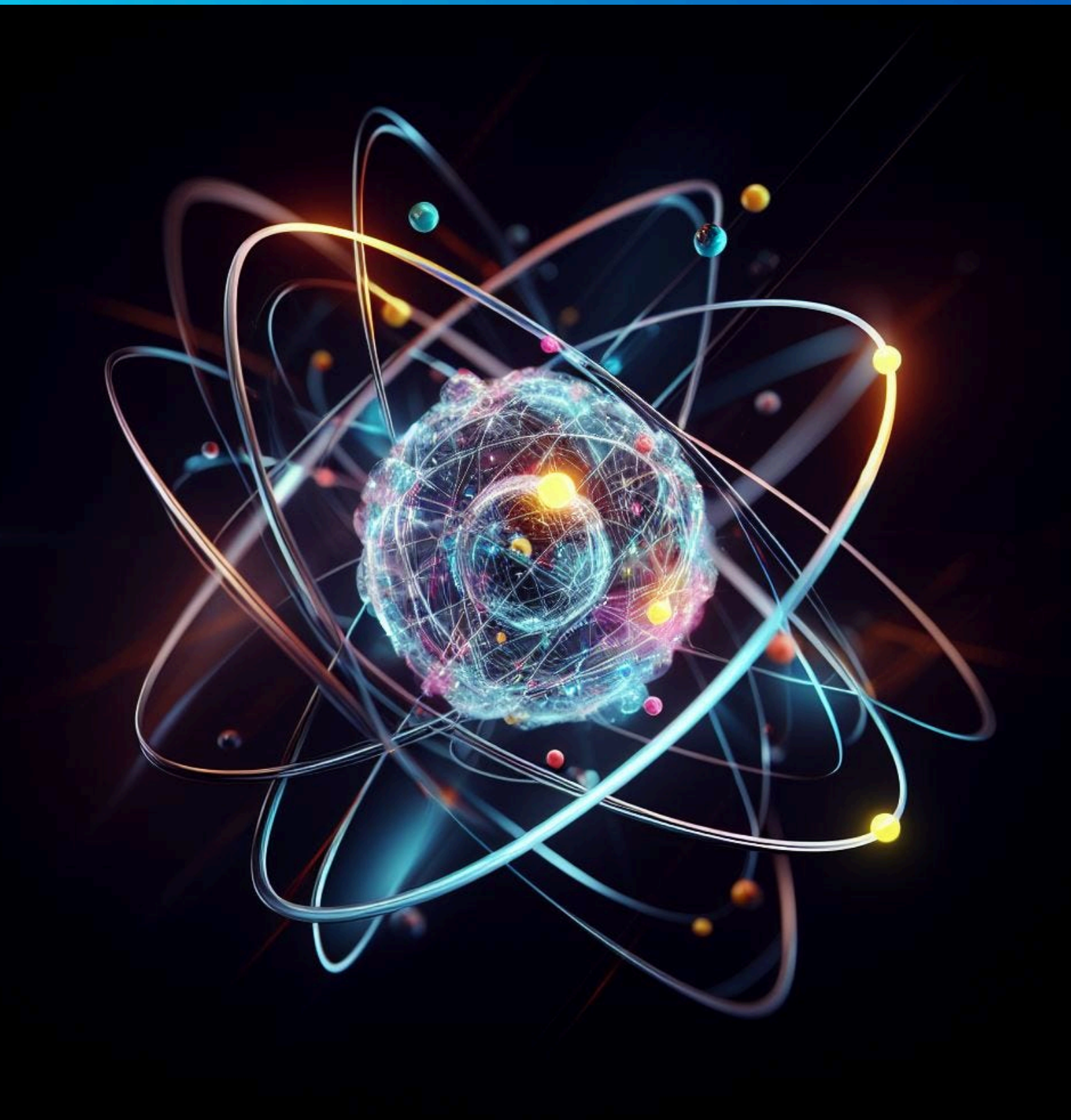

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MEMOIRS OF NMPAICON 2024

NMPAICON 2024

Dear Colleagues,

As you all are aware that this year the 8th Annual conference of Nuclear Medicine Physicist Association of India (NMPAI) hosted by Shri Mata Vaishno Devi Narayana Super Specialty Hospital, Katra was held in Jammu from 23rd and 24th 2024 (NMPAICON-2024).

The conference was inaugurated by Dr. Yashpal Sharma, Director, GMC, Nursing & Paramedical College of Jammu & Kashmir as chief guest. The guest of honors were were: Dr. Jetinder Pal Singh, Clinical Director & Mr. M Muthuvan, Faculty Director of SMVDNSH, Katara.

This two day academic feast was well attended by around 120 delegates from across the country. The scientific program divided in 8 scientific session covered the basics to the advances of nuclear medicine. Around 40 eminent Physicist, scientist, doctors from premier institute of the country such as AIIMS, Delhi; PGIMER, Chandigarh; Tata Memorial Hospital, Bhabha Atomic Research Centre (BARC), AERB, Mumbai, Manipal Hospital, Udapi. delivered talks. Dr. Basanth Malpani, Scientist , Radiation Medicine Centre, Mumbai delivered the prestigious Ernest Lawrence Oration and Dr. Anil K Pandey, Professor, AIIMS, Delhi delivered the prestigious Hall Anger for the year 2024.

Around 30 students from different parts of the country presented their research work as oral and “Chai pe ePoster charcha” sessions. The proceedings of the conference have gone completely paperless and were released in the form of QR Code. In the research paper category – 1st best oral paper was given to Ms. Maya Shetty, Manipal , 2nd best oral paper was given to Mr. Navneet, Fortis, Gurgaon. Best paper in the category of ePoster was given to Nishant Rana, Fortis, Gurgaon- (1st); Sharvi Gupta, GMC, Faridkot- (2nd); Monika ,PGIMER, Chandigarh – (3rd).

As I pen down in my capacity as the organizing chairman of NMPAICON 2024 for one last time, I would like to thank whole NMPAI family for all the support and making NMPAICON 2024 a grand success.

Wish the organizers of NMPAICON-2025 all the best. See you all in “Dil Walo ki Delhi”

Dr. Ankit Watts
Nuclear Medicine Physicist, PGIMER Chandigarh
NMPAICON 2024

Organizing Chairman

MEMOIRS OF NMPAICON 2024

NMPAICON 2024

Dear Delegates,

Warm Greetings !

On behalf of the organizing committee, it is my great pleasure and honor to extend my thanks to all the delegates who participated in the 8th annual conference (NMPAICON-2024), which was held on February 23–24, 2024, in the city of Temples Jammu.

The theme of the conference was **" Igniting minds with radioactivity "** which would lay a platform for both clinical and non-clinical lectures that allowed all faculties and delegates to jointly explore current and future research directions in the field of nuclear medicine to share their thoughts and exchange ideas to ignite minds. We had challenges to make the conference successful, and we tried our best to ensure that your time and stay in the city of Jammu during the NMPAICON 2024 conference were one of the most memorable ones.

I thank and congratulate each and every one of you for a wonderful gathering and for making the NMPAICON conference successful.

Thanks & Regards

Mr. Sunil Rana
Nuclear Medicine Physicist cum R.S.O
Shri Mata Vaishno Devi Narayana Superspeciality Hospital, Jammu

Organizing Secretary & Treasurer
NMPAICON 2024

MEMOIRS OF NMPAICON 2024

NMPAICON 2024

Dear Delegates,

Warm Greetings !

Earlier this year on February 23rd 24th, I had the opportunity to organize and execute the 8th annual conference NMPAICON, 2024 in our institution.

The theme of the conference was **" Igniting minds with radioactivity "** and it's quite fulfilled in its form. It was a challenging yet great experience to organize a conference at such a huge level. Good team work is the key to organizing big events and making all difficulties on spot more manageable. I am very much thankful to the Director and management of my institution Shri Mata Vaishno Devi Narayana Superspeciality Hospital for their unending support. I am also deeply indebted to all the seniors and juniors of the nuclear medicine fraternity for helping me in the smooth organizing process.

The conference was a remarkable gathering of experts, researchers and professionals from around the country. It was great hosting you all and enjoying your company. We tried our best to make your experience a memorable one. I hope you all enjoyed and had one of a lifetime stay in the city of temple jammu. Hope to see you all soon.

Thanks & Regards

Dr. Aditya Mahajan
Consultant and Head, Nuclear Medicine,
Shri Mata Vaishno Devi Narayana Superspeciality Hospital, Jammu

Executive Chairman
NMPAICON 2024

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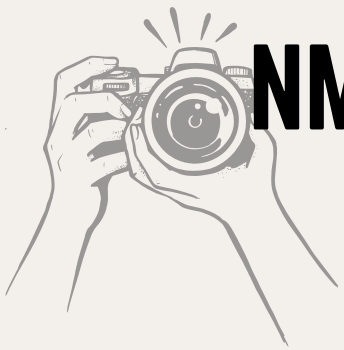

NMPAICON 2024




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56th Annual Conference of Society of Nuclear Medicine India (SNMI)

29th Annual Conference of SNMI, Southern Chapter

SNMICON 2024

December 05-08

KMCH, Coimbatore

Theme: Nuclear Medicine - Precise, Prognose and Personalize

56th Annual Conference of

The Society of Nuclear Medicine India

Nuclear Medicine - Precise, Prognose and Personalize

05th - 08th December, 2024

Welcome Message

Dear Colleagues,

Greetings from SNMICON 2024 and SNMISC 2024, KMCH, Coimbatore (Manchester of South India)

It is our great pleasure to warmly invite you all to the 56th Annual Conference of Society of Nuclear Medicine India (SNMICON 2024) and the 29th Annual Conference of SNMI Southern Chapter (SNMISC 2024), which will be hosted by the Department of Nuclear Medicine, KMCH, Coimbatore. The conference is scheduled to take place from December 5th to 8th, 2024.

Society of Nuclear Medicine, India (SNMI), established in 1967, has been a driving force in promoting and advancing the field of Nuclear Medicine in the country. With over 1600 life members, SNMI has been facilitating the exchange of ideas and experiences through its annual conferences. SNMI Southern Chapter (SC) has actively organized separate annual conferences since 1995, in addition to collaborating with SNMICON. This year, SNMICON and SNMISC will have separate oration and award papers, adding to the diverse scientific program.

We are proud to host the conference by Kovai Medical Center and Hospital (KMCH), a leading 1000-bed multispecialty hospital in Coimbatore, Tamil Nadu. With a history spanning 33 years, KMCH has been dedicated to providing top-tier healthcare services to both urban and rural populations. Committed to modern medical practices and high ethical standards, the hospital has been a pioneer in comprehensive cancer care since 2011, offering advanced Nuclear Medicine services and state-of-the-art cancer treatments.

The conference theme, "Nuclear Medicine – Precise, Prognose, and Personalize," highlights the significant impact of Nuclear Medicine in the precise diagnosis, disease prognosis, and personalized treatment of various cancers, ultimately leading to improved cancer care. This four-day conference aims to bring together Nuclear Medicine professionals, including doctors, technologists, professors, researchers, resident doctors, and students from across India and around the world, fostering the sharing of experiences, research ideas, and the establishment of collaborations.

The scientific program will delve into the latest advancements in molecular imaging techniques, radionuclide therapy, and their clinical applications. It will also cover topics such as radionuclide drug development, Dosimetry (featuring experts from South Africa), radiation safety, and the medico-legal considerations of SPECT/CT, PET/CT, and PET/MR fusion imaging. The emphasis will be on interactive sessions, debates, current evidence, clinical perspectives, panel discussions, challenging case discussions, and scan reading sessions with clinical colleagues, encouraging active participation from all delegates. Notable highlights include three SNMI orations (Homi Bhabha, Brig S K Mazumdar, Vikram Sarabhai) and one SNMISC oration (Prof N Ramdas). The conference will also feature separate technologist's sessions for three days, along with best paper awards, quiz competitions for students, and opportunities for oral and poster presentations. The involvement of industry professionals will facilitate discussions on upcoming technologies and further avenues for innovation, with potential opportunities for industry research collaborations.

In addition to the enriching scientific discussions, we encourage all attendees to explore the vibrant city of Coimbatore, also known as the "Manchester of South India." Boasting a rich cultural heritage and breathtaking natural beauty, Coimbatore offers a wide array of attractions, including temples, museums,nearby hill station ooty and local cuisines that are sure to leave a lasting impression.

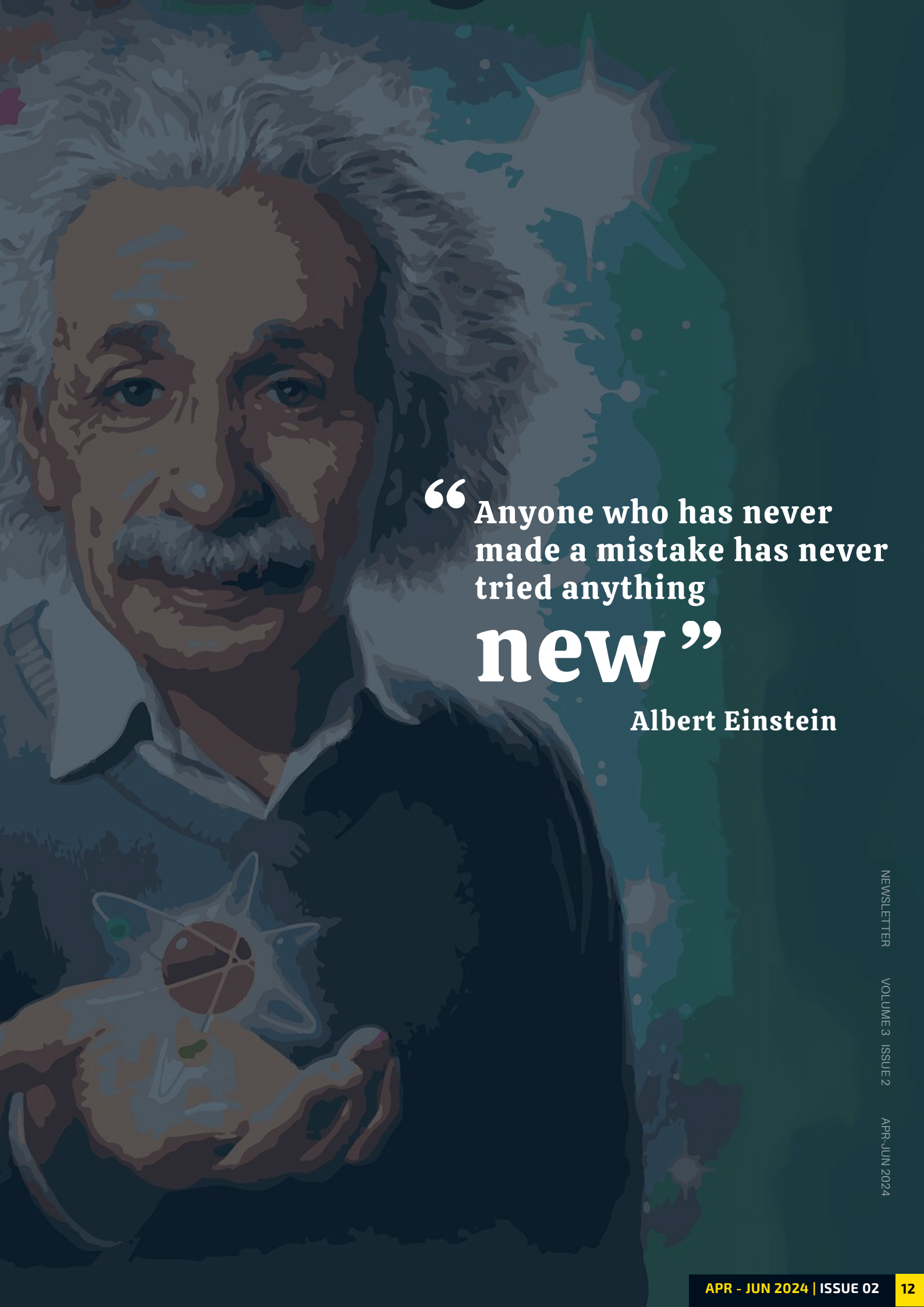
We eagerly anticipate your participation and contribution to the success of SNMICON 2024. On behalf of KMCH, SNMI, and SNMISC, we look forward to welcoming you to Coimbatore in December 2024.

Best Regards,

Dr. K K Kamaleshwaran MD (NucMed)
Organising Chairman

Dr. E Ramkumar DNB (NucMed)
Organising Secretary

Mr. Radhakrishnan ER
Co Organising Secretary



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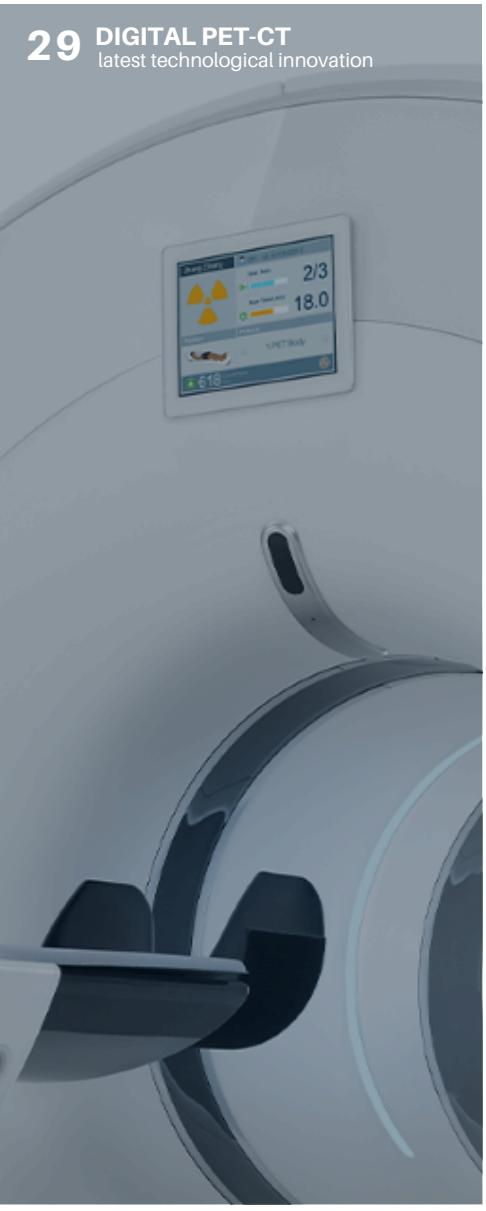

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Astatine-211: The Future Replacement for Iodine-131 in Thyroid Cancer Treatment

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Introduction

The introduction of radioactive iodine, especially [I-131]NaI, marks a pivotal moment in the history of treating thyroid cancer. Its legacy is profound, shaping modern medical practices and offering hope to countless patients, worldwide. Astatine-211(At-211), an alpha emitter has shown better treatment efficacy in thyroid cancer compared with I-131 [1]. It's a new approach that might be better at helping the patients with thyroid cancer. Alpha therapy has shown promise in effectively targeting tumors while minimizing toxicity to healthy tissues. Its ability to induce double-strand breaks (DSBs) in DNA presents a potent mechanism for destroying cancer cells [2]. In recent years, At-211 has gained significant attention in the medical community due to its similarities in chemical properties to I-131. This resemblance opens the door to the potential use of At-211 alpha-emitting capabilities for targeted therapy, leveraging its affinity with tissues that traditionally uptake iodine, the thyroid gland in thyroid cancer treatment [3].

Astatine-211: Insights into Production, Physical Characteristics, and Chemical Behavior

Astatine (At), positioned below iodine in group 17 of the periodic table, also known as the halogens group, stands as the rarest naturally occurring element on earth. Astatine was discovered at the University of California, Berkeley, in 1940 through alpha particle bombardment of natural bismuth (Bi). Because it is extremely rare in nature, At-211 is typically produced artificially. The primary method involves irradiating a bismuth-209 target in a cyclotron capable of generating a 28 MeV alpha beam that converts the target Bi-209 into At-221 via (209Bi [α, 2n] 211At) reaction. Alternatively, At-211 can also be generated by irradiating bismuth with heavy ions, as observed in the nuclear reaction 209Bi [7Li,5n] 211Rn, followed by using Rn-211 as a generator of At-211 [4,5].

At-211 has a half-life of 7.21 h and decays in two ways as depicted in **Figure 1**. First, it emits alpha particles and turns into bismuth-207. Second, it undergoes electron capture and changes into Polonium-211. The Po-211 quickly decays by emitting alpha particles and becomes stable lead-207. Each disintegration releases one alpha particle. Additionally, the decay to Po-211 produces characteristic x-rays with energies between 70 and 90 keV, which can be detected by a gamma camera [4,5].

When At-211 is compared to other alpha emitters such as Th-227, Ra-223, Pb-212, Bi-212, and Ac-225, which have long decay schemes and potential recoil issues, At-211 emerges as the better choice of radionuclide. This is because when astatine converts to polonium, it may cause the radionuclide to detach from carriers. However, the Po-211 daughter is not affected by nuclear recoil since it arises from At-211 through electron capture (EC). These characteristics makes At-211 a more stable and reliable option for various application [3].

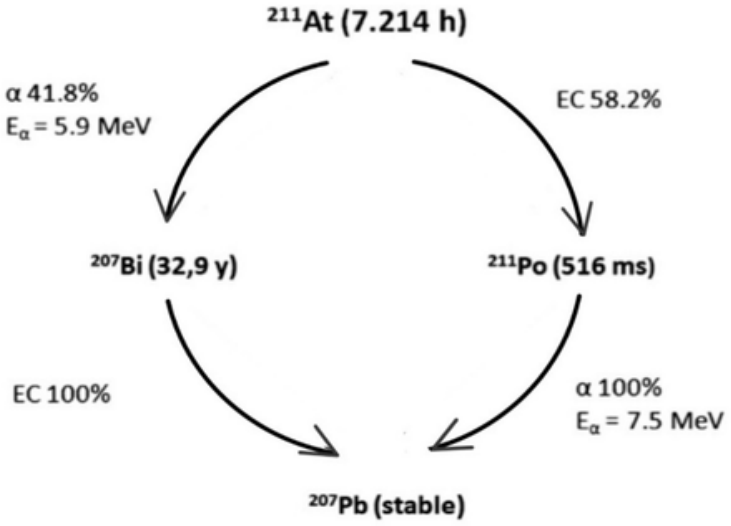

Figure 1 : Decay Scheme of At-211

Astatine's chemical properties have been shaped by comparing it to iodine, its nearest element in the periodic table. Astatine shares similarities with iodine in its negative (-) oxidation states but displays distinct metal-like properties in positive (+) oxidation states. In its +1 state, astatine resembles silver, while its higher oxidation states are like to those of polonium. Guérard et al. demonstrated its dual nature using a Pourbaix diagram, highlighting its challenge in bonding like other halogens due to charge-shift bonding [6]. The question arises: should astatine be classified as a metalloid instead? With our current knowledge, this remains an open question.

Exploring the Evolution and Potential of Astatine-211 in Thyroid Cancer Therapy: Past, Present, and Future Perspectives

After its discovery in 1940, Astatine emerged as a potential candidate for thyroid cancer treatment due to its chemical properties resembling iodine. In a significant study conducted at the Crocker Laboratory in Berkeley, California, in 1954, Hamilton et al. conducted the first human investigation into the thyroid accumulation of At-211. Their study, involving seven patients with various thyroid disorders and one with papillary adenocarcinoma, revealed notable accumulation of the isotope. This foundational research highlighted the potential of At-211 in thyroid cancer management [7].

In a subsequent study by T. Petrich et al., it was discovered that radioactive astatine and iodine are effectively taken up by cancer cell lines expressing human sodium/iodide symporter (NIS). This research further underscored the potential of [At-211]NaAt in tumor treatment, as it is efficiently transported by NIS. Moreover, the adequate retention time of At-211 in experimental NIS-modified tumors in vivo, relative to its 7-hour half-life, suggests the possibility of achieving effective tumor-killing doses. Compared to I-131, At-211 may be more suitable for NIS-mediated tumor therapy due to its similar kinetics in NIS-transfected cells [8]. Further studies, such as the one conducted by Tadashi Watabe et al., delved deeper into the therapeutic effects of [At-211]NaAt and [I-131]NaI in mouse models of thyroid cancer expressing NIS. Their findings revealed that At-211 induced more double-stranded breaks and higher cellular toxicity than I-131 in NIS-expressing thyroid cancer models, indicating its enhanced efficacy in tumor treatment [Relative Biological effect (RBE)-1.61]. Based on the reported energy per unit decay (6927 keV/Bq·s for At-211 and 570 keV/Bq·s for I-131), there's approximately a 10-fold difference between both radioisotopes [1,9].

Recent research at Osaka University, Japan has shown potential advancements in this treatment approach. By adding 1% ascorbic acid to the [At-211]NaAt solution, researchers were able to improve radiochemical purity and increase the uptake of astatide (At-) in differentiated thyroid cancer cells. This addition stabilized the oxidative state of At-211, enhancing its effectiveness in targeting cancer cells [10]. The start of a clinical trial in November 2021 (ClinicalTrials.gov, Identifier: NCT05275946) using [At-211]NaAt strengthened the potential therapy for patients with thyroid cancer refractory to [I-131]NaI treatment [11].

The future of At-211 in thyroid cancer therapy holds promise as researchers continue to explore its potential and address existing challenges. With advancements in radiochemistry and targeted delivery methods, efforts are underway to optimize the efficacy and safety of At-211 based treatments. Currently, around 36 cyclotrons (28-32MeV α-particle beam) worldwide possess the capability to produce At-211 [4], with VECC Kolkata among them. India's inclusion in this list signifies its substantial contribution to the availability of this valuable isotope for medical applications in the future [12]. Ultimately, the increased availability of astatine will contribute to improving healthcare outcomes and the community's overall well-being.

In conclusion, the introduction of radioactive iodine i.e. [I-131]NaI, revolutionized thyroid cancer treatment. The emergence of [At-211]At-NaAt presents a promising avenue for enhancing therapeutic outcomes. With ongoing research and technological advancements, At -211 holds great potential for further improving thyroid cancer therapy.

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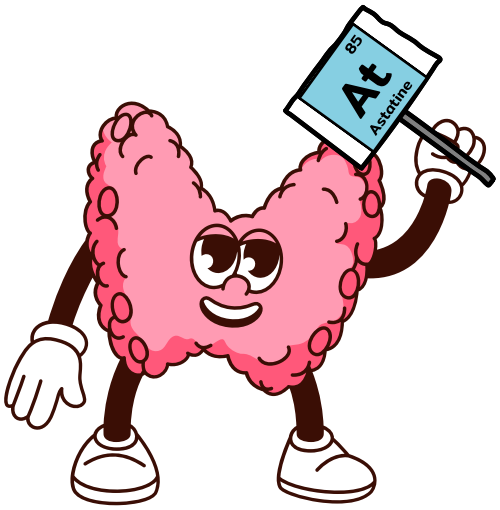

Imaging of Y-90 Radiotracers

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[3]Nueclear Healthcare Limited, Bengaluru

The therapeutic application of yttrium-90 dates back to 1965 when Ariel et al., proposed an intra-arterial route for the administration of Y-90 labelled microspheres resulting in improvement of associated symptoms in patients with inoperable primary pancreatic and liver cancer [1]. The efficacy of Y-90 as a part of a radio-embolizing agent and its attractive feature has led it to consideration for tagging with other agents. So far, the Y-90 labelled radiotracers that are under preclinical and clinical trials are briefed in Table 1 [2]. Out of these Y-90 labelled agents, glass microspheres, and resin microspheres are FDA-approved for hepatocellular carcinoma (HCC) and colorectal liver metastases [3].

Table 1 : Different Y-90-labeled radiotracers and their clinical utility.

Y-90 labeled radiotracers	Clinical Utility
Y-90 Therasphere (glass microspheres)	Hepatocellular Carcinoma (HCC)
Y-90 SIRsphere (resin microspheres)	Unresectable metastatic liver tumors from primary colorectal cancer
Y-90 DOTATATE/TOC	Metastatic NETs
Y-90 Hydroxyapatite	Pigmented villonodular synovitis (PVNS)
Y-90 DTPA Rituximab	B-cell Non-Hodgkin Lymphoma
Y-90 ibritumomab tiu-xetan	B-cell Non-Hodgkin Lymphoma
Y-90 ERIC1	Malignant gliomas
Y-90 citrate colloid	Chronic proliferative synovitis and effusions of large joints

Post-therapy imaging is an essential tool for quantitative and qualitative assessment. Quantitative assessment includes dosimetry for estimation of dose to tumor and normal organs leading to personalized planning of therapy. Qualitative imaging can be used as confirmation for the targeted therapeutic radiopharmaceutical delivery.

Y-90 has a physical half-life of 64.1 h. It primarily undergoes beta-particle (electron) decay to daughter nucleus zirconium-90 with beta particle having the maximum energy of 2.28 MeV resulting in maximum tissue penetration of 11mm [4]. Although there is no gamma emission during direct Y-90 decay, many research studies have focussed on the optimal use of currently available modalities for imaging of Y-90 [5].

So far, there are three possible ways of imaging Y-90 based radiotracers.

(a)Bremsstrahlung radiation imaging

(b)Internal pair production

(c) Cerenkov luminescence imaging

(a) Bremsstrahlung (BS) Imaging

The beta particle emitted from Y-90 decelerates under the attraction of a positively charged nucleus of an adjacent atom and the decrease in energy is emitted in the form of bremsstrahlung radiation resulting in a spectrum of its energies. Bremsstrahlung imaging can be done using planar imaging which is two dimensional. However, the bremsstrahlung photons emitted from Y-90 suffer from attenuation within the body. The attenuation of BS photons and also the overlapping of adjacent organs containing activity pose limitations in accurate quantification in planar imaging. Thus, SPECT/CT modality which is three dimensional is a suitable imaging modality compared to planar imaging and can overcome the problem of attenuation and organ overlap. However, SPECT/CT is time-consuming compared to planar imaging, and also it cannot differentiate between primary and scatter radiation. The choice of energy window and collimator decides the image quality. The energies of the BS radiation having the highest intensities are included within the energy window. There are no standardized energy windows documented to be implemented for bremsstrahlung imaging. Most of the authors suggest the use of either medium energy general purpose (MEGP) or high energy general purpose (HEGP) collimators. The recommended energy window by the American Association of Physicists in Medicine (AAPM) task group in 2011 for BS imaging is 68-92 keV. The factors like absence of dominant photopeak of BS radiation, scattering of low energy BS photons, septal penetration due to high energy BS photons, varying attenuation coefficient due to range of energies cause degradation in image quality and error in quantification. Thus it is recommended to use BS imaging for qualitative assessment [5-8]

(b) Internal Pair Production

Y-90 decays by internal pair production with the probability being 32 in one million. The positron from pair production undergoes annihilation with nearby electrons resulting in two 511 keV gamma photons emitted in opposite directions which are used for PET imaging. Studies suggest that time-of-flight (TOF) PET imaging adds an advantage compared to non-TOF PET imaging because of the difference in response rates in detector crystals [5]. However, in the case of lutetium oxyorthosilicate (LYSO) detector background correction due to the inherent emission of radiation from Lu-176 is required. In terms of spatial resolution, PET outranks planar or SPECT/CT imaging of Y-90 radiotracers, thus it is a useful modality for both qualitative and quantitative assessment. TheY-90 microsphere post-therapeutic PET imaging of the liver and lungs usually takes a much longer time due to the lower count rate in Y-90 decay. So, it becomes cumbersome when considering therapies using Y-90 labelled radiotracers due to the patient inconvenience and departmental burden due to longer imaging time [5, 8].

(c) Cerenkov Luminescence Imaging (CLI)

Y-90 is considered to be among the brightest medical radionuclide emitters of Cerenkov radiation due to the high energy beta particle emission. When a high energy beta particle emitted during radionuclide decay travels faster than the speed of light in water, it emits Cerenkov radiation which can be used for optical imaging. Compared to PET and SPECT, it requires less time. However, current research favours the success of this imaging method in a preclinical setting. CLI requires complete darkness while imaging, since even a small amount of visible light can saturate the detectors used for this process. Also, studies have shown that CLI is useful in the absence of radionuclide background. To date, there is no documented evidence of CLI in clinical settings [5, 8, 9].

The prescription of activity for the administration of Y-90 microspheres is currently based on the compartmental model. However, it does not take into account the heterogeneity of distribution in tumors. Monte Carlo simulation-based dosimetry is very complex and it requires a lot of time and computational work which is difficult to implement in every clinical practice. Thus, personalized treatment should be approached using imaging methods. Accuracy in quantification is dependent on image quality. Image quality in Y-90 is affected by inherent factors such as the resolution of the imaging modality, lack of gamma emission from Y-90, septal penetration from high energy photons, scatter component etc. Thus, with the advancement in the development of imaging instruments and with the development of new quantitative methods, the imaging aspect of Y-90 tracers may become feasible for more accurate personalized treatment.

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Dual Tracer PET Imaging

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Introduction

Positron Emission Tomography (PET) is an essential type of imaging in visualizing and measuring a wide range of physiological and metabolic processes in the human body. This imaging modality involves the injection of a radioactive tracer into the subject's body, followed by detection by the PET scanner. The dual tracer PET imaging concept involves use of two radioactive tracers in a single imaging session [1]. This approach can provide a more comprehensive understanding of the underlying biological processes and offer several advantages over single tracer imaging [1,2]. Dual tracer PET imaging can be used to study the interaction between different physiological systems, such as the relationship between glucose metabolism and neuro-receptor binding in the brain or to assess the effects of therapeutic interventions on multiple biological targets simultaneously [3]. The dual tracer PET imaging applications span various medical fields, including oncology, neurology, and cardiology.

Dual Tracer PET Imaging Techniques

Simultaneous acquisition of multiple tracers:

Injecting and detecting tracers simultaneously in a PET imaging session enables a direct comparison between spatial and temporal distribution of these tracers [4]. This method offers insights into how biological processes interact and relate. The significant benefit of simultaneous dual tracer PET imaging is the possibility of investigating different physiological systems in the same subject and, simultaneously, logging the mutual dynamics between them [5]. Simultaneous dual tracer PET imaging also reduces the overall imaging time and radiation exposure for the patient, as the data for both tracers is acquired concurrently. This can be particularly beneficial in clinical settings where patient comfort and minimizing radiation dose are essential considerations.

Sequential acquisition of multiple tracers:

The process of acquiring tracers sequentially includes injecting and detecting two or more tracers during distinct imaging sessions. This approach allows for assessing different biological processes at different time points, providing a more comprehensive understanding of the underlying physiology [6]. One crucial advantage of combining sequential multi-tracer PET imaging is the possibility of studying the temporal behavior of the processes under consideration. Other advantage of sequential dual tracer PET imaging is its flexibility regarding tracer selection and imaging protocols. Since the tracers are administered and imaged separately. This can lead to improved signal-to-noise ratios and more accurate quantification of the targeted biological processes.

Data Analysis and Quantification Methods

The data analysis and quantification methods for dual tracer PET imaging can be quite complex, as they involve integrating information from multiple tracer distributions and modelling the underlying physiological processes. Advanced mathematical and computational techniques are often employed to extract meaningful and quantitative information from the acquired data [7]. One common approach is kinetic modelling, which involves the development of mathematical models that describe the time-dependent behavior of the radioactive tracers within the body [8]. These models consider tracer uptake, clearance, and binding to specific biological targets. By fitting the model parameters to the observed PET data, researchers can derive quantitative measures of physiological processes, such as blood flow, receptor density, or metabolic rates. Another important aspect of dual tracer PET data analysis is the co-registration and integration of the information from the two tracer distributions. This may involve using image registration algorithms to align the data from the two imaging sessions and developing computational tools to visualize and analyse the spatial and temporal relationships between the two tracers.

Applications of Dual Tracer PET Imaging

Oncology application

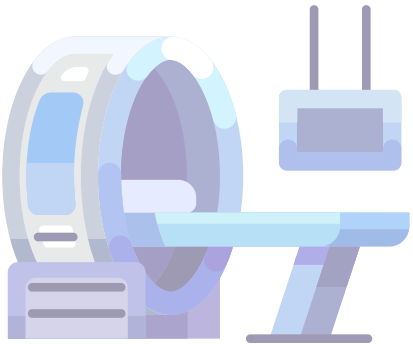
Oncology applications of dual tracer PET imaging are numerous and diverse. One major application is the simultaneous assessment of tumour metabolism and angiogenesis. By using a glucose-based tracer, such as F-18 FDG, to measure the metabolic activity of tumour cells and a tracer that targets angiogenic markers, such as Ga-68 RGD, researchers can gain valuable insights into the complex relationship between tumor growth, nutrient supply, and vascular development.

Neurology applications

Dual tracer PET imaging has numerous applications in neurology. One key application is the study of the interplay between different neurotransmitter systems and their role in neurological disorders. By using complementary tracers that target distinct neurotransmitter receptors, researchers can gain insights into the complex neurochemical changes associated with conditions such as Parkinson's disease, Alzheimer's disease, and psychiatric disorders [9]. This information can aid in the development of targeted therapies and monitoring of treatment response.

Cardiology applications

Dual tracer PET imaging can be used to evaluate myocardial inflammation, an essential component in the pathogenesis of various cardiovascular conditions [10]. By employing tracers that target inflammatory markers, clinicians can gain insights into the extent and severity of the inflammatory process, which can inform treatment strategies and help monitor the response to anti-inflammatory therapies.



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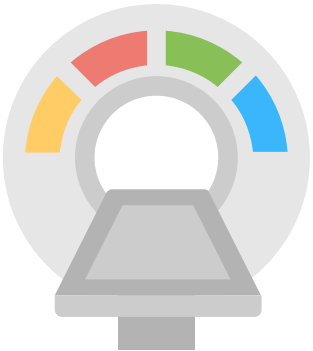

Logistics And Associated Problems In Establishing A Theranostic Center With Special Reference To Developing Countries.

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Introduction

The specialty of nuclear medicine is fast expanding by virtue of its capability to provide functional as well as morphological information. However, in developing countries the growth is not as rapid as is seen in developed countries, though developing countries have large proportion of global population. In Indian scenario, the number of nuclear medicine facilities has grown at a moderate pace and as of now there are 520 centers in a population of 1.4 billion.

Challenges Hindering the Growth of Nuclear Medicine Facilities in Developing countries

1. Space constraints and rigorous compliance of regulatory requirement prevents growth as many centers have inadequate infrastructure.

2. Inadequate funding available in creation of a functioning nuclear medicine facility. Infrastructure requires large magnitudes of funding as initial investments and thereafter continuous and sustained operation of department is a major challenge for many centers.

3. The limited availability of trained and qualified (in accordance with AERB guidelines) manpower for running a nuclear medicine facility. In India, government/private sectors together provide annual intake of more than 50 medical and about 250 non-medical postgraduates, apart from some institutions having intake for PhD programs as well. With new AIIMS being opened, this intake is likely to increase and may contribute to faster growth of nuclear medicine facilities.

4. Availability and access of commonly used radionuclides such as iodine-123, thallium-201, and many therapeutic radiopharmaceuticals like yttrium-90, germanium-68/gallium-68 generators and alpha emitters are not produced in India and are therefore imported. It may not be out of place to mention that BRIT, Mumbai although economical in terms of cost but has been not been able to largely meet the requirements of molybdenum-99/technetium-99m generator and iodine-131 for the existing nuclear medicine facilities.

Strategies for Expansion and Accessibility in Developing Countries

Although a significant and visible improvement has already been done, the initiatives by agencies are worth mentioning and it is expected that in near future, the growth and expansion would register the quantum jump to cater to large cross section of population both in terms of horizontal and vertical growth:

1. Various bodies such as Department of Atomic Energy (DAE), the Union Health Ministry and states should work in coherence to uplift the growth of nuclear medicine.

2. Public-private partnership (PPP) mode can be explored as one of solutions to tide over the crisis particularly in government sectors.

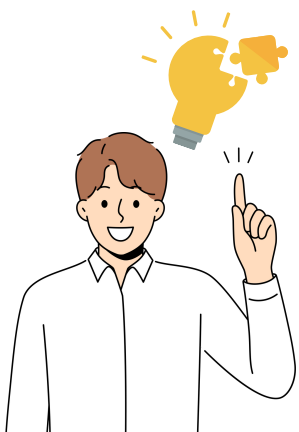
3. To encourage private sectors for taking initiatives to establish more NM centers to inch towards the required number to benefit population at large.

4. Price capping for all diagnostic and therapeutic procedures can be made mandatory as per AYUSHMAN or central government health scheme prices.

5. Encourage inclusion of all diagnostic and therapeutic procedures of NM in most of the health insurance schemes being offered.

Conclusion

Indigenous initiatives taken both at government and non-government levels are likely to overcome the logistic problems including availability and access of theranostic radionuclides and hence, help enhancing the current pool of nuclear medicine facilities in the country.



Nuclear Medicine Quirks: The Surreal Side of Radiation

Gurkirat Singh Nizer

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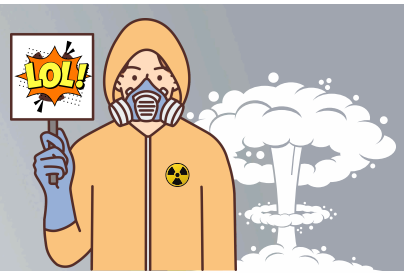

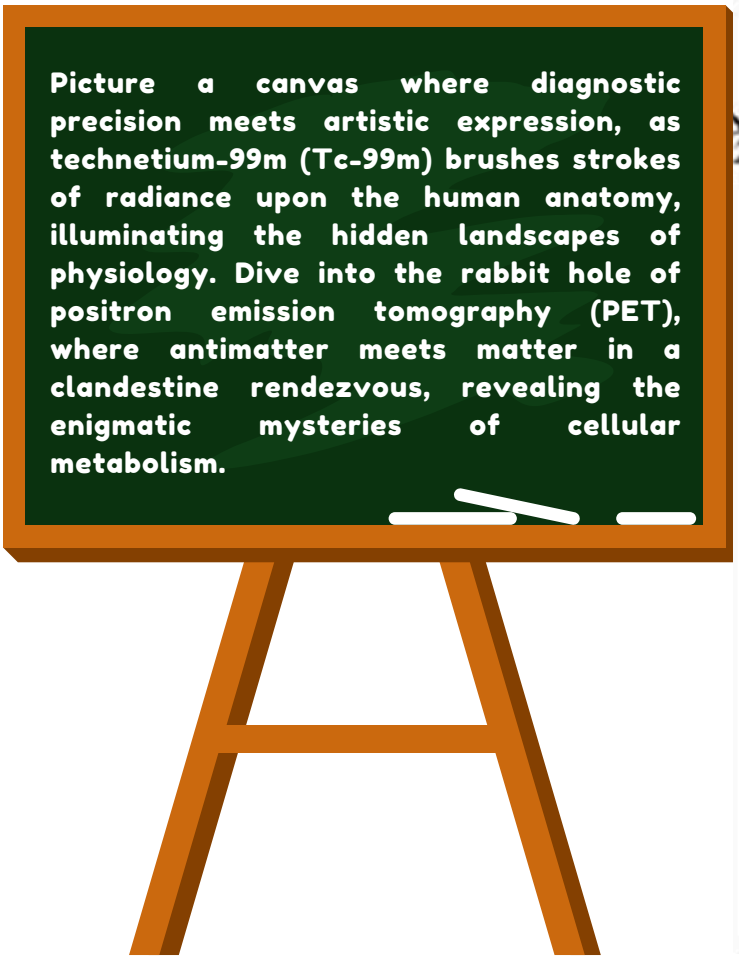

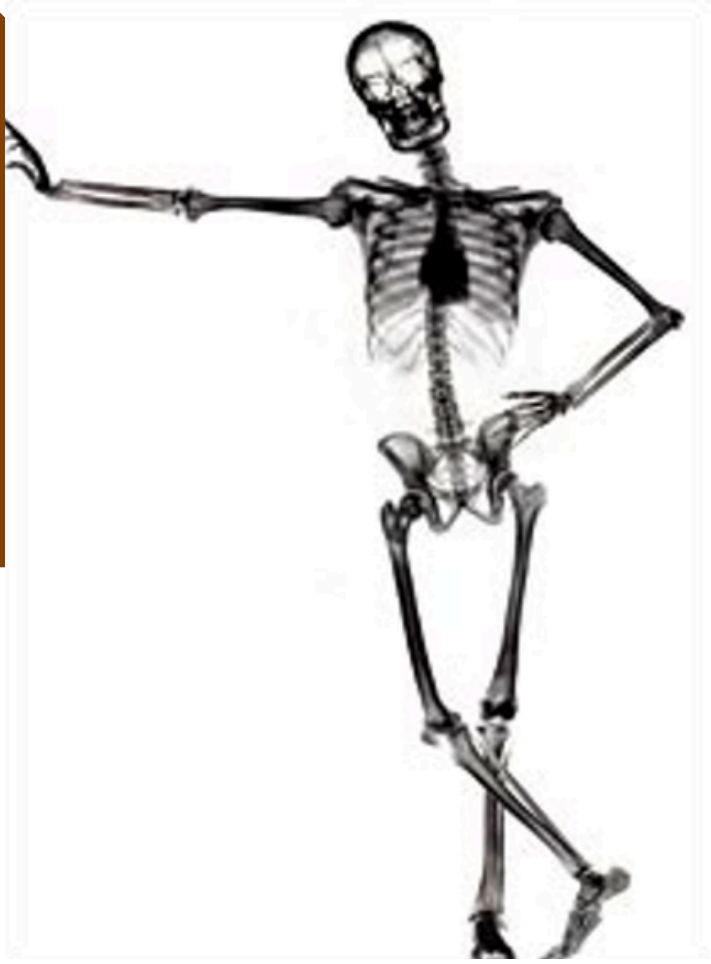

Certainly! Nuclear medicine is a fascinating field with some quirky and amusing facts about radiation. Here are a few:

1. **Radioactive Hugs:** Patients who have undergone nuclear medicine procedures may emit low levels of radiation for a short period. This has led to jokes about "radioactive hugs" where someone might humorously avoid hugging the person recently exposed to radiation, fearing they might "glow in the dark" or be harmful to touch.

2. **Radiation Levels Compared To Bananas:** It's often mentioned in nuclear medicine that bananas are slightly radioactive due to the presence of pottasium-40 (40K). To put radiation doses into perspective, sometimes medical professionals humorously compare the radiation exposure from certain procedures to the radiation you'd receive from eating a banana, just to ease patient concerns.

3. **Gamma Camera Selfies:** Some patients, particularly those undergoing gamma camera based nuclear imaging tests, have been known to joke about taking "gamma camera selfies" during their procedures. Of course, this is not allowed for safety reasons, but the idea of capturing oneself undergoing such a unique medical test adds a touch of humour to the experience.

4. **Radiation Superhero:** In a light-hearted vein, some patients undergoing nuclear medicine procedures playfully refer to themselves as "radiation superheroes" or "radioactive man/woman," imagining themselves with superpowers after being exposed to radiation. It's a fun way to cope with the anxiety that can come with medical tests.

5. **Radioactive Love:** Couples where one partner works in nuclear medicine may joke about "radiating love" or having a "nuclear romance." It's a light-hearted way to acknowledge the unique aspects of their relationship, given one partner's profession involves working with radiation.

6. **Attraction Of The Specialty (Nuclear Medicine):** Perhaps the single most attractive feature of a career as a nuclear medicine physician is the holistic nature of the speciality as there are interactions with all clinical specialties.

While these humorous aspects offer some levity, it's essential to remember the serious and crucial role nuclear medicine plays in diagnosing and treating various medical conditions. Suspend the disbelief and embrace the surreal, as we navigate the labyrinth of Nuclear Medicine, where reality and abstraction converge in a kaleidoscope of infinite possibilities.

Digital PET/CT: The Latest Technological Innovation In Nuclear Medicine

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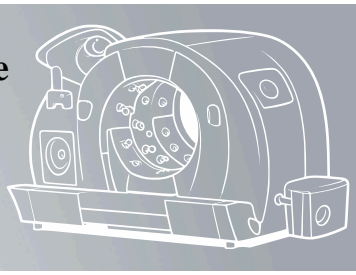


Introduction

The first large-scale use of a human positron imaging device was developed by physicist Gordon Brownell and neurosurgeon William Sweet at the Massachusetts General Hospital in the 1950s. The machine was used to detect brain tumours with sodium iodide (Na-I). Refinements led to increased sensitivity and multiple detectors, and in 1974, Hoffman and Phelps developed PET, an imaging system. It provided the means to watch and measure biochemical processes in the human body.

In the last fifty years, positron emission tomography (PET) imaging technology has achieved tremendous improvements in performance since it was first conceived as a medical imaging modality. The spatial resolution has improved by 10x and sensitivity by 40x from the early designs in the 1970s to the current high-performance PET scanners. In recent times, hybrid configurations have emerged that combine PET with computed tomography (CT), and whole-body scans for clinical purposes can now be done in well under 10 min on a state-of-the-art PET/CT.

Positron emission tomography (PET) is a specific imaging technique which is sensitive to the picomolar concentration level molecular interactions and pathways within the human body. The specificity arises from the range of PET radionuclides that can tag specific biochemicals, biomarkers and pharmaceuticals without disturbing their biological pathway or function. In addition, radiation emitted from a radiolabelled tracer is specific to that tracer and can be detected above the low natural radiation background **[Figure 1]**.

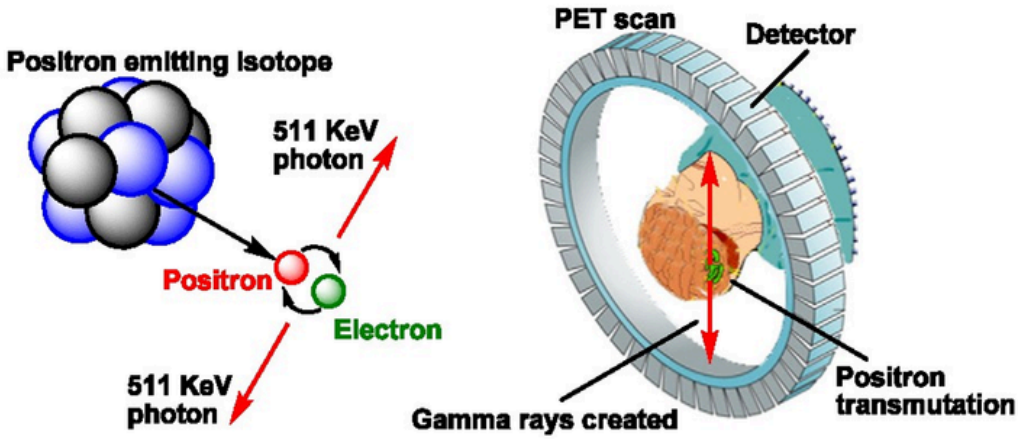


Figure 1 : Basic principle of PET imaging showing positron emission and pair production along with PET detector arrangement for photon detection.

Over the last fifty years, coincidence detection of PET radionuclides has evolved from single pairs of detectors for planar imaging to arrays of detector elements covering 25 cm or more in axial length in current PET Scanners. The purpose is always to improve the sensitivity to maximize the acquired counts per unit of dose to the patient and attain high spatial and temporal resolutions.

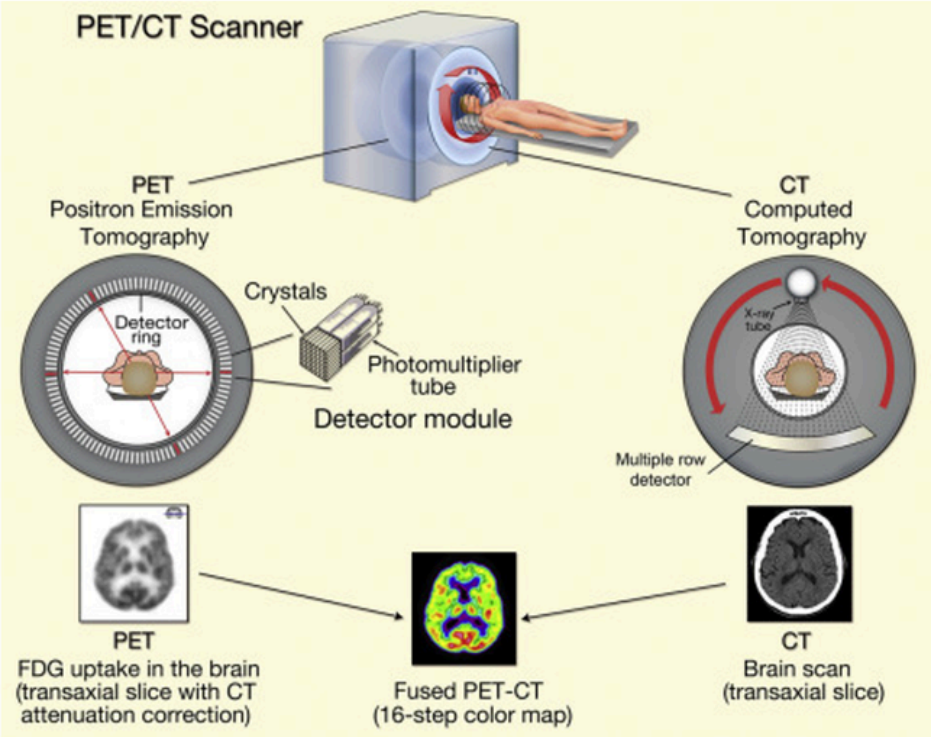


Figure 2 : Conventional PET-CT Scanner and Image formation

Since 2001, essentially all PET scanners have been physically combined with a CT or, from 2010, an MR scanner. The second modality provides a high spatial resolution anatomical framework that is accurately co-registered with the functional PET image and can be used to improve the quality of the PET image. Historically, clinical PET/CT development occurred in the mid-1990s, when the concept of preclinical PET/MR was being explored.

The systematic advances in PET scanner technology have resulted in 40 times increase in sensitivity from the early single-slice designs to the commercial scanners of today. Each new phase in this advancement has come at an additional cost. However, an increase in the acquired signal per unit of cost has been offset, resulting in potential new clinical and research applications.

In the initial PET, there were septa, but it significantly decreased the system's sensitivity. The temporary removal of the septa from the first block detector scanner demonstrated both the sensitivity improvement and the ability to perform fully three-dimensional (3-D) reconstructions. This led to the design of a new generation of PET scanners, which had the option in both the septa-in (2-D model) and with septa retracted (high sensitivity "3-D" mode). The widespread adoption of 3-D acquisitions challenged the limits of the BGO detector of PET scanner, especially for whole-body imaging of large and obese patients. The researcher's response was an ongoing search for a scintillator with characteristics like better light output, faster decay times, improved energy resolution, and reduced dead time. The search led to the discovery of a new scintillator, lutetium oxyorthosilicate (LSO), originally used for nuclear good logging but had much superior light emission properties than BGO for PET imaging.

The first commercial PET scanner with an LSO detector was the ECAT ACCEL, which appeared around 1999. A major advantage of the LSO detector along with the higher light output (leading to better spatial and energy resolution) is, the fast timing resolution that leads to lower detector dead time, and, above all, it allows measuring the time difference between the arrivals of the two annihilation photons in the detectors or timing resolution. The time-of-flight (ToF) provides positioning information for the annihilation point that is unavailable without ToF.

The BGO crystal is too slow for conventional TOF-based imaging. It was when LSO appeared that TOF made resurgence with the Philips Gemini TF (True Flight) launch, followed by the Siemens Biograph mCT. The introduction of LSO scintillator led to the incorporation of TOF information into the reconstruction algorithms. Each response line is subdivided into several different time bins, typically depending on the timing resolution.

Need for Digitalization of Photo Detector: Pathway for Digital PET-CT

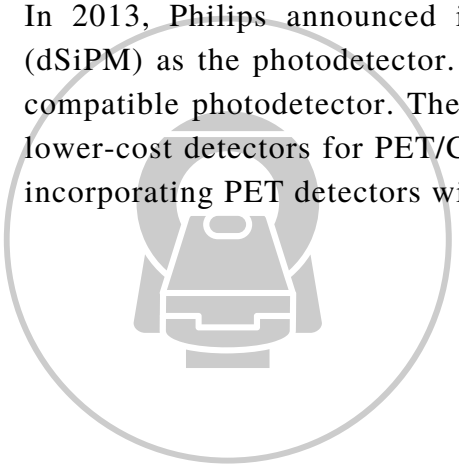
Since the beginning of positron tomography, the photomultiplier-based photodetector does not function in a magnetic field and requires shielding even from the earth's field. Because of this, PET detectors could not be operated inside, or even close to, an MR scanner. It eliminated the possibility of a PET/CT-like approach without additional shielding or a different detector configuration. In the 1990s and after the turn of the century, much effort was devoted to developing semiconductor photodetectors with characteristics that should be stable, low noise, fast, efficient, and operate at reasonable temperatures. The first such device that satisfied some of these specifications in a PET detector was avalanche photodiode (APD) technology, and with this technology, a prototype preclinical imaging device appeared in 2005.

A year later, in 2006, the first PET detector ring using APD technology that could be inserted into a clinical MR to acquire PET data simultaneously with the operation of the MR was produced by Siemens Healthcare Molecular Imaging.

Opening of the current Digital Era of PET-CT

With the announcement of the mMR in 2010 by Siemens Incorporation, a new photodetector, the silicon photomultiplier (SiPM), was introduced. It offered much faster timing than the older APD. It opened the possibility of one-to-one coupling between the scintillator elements and the photodetector, leading to further digitization of signal and opening a path to complete removal of photomultiplier tubes from PET-CT scanner that lead to the new types of PET Scanner called digital PET.

In 2013, Philips announced its first Vereos PET/CT scanner, which incorporated a digital SiPM (dSiPM) as the photodetector. This photodetector was earlier developed to fulfil the need for an MR-compatible photodetector. The emergence of SiPMs might result in compact, higher-performance, and lower-cost detectors for PET/CT. GE further announced a PET/CT scanner in 2016, the Discovery MI, incorporating PET detectors with SiPMs.



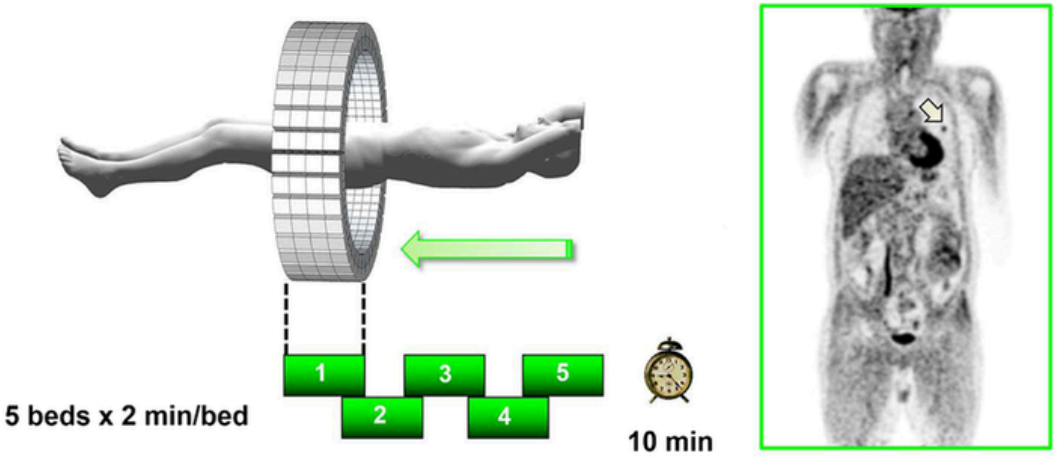


Figure 3 : Multiple ring detectors arrangement for faster acquisition.

Power of Digital PET-CT

Digital PET-CT is indispensable in every stage of cancer treatment, from diagnosis to staging, from monitoring to evaluating the patient's response to the therapy. It redefines precision with advanced sensitivity and detectability parameters than conventional PET-CT scanners. This helps in efficient dose management, devising effective treatment plans, reducing scan times, and eventually helps in enhancing the patient experience significantly. Diagnosis with the digital PET-CT provides a better understanding of the disease progression, including detecting smaller lesions at lower PET isotope doses.

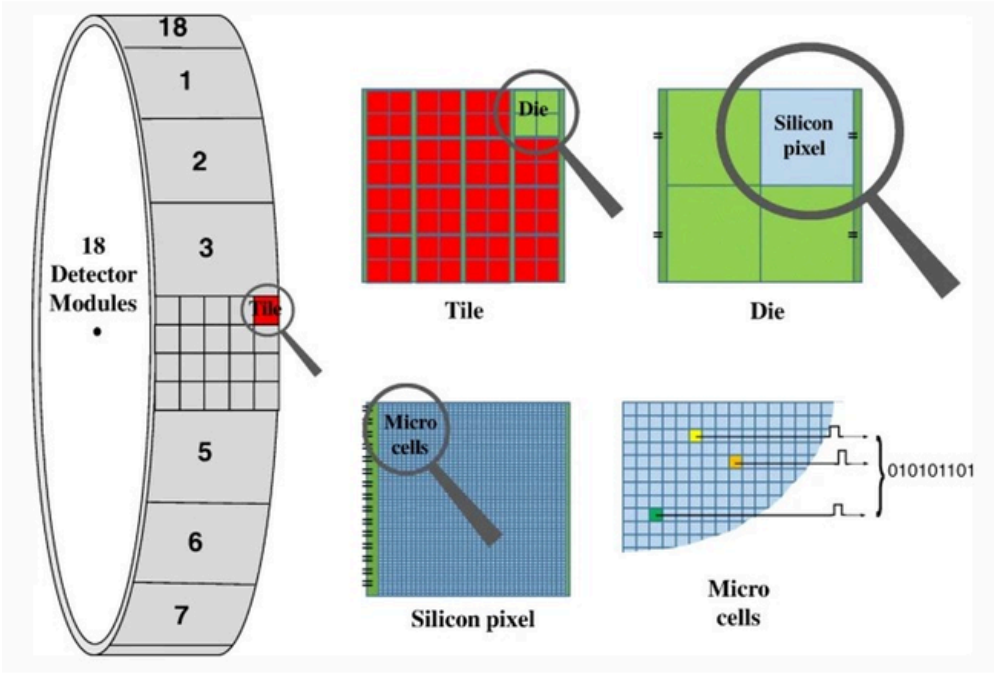


Figure 4 : Solid-state digital photon counting PET detector design. When a scintillation photon hits a very small cell, i.e., a microcell sensor, the value of the integrated photon counter increases, and the integrated timer measures the arrival time of the individual photon on that die. The chip measures all photons during the desired duration of the detection process. The values of the integrated photon counter and timer are read out via a digital interface.

Features of Digital PET-CT

- *Improved lesion detectability*: Visualization of small lesions is essential for clinicians to diagnose, monitor, and restage / stage therapy in oncology patients. In molecular imaging, the challenge is to detect these small lesions reliably. Digital PET provides improved detectability and characterization of small lesions.

- *Reduced PET dose*: Dose reduction in PET radiopharmaceutical administration does not have to be a trade-off between radiation exposure and diagnostic image quality. A reduced radioactive tracer dose can be administered using appropriate reconstruction algorithms without reducing diagnostic confidence. Digital PET provides uncompromised lesion detectability and quantification at half the PET dose.

- *Fast scan*: It allows patients to spend less time in the scanner, increases throughput, and enhances the overall patient experience. Digital PET provides uncompromised lesion detectability at one-tenth the time.

- *Ready for the future*: Digital PET enhances diagnostic confidence with emerging applications that use short half-life tracers.

Future opportunities and limitations

- Effective sensitivity is lost at a higher count rate due to random coincidences and detector dead time. Thus, to minimize these effects, the coincidence timing window and incorporation of efficient parallel data collection are approaches for reducing these sources of loss of sensitivity.

- Quantification to deriving regional rate constants of compartmental exchange. Thus specific biological parameters are rarely implemented in PET mainly because of the difficulty in obtaining the arterial blood input function.

- The inherent specificity and sensitivity of PET: There is a case for capitalizing further on developments to date by exploring the means for detecting lower levels of pathophysiological processes that can be achieved.

- Using more sensitive whole-body PET (Total Body PET) scanners to improve the throughput would make much better use of space and staff complement and be more cost-effective because the scan charge per patient will likely be decreased significantly.

Conclusion

In the last five decades, technical developments in PET instrumentation have resulted in major improvements in image quality for patient studies. Although initially seen as somewhat costly, these advances have, by opening up various new clinical applications, proved ultimately to be cost-effective. There is no reason to disbelieve that these advances cannot continue to the extent envisioned above.

Digital PET/CT is a new relevant opportunity for this issue and for improving lesion detectability and diagnostic confidence. How these encouraging initial findings could be translated rapidly into the patient care paradigm and improve is a matter for further studies in larger populations.

We hope that digital PET/CT can expand current and more importantly, open new, translational healthcare applications for nuclear medicine molecular imaging in the study of human disease as part of the developing vision of precision, personalized, systems-based medicine. This progress will come with overcoming major technical challenges that must be tackled by physicists, engineers, and commercial firms.

References

1. Jones T, Townsend D. History and future technical innovation in positron emission tomography. Journal of Medical Imaging. 2017 Jan 1;4(1):011013. doi:10.1117/1.JMI.4.1.011013

Therapeutic Radiopharmaceuticals

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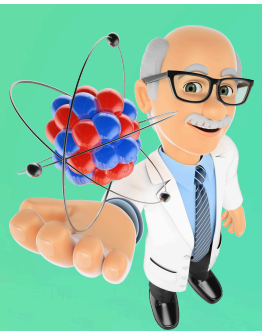


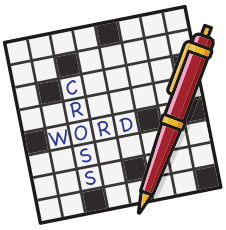
The therapeutic application of radiopharmaceuticals (RPs) dates back to the 1930s, when radioiodine-131 (I-131) was used to diagnose and treat thyroid cancer. Similar to other RPs, the therapeutic RPs also consist of two main components: i) Pharmacophore and ii) Radionuclide. The pharmacophore can be a small molecule, peptide, or protein that targets a specific pathway or receptor, over-expressed in a malignancy. Depending upon the indication and application, the biomolecules can be tagged with alpha or beta emitting radionuclides [Table 1] like actinium-225, lutetium-177, yttrium-90, rhenium-186, and rhenium-188. On one hand the high linear energy transfer (LET) of these radionuclides kills the cancer cells efficiently on the other hand the accompanying gamma/bremsstrahlung radiations help in post-therapy imaging to observe the biodistribution of administered radiopharmaceutical. Unlike radiotherapy, the therapeutic radiopharmaceuticals are commonly administered intravenously and a few times loco-regionally, like in radiation synovectomy or selective intra-arterial radionuclide therapy (SIRT). Radionuclide therapy has shown good efficacy and lesser toxicity than all other available forms of systemic cancer treatment options. Also, lesser number of treatment cycles are required for radionuclide therapy in comparison to the conventional ones.

The success of peptide receptor radionuclide therapy (PRRT) using radiolabeled octreotide analogs for targeting the over-expressed somatostatin receptors (SSTRs) in neuroendocrine tumors (NETs) has popularised the therapeutic application of radiopharmaceuticals globally. Prostate-specific membrane antigen (PSMA) targeting radiolabled PSMA inhibitors are used to treat the patients with metastatic prostate cancer. Patients who have exhausted all the other available treatment options have shown encouraging results for alpha therapies.

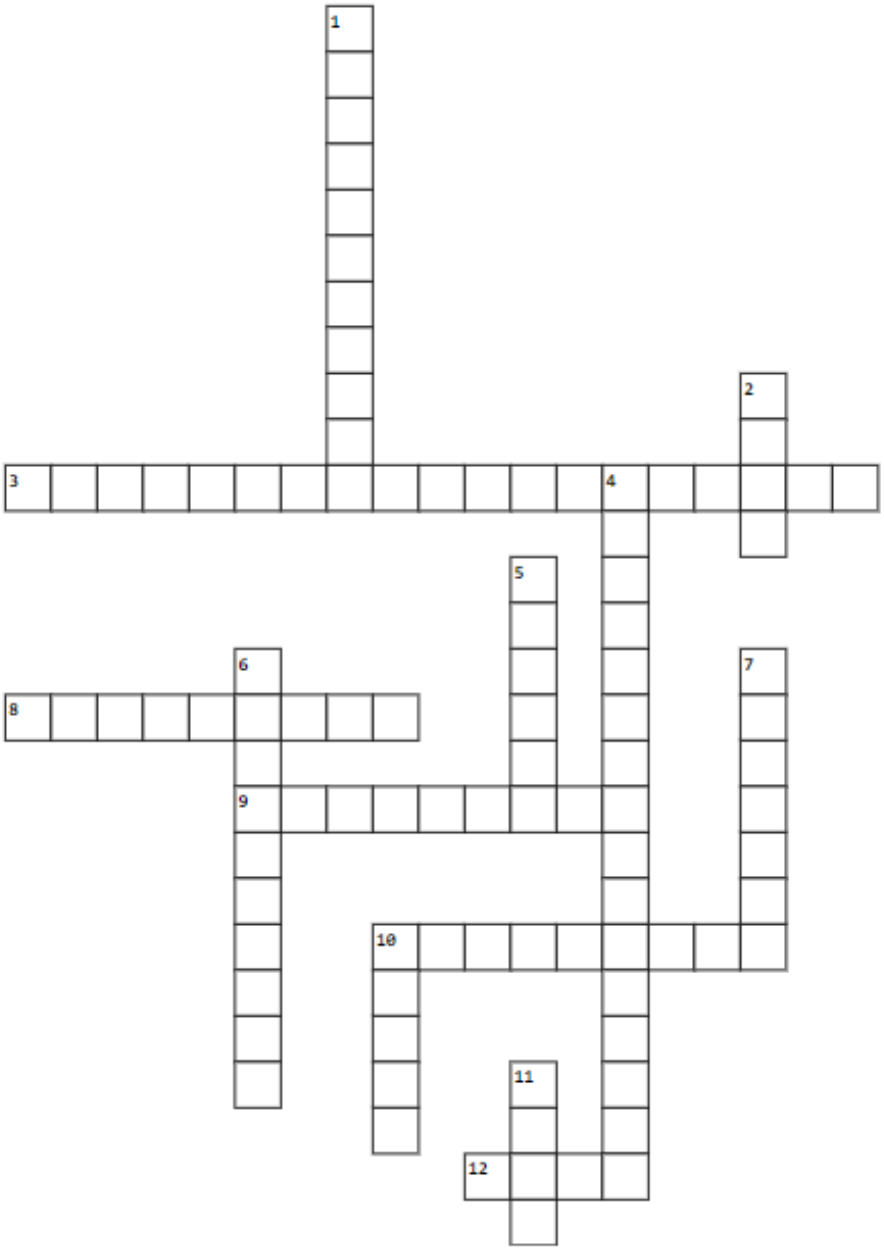
Many new developed RPs are under pre-clinical stages, and few targeting chemokine receptors, cancer cell-associated fibroblast have reached early clinical trial stage. Multiple trials with antibodies are also going for radioimmunotherapy. However, the limited availability and high cost associated with the available radionuclides hinder the widespread use of these radiopharmaceuticals. Research is ongoing for newer production methods to meet the global demand for such radionuclides. Newer therapeutic radionuclides like terbium, astatine, and scandium are also being explored. Good collaboration between industry and academia is needed to fulfil the practical needs. Therapeutic radiopharmaceuticals, once named magic bullets by Paul Elrich, is the future of personalised treatment bringing hope and impacting the lives of thousands of patients worldwide.

Isotope	Half-life ($t_{1/2}$)	Energy	Stable Daughter
Iodine-131	8.02 d	E_{β^-max} 606 KeV E_γ 364 keV	Xenon-131
Lutetium-177	6.73 d	E_{β^-max} 497 KeV E_γ 113 and 208 keV	Hafnium-177
Rhenium-188	17.9 h	E_{β^-max} 2.12 MeV E_γ155 KeV	Osmium-188
Rhenium-186	3.718 d	E_{β^-max} 1.07 MeV E_γ137.2 and 122.6 KeV	Tungestun-186 Osmium-186
Strontium-89	50.6 d	E_{β^-max} 1.46 MeV	Yttrium-89
Samarium-153	46.3 h	E_{β^-max} 0.81 MeV E_γ103 KeV	Europium-153
Yttrium-90	64.1	E_{β^-max} 2.28 MeV	Zirconium-90
Radium-223	11.4 d	E_α 5.64 MeV E_γ 82, 154, 269, 351 and 402 keV	Lead-207
Actinium-225	9.92	E_α 5.935 MeV E_γ 78, 218, and 440 keV	Thalium-205
Bismuth-213	45.6 min	E_α 5.89 MeV E_γ 440 keV	Thalium-205
Bismuth-212	60.55 min	E_{β^-max} 2.254 MeV E_α 6.090 MeV E_γ727.3 and 1620.5 KeV	Lead-208
Lead-212	10.64 h	E_{β^-max} 2.25 MeV $E_{\gamma max}$ 2614.5 keV	Lead-208
Scandium-47	3.35 d	E_{β^-max} 600 KeV E_γ 159 keV	Titanium-47
Terbium-149	4.1 h	E_α 3.97 MeV E_γ165.0 keV, 352.2 keV, 388.6 keV, 652.1 keV, 853.4 keV	Neodymium-145 Praseodymium-141
Terbium-161	6.9 d	E_{β^-mean} 0.154 MeV E_γ 48.9 KeV, 74.6 KeV	Dysprosium-161
Copper-67	2.57 d	E_{β^-max} 0.561 MeV E_γ 184.6 KeV, 91.3/93.3 KeV	Zinc-67
Astatine-211	7.21 h	$E_{\alpha\ mean}$ 6.79 MeV E_γ5.63 MeV	Lead-206

Table 1 : Showing characteristics of various therapeutic radionuclides.



CROSSWORDS



ACROSS

3. The first radiopharmaceutical specific for a category of bacteria

8. The trade name of first FDA approved radiopharmaceutical for PRRT

9. Used to force protons into the nucleus

10. Equivalent dose takes into account which weighing factor

12. SI unit for absorbed dose of radiation

DOWN

1. The liquid target for production of Ga-68 using cyclotron(2 words)

2. This ligand labelled with Ga-68, is a renal PET probe which is almost exclusively excreted by glomerular filtration

4. The effective dose takes into account the _____ of the tissues

5. The radioisotopes of this nuclide can form true Theranostic pair

6. Radiation effects that are probable in nature

7. The process of splitting of nucleus into two or more fragments

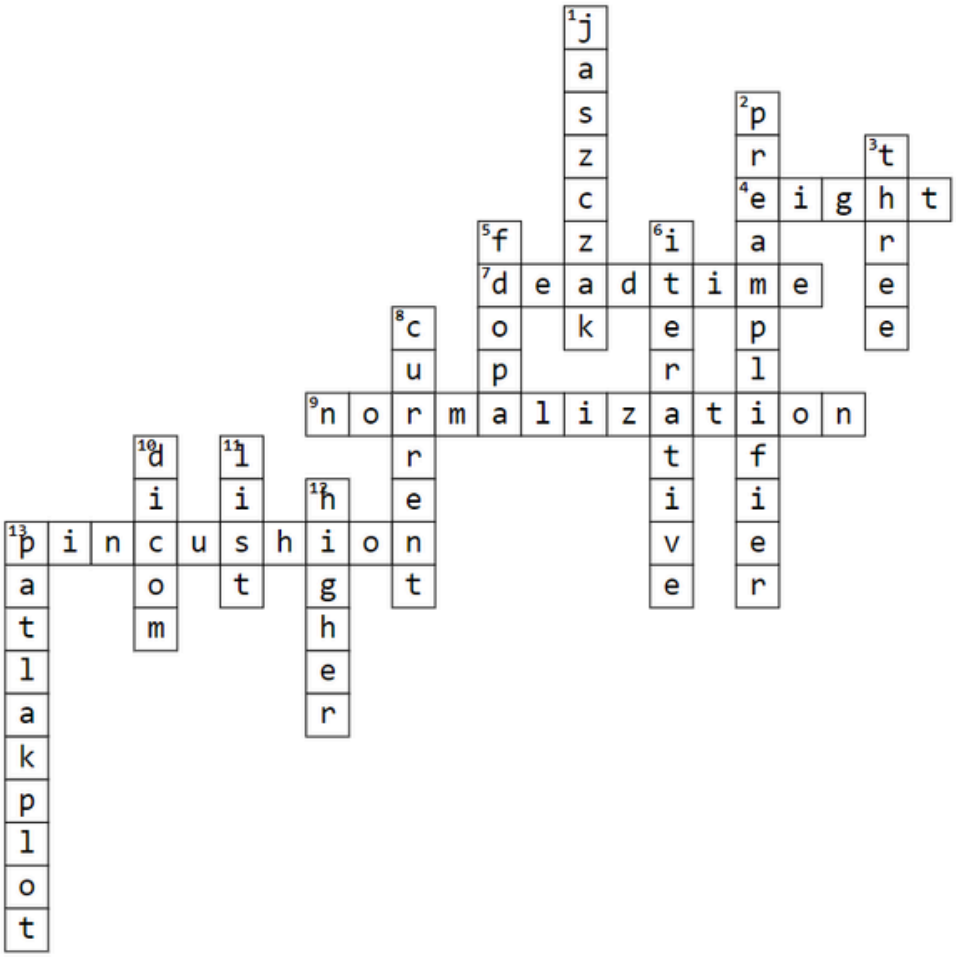
10. This element contributes to background radiation

11. Committee proposed a complete and self-consistent system of absorbed-dose calculationsinthe scale of human organs

ANSWERS IN NEXT ISSUE

CROSSWORDS

ANSWERS OF JAN-MAR 2024 ISSUE



ACROSS

4. How many bits form a byte

7. High counting rates result in higher _____losses (2 words)

9. The purpose of this correction is eliminating differences in sensitivity between detectors

13. Image nonlinearity/Distortion in gamma camera imaging presented as inward "bowing"

DOWN

1. Commonly used phantom in quality control of gamma camera

2. Electronics responsible for matching impedance levels between the detector and subsequent components in the system

3. How many times is TVT that of HVT

5. PET tracer for studying presynaptic dopaminergic function in Parkinson's disease

6. Using this reconstruction method, prior knowledge of the system can be built into a system matrix

8. Parameter of CT tube responsible for increasing photon flux

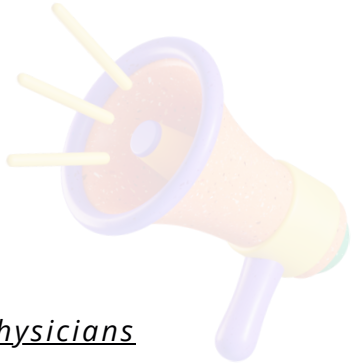
10. It is both a protocol for transmitting images and a file format for storing them

11. Mode of acquisition used for dynamic image acquisition

12. Quadrant sharing of PMTs results in _____ dead time losses

13. One of the kinetic models developed for quantitative PET imaging(2 words)

Schedule



NATIONAL

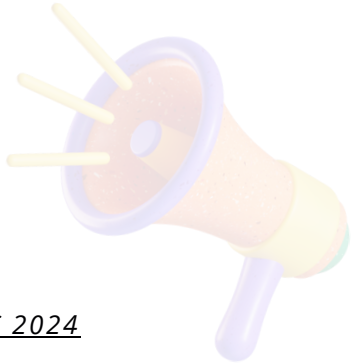
22nd Annual Conference of Association of Nuclear Medicine Physicians of India -ANMPICON 2024
27th-29th September, 2024
PGIMER Chandigarh
Last Date of Abstract Submission: Yet to be announced

56th Annual Conference of Society of Nuclear Medicine India (SNMI)
29th Annual Conference of SNMI, Southern Chapter
5th-8th December, 2024
KMCH, Coimbatore
Last Date of Abstract Submission: Yet to be announced

9th Annual Conference of Nuclear Medicine Physicists Association of India NMPAICON-2025
15th-16th February, 2025
AIIMS, New Delhi
Last Date of Abstract Submission: Yet to be announced

15th Biennial Nuclear Cardiological Society of India Conference (NCSICON 2025)
March 2025
Sarvodaya Hospital, Faridabad.
Last date of Abstract Submission: Yet to be announced

Schedule



INTERNATIONAL

Annual Conference of the American Society of Nuclear Cardiology ASNC 2024
05th– 07th September, 2024
Austin, Texas
Abstract Submission: 10 April, 2024

BNMS Autumn Meeting 2024
14th-15th October, 2024
Norwich, United Kingdom
Last date of Abstract Submission: 1st September 2024

37th Annual Congress of the European Association of Nuclear Medicine
19th– 23rd October, 2024
Hamburg, Germany
Abstract Submission: Yet to be announced

20th European Molecular Imaging Meeting (EMIM 2025)
11th- 14th March 2025
Bilbao, Spain
Last date of Abstract Submission: 19th November 2024

55th Annual Scientific Meeting of the Australian and New Zealand Society of Nuclear Medicine
16th-18th May 2025
Melbourne, Australia
Last date of Abstract Submission: Yet to be announced

BNMS Annual Spring Meeting 2025
19th- 21st May 2025
Glasgow, United Kingdom.
Last date of Abstract Submission: Yet to be announced

Society of Nuclear Medicine and Molecular Imaging (SNMMI) 2025 Annual Meeting
21st- 24th June 2025
New Orleans, Louisiana, USA.
Last date of Abstract Submission: Yet to be announced

22nd European Symposium on Radiopharmacy and Radiopharmaceuticals
16th- 19th April 2026
Bergen, Norway
Last date of Abstract Submission: Yet to be announced

Upcoming Events

NMPAICON 2025

15th - 16th FEBRUARY, 2025

ALL INDIA INSTITUTE OF MEDICAL SCIENCES
NEW DELHI