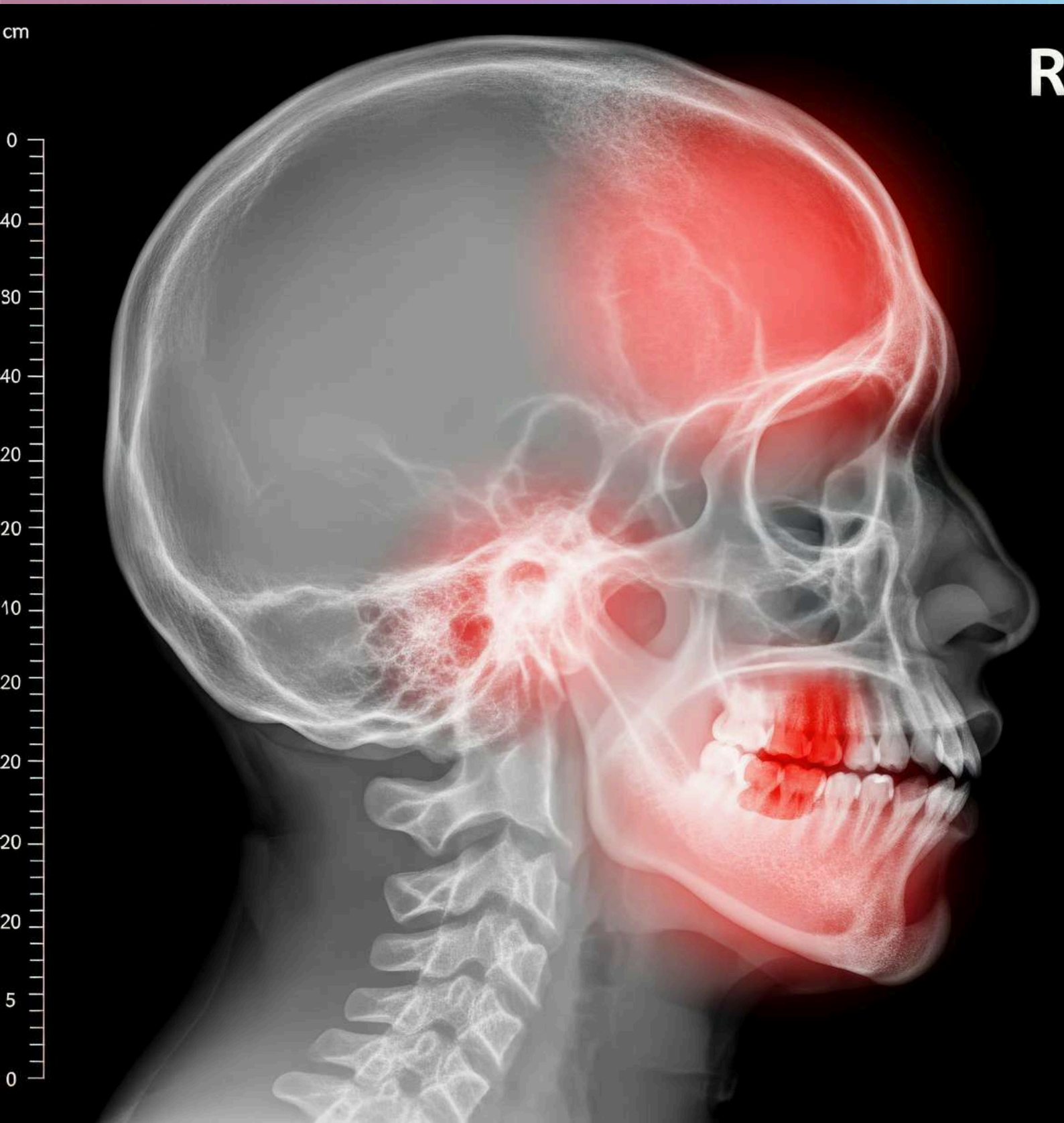
Since 2004 For free Circulation

Radiographers' Journal

The official magazine of Society of Indian Radiographers (SIR)
Published by Radiographers' Association of Maharashtra (RAM)

December 2025



Editorial

Shankar K. Bhagat
Editor-in-chief

Dear Readers,

As we conclude the year 2025, this December issue of the Radiographers Journal reflects the remarkable pace at which medical imaging continues to evolve. The articles featured in this edition collectively highlight innovation, clinical relevance, and the growing integration of advanced technologies that are reshaping the role of radiographers and imaging professionals. From radiation protection and portable imaging to artificial intelligence and sophisticated tomographic techniques, this issue offers a comprehensive snapshot of where the profession stands today and where it is headed.

Radiation safety remains a cornerstone of radiographic practice, and the article on novel shielding materials using tungsten-polymer composites presents an important advancement in this area. By exploring lightweight yet highly effective alternatives to traditional lead shielding, the authors emphasize improved ergonomics, enhanced protection, and environmental benefits. Such innovations are particularly relevant as radiographers seek safer and more sustainable solutions without compromising image quality or occupational safety.

Emergency and trauma imaging is another critical domain addressed in this issue through the article on advancements in portable X-ray units. The discussion highlights technological improvements that enable rapid, high-quality imaging at the point of care. These developments are especially valuable in emergency departments, intensive care units, and disaster settings, where timely diagnosis can significantly influence patient outcomes and workflow efficiency.

The evolving capabilities of chest and pulmonary imaging are well represented through articles on dynamic digital radiography and dark-field chest radiography with beam-hardening correction using deep-learning bone segmentation. Together, these contributions demonstrate how motion-based imaging and artificial intelligence-driven corrections can enhance visualization of lung function and structure. Such techniques open new possibilities for early detection and functional assessment of pulmonary diseases beyond conventional static imaging.

Advanced and specialized imaging applications also feature prominently. The article on post-mortem MRI underscores the growing role of non-invasive imaging in forensic medicine, offering valuable insights while respecting ethical and cultural considerations. Similarly, the comprehensive study on hierarchical phase-contrast tomography for intact human organ imaging showcases cutting-edge research that pushes the boundaries of resolution and contrast, bridging the gap between clinical imaging and high-end research applications.
Artificial intelligence continues to be a transformative force in healthcare, and its role in early cancer diagnosis is thoughtfully examined in this issue. The article outlines how AI-assisted image analysis can support radiographers and radiologists in detecting subtle pathological changes, improving diagnostic accuracy, and facilitating personalized patient care. This reinforces the importance of radiographers staying informed and skilled in emerging digital tools.

Abdominal imaging and hepatology are addressed through two clinically relevant articles. The discussion on the role of triple-phase computed tomography in the evaluation of hepatic lesions highlights its diagnostic value in lesion characterization and management planning. Complementing this, the article on estimation of standard liver volume using computed tomography with comparison to ultrasonography provides practical insights into volumetric assessment, emphasizing accuracy, reproducibility, and clinical utility.

In summary, the December 2025 issue of the Radiographers Journal brings together diverse yet interconnected themes that reflect the profession's commitment to innovation, patient safety, and clinical excellence. We extend our sincere gratitude to all contributors for their valuable work and to our readers for their continued engagement. As we move into the new year, may this issue inspire learning, adaptation, and progress in the ever-evolving field of medical imaging.

F.No.Z.20025/9/2025-NCAHP
Government of India
Ministry of Health & Family Welfare
National Commission for Allied and Healthcare Professions

2nd Floor Academic Block, NIFHW Building,
Baba Gangnath Marg, Munirka,
New Delhi
Dated: 19-11-2025

To

1. Secretary, Department Higher Education,
M/o Education, Govt. Of India, Shastri Bhavan, New Delhi
2. Secretary, Department of School Education and Literacy
M/o Education, Govt. Of India, Shastri Bhavan, New Delhi
3. Secretary, Department of Education
State Governments/ UT Administrations

Sub: Admission eligibility to various courses in the field of Allied and Healthcare for the curriculum issued by the National Commission for Allied and Healthcare Professions (NCAHP)

Sir,

I am directed to say that the National Commission for Allied and Healthcare Professions (NCAHP) has notified 13 curricula so far for different courses of Allied and Healthcare Professions for graduate and postgraduate levels, which are to be implemented from the 2026-27 academic year. Also, to be noted that NCAHP is in process of releasing more curricula. The details may be seen on the Commission's website (https://ncahp.abdm.gov.in/Curriculum).

2. As per the NCAHP Act, 2021, the entry criteria to the admission to Allied and Healthcare courses to be defined has been incorporated in the notified curricula. In majority of curricula notified have one of the eligibility criterion for admission is appearing in NEET (National Eligibility cum Entrance Test) exam over and above other criteria. Admission to these courses is slated to begin from 2026–27 academic year.

3. Therefore, it is requested that the Boards working under the Central/State Govt./UTs may be directed to disseminate information to Schools/Institutes that students aspiring for admission into Allied and Healthcare undergraduate courses after passing the Senior Secondary level equivalent exam will require NEET appearance as a basic eligibility criterion, along with other eligibility criteria

4. This issues with the approval of Competent authority.

Yours faithfully,
Digitally signed by
Rajender Singh Sidhu
Date: 19-11-2025
12:40:07
(Rajender Singh Sidhu)
Under Secretary (NCAHP)

Copy for information & necessary action to:

1. Secretary, Central Board of Secondary Education
2. Secretary, ICSE Board
3. Secretary, State Council for Allied and Healthcare Professions
4. Secretary, University Grant Commission
5. Secretary, National Testing Agency

QUIZ to Recapitulate

Pawan Kumar Popli, Chief Technical officer-Radiology (Retd.), AIIMS, New Delhi

1. Name the active constituent of fixer in automatic processor?

2. Describe the patient position for post fatty meal OCG radiograph?

3. What is the role of Methyl cellulose in enteroclysis ?

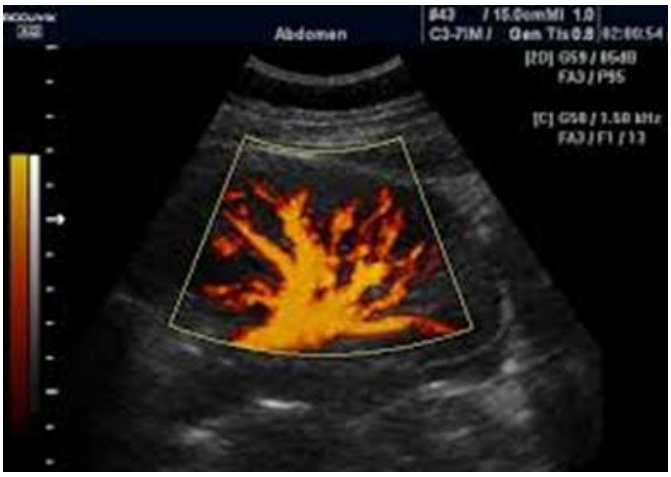
4. The shaft of node in rotalix X-Ray tube is made up of which material and why?

5. Name the two materials used for reflective layer of intensifying screen?

6. In an EBCT what is position of anode ?

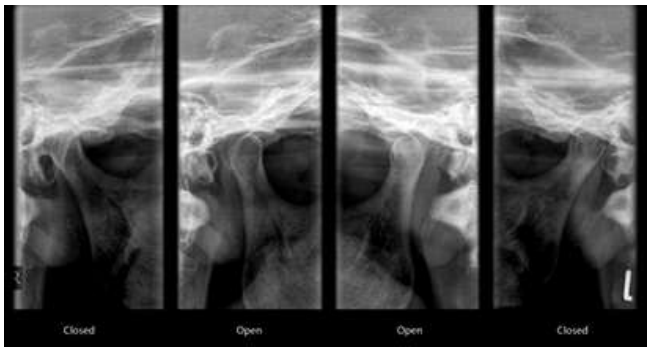
7. Which type of pace maker is MRI Compatible

8. Name the procedure.



9. Identify the object its use.

10. Describe the Radiograph



- Please send your answers in through email on **pkpopli@gmail.com** on or before **10th January 2026.**
- Send your **Name with Hospital/Institution Information** and Passport size **photograph** along with the **answers in a word format file attachement.**
- **Best 3 participants** (early birds and correct) in each month will get the prizes **(Sponsored by JBD Publications).**
- Correct answers will be published in the next issue.
- If required /requested by participants more details about any question can be provided in upcoming issues under title **"Your Requests"**

Answers for the Quiz - November 2025 issue

1. PQ stands for a combination of Phenidone and Hydroquinone.

2. No oblique view is usually required.

3. No bowel preparation is advised for this examination.

4. International Commission on Radiological Protection (ICRP).

5. Lateral view of the skull.

6. Maximum Intensity Projection (MIP).

7. Mammography (the first AI-based CAD approved by the FDA).

8. Chest PA view (erect).

9. Modified Stenver's view for cochlear implant.

10. Vascular sheath set.

The following readers participated in the Quiz – November 2025 issue.

Kalai Selvi S
Sree Chitra Tirunal Institute for Medical Sciences & Technology
Trivandrum, Kerala

Sriram. R,
DAE Hospital
Kalpakkam, Tamil Nadu

Tushar Bhagwan Pawar
Dignocare Diagnostic Centre
Baramati, Maharashtra

Darji Himanshukumar
IKDRC - ITS
Ahmedabad,Gujarat

Simi Paxleal J

Ancy Rose

Dr. Jeyasekharan Medical Trust Nagercoil, Tamil Nadu

R. Ramiya

Keerthika

Abirami Sivaraj

Panimalar College of Allied Health Sciences, Chennai, Tamil Nadu

Kratika Rawal

Radhika

Gulshan Kumar

Ekta Singh

Kanika Saini

Kalash Jain

Subharti College of Allied and Healthcare, Swami Vivekanand Subharti University Meerut, Uttar Pradesh

Vishakha Choudhary
Assistant Professor
Motherhood University
Roorkee

Asma A
Government Stanley College Chennai,
Tamil Nadu

Mohammed Shoeb Akthar
Malla Reddy University,
Hyderabad, Telangana

October 2025 Quiz Winner with a Prize
Simi Paxleal J,
Dr. Jeyasekharan Medical Trust Hospital,
Nagercoil, Tamil Nadu

Sahil Bhawar
NITTE Institute
Mangalore, Karnataka

Ravindra Kumar
PGIMER, Chandigarh

Kushal Dey
NH-RTIICS, Kolkata

John Salamon

National Conference on Radiology and Imaging Sciences (NCRIS 2025)

The School of Allied Health Sciences, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Puducherry Campus — SAHS Department of Radiology and Imaging Technology, in collaboration with the Society of Indian Radiographers – Puducherry Chapter, successfully organized the National Conference on Radiology and Imaging Sciences (NCRIS 2025) on 15th November, 2025.

The event commenced with a warm Welcome Address delivered by Mrs. Deepika S., Assistant Professor and Academic Coordinator, SAHS – Chennai Campus, who extended heartfelt greetings to the dignitaries, speakers, faculty members, and participants. This was followed by the symbolic Lamp Lighting Ceremony, signifying the light of knowledge, innovation, and professional excellence.
Prof. S. Andrew John Silvester, Director SAHS, Puducherry campus VMRF-DU, delivered Keynote Address, offering valuable insights into advancements and evolving responsibilities in the allied health sector.

Following this, Dr. S. Tamijeselvan, Asst. Professor in Radiography, MTPGRIHS and General Secretary, Society of Indian Radiographers -Puducherry Chapter, presented Keynote Address, highlighting the relevance of emerging technologies, adherence to safety protocols, and professional preparedness in radiology and imaging sciences.

Prof. Dr. B. Sendilkumar, Dean Allied Health Sciences, VMRF-DU emphasized academic excellence, research orientation, and the importance of continuous professional development, Skilling, reskilling and Upskilling in the modern healthcare landscape.

The conference proudly featured distinguished national speakers whose expert contributions enriched the academic experience: Ms. Anne Portia, Assistant Professor & Medical Physicist, Dhanalakshmi Srinivasa University. Dr. Victor R. Lazar, Associate Professor, Department of Radiodiagnosis, SRM Medical College Hospital & Research Centre. Dr. Arun Kumar K., MBBS, MD Radiodiagnosis. Consultant Radiologist, Government Hospital Ulundurpet. Mrs. Deepega S., Assistant Professor, SAHS – VMRF-DU, Chennai Campus. Mr. Alphonse D., Assistant Professor, SAHS – VMRF-DU, Salem Campus

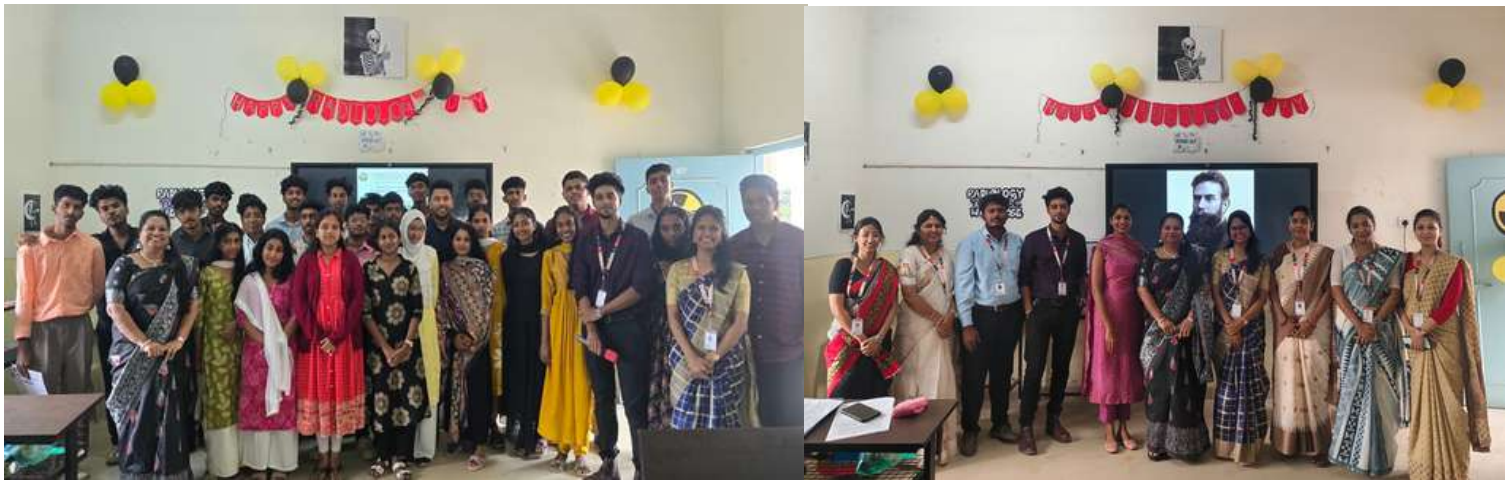
Engaging Oral and Poster Presentations were conducted, providing a platform for students to showcase their academic excellence, research skills, and innovative ideas. About 15 oral presentations and 60 poster presentation taken place in this academic event.

With over 400 enthusiastic student participants, NCRIS 2025 stood out as a resounding success — a vibrant celebration of learning, leadership, and collaboration in the field of Radiography.

The event concluded with a heartfelt Vote of Thanks delivered by Mr. D. Guruprakash, Assistant Professor and Department In-Charge, Radiology & Imaging Technology, SAHS – Puducherry Campus, who expressed gratitude to all dignitaries, speakers, faculties, students, and organizing members for their contribution to the grand success of the conference.

World Radiography Day 2025 Celebrations

Homi Bhabha Cancer Hospital & Research Centre, Visakhapatnam, Tamil Nadu



R. R. Institute of Medical Sciences, Bangalore, Karnataka

भास्कर फॉलोअप 2026 से नीट से प्रवेश शुरू होंगे, पर राज्य की तैयारी पूरी नहीं

मप्र में 225 पैरामेडिकल कॉलेजों में दाखिला अटका, 2025 का सत्र जीरो ईयर की ओर

लवीन ओबरात | इंदौर

पैरामेडिकल और एलाइड हेल्थ कोर्सेस में 2026-27 से नीट आधारित राष्ट्रीय प्रवेश व्यवस्था लागू होने जा रही है, लेकिन मध्यप्रदेश की तैयारियां इस बदलाव की गति को संभाल नहीं पा रही हैं। प्रदेश के 225 से अधिक पैरामेडिकल कॉलेजों में 2025 सत्र के दाखिले की प्रक्रिया अभी तक राज्य शासन द्वारा घोषित नहीं की है, जिससे समस्त पैरामेडिकल कॉलेजों में सत्र 2025 के शून्य प्रवेश की स्थिति उत्पन्न हो रही है । इसकी माह फरवरी 2026 में शुरू होने की संभावना है। लेकिन सबसे बड़ी समस्या यह है कि 2025-26 की प्रवेश प्रक्रिया के लिए न तो मप्र पैरामेडिकल काउंसिल और न ही चिकित्सा शिक्षा विभाग द्वारा कोई नोटिफिकेशन जारी किया गया है। इससे हजारों विद्यार्थी न सिर्फ अनिश्चितता में हैं, बल्कि जीरो ईयर का खतरा भी खड़ा हो गया है।

पिछले चार-पांच सालों से प्रदेश में मान्यता और प्रवेश प्रक्रियाओं का समय पर न चलना एक स्थायी प्रशासनिक पैटर्न बन चुका है। नर्सिंग घोटाले के बाद परिषद की कार्यप्रणाली हाई कोर्ट की कड़ी निगरानी में है और निरीक्षण-मान्यता की फाइलें लम्बे समय तक पेंडिंग रहती हैं। इस वर्ष स्थिति और भी ज्यादा खराब हो गई है, क्योंकि दाखिला प्रक्रिया शुरू ही नहीं हो सकी। नतीजतन कई निजी कॉलेजों में अनौपचारिक रूप से

प्रदेश में कानूनी ढांचा अधूरा, आयोग ही नहीं बना

इस बीच केंद्र सरकार के एनसीएचपी एक्ट 2021 के तहत राज्यों में स्टेट एलाइड हेल्थ प्रोफेशन कमीशन (एएचपी आयोग) का गठन अनिवार्य है। यह आयोग कॉलेजों के निरीक्षण, सीट निर्धारण, फीस नियंत्रण और पारदर्शी काउंसलिंग जैसी मुख्य भूमिका निभाता है। लेकिन मप्र ने अब तक यह आयोग नहीं बनाया है। इतना ही नहीं, 9 मई 2024 को राज्य शासन द्वारा जारी आदेश में पैरामेडिकल परिषद की जो संरचना घोषित हुई है, वह एनसीएचपी एक्ट 2021 की धारा 22(3) के अनुरूप नहीं है। परिषद के गठन में केंद्र की गाइडलाइन से स्पष्ट अलग है, जिसके कारण निरीक्षण और मान्यता का ढांचा कानूनी रूप से मजबूत नहीं हो पा रहा।

- *कुछ कॉलेजों की फाइलें न्यायालय और प्रशासनिक प्रक्रियाओं में लंबित होने के कारण देरी हो रही है। हमारी कोशिश है कि 2025-26 की प्रवेश प्रक्रिया जल्द शुरू की जाए।* - **डॉ. भ्रलोज जोशी**, रजिस्ट्रार, मप्र पैरामेडिकल काउंसिल
- *मप्र की परिषद एनसीएचपी एक्ट 2021 के अनुसार नहीं है। हमने परिषद को पुनर्गठित की मांग सीएम से की है। बिना वैधानिक परिषद के नीट द्वारा प्रवेश प्रक्रिया लागू करना आधा-अधूरा सुधार ही रहेगा।* - **शिवाकांत वाजपेयी**, सचिव, सोसाइटी ऑफ इंडियन रेडियोग्राफर

भास्कर नॉलेज समय पर नियामक बनना जरूरी

नीट आधारित प्रवेश व्यवस्था का उद्देश्य यह है कि पूरे देश में पैरामेडिकल जैसे रेडियोलॉजी, रेडियोथैरेपी, लैब टेक्नोलॉजी, एनेस्थीसिया, ऑपरेशन थिएटर टेक्नोलॉजी आदि सभी कोर्सेस राष्ट्रीय स्तर पर एक जैसे करिकुलम, फैकल्टी क्वालिफिकेशन और इन्फ्रास्ट्रक्चर मानकों पर चलें। अगर नियामक ढांचा समय पर तैयार नहीं होगा, तो कॉलेजों में एडमिशन अटक जाएंगे।

रेडियोग्राफर बोले- गाइडलाइन लागू कराने में विफल रही सरकार

भास्कर संवाददाता | इंदौर

एक्सरे एक ऐसी दोधारी तलवार है, जो जरा सी लापरवाही से इलाज के साथ खतरा भी पैदा कर सकती है। सरकार इंदौर को मेडिकल हब कहती है, लेकिन मप्र में रेडियोग्राफी में एमएससी तक की पढ़ाई उपलब्ध नहीं है, जबकि अन्य राज्यों में पीएचडी तक हो रही है। यह बात वर्ल्ड रेडियोग्राफी डे के समापन कार्यक्रम में सोसाइटी ऑफ इंडियन रेडियोग्राफर के सेक्रेटरी शिवाकान्त वाजपेयी ने कही। उन्होंने बताया कि एक्सरे के आविष्कार के 130 वर्ष बाद भी रेडिएशन सुरक्षा की स्थिति कमजोर है। कई रेडियोग्राफी कर्मचारी रेडिएशन के दुष्प्रभाव से बीमार हुए हैं और कुछ मौत का शिकार भी। एईआरबी की गाइडलाइन का पालन करवाने में सरकार लगातार विफल साबित हो रही है। कार्यक्रम में रेडियोग्राफी स्टूडेंट, डेंटल, मेंटल, टीबी और अन्य अस्पतालों के रेडियोग्राफर शामिल हुए। संचालन अजय सोनी ने किया। आभार रजनीकांत ने व्यक्त किया। आयोजन में गगन मोदी, क्षितिज, इम्तियाज खान, उमेश श्रीवास्तव आदि का विशेष योगदान रहा।

Usage of Novel Shielding Materials: Tungsten-Polymer Composites in Medical Imaging

Firdous Nazir, Radiographic Technologist, DMST, Pulwama, Jammu & Kashmir

Radiation protection is a cornerstone of safe radiographic practice. As diagnostic imaging technologies advance and radiation use increases, protecting patients, radiographers, and the public from unnecessary exposure has become more important than ever. Traditionally, lead has been the most effective and widely used shielding material due to its high atomic number and density. However, concerns over its toxicity, weight, and environmental impact have led researchers to explore new alternatives. One of the most promising innovations in this area is the development of tungsten-polymer composites.

The Need for Lead Alternatives

Lead has served radiology well for decades. It efficiently attenuates X-rays and gamma rays and has been used in aprons, gloves, walls, and mobile barriers. Yet, its toxic nature presents serious health and environmental hazards. Lead exposure can cause neurological, renal, and developmental issues, especially in children and pregnant women. Moreover, disposal of lead-containing materials poses long-term ecological risks.

Healthcare facilities are therefore under growing pressure to adopt safer, eco-friendly materials without compromising protection. This demand has led to the rise of novel shielding materials that maintain strong radiation attenuation while improving safety, comfort, and sustainability.

Tungsten-Polymer Composites: The Concept

Tungsten-polymer composites are engineered materials made by dispersing tungsten powder within a polymer matrix. Tungsten, with an atomic number of 74, is the next most effective attenuator after lead. When combined with flexible polymers, it forms a non-toxic, lightweight, and durable shielding material.

The result is a product that provides comparable or even superior shielding performance to lead, depending on composition and thickness. These composites are already finding applications in protective aprons, drapes, curtains, and radiation barriers used in diagnostic radiology, fluoroscopy, nuclear medicine, and interventional procedures.

Why Tungsten?

Tungsten's properties make it an excellent candidate for radiation shielding:

- **High atomic number (Z = 74):** Ensures strong photoelectric absorption of X-rays and gamma rays.
- **High density (19.3 g/cm³):** Nearly equal to lead, offering equivalent attenuation at thinner layers.
- **Non-toxic:** Unlike lead, tungsten is environmentally safer and poses minimal health risks.
- **High melting point (3422°C):** Provides stability in demanding thermal environments.

- **Chemical resistance:** Resists corrosion and degradation over time.

These advantages allow tungsten-based composites to match or exceed the shielding efficiency of traditional lead materials while avoiding lead's toxicity and disposal challenges.

Role of Polymers

The polymer matrix serves several important functions:

- **Flexibility:** Converts rigid tungsten powder into a bendable, comfortable material suitable for aprons or curtains.
- **Durability:** Enhances mechanical strength and resistance to wear.
- **Lightweight design:** Reduces the total mass compared to pure tungsten or lead.
- **Customizability:** Allows engineers to adjust composition and thickness for specific radiation energies or applications.

Common polymers used include polyurethane, polyethylene, silicone rubber, and thermoplastic elastomers. These materials provide a balance between strength, comfort, and processability.

Manufacturing Process

The manufacturing of tungsten-polymer composites involves blending fine tungsten powder with a molten or liquid polymer. The mixture is then extruded, molded, or cast into sheets, films, or specific shapes. Uniform distribution of tungsten particles within the polymer is essential to ensure consistent shielding.

Advanced manufacturing methods such as injection molding and 3D printing are being used to create complex shielding designs, such as protective gear tailored to body contours or equipment components with embedded radiation barriers.

Radiation Attenuation Properties

Studies show that tungsten-polymer composites can achieve attenuation levels equivalent to 0.25–0.50 mm lead equivalence, depending on thickness and composition. For diagnostic X-ray energies (60–120 kVp),

these materials effectively reduce radiation dose while maintaining comfort and flexibility.

Example:
A tungsten-polymer apron of 0.5 mm lead equivalence can reduce radiation transmission by approximately 90–95%, comparable to standard lead aprons but 20–30% lighter.

Advantages Over Lead
Non-Toxicity: Tungsten-polymer composites eliminate the health and environmental hazards associated with lead exposure. They are safer for both users and manufacturers.
Weight Reduction: Although tungsten is dense, combining it with lightweight polymers reduces the overall weight. This leads to greater comfort, especially for radiographers and interventional staff who wear aprons for long hours.
Environmental Safety: Lead-free shielding materials simplify disposal and recycling processes, reducing hazardous waste management costs.
Durability and Flexibility: These composites resist cracking and deformation, ensuring long service life and consistent protection.
Aesthetic and Comfort Factors: Manufacturers can color, texture, or layer the material easily. This allows design flexibility for modern protective gear that is both functional and comfortable.

Applications in Radiology
Protective Aprons and Skirts: Commonly used by radiographers, interventionalists, and operating room staff for personal protection.
Thyroid and Gonadal Shields: Lightweight and form-fitting shields improve compliance and protection for sensitive organs.
Mobile Barriers and Curtains: Provide movable protection in cath labs and fluoroscopy suites.
Equipment Shielding: Tungsten-polymer sheets can line imaging rooms, CT gantries, or portable X-ray units.
Nuclear Medicine and Brachytherapy: Used for syringe shields, containers, and transport boxes where gamma radiation attenuation is required.

Research and Development
Research continues to optimize composite formulations to achieve maximum attenuation with minimal thickness. Studies are exploring hybrid composites that combine tungsten with other high-Z elements like bismuth, tin, or barium to fine-tune energy absorption. Nanotechnology is also being applied to create tungsten nanoparticle-polymer blends with improved homogeneity and shielding efficiency.

Efforts are underway to standardize testing methods and establish international benchmarks for lead equivalence, mechanical strength, and radiation durability of these materials.

Challenges and Limitations
While promising, tungsten-polymer composites are not without challenges:
Cost: Tungsten is expensive, and production of fine powders adds to manufacturing costs.
Processing Difficulty: Ensuring uniform tungsten dispersion in polymers requires precision and advanced equipment.
Limited Recycling Infrastructure: Although safer than lead, tungsten recycling systems are still developing.
Performance at Higher Energies: At very high photon energies (above 150 keV), lead still provides slightly better attenuation efficiency.

However, as technology matures and demand grows, production costs are expected to decline.

Future Outlook
The global shift toward sustainable healthcare and stricter environmental laws will accelerate adoption of lead-free shielding materials. Tungsten-polymer composites represent a major step in achieving both safety and sustainability in radiology.

Future trends include:
- Integration of smart shielding with embedded sensors for dose monitoring.
- Use of 3D-printed customized shields for equipment and patient protection.
- Expansion of multilayer composites that combine tungsten with lightweight foams for improved ergonomics.

These innovations will shape a new generation of protective materials that align with modern imaging needs.

Conclusion
Tungsten-polymer composites have emerged as a practical, safe, and efficient alternative to traditional lead shielding in medical imaging. They provide high attenuation, flexibility, and comfort without the health and environmental risks of lead. As research and manufacturing advance, these materials will likely become the new standard for radiation protection in healthcare.

For radiographers and medical professionals, adopting such materials means better protection, improved ergonomics, and responsible environmental practice. The shift toward tungsten-polymer shielding marks not just a technological improvement, but a step forward in building a safer and more sustainable future for radiology.

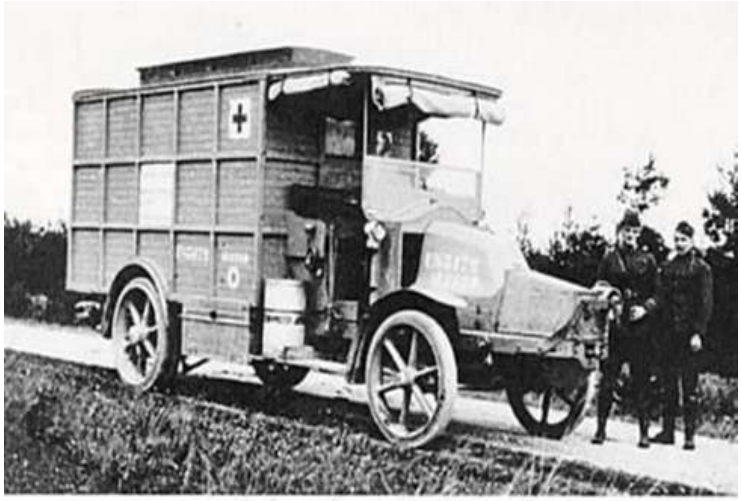
Advancement in Portable X-Ray Unit for Emergency Trauma Care

Hibu Rimu, David Touthang, Rilana Malang, MMRIT Student**, Subarna Debnath,** Asst. Professor,
Regional Institute of Paramedical and Nursing Sciences (RIPANS), Aizawl, Mizoram

Abstract: The portable units are small and light in weight and it can be carried by a person. It can be taken around the hospital's wards or to a patient's home. It provides flexibility and convenience in various medical setting, Including remote areas, emergency situation and critical care environment. The units enable healthcare professionals to capture high quality images, quickly and efficiently, facilitating timely diagnosis and treatment. [1,2]

Objective:
To evaluate the clinical efficacy and feasibility of portable x-ray unit in emergency department assessing their ability to enhance diagnostic accuracy, reduce radiation exposure and streamline emergency workflow.

History:
During world war I in 1914, Madam Marie Curie invented the first radiological car- a vehicle containing an x-ray machine and photographic darkroom equipment which could be driven right up to the battlefield where every surgeon could use x-rays to guide their surgeries. [3]



Radiological car, "Little Curie"

Components:
The portable units have the following components:
Stationary anode:
It is typically made up of tungsten (Z=74).
High tension transformer:
It provides necessary electrical energy in the correct form to power x-ray tube and produce x-rays.
Filament transformer: It is a step-down transformer that provides a low, high current supply to heat the x-ray tubes filament causing electron to be emitted
Rheostats for selection of mA and kV. : These units have low radiation output usually 80 kVp and 20 mA.
X-ray generator: Three types of generators used are cine powered, capacitive discharge and battery powered (most commonly used).

Types of portable x-ray units
Handheld x-ray devices: Ultra-portable, battery operated, and easy to transport and use digital sensor.
Uses: Dentistry, veterinary clinics, remote areas, homecare

Handheld x-ray unit

Backpack or suitcase x-ray system – Compact units designed for military, disaster or remote location use
Uses: Military field hospitals, rural outreach, NGOs, veterinary field use.

Veterinary portable x-ray unit

Veterinary portable x-ray units – Designed for animal imaging
Features: Can be mobile or handheld.

Veterinary portable x-ray unit

Mobile x-ray units – These are wheeled, self-contained machines used mostly in hospitals or clinics.
Uses: ICU, ER, bedside imaging

Mobile x-ray unit

Dental portable x-ray units – It is designed for taking dental x-rays outside of a traditional dental office setting

Dental portable x-ray unit

Advancements in Portable X-Ray Units for Emergency Trauma Care:
The advancements in portable x-ray units impacted emergency trauma care in various ways that makes the diagnosis more accurate in emergency situations. Below are some of the key developments:

Enhanced portability - A Japanese brand called FUJIFILM developed a portable x-ray system called the CALNEO Xair.

The system has a special type of cassette and a notebook-type personal computer to operate and display the x-ray images.

CALNEO Xair® developed by FUJIFILM

This advancement in portable x-ray imaging has demonstrated its usefulness of managing emergency trauma patients by making pre-hospital diagnosis possible even in rural areas, weighing only 3.5 kg and can last for 8 hours on a full charged battery. [4]

AI integration and automated image diagnosis- Artificial intelligence (AI) helps portable x-rays to automate image interpretation, highlight critical findings such as pneumothorax, fractures or pleural effusions and is useful in triage of images as well.

AI techniques used in particular used in emergency settings such as CXR provided crucial information on lung parenchyma, pleural disorders and cardiovascular circulation. AI driven analysis in emergency care is made possible by big data which refers to large sets of patient records, lab results and imaging reports, AI also uses this to predict ED overcrowding, patient deterioration and other critical issues.[5]

Market growth of portable x-ray devices – The portable x-ray systems market has a valuation of USD 8.99 billion in 2025 and is estimated to reach 16.98 billion dollars. The aging population and growth in age-related diseases and increasing healthcare expenses drives this market. Portable x-rays offer mobility and enable radiological diagnosis at the point-of-care.

The ability to obtain
high-resolution images rivaling traditional larger machines has boosted the demand for portable x-ray units.

FDR Nano mobile x-ray cart

In March 2021, Fujifilm India Private Limited, introduced a mobile radiology unit named "FDR Nano" which delivers high-resolution images while minimizing radiation doses in nearby environments. FDR nano incorporates noise reduction circuits that enhance the clarity of low-density areas which gives an even better image quality than traditional x-ray. [6]

Benefits of X-ray portable units

ICMR Ongoing project "accelerating efforts to end tuberculosis in India"

- Play a crucial role in tuberculosis (TB) screening, especially in community-based and house-to-house surveys in rural and hard-to-reach areas.
- Enable early detection of radiographic changes suggestive of TB, even in individuals without obvious symptoms.
- Improve case detection rates and strengthen TB control programs.
- Increased Screening Coverage and Efficiency.
- Real-Time Diagnosis and Immediate Follow-up.
- Cost-Effectiveness for Public Health Campaigns.[7]

Portable digital x-ray for Tuberculosis

Home healthcare and nursing homes, emergency and disaster response, sports medicine

- Elderly or bedridden patients often struggle to visit hospitals for routine X-rays. Portable X ray services provide a convenient solution, allowing diagnostic procedures to be conducted in the comfort of patients' homes or care.
- Portable imaging is crucial in emergencies, such as natural disasters, battlefield injuries, and accident sites. First responders and medical teams use mobile X-ray units to assess injuries quickly, ensuring immediate medical intervention.
- Athletes frequently require on-the-spot medical assessments. Mobile X ray units are most employed in sports medicine to evaluate fracture, dislocation, and soft tissue injury during games or training. [8]

Ward radiography

- Ward radiography is performed for those patients who is not well to move in the radiology department for radiographic examination.
- The mobile and portable X-ray units are used for bedside radiography.
- The ward radiography is commonly performed in hospital ward, ICU, Emergency and neonatal ward.
- The common ward radiographic procedure Chest AP and PA, Abdomen AP and Extremities.

Radiation Protection

- The exposure should be as low as reasonably achievable (ALARA). Three basic methods for reducing exposure – minimize exposure time, maximize distance from the X-ray tube following inverse square law and use proper shielding like lead apron of size 2.5mm lead equivalent and thyroid shield of size 0.5mm lead equivalent.

- The radio technologist should use correct exposure by using high kVp and low mA and maintain the exposure as short as possible and avoid repeat exposure. [1]

Conclusion

In conclusion, portable X-ray units are a vital tool in modern healthcare, providing convenience, accessibility, and efficiency. They play a crucial role in a wide range of applications, including intensive care units, home health care for bed ridden patient's emergency response, sports medicine and in the ICMR ongoing project to combat tuberculosis. By bringing diagnostic imaging directly to the patient, these units enable faster diagnosis and treatment, while also reducing the risk of cross-contamination. Ultimately, portable X-ray machines improve patient outcomes and save costs by eliminating the need for patient transport and reducing hospital visits.

Pulmonary Imaging with Dynamic Digital Radiography

Lena Abraham, B.Sc. (Hons.) MRIT Student, M.S. Ramaiah University of Applied Sciences, Bangalore

Abstract

Dynamic Digital Radiography (DDR) is an advanced imaging technique that captures continuous low-dose X-ray images during breathing to assess lung structure and function in real time. Unlike conventional chest radiography, DDR provides functional information such as ventilation, diaphragmatic movement, and pulmonary blood flow without the use of contrast media. It offers faster imaging with lower radiation dose than CT, making it a safe and patient-friendly option. DDR shows promising potential in the evaluation of conditions such as COPD, pulmonary embolism, and other lung disorders. This article highlights the principles, technique, and clinical relevance of DDR in pulmonary imaging.

Keywords

Dynamic Digital Radiography (DDR), pulmonary imaging, functional lung imaging, ventilation assessment, diaphragmatic motion, low-dose radiography, thoracic imaging, pulmonary perfusion, non-contrast imaging.

Introduction

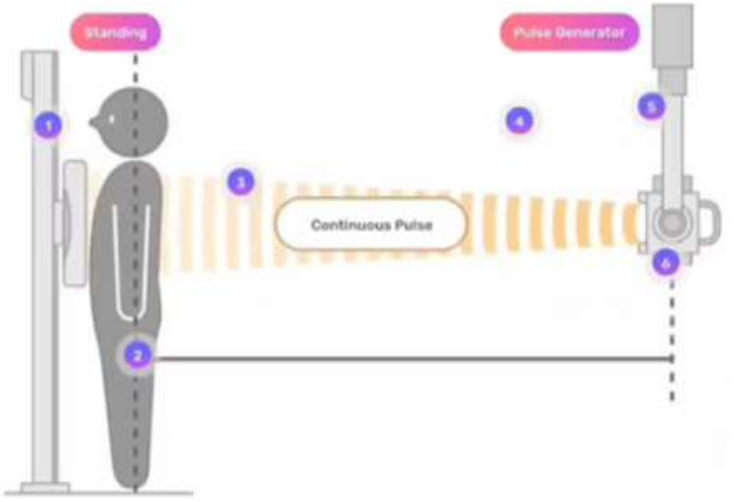
Pulmonary imaging is essential for diagnosing and monitoring lung diseases. Conventional chest radiography provides static anatomical information, while advanced modalities like CT offer detailed structure but limited functional insight. Dynamic Digital Radiography (DDR) is a novel technique that captures continuous low-dose X-ray images during breathing, allowing real-time evaluation of lung ventilation, diaphragmatic motion, and pulmonary perfusion. By combining structural and functional assessment in a non-invasive, contrast-free, and low-radiation examination, DDR offers a practical tool for assessing a wide range of pulmonary conditions and monitoring treatment response.

Working Principle

Dynamic Digital Radiography (DDR) is based on capturing a rapid sequence of low-dose X-ray images while the patient breathes normally or performs guided breathing maneuvers. Unlike conventional radiography, which provides only a single static image, DDR records multiple frames per second using a flat-panel digital detector. These sequential images are processed by specialized software to create a real-time moving display of thoracic structures. As the lungs inflate and deflate, subtle changes in tissue density are detected, allowing assessment of regional ventilation and airflow. Similarly, diaphragmatic and chest wall movements can be visualized and measured, while changes in pixel intensity related to blood flow provide indirect information about pulmonary perfusion. DDR thus combines structural imaging with functional assessment in a single, low-dose examination.

Technique & Procedure

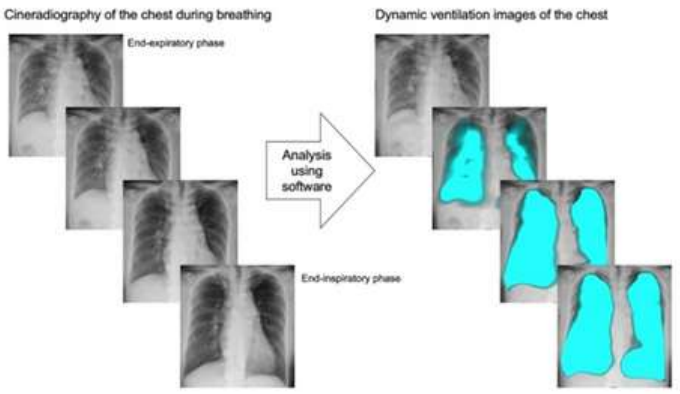
In performing DDR, the patient is typically positioned upright, either standing or sitting, in front of a flat-panel digital detector. Standard posteroanterior chest positioning is commonly used, though lateral views may be obtained if needed. The patient is instructed to breathe normally, perform deep inspiration or expiration, or hold their breath according to the study protocol. A series of low-dose X-ray images is acquired continuously over several seconds, capturing multiple frames per second. These images are then processed using dedicated software to generate a dynamic (cine) sequence, allowing evaluation of lung ventilation, pulmonary perfusion, diaphragmatic motion, and chest wall mechanics. The procedure is non-invasive, does not require contrast agents, and is completed quickly with minimal radiation exposure, making it suitable for repeated studies and functional assessment of the lungs.



Clinical Applications

Ventilation assessment: Evaluation of regional lung ventilation in COPD, asthma, and other obstructive lung diseases

Airflow analysis: Detection of reduced airflow, air trapping, and asymmetrical ventilation patterns



Diaphragm evaluation: Assessment of diaphragmatic motion to identify paralysis, weakness, or paradoxical movement
Chest wall mechanics: Analysis of chest wall movement in neuromuscular disorders and post-thoracic surgery cases
Perfusion assessment: Indirect evaluation of pulmonary blood flow through pixel-intensity variations
Pre-operative assessment: Functional evaluation of lungs prior to thoracic surgery
Treatment monitoring: Assessment of disease progression and response to therapy.

Advantages

- **Functional imaging:** Provides real-time assessment of ventilation, diaphragmatic motion, and pulmonary circulation
- **Low radiation dose:** Delivers significantly less radiation compared to CT and even some fluoroscopic procedures
- **Fast acquisition:** Image capture is completed within a few seconds, allowing quick workflow and patient comfort
- **Non-invasive and painless:** Simple, safe, and comfortable for all age groups
- **Quantitative assessment:** Provides objective data on regional ventilation and perfusion
- **Cost-effective:** Requires less expensive equipment and maintenance compared to CT or MRI

Limitations

- Provides lower spatial resolution compared to CT and MRI
- Limited tissue characterization and poor soft-tissue contrast
- Indirect assessment of pulmonary perfusion, not as accurate as nuclear medicine or CT angiography
- Requires patient cooperation and controlled breathing for optimal results

Conclusion

Dynamic Digital Radiography (DDR) is an innovative imaging technique that provides real-time structural and functional assessment of the lungs, diaphragm, and chest wall with minimal radiation. It is non-invasive, contrast-free, and suitable for repeated studies, making it valuable for evaluating ventilation, perfusion, and diaphragmatic motion in various pulmonary conditions. While it does not replace high-resolution CT for detailed tissue analysis, DDR serves as a practical and efficient tool for functional assessment, follow-up, and screening in modern thoracic radiology.

References

- Dynamic Digital Radiography (DDR) for pulmonary blood flow monitoring. (2025). PubMed Central (PMC12085977). https://doi.org/10.XXXXX/PMC12085977
- Dynamic chest radiography: State-of-the-art review. (2023). PubMed Central (PMC10277270). https://doi.org/10.XXXXX/PMC10277270
- Konica Minolta Research. (2024). DDR & image analysis technologies. https://www.konicaminolta.com
- Shimadzu. (2023). The 5th DDR seminar: Pulmonary blood flow evaluation. https://www.shimadzu.com
- Radiological Society of North America. [YouTube]. (n.d.). Dynamic Digital Radiography in chest imaging. https://youtu.be/QE1ruslKhVU?si=gWvyyml2i3TLJjn

Be a Good Reader

Got the issue of the magazine, downloaded it, read it and deleted it. Only this does not prove you a good reader. You can agree with or add to the content published in the magazine, so in such cases please write us your comment or feedback. Similarly, debate openly on the issues rose in the magazine and the questions raised and send it to us in writing. With this act of yours, where other readers will be benefited; we will also get guidance in various forms. So, whenever the time demands, do not forget to pick up the pen.

And one more thing, we have conveyed this issue to you, as an enlightened Radiographer, now it is your responsibility to forward this issue to other Radiographers.

Thanks in advance,
Editor

Post mortem MRI

Pratik Virat, M. Sc. Research fellow, **Mamta Verma, Raushan Kumar,** Assistant Professors,
College of Paramedical Sciences, Teerthankher Mahaveer University, Moradabad, UP.

Abstract

An important development in forensic and clinical pathology is post-mortem magnetic resonance imaging (PMMR), which provides a non-invasive substitute or supplement to conventional autopsy. In order to provide vital information regarding the cause and manner of death, this method makes use of MRI's high-resolution imaging capabilities to examine internal anatomical structures in remarkable detail. PMMR addresses cultural and religious sensitivity while preserving the possibility of visual identification, in contrast to traditional autopsies. The ability to produce permanent, digital records of findings enhances recordkeeping and facilitates retrospective analysis in legal proceedings and research efforts. PMMR's capacity to visualize soft tissue structures, particularly those in the heart, brain, and abdominal organs, makes it possible to spot subtle disease changes that a conventional autopsy could overlook. It is used in a variety of settings, including forensic investigations into suspicious deaths, clinical studies of disease progression, and fetal mortality study. However, interpreting PMMR images requires specific understanding because post-mortem events such as fluid movements and decomposition can alter tissue properties. While PMMR has significant advantages, it may not replace traditional autopsies fully, particularly in cases requiring penetrating trauma or the necessity for microscopic tissue investigation. Nevertheless, the continual development of PMMR methods and the rising availability of advanced imaging technologies are expanding its breadth and accuracy, establishing its place as a critical instrument in modern post-mortem investigations. The balance between the non-invasive nature and the diagnostic capability of PMMR assures its expanding popularity in medical and legal professions worldwide.

Keywords: PMMR, non-invasive, hemorrhages

Introduction

Traditional autopsy methods have long been a major part of the study of death, both in forensic and clinical settings. Despite their value, these intrusive techniques have drawbacks, especially when it comes to cultural and religious sensitivities and the need to maintain the deceased's physical integrity. Post-mortem magnetic resonance imaging (PMMR), a potent non-invasive substitute that provides a thorough internal assessment without requiring surgery, has arisen in response to these difficulties. PMMR provides a thorough anatomical overview by producing high-resolution images of the body's internal structures using the well-established principles of magnetic resonance imaging. Soft tissues,

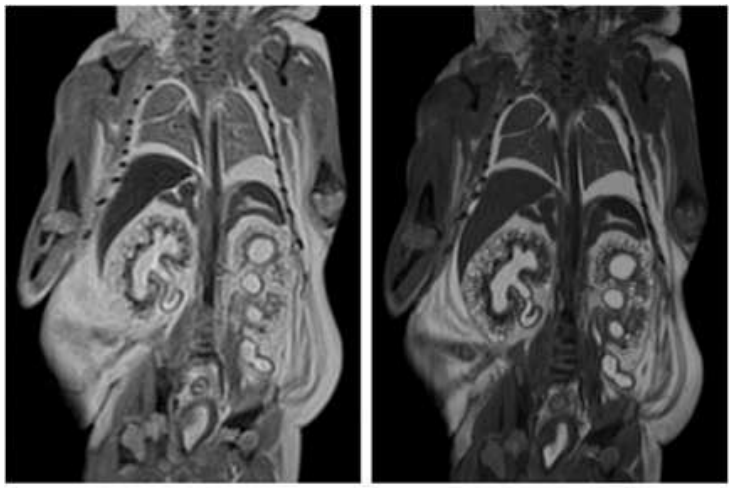


Figure 1: Body post-mortem MRI. Comparison of coronally acquired vs reconstructed coronal body imaging. The high-resolution isotropic constructive interference steady state sequence (b) gives much higher detail than the conventional T2-w imaging (a), particularly

such as the brain, heart, and abdominal organs, can be seen with remarkable clarity thanks to this method, which makes it possible to identify minute pathological alterations that might go unnoticed during an external examination. One PMMR is used in a wide range of investigations, from clinical research to better understand disease processes to forensic situations involving suspicious deaths. Its capacity to offer a permanent, digital record of results improves recordkeeping and makes retrospective analysis easier, which is advantageous in both legal and research contexts. Additionally, PMMR is especially useful in pediatric instances, such as baby deaths and stillbirths, when it can offer vital information about developmental problems without the need for intrusive procedures. Even though PMMR has several benefits, it is important to recognize how post-mortem alterations affect picture interpretation and how specific knowledge is required to analyze these images. The future of death inquiry is being shaped by the growing integration of PMMR into contemporary post-mortem examinations, which can supplement or even replace traditional autopsies in some situations as technology and methods improve.

Non-invasive

The increasing use of post-mortem magnetic resonance imaging (PMMR) in both clinical and forensic pathology is largely due to the idea of non-invasiveness. PMMR provides a thorough inside inspection without sacrificing the body's physical integrity, in contrast to standard autopsy that necessitate surgical incisions and organ removal. When cultural or religious beliefs forbid invasive procedures, this trait is especially important since it permits a comprehensive examination while honoring the departed and their relatives. The fact that PMMR is non-

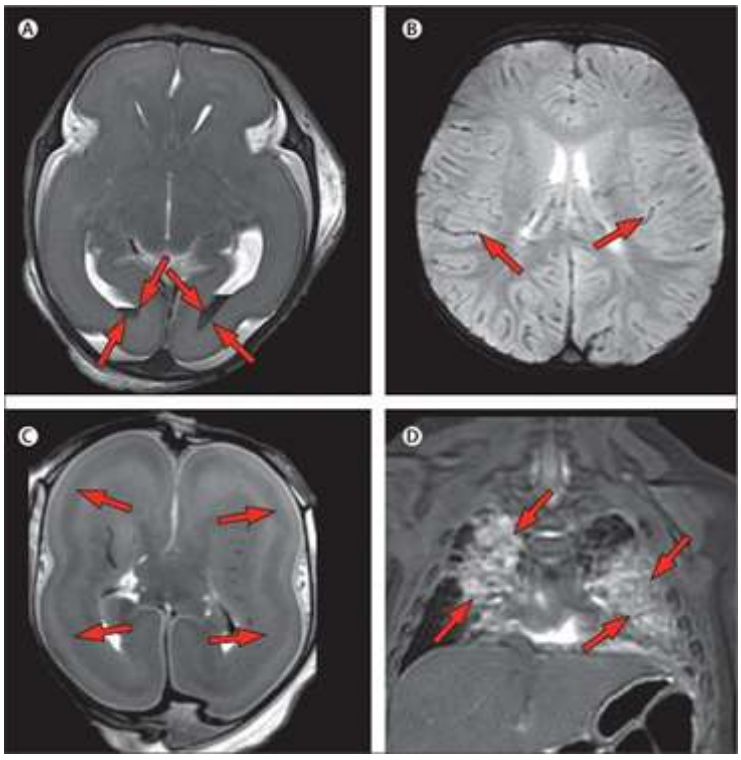


Figure 2Artifacts and apparent false-positives on post-mortem MRI

invasive goes beyond aesthetics alone. It preserves the integrity of fragile structures and pathological findings by reducing the possibility of tissue damage and artifact creation that may arise during surgical autopsy. In forensic investigations, where precise documenting of injuries and disease processes is essential, this is particularly important. PMMR also lessens the possibility of introducing artifacts or contaminating evidence by avoiding manual dissection, which could make it more difficult to interpret results. Creating a comprehensive digital record of the internal anatomy also makes it possible to review and analyze it again without causing the body any more harm. In research and legal actions, when expert assistance and retrospective analysis may be required, this is quite helpful. Fundamentally, PMMR's non-invasiveness means a more thorough, accurate, and respectful approach to post-mortem inquiry, which helps to close the gap between conventional methods and the changing demands of contemporary law and medicine.

DeTailed imaging

Compared to many conventional post-mortem techniques, post-mortem magnetic resonance imaging (PMMR) provides incredibly detailed imaging. The primary advantage of MRI is its capacity to provide multiplanar, high-resolution pictures that clearly distinguish between different soft tissues. Visualizing complex anatomical systems is essential, especially in organs like the brain, heart, and abdomen where minute pathological alterations can be critical in establishing the cause of death. A traditional autopsy or external examination could miss minute abnormalities including tiny hemorrhages, faint infarctions, and diffuse infiltrative processes, but PMMR's excellent contrast resolution makes it possible to detect them. Additionally, PMMR makes accurate volumetric studies possible, allowing for the measurement of lesion volumes, organ sizes, and other crucial parameters. In cases involving neurological illnesses, when precise assessment of brain structures and lesion volumes is crucial for comprehending the course and effects of the disease, this is very helpful. Aneurysms, dissections, and other vascular diseases can be identified thanks to PMMR's comprehensive imaging, which also makes complex vascular structures visible. In juvenile cases, where congenital defects and developmental disorders may be precisely evaluated, this degree of anatomical information is also extremely helpful. In the end, PMMR is a vital tool in contemporary post-mortem investigations due to its capacity to produce thorough, high-resolution images of internal structures, which in some therapeutic and forensic contexts can even replace traditional autopsy.

Documentation

An unmatched degree of documentation is provided by post-mortem magnetic resonance imaging (PMMR), which is a major improvement over conventional autopsy technique. A thorough, three-dimensional record of the deceased's internal anatomy can be created thanks to the digital nature of PMMR data. As a permanent, retrievable resource, this digital archive guarantees that results are kept safe and available for further examination or analysis. In forensic investigations, where legal actions may require reviewing evidence or seeking expert views years after the first examination, this is very important.

Expert consultation and collaboration are made easier by the digital format of PMMR material. No matter where they are in the world, radiologists, pathologists, and other experts can easily exchange and examine PMMR images from a distance. By working together, post-mortem investigations become more accurate and reliable and all pertinent findings are considered. Additionally, extensive comments that are not possible with standard autopsy photos are made possible by the digital annotation and manipulation of PMMR images. PMMR documentation facilitates research and educational activities in addition to forensic applications. To investigate disease processes, improve diagnostic standards, and create new imaging methods, researchers can access and examine enormous datasets of PMMR pictures. The comprehensive anatomical data offered by PMMR helps medical students and trainees better grasp human anatomy and pathology. The capacity to review and re-examine PMMR data guarantees an ongoing learning loop, advancing medical practice and understanding.

Applications of post-mortem MRI

- Determining the cause and method of death in cases that seem suspicious or inexplicable is known as forensic investigation.
- Injury Identification: Recording and describing traumatic injuries, particularly injury to soft tissues.
- Visualizing abnormalities of the brain, such as strokes, hemorrhages, and neurodegenerative disorders, is known as neuropathology.

Calibration Laboratory

For Radiation Monitoring Instruments & Dose Calibrators

India's first and only comprehensive calibration facility for any brand of Radiation Survey meter, Contamination Monitor, Pocket Dosimeter, Area Zone Monitor and Radioisotope Dose Calibrator.

We are recognized by Atomic Energy Regulatory Board (AERB) and Accredited by N.A.B.L.

We offer complete solution for service, repairs and recalibration for any brand or type of RMIs and Dose Calibrators. We are specialized and factory trained and have the required infrastructure to repair Pressurised Ion Chamber Survey Meters.

NABL ACCREDITED
Certificate No. CC-1027

Salient Features:

- Calibration reminder services
- Pickup and drop facility for RMIs
- Routine turnaround recalibration time is 5-6 days from any part of country
- Before sending the instrument, please make sure about the working condition, to avoid delays
- Calibration Validity: Two Years
- ISO9001:2015 Certified
- ISO/IEC 17025 Certified





Radimage Healthcare India Pvt. Ltd.
(An ISO 9001 : 2015 Certified Company)
G-236, Sector-63, Noida - 201 303 (INDIA)
Telefax: +91 120 4263270, 2406096, 2406097
• www.radimageindia.com • radimagehealthcare@gmail.com
(A Meditronix Corporation Group Company)

Design to Print #9250671670

- Cardiovascular Pathology Evaluating the anatomy of the heart and identifying anomalies such aneurysms or infarctions.
- Pediatric pathology Investigating new-born deaths and stillbirths to find developmental problems and congenital defects.
- Finding and locating internal bleeding, which can be challenging to find outwardly, is known as internal hemorrhage detection.
- Assessing the state of internal organs, including the liver, kidneys, and spleen, is known as organ pathology assessment.
- Finding and describing foreign items inside the body is known as "documentation of foreign bodies."
- Research and Education Providing comprehensive anatomical knowledge for medical training and researching disease processes.
- Cultural/Religious Sensitivity Offering a non-invasive substitute for conventional autopsies while honoring religious and cultural convictions

Important consideration

- Post-mortem Interval (PMI): Because of decompositional changes, the amount of time following death has a major impact on image quality.
- The rate of decomposition and ensuing visual artifacts are influenced by temperature and environmental factors.
- Fluid Shifts and Gas Formation: Anatomical structures are distorted by post-mortem alterations that cause fluid redistribution and gas build-up.
- Expertise in Image Interpretation: Needs specific radiologists who have knowledge on how to interpret post-mortem MRI results.
- Differentiating Artifacts from Pathology It's critical to distinguish between post-mortem alterations and actual diseased signs.
- Availability of Proper MRI Protocols To maximize picture quality during post-mortem exams, specialized protocols are required.
- Comparison with Clinical History Accurate diagnosis depends on combining clinical data with PMMR results.
- Correlation with Traditional Autopsy (if conducted): The diagnosis accuracy is improved by comparing PMMR results with those of a traditional autopsy.
- Legal and Moral Aspects to Consider It is essential to make sure that legal requirements are followed and that cultural and religious sensitivities are respected.
- Cost and Availability of Resources: PMMR calls for specific tools and knowledge that aren't always easily accessible.

Limitations of post-mortem MRI

Even though post-mortem magnetic resonance imaging (PMMR) has many benefits, there are some drawbacks that need to be considered. The impact of post-mortem alterations, such as decomposition, fluid shifts, and gas production, which can drastically modify tissue properties and add artifacts to the photos, is one important drawback. These modifications may make it more difficult to evaluate images and distinguish between post-mortem alterations and actual disease features. Additionally, PMMR might not be as good as standard autopsies at identifying some injuries or illnesses, especially those involving microscopic tissue alterations, deep trauma, or small foreign objects. For instance, PMMR may not be able to detect small histology abnormalities or visualize fine bone fractures. Furthermore, because radiologists must be educated to identify and account for post-mortem artifacts, interpreting PMMR images calls for specific knowledge. Since specific MRI protocols and expertise are not always available, the availability of PMMR equipment and experienced staff may potentially be a limiting issue. Another factor to consider is the expense of PMMR exams, particularly in environments with limited resources. Furthermore, even while PMMR can offer comprehensive anatomical details, it could not always offer the same degree of diagnostic certainty as a conventional autopsy. A traditional autopsy could still be required in some cases in order to collect tissue samples for microscopic inspection or to carry out particular chemical investigations. Lastly, the post-mortem interval, or the amount of time since death, can have a big influence on image quality; longer intervals result in more decompositional changes and less accurate diagnosis.

Availability and cost

The expense and accessibility of post-mortem magnetic resonance imaging (PMMR) pose important obstacles to its widespread use. In contrast to conventional autopsies, which may be carried out in the majority of hospital settings, PMMR requires specialist MRI equipment, which is not always accessible. Its accessibility is restricted by this restriction, especially in areas with few resources or in rural areas. Additionally, the staff needed to do PMMR exams needs to be specially trained in both radiology and post-mortem imaging, which further limits its accessibility to facilities with specialized knowledge. Radiologists with specialized training are needed to interpret PMMR pictures since it requires a sophisticated grasp of post-mortem alterations and artifacts. This knowledge is less accessible than standard radiology abilities, which could cause delays in diagnosis and reduce the overall number of PMMR exams that can be performed.

Another important issue affecting PMMR's uptake is its cost. Because MRI scans need a significant capital investment in equipment, maintenance, and trained staff, they are by nature costly. The cost of PMMR exams may rise even more due to the complexity of post-mortem imaging methods, which may call for lengthier scan times and specialized sequences. Hospitals and families seeking PMMR may face financial obstacles due to the lack of completely established payment regulations in many healthcare systems. There is continuous discussion on PMMR's cost-effectiveness in comparison to conventional autopsies. Although PMMR may lessen the need for some invasive treatments and the expenses that go along with them, there may be a significant upfront cost for training and equipment. PMMR's entire cost-benefit analysis needs to consider things like the possibility of increased diagnostic precision, less infection risk, and better

documentation for research and legal needs. Costs may drop as a result of economies of scale and increased efficiency as technology develops and PMMR is embraced more broadly. But until then, PMMR's cost and availability continue to be major obstacles to its wider adoption.

Conclusion

To sum up, post-mortem MRI (PMMR) offers a non-invasive and thorough method of studying the deceased, marking a substantial progress in the field of post-mortem examinations. It can reveal subtle disease changes that traditional autopsies might overlook since it can offer high-resolution images of internal structures, especially soft tissues. Because PMMR is non-invasive and sensitive to cultural and religious sensitivities, it is a useful substitute for traditional autopsy in situations where they are not appropriate. Additionally, PMMR's digital documentation improves teamwork, makes retrospective analysis easier, and aids in research and teaching. Notwithstanding its benefits, PMMR has drawbacks. Decomposition and fluid shifts are examples of post-mortem alterations that might generate artifacts and make image interpretation more difficult, necessitating specific knowledge. The expense and accessibility of PMMR training and equipment continue to be major obstacles to its wider adoption. Even though PMMR has demonstrated significant potential in pediatric cases, clinical pathology, and forensic investigations, it might not completely replace conventional autopsies. Traditional autopsies are still necessary in some circumstances, such as those involving penetrating injuries or the requirement for microscopic tissue investigation. PMMR's future depends on ongoing technical developments, enhanced procedures, and greater accessibility. The accuracy and reliability of PMMR will continue to increase as imaging technology advances and our understanding of post-mortem alterations deepens. The procedure will run more smoothly and require less specialized knowledge if more research is done on improving imaging methods and creating automated image analysis tools. Its availability will also be expanded via the creation of affordable PMMR solutions and more training possibilities. In the end, PMMR is expected to become more significant in post-mortem examinations, supplementing conventional autopsy and offering critical information on the cause and manner of death. It is a tool that will keep developing and improving, guaranteeing its position in contemporary forensic and medical practice.

References

- Koch-Henriksen N, Sørensen PS. The changing demographic pat tern of multiple sclerosis epidemiology. Lancet Neurol. 2010;9(5): 520–32. https://doi.org/10.1016/S1474-4422(10)70064-8
- Adams CW, Poston RN, Buk SJ. Pathology, histochemistry and immunocytochemistry of lesions in acute multiple sclerosis. J Neurol Sci. 1989;92(2–3):291–306. https://doi.org/10.1016/0022 510x(89)90144-5
- Lucchinetti C, Brück W, Parisi J, Scheithauer B, Rodriguez M, Lassmann H. Heterogeneity of multiple sclerosis lesions: implica tions for the pathogenesis of demyelination. Ann Neurol. 2000 47(6):707–17. https://doi.org/10.1002/1531-8249(200006)47:63.0.co;2-q
- Barnett MH, Prineas JW. Relapsing and remitting multiple sclero sis: pathology of the newly forming lesion. Ann Neurol. 2004; 55(4):458–68. https://doi.org/10.1002/ana.20016
- Prineas JW, Kwon EE, Cho ES, Sharer LR, Barnett MH, Oleszak EL, et al. Immunopathology of secondary-progressive multiple sclerosis. Ann Neurol. 2001;50(5):646–57. https://doi.org/ 10.1002/ana.1255
- Lucchinetti CF, Bruck W, Lassmann H. Evidence for pathogenic heterogeneity in multiple sclerosis. Ann Neurol. 2004;56(2):308. https://doi.org/10.1002/ana.20182
- Brück W, Bitsch A, Kolenda H, Brück Y, Stiefel M, Lassmann H. Inflammatory central nervous system demyelination: corre lation of magnetic resonance imaging findings with lesion pathol ogy. Ann Neurol. 1997;42(5):783–93. https://doi.org/10.1002/ana.410420515
- Bouman PM, Steenwijk MD, Pouwels PJW, Schoonheim MM, Barkhof F, Jonkman LE, et al. Histopathology-validated recom mendations for cortical lesion imaging in multiple sclerosis. Brain. 2020;143(10):2988–97. https://doi.org/10.1093/brain/awaa233
- Absinta M, Sati P, Masuzzo F, Nair G, Sethi V, Kolb H, et al. Association of chronic active multiple sclerosis lesions with disabil ity in vivo. JAMA Neurol. 2019;76(12):1474–83. https://doi.org/
- 1001/jamaneurol.2019.2399 10. Stadelmann C, Timmler S, Barrantes-Freer A, Simons M. Myelin in the central nervous system: structure, function, and pathology. Physiol Rev. 2019;99(3):1381–431. https://doi.org/10.1152/physrev. 00031.2018 .

Hierarchical Phase-Contrast Tomography use in Intact Imaging of Human Organs : A Comprehensive Study.

Harsh Maurya, Sonu Kumar, M. Sc. Research fellow, Raushan Kumar**,** Assistant Professors,
College of Paramedical Sciences, Teerthankher Mahaveer University, Moradabad, UP.

Abstract

The extremely brilliant source, X-ray phase-contrast imaging method known as hierarchical phase-contrast tomography (HiP-CT) was created at the European Synchrotron Radiation Facility (ESRF), is especially useful in scientific investigation since it enables non-destructive imaging at several scales, it has enabled radiographing any part of the human body with cellular (micron) accuracy (1). With a resolution of 25 microns thinner than a human hair and ten times the resolution of a medical CT scanner, this technique makes it possible to scan whole bodies. The local micron resolution, which is 100 times the resolution of medical CT, can subsequently be achieved by selecting areas to zoom in on. HiP-CT (2). With the significant gains in x-ray brightness and high energies over earlier devices, this most recent fourth-generation synchrotron technology makes it possible to quickly scan huge organs with great contrast and spatial precision. Phase-contrast imaging uses the phase shift (or refraction) of x-rays as they travel through tissues instead of only depending on x-ray absorption, which is how it varies from standard x-ray imaging. Without the need of an external contrast agent, it produces pictures with noticeably better contrast and resolution, which is especially useful for seeing delicate structures and soft tissues like those in the heart. The purpose of this article is to assess HiP-CT's capacity to represent the macro-to-microanatomy of adult human body (1).

Working Principle of Hierarchical Phase Contrast Tomography (HiP-CT)

Major advancement in radiological imaging became available with HiP-CT by uniquely exploiting phase contrast and hierarchical scanning for complete analyses of the intact human organ as a whole, at all levels of analysis.

Figure 1: Sample preparation and Imaging procedure (3).

Here are the 4 fundamental steps in hierarchical phase-contrast tomography (hip-ct).

1. Synchrotron X-Ray Phase: -

Unlike conventional absorption-based imaging methods, HiP-CT employs X-ray phase contrast soft tissues that would otherwise be undetectable with traditional X-ray imaging are visible due to this technique, which highlights on the differences in X-ray phase as they pass through materials with different densities. Wavy lines from refraction-mediated interference patterns reveal the boundaries of tissues of disparate physical densities, producing the contrast (3) (4).

2. Protocols for Scanning: -

The hierarchical imaging approach begins with a low-resolution scan of the whole organ, typically with an isotropic voxel size of approximately 25 µm. After this first scan, higher resolution scans are performed over selected regions of interest (ROIs) to achieve voxel sizes as small as 1.3–2.5 µm. The multiscale aspect of the technique allows researchers to capture both the tiny features and the basic structure of an object (3) (4).

3. Processing the sample: -

The samples are fixed and partially dehydrated in an agar-ethanol solution. This stability is vital to keep the biological structures intact during imaging. The team then scan's the samples using custom-designed beamlines at the European Synchrotron Radiation Facility (ESRF), which provides the high-energy X-rays needed for performant imaging (1).

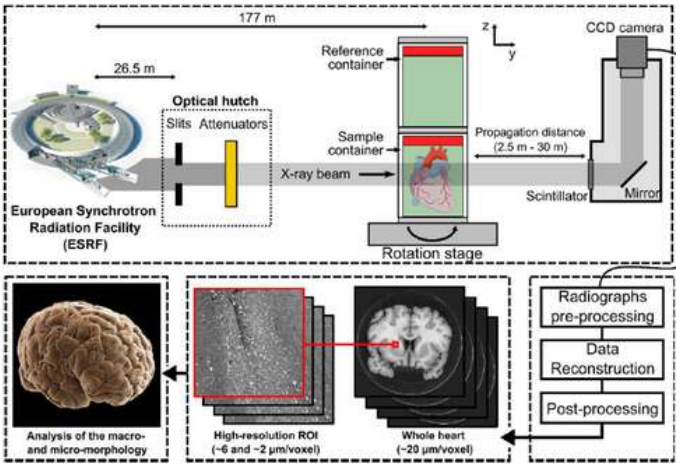


Figure 2: Modified diagrammatic representation of Hierarchical Phase Contrast Tomography (HiP-CT) setup and data propagation from brunet-et-al-2024 (5).

4. Reconstruction of image: -

The captured images are then reconstructed using phase retrieval techniques and a filtered back-projection algorithm after data collection. This allows us to visualize and study the internal structure of isotropic 3D datasets generated from this method. Acquisition of reference scans is also helpful in improving image quality in the reconstructed data and normalizing differences in the background (3).

Advantages of Hierarchical Phase Contrast Tomography (HiP-CT)

The non-destructive, high-resolution, and full 3D visualization capabilities, HiP-CT is a major improvement in imaging technology that is essential for both therapeutic applications and research into human anatomy and disease. The following benefits of Hierarchical Phase-Contrast Tomography (HiP-CT) increase its usefulness in radiological imaging.

1. Non-Destructive Imaging:

HiP-CT scan whole human organs without the need for true sectioning. In the context of other imaging techniques, such histology, which are destructive, validation is simpler with and the data interpretation which is enriched with this technique (5).

2. Complete 3D Visualization:

HiP-CT captures macroscopic and microscopic features, allowing a comprehensive three-dimensional view of organs. This ability is especially useful for understanding complex structures at various scales of size, including the vascular system (3).

3. Improved Contrast Sensitivity:
Hierarchal Phase Contrast X-ray Tomography (HiP-CT) has enhanced sensitivity to density changes within soft tissues by taking advantage of phase contrast rather than using conventional absorption methods. This allows more subtle anatomical features to be observed that might be missed with conventional imaging techniques (4).

4. Superior Data Processing Capabilities:
The method makes use of high-performance computer resources to handle massive datasets produced by scans, enabling intricate anatomical structure analysis and visualization (5).

Drawbacks of Hierarchical Phase Contrast Tomography (HiP-CT)

1) High Radiation Doses:
To achieve the necessary picture quality, HiP-CT is often forced to use large radiation doses, which can be an issue, especially for sensitive biological materials or multiple imaging. This limitation may preclude its use in certain therapeutic settings where exposure mitigation is critical (5).

2) Restricted Field of View:
Phase-contrast imaging's great sensitivity necessitates a limited field of view, which makes it less appropriate for bigger samples or whole organs without segmenting them into smaller pieces (6).

3) Heterogeneous Data Quality:
Image quality varies throughout datasets due to the continuous advancement of HiP-CT technology. Resolution, signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) improvements might produce heterogeneous datasets that make data interpretation and analysis more difficult (7).

4) Segmentation Challenges:
Moreover, vascular segmentation may be difficult in HiP-CT images. The problems of larger vessels collapsing due to having little hydrostatic pressure (since HiP-CT is usually performed ex vivo) and smaller vessels having less connectivity result in higher segmentation errors, particularly around the border between vessels. So these difficulties can make it hard to understand vascular structures and how they are related to each other (7).

Imaging of some Intact organs with HiP-CT
A various kind of organs, such as the Lungs, Hearts, Brains, Kidneys, and Spleens from different donors were imaged using HiP-CT. This shows specialized cells and functional units in several organs depending on the size of the organ, the approach captures the complete organ at an initial voxel size of 12 to 24 µm. This provides a thorough macroscopic picture with good contrast, making it possible to clearly observe anatomical boundaries then more extensive analysis of particular areas of interest (ROIs) is possible with higher resolution scans down to 2 µm per voxel (1.4 µm for the tiny organs), exposing complex microstructures. Significant new information on the pathogenic and anatomical characteristics of these organs has been made possible by the imaging technology(5).

Imaging of Heart:
Figures 3A and B show the intact heart, complete with its four chambers and related coronary arteries. Figure 3C shows the structure of cardiac muscle, fibers, and individual cardiomyocytes.

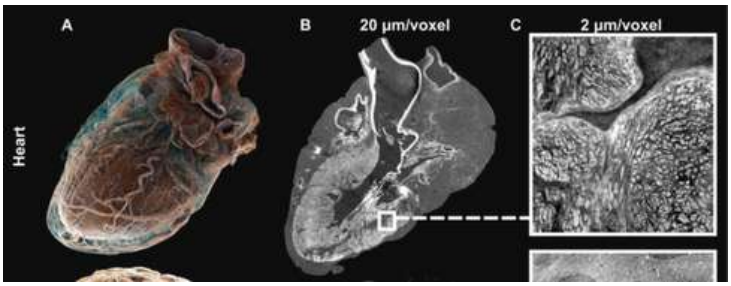


Figure 3: HiP-CT imaging of Heart (5).

Protocols: -
A standard protocol for Hierarchical Phase-Contrast Tomography (HiP-CT) of the heart includes: preparing the heart ex vivo, mounting it in a stabilizing medium, scanning the entire organ at low resolution, and then using a synchrotron X-ray source to perform high-resolution scans of specific regions of interest (ROIs). Phase-contrast imaging is then used to visualize subtle tissue variations and microstructures within the cardiac tissue.

1) Accusation of Sample:
- Obtain a human heart, preferably from a donor, that is either healthy or sick, depending on the study's objectives.
- In order to maintain tissue structure, infuse the heart with a fixative solution(1).

2) Mounting and Preparation:
- If needed, carefully cut off any superfluous tissue from the heart.
- When scanning, submerge the heart in a stabilizing agent, such as agarose gel, to preserve its form and reduce artifacts.
- Put the heart in a sample container that has been particularly made to work with the synchrotron beamline(1).

3) The process of Scanning:

Low-resolution scan:
- Perform a full-volume scan of the entire heart at a lower resolution (around 20 µm voxel size) to capture the overall anatomy.

High-resolution scans (ROI):
- Identify regions of interest (e.g., coronary arteries, valves, conduction system) based on the low-resolution scan.
- Perform focused, higher resolution scans on these ROIs, achieving voxel sizes down to 2 µm or even smaller, depending on the desired detail level(8).

4) Data Processing and Analysis:
- Image reconstruction using specialized algorithms to account for phase-contrast information.
- 3D visualization and segmentation of cardiac structures using dedicated software.
- Quantitative analysis of parameters like tissue density, vessel diameter, and wall thickness within the ROIs(9).

Imaging of Brain:
Figure 4A, B shows the cerebral cortex of the brain together with its sulci and gyri. Figure 4C shows the distinction between the cerebellum and microvasculature layers.

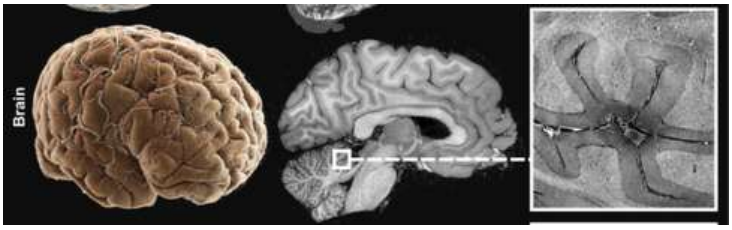


Figure 4: HiP-CT image of Brain (5).

1) Sample Acquisition:

- To maintain tissue integrity, acquire a post-mortem human brain from a donor program, preferably with quick post-mortem fixation, for the best tissue preservation.
- Perfusion fixation via the carotid arteries to be adopted(10).

2) Preparation of Tissue:

- **Fixation:** For a certain amount of time, such as a week, submerge the brain in a 4% formaldehyde solution.
- **Dehydration:** Move the brain through a succession of ethanol baths with escalating concentrations (up to 70% ethanol) to gradually dry it.
- **Degasification:** To eliminate trapped air bubbles that may cause imaging distortions, degas the brain at each stage of the ethanol dehydration procedure(10).

3) Embedding:

- **Agar Gel:** To stabilize the tissue and stop it from moving during scanning, combine the partly desiccated brain with 70% ethanol agar gel.
- **Mounting:** Put the brain-agar gel combination in an imaging-appropriate container, such as a cylindrical plastic tube(5).

4) Scanning using HiP-CT:

Synchrotron Scanning with HiP-CT Facility:

- Use a high-quality X-ray beam and a synchrotron light source to conduct the scans.

The hierarchical approach:

- A low-resolution tomographic scan of the entire brain is obtained as a full-field scan in order to provide anatomical context.
- Based on the results of the initial scan, choose particular brain regions of interest (ROI) and conduct high-resolution scans at various magnifications.
- Reference Scan: In order to correct for beam variations, concurrently scan a container that is 70% ethanol(11).

5) Image Reconstruction:

Data Processing:

- Utilize the reference scan to perform flat-field correction and apply the proper methods to rebuild the 3D image data from the projections.

Segmentation and Analysis:

- Using the reconstructed 3D pictures, segment certain brain regions and conduct quantitative analysis(11).

Imaging of Kidney:

Figure 5A, B displays the kidney's pelvis and calyces. The glomeruli and their complex capillary network are shown in **Figure 5C** of the kidney imaging.

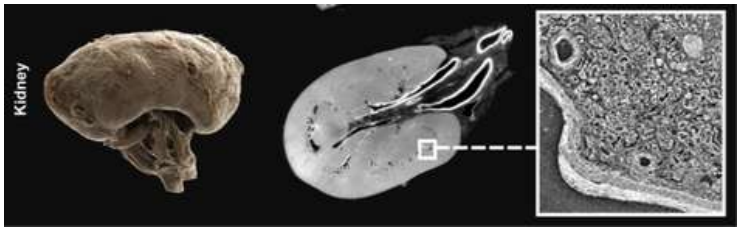


Figure 5: HiP-CT Image of Kidney (5).

Protocols: -

Typically, a kidney's Hierarchical Phase-Contrast Tomography (HiP-CT) protocol consists of first scanning the entire kidney at a lower resolution to provide a comprehensive anatomical overview, followed by high-resolution scans of particular kidney regions of interest (ROIs) to obtain cellular-level detail.

1) Sample Preparation:

- Obtain a fresh kidney from a donor through organ procurement.
- **Fixation:** To maintain tissue structure, submerge the kidney in a fixative solution, such as formalin.
- **Dehydration:** Use an ethanol series to partially dehydrate the kidney.
- **Stabilization:** To keep the partially dehydrated kidney in form during scanning, embed it in a supportive media such as agar gel(8).

2) Method of Scanning:

- Whole-organ scan at low resolution: For a thorough anatomical overview, scan the whole kidney at a comparatively large voxel size (around 25 µm)(4).
- ROI scans with high resolution: Determine certain kidney areas of interest (such as the glomeruli or tubules) using the low-resolution image.
- To see cellular features, run high-resolution scans of these ROIs at lower voxel sizes (around 1.3–2.5 µm)(3).

3) Beam configuration:

- Depending on the required degree of resolution, modify the X-ray beam's size and propagation distance.
- To account for beam hardening artifacts, conduct reference scans using a sample that just contains the supporting medium(8).

4) Image Reconstruction:

- **Filtered back projection:** Recreate the 3D image volumes from the projection data by applying a filtered back projection technique.
- **Registration:** To ensure precise spatial context, register the high-resolution ROI scans to the low-resolution whole-organ scan(4).

References

1. Brunet J, Cook AC, Walsh CL, Cranley J, Tafforeau P, Engel K, et al. Multidimensional Analysis of the Adult Human Heart in Health and Disease Using Hierarchical Phase-Contrast Tomography. Radiology. 2024 Jul 1;312(1):e232731.
2. HiP-CT - HiP-CT - HiP-CT.
3. Walsh CL, Tafforeau P, Wagner WL, Jafree DJ, Bellier A, Werlein C, et al. Imaging intact human organs with local resolution of cellular structures using hierarchical phase-contrast tomography. Nat Methods. 2021 Dec;18(12):1532–41.
4. Jain Y, Walsh CL, Yagis E, Aslani S, Nandanwar S, Zhou Y, et al. Vasculature segmentation in 3D hierarchical phase-contrast tomography images of human kidneys [Internet]. Bioinformatics; 2024 [cited 2025 Feb 4]. Available from: http://biorxiv.org/lookup/doi/10.1101/2024.08.25.609595
5. Brunet J, Walsh C, Tafforeau P, Dejea H, Cook A, Bellier A, et al. Hierarchical phase-contrast tomography: a non-destructive multiscale imaging approach for whole human organs. In: Müller B, Wang G, editors. Developments in X-Ray Tomography XV [Internet]. San Diego, United States: SPIE; 2024 [cited 2025 Feb 5]. p. 40. Available from: https://www.spiedigitallibrary.org/conference-proceedings-of-spie/13152/3028717/Hierarchical-phase-contrast-tomography--a-non-destructive-multiscale-imaging/10.1117/12.3028717.full
6. Phase-contrast X-ray imaging - Wikipedia.
7. Yagis E, Aslani S, Jain Y, Zhou Y, Rahmani S, Brunet J, et al. Deep learning for 3D vascular segmentation in hierarchical phase contrast tomography: a case study on kidney. Sci Rep. 2024 Nov 8;14(1):27258.
8. Walsh C, Tafforeau P, Wagner WL, Jafree DJ, Bellier A, Werlein C, et al. Multiscale three-dimensional imaging of intact human organs down to the cellular scale using hierarchical phase-contrast tomography [Internet]. Physiology; 2021 [cited 2025 Feb 4]. Available from: http://biorxiv.org/lookup/doi/10.1101/2021.02.03.429481
9. Tretter JT, Koneru JN, Spicer DE, Ellenbogen KA, Anderson RH, Ben-Haim S. A new dimension in cardiac imaging: Three-dimensional exploration of the atrioventricular conduction axis with hierarchical phase-contrast tomography. Heart Rhythm. 2024 Dec;21(12):2388–96.
10. Bellier A, Tafforeau P, Bouziane A, Angelloz-Nicoud T, Lee PD, Walsh C. Micro to macro scale anatomical analysis of the human hippocampal arteries with synchrotron hierarchical phase-contrast tomography. Surg Radiol Anat. 2024 Sep 3;46(11):1753–60.
11. Xian RP, Walsh CL, Verleden SE, Wagner WL, Bellier A, Marussi S, et al. A multiscale X-ray phase-contrast tomography dataset of a whole human left lung. Sci Data. 2022 Jun 2;9(1):264.
12. Pereira, A. F., Hageman, D. J., Garbowski, T., Riedesel, C., Knothe, U., Zeidler, D., & Knothe Tate, M. L. (2016). Creating high-resolution multiscale maps of human tissue using multi-beam SEM. PLoS Computational Biology, 12(11), e1005217. https://doi.org/10.1371/journal.pcbi.1005217
13. Reichmann, J., Verleden, S. E., Kühnel, M., Kamp, J. C., Werlein, C., Neubert, L., Müller, J.-H., Bui, T. Q., Ackermann, M., Jonigk, D., & Salditt, T. (2023). Human lung virtual histology by multi-scale x-ray phase-contrast computed tomography. Physics in Medicine and Biology, 68(11). https://doi.org/10.1088/1361-6560/acd48d
14. d'Esposito, A., Sweeney, P. W., Ali, M., Saleh, M., Ramasawmy, R., Roberts, T. A., Agliardi, G., Desjardins, A., Lythgoe, M. F., Pedley, R. B., Shipley, R., & Walker-Samuel, S. (2018). Computational fluid dynamics with imaging of cleared tissue and of in vivo perfusion predicts drug uptake and treatment responses in tumours. Nature Biomedical Engineering, 2(10), 773–787. https://doi.org/10.1038/s41551-018-0306-y
15. Barbone, G. E., Bravin, A., Mittone, A., Grosu, S., Ricke, J., Cavaletti, G., Djonov, V., & Coan, P. (2021). High-spatial-resolution three-dimensional imaging of human spinal cord and column anatomy with postmortem X-ray phase-contrast micro-CT. Radiology, 298(1), 135–146. https://doi.org/10.1148/radiol.2020201622

The role of Artificial Intelligence (AI)in early cancer diagnosis

Vanshu Saxena , M. Sc. Research fellow, **Rashmi Pandey,** Assistant Professor,
College of Paramedical Sciences, Teerthankher Mahaveer University, Moradabad, UP.

Abstract

Early cancer diagnosis and artificial intelligence (AI) are rapidly evolving fields with important areas of convergence. In the United Kingdom, national registry data suggest that cancer stage is closely correlated with 1-year cancer mortality, with incremental declines in outcome per stage increase for some subtypes. A national priority to improve early diagnosis rates to 75% by 2028 was outlined in the National Health Service (NHS) long-term plan. [1] The past 10 years have seen a remarkable acceptance of Artificial intelligence (AI) and Machine Learning (ML), which can help medical innovation for a more sustainable Precision Medicine (PM). The advantage of adopting AI and ML allows the analysis of extensive complex data, opening a new era for more sustainable healthcare. The potential of AI to generate insights from multi-dimensional data sets can support the use of PM in various diseases to discover new diagnostic and prognostic biomarkers. AI works through ML, allowing computers to learn without being explicitly programmed for a specific task. Indeed, if you feed the algorithm with enough good-quality data, ML will generate strategies for excelling at that task. However, so far, the power of AI to recognize sophisticated patterns and hidden structures has been limited to imaging and histopathology in the medical field. [2] Internationally, early diagnosis is recognised as a key priority by a number of organisations, including the World Health Organisation (WHO) and the International Alliance for Cancer Early Detection (ACED). Many studies indicate that screening can improve early cancer detection and mortality, but even in disease groups with established screening programmes such as breast cancer, there are ongoing debates surrounding patient selection and risk–benefit trade-offs, and concerns have been raised about a perceived 'one size fits all' approach incongruous with the aims of personalised medicine. [3,4,5] Patient selection and risk stratification are key challenges for screening programmes. AI algorithms, which can process vast amounts of multi-modal data to identify otherwise difficult-to-detect signals, may have a role in improving this process in the near future. [6,7,8] Moreover, AI has the potential to directly facilitate cancer diagnosis by triggering investigation or referral in screened individuals according to clinical parameters, and automating clinical workflows where capacity is limited. [9]The prospective uses of AI for early cancer diagnosis in symptomatic and asymptomatic patients are covered in this paper, with particular attention paid to the kinds of data that can be employed and the clinical areas most likely to experience changes in the near future.

Terms and Model Structures

Artificial Intelligence (AI) is a catch-all phrase for computers that simulate human intelligence (Figure 1). Under artificial intelligence (AI), machine learning (ML) is the process of teaching computer algorithms to make predictions based on past performance. ML may be generally classified into two categories: supervised learning, which allows the computer to see outcome data, and unsupervised learning, which does not offer end data. In order to predict outcomes, such as the existence or absence of cancer, survival rates, or risk groups, both strategies search for patterns in the data. Natural language processing (NLP) is a frequently used technology in cancer and other fields when analysing unstructured clinical data. [10]

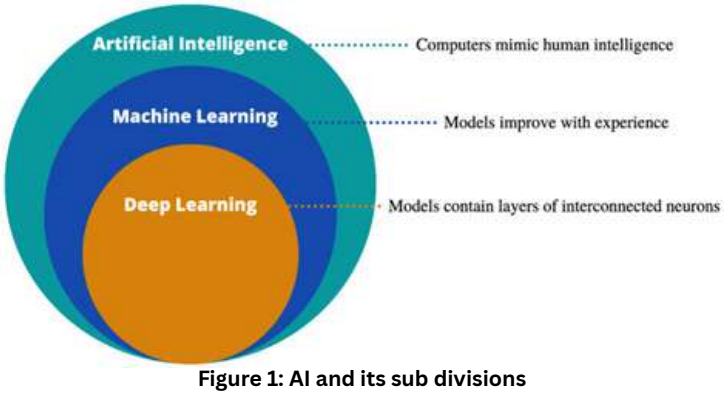


Figure 1: AI and its sub divisions

In machine learning, partitioning data into subsets is a standard procedure for developing and optimizing models on training and validation subsets. To prevent over-optimism, these models are then assessed on an unknown test set. Table 1 gives an overview of popular supervised learning techniques. These techniques include cutting-edge decision tree and deep learning algorithms in addition to conventional statistical models like logistic regression (LR).

Table 1

Model	Type	Description	Example
LR	R	Uses logistic function to predict categorical outcomes	Chhatwal et al. [13]
SVM	R, C	Constructs hyperplanes to maximise data separation	Zhang et al. [14]
NB	C	Utilises Bayesian probability including priors for classification	Olatunji et al. [15]
RF	R, C	Ensembles predictions of random decision trees	Xiao et al. [16]
XGB	R, C	As RF, but sequential errors minimised by gradient descent	Liew et al. [17]
ANN	R, C	Multiplies input by weights and biases to predict outcome	Muhammad [18]
CNN	R, C	Uses kernels to detect image features	Suh [19]

Abbreviations: R: regression, C: classification, LR: logistic regression, SVM: support vector machine, NB: naïve Bayes, RF: random forest, XGB: extreme gradient boosting, ANN: artificial neural network, CNN: convolutional neural network.

development, training and evaluation. Google also provides a free online notebook environment, Google Collaboratory, allowing cloud-based Python use and access to graphic processing units (GPUs) without local software installation. [11] Many early diagnosis models have exploited convolutional neural network (CNN) architectures, which led to a revolution in computer-vision research by allowing the use of colour images as input data. While the downstream fully connected layers resemble those of an ANN, the input data are processed by a series of kernels which slide over image colour channels and extract features, such as edges and colour gradients. These inputs are then pooled and flattened before being passed to the fully connected layer. Many pre-defined CNN architectures with varying degrees of complexity are available for use, including Alex Net [12]

2.1 Data types- Electronic healthcare records

A number of emerging healthcare data modalities are suitable for analysis with AI. In recent years, a global expansion in electronic healthcare record (EHR) infrastructures has occurred, enabling vast amounts of clinical data to be stored and accessed efficiently. [13] Many exciting digital collaborations are arising to facilitate early diagnosis research using EHRs, including the UK-wide DATA-CAN hub. [14]

2.2 Data types- Radiology:

The migration from radiographic film to digital scans within Patient Archive and Communication Systems (PACS) has yielded similar benefits for imaging research. Radiomics refers to quantitative methods for analysing radiology images (including CT, nuclear medicine, MRI and ultrasound scans), and may be divided into traditional ML and DL approaches. For traditional ML approaches, textural features are captured from highlighted regions of interest (ROIs), and relate broadly to size and shape, intensity and heterogeneity readouts. These features are used to train models for classification or prognostication. In the early cancer diagnosis setting, this includes classification of indeterminate nodules or cysts as benign or malignant. Many studies have employed a radiomics approach to accurately classify lung nodules in this fashion. [15,16]

The possible benefits and drawbacks of traditional ML and DL approaches are presented in Table 2. A cited advantage of traditional ML models is explainability–features are hand-crafted and defined upfront, and their expression levels can be readily quantified. [17]

Table 2 Possible benefits and limitations of traditional ML vs. deep learning.

Traditional Machine Learning	Deep Learning
Requires ROI segmentation	ROI segmentation optional
Features are pre-specified	Features generated by model
Features are easily quantified	Features difficult to quantify
Computationally less intensive	Computationally more intensive
May perform better on small datasets	May perform better on large datasets

2.3 Data types- digital pathology:

Digital pathology, referring to the creation and analysis of digital images from scanned pathology slides, is another important field of AI research relevant to early diagnosis. [18]

The authors also describe the benefits of integrated digital programmes, whereby histopathology data are automatically linked with relevant tests, such as molecular results, and viewed on an integrated platform, reducing the inefficiency of opening multiple windows per case. [19]

2.4 Datatypes- multi-Omic data:

Given the complexity of tumour biology, models based on single data types could miss important predictive information arising from the interaction between interdependent biological systems. There is, therefore, a drive to integrate multi-model data, which may include radiomic, genomic, transcriptomic, metabolomic and clinical factors, to better describe the tumour landscape and improve diagnostic precision. Several large-scale databases, including 'Linked Omics', which contains multi-omic data for 11,158 patients across 32 cancer types, are available to facilitate the detection of associations between data modalities and assist model development. [20]

3- Clinical applications:

Below, we discuss the areas where AI is likely to have clinical impact in the near future, using exemplar cancer groups (figure2).

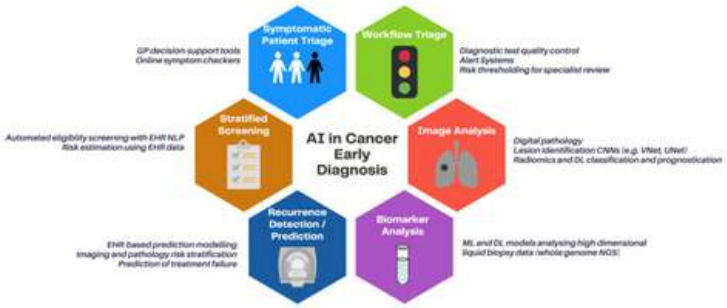


Figure 2 Clinical applications of AI in early cancer diagnosis. Abbreviations: GP: general practitioner, NLP: natural language processing, EHR: electronic healthcare record, ML: machine learning, DL: deep learning, NGS: next-generation sequencing.

3.1 Risk stratified screening of asymptomatic patients:

Gould et al. published an ML model based on non-imaging EHR data. [21] Using a dataset of 6505 patients with lung cancer and 189,597 controls, the model was more accurate than the PLCO criteria at predicting lung cancer within the next 9–12 months (AUC 0.86). Moreover, it improved upon standard eligibility criteria for lung cancer screening, providing evidence that AI-enhanced assessment of routine clinical data can help identify patients for targeted screening programs. Use of AI to improve patient selection for screening may be a useful path to early diagnosis in the future. [22]

3.2 Symptomatic patient triage:

General practitioners (GPs) are often the first port of call for patients with cancer symptoms, and have a critical role to play as gatekeepers to secondary care. [22]

Technologies are also emerging to diagnose and triage patients

directly according to self-described symptoms, using chat-bots or online symptom checkers. The commercial digital healthcare provider, Babylon Health, provides patients access to private consultations by phone or computer apps. [23]

3.3 Diagnostic workflow triage:

Given increasing concerns about the limited diagnostic workforce and infrastructure, particularly after the COVID-19 pandemic which disrupted diagnostic workflows and halted screening programs [24,25] we are likely to see an increasing role for AI-based workflow triage in the near future. Such systems are intended to screen diagnostic test results and allocate cases for specialist review, for example by pathologists or radiologists, based on risk, so that the large volume of normal or low-risk examinations are not escalated (figure 3).

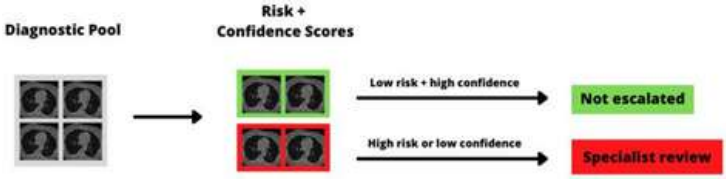


Figure 3 Example diagnostic triage pipeline. The AI model assigns a risk group to each examination, as well as a confidence estimate, and scans that are either high risk or have low diagnostic confidence are escalated for specialist review. CT images taken from the public LUNGx dataset. (26)

These studies provide good evidence that AI systems can be well integrated into clinical workstreams, and that with appropriate risk thresholding, can reduce the burden of diagnostic work through enhanced triage.

3.4 Early detection:

Cancer SEEK is a notable example: the test can detect eight common cancer types through analysis of cell-free DNA, and is based on a random forest model evaluating eight proteins and 1933 gene positions. Cancer SEEK can predict malignancy with an AUC of 91%, and although performance varied across tumour groups, it identified a very high proportion of ovarian and liver cancers. [26]

It is likely that ML-enhanced methods will play a central role in high-dimensional cancer biomarker analysis, particularly as the amount of extractable data increases and the appetite to combine imaging with liquid biopsy and digital pathology data evolves. [27]

3.5 Early detection of recurrence:

Another application of AI to oncology which is making strides is improved prognostication and earlier recurrence detection following treatment. In the pre-treatment setting, accurate prognostication could facilitate personalised therapy. [28]

So that cases identified as high-risk may be offered more intensive primary treatment, for example, radiotherapy dose escalation, whereas lower risk patients could be stratified to less intensive treatment to reduce side effect. [29]

Zhang et al. applied machine learning to pre-operative CT-derived radiomic and clinical features to develop a recurrence prediction model for gastric cancer. With an external test set AUC of 0.808 (confidence interval 0.732–0.881), this model lays the foundation for future pre-operative personalised prognostic tools to guide further treatment in gastric cancer. [30]

DL combined with radiomics has been used to predict treatment failure following stereotactic ablative radiotherapy (SABR) in NSCLC and make recommendations towards individualised radiotherapy doses to reduce failure-risk. [31] When combined with clinical features, the 'Deep Profiler' model had a concordance index of 0.72 (95% CI 0.67–0.77) for predicting local treatment failure. Results from this study suggest the existence of image-distinct subpopulations with varying sensitivity to radiation, and that AI can be used to individualise radiotherapy doses [31]

Challenges and future directions:

The promise of healthcare AI comes with several challenges, including ethical considerations, algorithmic fairness, data bias, governance and security. (32,33,34). (Figure-4)

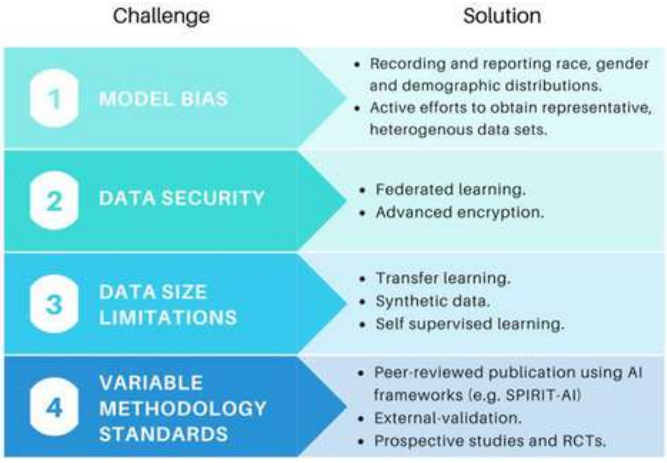


Figure 4: challenges and possible solutions to improve the robustness of AI models in the future.

As the field evolves, there is increasing awareness of the negative consequences of model bias, particularly in respect to demographic characteristics such as sex and ethnicity. As one example, an AI-tool for diagnosing skin cancer based on 129,450 clinical images achieved parity with dermatologists. [35], but less than 5% of images pertained to darker skin, drawing criticism about reproducibility and external validity. [36]A large meta-analysis published recently concluded that ethnicity data are available for only 1.3% of images in publicly available skin datasets, with 'substantial underrepresentation of darker skin types. [37]A commentary by Robinson et al. highlights that understanding and addressing structural racism and bias is likely to improve both model accuracy and external validity, and we hope that measures to describe ethnic distributions and address biases will become increasingly adopted [38]

Perhaps the most significant criticism of AI is that many models have not been evaluated with the same rigour as expected for other medical interventions. Firstly, as mentioned above, some tools have been used clinically without peer-reviewed publication, meaning they have not been subjected to the standard of rigorous adversarial feedback expected by the scientific community. Moreover, if the methodology is not published it cannot be reproduced, which is concerning given claims of an ongoing reproducibility crisis in academia.[39]

Models which are not externally validated do not provide good evidence of generalisability required for clinical adoption. A number of frameworks have been developed to improve the standard of healthcare AI publications, including CONSORT-AI, SPIRIT-AI and TRIPOD-AI.[40]

Conclusion:

We have seen that the application of AI to healthcare data has the potential to revolutionise early cancer diagnosis and provide support for capacity concerns through automation. AI may allow us to effectively analyse complex data from many modalities. Many commercial solutions for automated cancer detection are becoming available, and we are likely to see increasing adoption in the coming years. Moreover, we identified a number of challenges to the implementation of AI, including data anonymisation and storage, which can be time-consuming and costly for healthcare institutions. In terms of how study quality and model uptake can be improved going forwards, quality assurance frameworks (such as SPIRIT-AI), and methods to standardise radiomic feature values across institutions, as proposed by the image biomarker standardisation initiative, may help. Moreover, disease-specific, 'gold standard' test sets could help clinicians benchmark multiple competing models more readily. Despite the above challenges, the implications of AI for early cancer diagnosis are highly promising, and this field is likely to grow rapidly in the coming years.

References:

1-Hunter B, Hindocha S, Lee RW. The Role of Artificial Intelligence in Early Cancer Diagnosis. Cancers (Basel). 2022 Mar 16;14(6):1524. doi: 10.3390/cancers14061524. PMID: 35326674; PMCID: PMC8946688.

2- Carini C, Seyhan AA. Tribulations and future opportunities for artificial intelligence in precision medicine. J Transl Med. 2024 Apr 30;22(1):411. doi: 10.1186/s12967-024-05067-0. PMID: 38702711; PMCID: PMC11069149.

3- Sasieni P. Evaluation of the UK breast screening programmes. Ann. Oncol. 2003;14:1206–1208. doi: 10.1093/annonc/ /mdg325.

4-Maroni R., Massat N.J., Parmar D., Dibden A., Cuzick J., Sasieni P.D., Duffy S.W. A case-control study to evaluate the impact of the breast screening programme on mortality in England. Br. J. Cancer. 2020;124:736–743. doi: 10.1038/s41416-020-01163-2.

5- Esserman L.J. The WISDOM Study: Breaking the deadlock in the breast cancer screening debate. NPJ Breast Cancer. 2017;3:34. doi: 10.1038/s41523-017-0035-5.

6-Dembrower K., Wåhlin E., Liu Y., Salim M., Smith K., Lindholm P., Eklund M., Strand F. Effect of artificial intelligence-based triaging of breast cancer screening mammograms on cancer detection and radiologist workload: A retrospective simulation study. Lancet Digit. Health. 2020;2:e468–e474. doi: 10.1016/S2589-7500(20)30185-0.

7- Meystre S.M., Heider P.M., Kim Y., Aruch D.B., Britten C.D. Automatic trial eligibility surveillance based on unstructured clinical data. Int. J. Med. Inform. 2019;129:13–19. doi: 10.1016/j.ijmedinf.2019.05.018.

8- Beck J.T., Rammage M., Jackson G.P., Preininger A.M., Dankwa-Mullan I., Roebuck M.C., Torres A., Holtzen H., Coverdill S.E., Williamson M.P., et al. Artificial Intelligence Tool for Optimizing Eligibility Screening for Clinical Trials in a Large Community Cancer Center. JCO Clin. Cancer Inform. 2020;4:50–59. doi: 10.1200/CCI.19.00079.

9- Huang S., Yang J., Fong S., Zhao Q. Artificial intelligence in cancer diagnosis and prognosis: Opportunities and challenges. Cancer Lett. 2020;471:61–71. doi: 10.1016/j.canlet.2019.12.007

10- Yim W., Yetisgen M., Harris W.P., Kwan S.W. Natural Language Processing in Oncology: A Review. JAMA Oncol. 2016;2:797–804. doi: 10.1001/jamaoncol.2016.0213

11- Muhammad W., Hart G.R., Nartowt B., Farrell J.J., Johung K., Liang Y., Deng J. Pancreatic Cancer Prediction Through an Artificial Neural Network. Front. Artif. Intell. 2019;2:2. doi: 10.3389/frai.2019.00002.

12- Krizhevsky A., Sutskever I., Hinton G.E. ImageNet classification with deep convolutional neural networks.

13- Gillum R.F. From papyrus to the electronic tablet: A brief history of the clinical medical record with lessons for the digital age. Am. J. Med. 2013;126:853–857. doi: 10.1016/j.amjmed.2013.03.024. [PubMed] [CrossRef] [Google Scholar]

.14-DATA-CAN: Health Data Research Hub for Cancer | UCLPartners

15- Chen X., Feng B., Chen Y., Liu K., Li K., Duan X., Hao Y., Cui E., Liu Z., Zhang C., et al. A CT-based radiomics nomogram for prediction of lung adenocarcinomas and granulomatous lesions in patient with solitary sub-centimeter solid nodules. Cancer Imaging. 2020;20:1–13. doi: 10.1186/s40644-020-00320-3.

16- Beig N., Khorrami M., Alilou M., Prasanna P., Braman N., Orooji M., Rakshit S., Bera K., Rajiah P., Ginsberg J., et al. Perinodular and Intranodular Radiomic Features on Lung CT Images Distinguish Adenocarcinomas from Granulomas. Radiology. 2019;290:783–792. doi: 10.1148/radiol.201818091

17- Mayerhoefer M.E., Materka A., Langs G., Häggström I., Szczypiński P., Gibbs P., Cook G. Introduction to radiomics. J. Nucl. Med. 2020;61:488–495. doi: 10.2967/jnumed.118.222893

18- Bera K., Schalper K.A., Rimm D.L., Velcheti V., Madabhushi A. Artificial intelligence in digital pathology—New tools for diagnosis and precision oncology. Nat. Rev. Clin. Oncol. 2019;16:703. doi: 10.1038/s41571-019-0252-y.

19- Schüffler P.J., Geneslaw L., Yarlagadda D.V.K., Hanna M.G., Samboy J., Stamelos E., Vanderbilt C., Philip J., Jean M.-H., Corsale L., et al. Integrated digital pathology at scale: A solution for clinical diagnostics and cancer research at a large academic medical center. J. Am. Med. Inform. Assoc. 2021;28:1874. doi: 10.1093/jamia/ocab085.

20- Vasaikar S.V., Straub P., Wang J., Zhang B. LinkedOmics: Analyzing multi-omics data within and across 32 cancer types. Nucleic Acids Res. 2018;46:D956. doi: 10.1093/nar/gkx1090

21- Gould M.K., Tang T., Liu I.L.A., Lee J., Zheng C., Danforth K.N., Kosco A.E., Di Fiore J.L., Suh D.E. Recent trends in the identification of incidental pulmonary nodules. Am. J. Respir. Crit. Care Med. 2015;192:1208–1214.

22- . Green T., Atkin K., Macleod U. Cancer detection in primary care: Insights from general practitioners. Br. J. Cancer. 2015;112:S41–S49. doi: 10.1038/bjc.2015.41.

23- Babylon Health UK—The Online Doctor and... | Babylon Health. [(accessed on 18 November 2021)].

24- Anderson M., O'Neill C., Macleod Clark J., Street A., Woods M., Johnston-Webber C., Charlesworth A., Whyte M., Foster M., Majeed A., et al. Securing a sustainable and fit-for-purpose UK health and care workforce. Lancet. 2021;397:1992–2011. doi: 10.1016/S0140-6736(21)00231-2.

25-Van Haren R.M., Delman A.M., Turner K.M., Waits B., Hemingway M., Shah S.A., Starnes S.L. Impact of the COVID-19 Pandemic on Lung Cancer Screening Program and Subsequent Lung Cancer. J. Am. Coll. Surg. 2021;232:600. doi: 10.1016/j.jamcollsurg.2020.12.002.

26- Mehralivand S., Harmon S.A., Shih J.H., Smith C.P., Lay N., Argun B., Bednarova S., Baroni R.H., Canda A.E., Ercan K., et al. Multicenter Multireader Evaluation of an Artificial Intelligence-Based Attention Mapping System for the Detection of Prostate Cancer With Multiparametric MRI. AJR. Am. J. Roentgenol. 2020;215:903–912. doi: 10.2214/AJR.19.22573.

27- Wildeboer R.R., van Sloun R.J.G., Wijkstra H., Mischi M. Artificial intelligence in multiparametric prostate cancer imaging with focus on deep-learning methods. Comput. Methods Programs Biomed. 2020;189:105316. doi: 10.1016/j.cmpb.2020.105316.

28-Yoo B.C., Kim K.H., Woo S.M., Myung J.K. Clinical multi-omics strategies for the effective cancer management. J. Proteom. 2018;188:97–106. doi: 10.1016/j.jprot.2017.08.010

29- Alonzi R. Functional Radiotherapy Targeting using Focused Dose Escalation. Clin. Oncol. 2015;27:601–617. doi: 10.1016/j.clon.2015.06.015

30- Zhang W., Fang M., Dong D., Wang X., Ke X., Zhang L., Hu C., Guo L., Guan X., Zhou J., et al. Development and validation of a CT-based radiomic nomogram for preoperative prediction of early recurrence in advanced gastric cancer. Radiother. Oncol. 2020;145:13–20. doi: 10.1016/j.radonc.2019.11.023

31-Lou B., Doken S., Zhuang T., Wingerter D., Gidwani M., Mistry N., Ladic L., Kamen A., Abazeed M.E. An image-based deep learning framework for individualizing radiotherapy dose. Lancet. Digit. Health. 2019;1:e136–e147. doi: 10.1016/S2589-7500(19)30058-5

32-Cirillo D., Catuara-Solarz S., Morey C., Guney E., Subirats L., Mellino S., Gigante A., Valencia A., Rementeria M.J., Chadha A.S., et al. Sex and gender differences and biases in artificial intelligence for biomedicine and healthcare. NPJ Digit. Med. 2020;3:81. doi: 10.1038/s41746-020-0288-5. –

33-Mhasawade V., Zhao Y., Chunara R. Machine learning and algorithmic fairness in public and population health. Nat. Mach. Intell. 2021;3:659–666. doi: 10.1038/s42256-021-00373-4. -

34-Winter J.S. AI in healthcare: Data governance challenges. J. Hosp. Manag. Health Policy. 2021;5 doi: 10.21037/jhmhp-2020-ai-05. –

35-Esteva A., Kuprel B., Novoa R.A., Ko J., Swetter S.M., Blau H.M., Thrun S. Dermatologist-level classification of skin cancer with deep neural networks. Nature. 2017;542:115–118. doi: 10.1038/nature21056. -

36-Zou J., Schiebinger L. AI can be sexist and racist—It's time to make it fair. Nature. 2018;559:324–326. doi: 10.1038/d41586-018-05707-8. -

37-Wen D., Khan S.M., Xu A.J., Ibrahim H., Smith L., Caballero J., Zepeda L., de Blas Perez C., Denniston A.K., Liu X., et al. Characteristics of publicly available skin cancer image datasets: A systematic review. Lancet Digit. Health. 2021;4:e64–e74. doi: 10.1016/S2589-7500(21)00252-1. -

38-Robinson W.R., Renson A., Naimi A.I. Teaching yourself about structural racism will improve your machine learning. Biostatistics. 2020;21:339.

39- Baker M. 1500 scientists lift the lid on reproducibility. Nature. 2016;533:452–454. doi: 10.1038/533452a.

40-Liu X., Faes L., Calvert M.J., Denniston A.K. Extension of the CONSORT and SPIRIT statements. Lancet. 2019;394:1225. doi: 10.1016/S0140-6736(19)31819-7

Beam-hardening correction in dark-field chest radiography using deep-learning bone segmentation

Firdous Nazir, Radiographic Technologist, DMST, Pulwama, Jammu & Kashmir

Beam-hardening correction in dark-field chest radiography using deep-learning bone segmentation is an advanced technique designed to improve the quality and diagnostic value of dark-field X-ray chest images by using deep learning to segment bone structures, such as ribs and clavicles, and correct for the artifacts introduced by beam-hardening effects.

Introduction to Dark-Field Chest Radiography

Dark-field radiography is a novel imaging modality based on X-ray scattering, providing insights into the microstructural properties of lung tissue that conventional attenuation-based radiography cannot reveal. Implemented via Talbot-Lau interferometry, it can deliver simultaneous conventional and dark-field images, aiding diagnosis and staging of pulmonary diseases like COPD and COVID-19.However, the technique suffers from artifacts, particularly beam-hardening, caused by polychromatic X-ray sources and the presence of high-attenuation materials like bones.

What Is Beam-Hardening?

Beam-hardening occurs because X-ray tubes emit a spectrum of energies rather than a single energy.As these X-rays pass through bones (such as ribs and clavicles), lower-energy photons are absorbed more readily than higher-energy ones, effectively "hardening" the beam (making it more penetrating). This effect introduces structured artifacts into dark-field images, which can obscure true tissue signals and reduce diagnostic accuracy. In dark-field radiography, this manifests as artificial signals, especially at the location of osseous structures, causing inaccurate representation of lung microstructure

The Need for Beam-Hardening Correction

- Beam-hardening-induced artifacts manifest as step or band-like features aligned with bone structures in chest images.
- These contribute to reduced image homogeneity, complicate quantitative assessment, and introduce cross-talk between attenuation and dark-field channels.
- Previous correction techniques (single look-up table, global weighting factors) often led to overcorrection or under correction in certain regions, limited by their lack of anatomical specificity.

Deep-Learning Bone Segmentation Approach

The key innovation in recent work is leveraging deep-learning models (e.g., U-Net architectures) to precisely segment ribs and clavicles directly in the attenuation images acquired with the dark-field system.

Segmentation Pipeline

- Deep learning models are trained with manually segmented chest radiographs, learning to identify bone structures.
- The model outputs segmentation masks for each rib and clavicle.
- These masks are then used to generate spatially adaptive attenuation maps, representing material distribution (bone vs. soft tissue).

Incorporating Dual-Energy Decomposition

To further refine accuracy, dual-energy CT data is used to decompose the material contributions of aluminium (as a bone surrogate) and water (for soft tissue). This enables personalized, pixel-wise correction factors rather than relying on global averages.

Beam-Hardening Correction Process

Image Acquisition: A dark-field and conventional X-ray image are acquired simultaneously, ensuring perfect registration.

Deep-Learning Segmentation: Ribs and clavicles are automatically identified on attenuation images using trained neural networks.

Attenuation Contribution Map Creation: Dual-energy decomposition yields separate maps for bone- and soft-tissue-like attenuation in each image region.

Lookup Table (LUT) Calibration: Calibration is performed using known materials (aluminium and water) to map signal to expected beam-hardening effects.

Pixel-wise Correction: For each pixel, a correction factor (based on proportion of bone/soft tissue) is computed and the corresponding artificial beam-hardening signal is subtracted from the raw dark-field image.

Artifact Reduction: The result is a corrected dark-field image with significantly reduced bone-induced artifacts and improved homogeneity within lung fields.

Evaluation and Clinical Impact

- The pipeline was evaluated on a large clinical cohort, including healthy subjects as well as patients with chronic lung diseases such as COPD and COVID-19.
- Metrics such as coefficient of variation and interquartile range within the segmented lungs were used to assess homogeneity improvement.
- Statistically significant reductions in bone-induced artifacts and enhanced uniformity of lung dark-field signals were observed ($p<0.001$, Wilcoxon signed-rank test).
- Better homogeneity translates to improved diagnostic confidence and more reliable quantitative assessments, particularly valuable for monitoring subtle microstructural lung changes.

Advantages over Previous Methods

- Manual or global correction methods lack specificity and adaptability, leading to under- or overcorrection depending on the region.
- Deep learning provides highly accurate, individually tailored (per patient, per scan) segmentation and correction, improving overall image quality.
- The approach is efficient and can be fully automated, making it clinically viable and scalable.

Technical and Practical Considerations

- Deep learning training requires a substantial, annotated dataset for bones in chest radiographs.
- Dual-energy data or suitable bone/soft tissue surrogates (aluminium/water) must be available for precise calibration.
- Implementation needs integration with clinical workflow, including image acquisition, processing, and review.

Future Directions

- Increased dataset diversity and size may further improve segmentation robustness
- Expansion to full 3D volumes or other projections may enhance diagnostic utility.
- Direct end-to-end correction models (predicting corrected dark-field images directly from raw images) could be possible with advanced AI architectures.

Conclusion

Beam-hardening correction in dark-field chest radiography using deep-learning bone segmentation represents a major advance in the clinical utility of dark-field imaging, allowing for more reliable detection of microstructural lung abnormalities by removing bone-induced artifacts and preserving true tissue signal. This approach leverages state-of-the-art AI methods, nuanced multi-material calibration, and thorough clinical validation, offering a template for similar artifact correction pipelines in other imaging modalities.

भास्कर एक्सक्लूसिव एनसीएएचपी ने 2026-27 के लिए करिकुलम बदला

फिजियोथैरेपी, ओटी टेक्नोलॉजी समेत सभी कोर्स में सीधी एंट्री खत्म, अब नीट से प्रवेश

तवीन ओझाल | इंदौर

देश में पैरामेडिकल और अलाइड हेल्थ की पढ़ाई को मेडिकल स्टैंडर्ड के बराबर लाने की दिशा में बड़ा बदलाव हो गया है। नेशनल कमीशन फॉर अलाइड एंड हेल्थकेयर प्रोफेशंस (एनसीएएचपी) ने आदेश जारी कर स्पष्ट किया है कि सत्र 2026-27 से फिजियोथैरेपी, आक्युपेशनल थैरेपी सहित अधिकांश एलाइड-हेल्थकेयर कोर्सेस में दाखिला अब नीट के जरिए ही होगा। अब तक बिना नीट चल रहे इन टेक्निकल कोर्सेस में यह बदलाव क्वालिटी बढ़ाने की दिशा में सबसे कड़ा कदम माना जा रहा है। इससे पहले एलाइड और हेल्थकेयर कोर्सेस एमबीबीएस-बीडीएस जैसी राष्ट्रीय परीक्षा व्यवस्था से बाहर थे। अब पहली बार पूरा पैरामेडिकल सेक्टर नीट आधारित दाखिला प्रणाली में आ जाएगा।

आयोग ने बताया कि 13 करिकुलम जारी हो चुके हैं और बाकी प्रक्रिया में हैं। हर करिकुलम में दाखिले का पहला आधार नीट रखा गया है, ताकि एडमिशन मेडिकल की तरह एक समान और राष्ट्रीय स्तर पर नियंत्रित हो सके। आयोग ने समीक्षा में पाया कि अलाइड और हेल्थकेयर कोर्सेस में भी प्रवेश प्रक्रिया ढीली रहने से क्वालिटी पर वही जोखिम पैदा हो रहा था। सेंट्रल और स्टेट बोर्डों को निर्देश दिए गए हैं कि वे स्कूलों को सूचित कर दें।

भास्कर इनसाइट

कई तकनीकी कोर्स नीट के दायरे में

- बीएससी मेडिकल रेडियोलॉजी एंड इमेजनिंग टेक्नोलॉजी (एमआरआईटी), बीएससी रेडियोथैरेपी टेक्नोलॉजी, लैब टेक्नोलॉजी, एनेस्थिसिया टेक्नोलॉजी, ओटी टेक्नोलॉजी सहित कई अलाइड कोर्सेस अब नीट आधारित हो जाएंगे।
- पैरामेडिकल कॉलेजों में हुए फर्जी एडमिशन जैसे मामलों ने यह साफ कर दिया था कि मेडिकल-संबंधी कोर्सेस में बिना राष्ट्रीय फिल्टर के दाखिला क्वालिटी के लिए जोखिम है। अलाइड सेक्टर में भी यही खतरा था। इसी वजह से अब पैरामेडिकल कोर्सेस को भी नीट के दायरे में लाकर पारदर्शी व्यवस्था लागू की जा रही है।
- केंद्र द्वारा तय मानकों के आधार पर ही सीटें स्वीकृत होंगी; 50 सीटों के लिए मापदंड पहले ही तय किए जा चुके हैं।
- NEET में अब एमबीबीएस, बीडीएस के बाद एलाइड हेल्थ सर्विसेस के लिए अलग कटऑफ निकाला जाएगा।
- 10 कैटेगरी में 64 कोर्सेस राष्ट्रीय स्तर पर एक ही समय और एक जैसे सिलेबस से संचालित होंगे।

देश में एडमिशन लेने वाले 5 लाख

- **मप्र पैरामेडिकल काउंसिल** प्रतिवर्ष लगभग 225 कॉलेज की 52 कोर्स संचालन की अनुमति देती है और प्रदेश से हर साल करीब 50 हजार छात्र तैयार होते हैं।
- **पूरे देश में** इन कोर्सेस में एडमिशन लेने वालों की संख्या 5 लाख से ज्यादा है।
- **नए नोटिफिकेशन** के बाद सभी राज्यों में एक जैसा करिकुलम, फैकल्टी क्वालिफिकेशन और इन्फ्रास्ट्रक्चर नियम लागू होंगे।

अगले सत्र से लागू होगी ये व्यवस्था

अधिकांश करिकुलम में प्रवेश का मूल पात्रता नियम नीट उपस्थिति को रखा गया है। यह व्यवस्था सत्र 2026-27 से लागू होगी। -राजेंद्र सिंह सिद्धू, अपर सचिव, भारत सरकार

इससे सिस्टम में पारदर्शिता आएगी

पहले कॉलेज अपनी सुविधा से एडमिशन देते थे, इससे क्वालिटी गिरती जा रही थी। अब कॉमन एन्ट्रेंस एग्जाम लागू होने से एडमिशन मेरिट पर होंगे और सिस्टम पारदर्शी बनेगा। - डॉ. रामहरि मीणा, प्राचार्य, एमजीएम अलाइड हेल्थ साइंस इंस्टीट्यूट

Role of Triple Phase Computed Tomography in Evolution of Hepatic Lesions

Ekta Singh, BRIT Intern, **Viswanath Pratap Singh,** Assistant Professor,
Subharti College of Allied and Healthcare, Meerut, Uttar Pradesh

Abstract

Triple phase Computed tomography (TPCT) is the imaging modality most often used to evaluate focal liver lesions, however, the complex blood supply of the liver to the search for a contrast-enhanced CT procedure that works best for identifying and characterizing localized liver lesions. TPCT includes three phases arterial, portal and venous for effective detection of lesion. It helps in the detection of hepatocellular carcinoma [HCC], liver cirrhosis, cysts, adenomas, hepatitis, pancreatic tumors, vascular diseases etc. The liver's intricate blood supply makes it difficult to find the best contrast-enhanced CT procedure for the identification and description of focal hepatic lesions, despite the fact that CT is the imaging modality most frequently employed to assess focal liver lesions. It includes advanced or poorly differentiated hepatocellular carcinomas are usually hypervascular lesions that derive most of their blood supply from the hepatic artery with the portal venous contribution decreasing as the grade of malignancy increases.

Introduction of CT

Computed tomography it is radiographic technique which utilizes the x-rays in creating an axial image of the body. Ct scan is a radiographic machine in assessing whole anatomy. CT scan machine utilizes high level x-ray to acquire image instantly in transverse plane in different flesh with. By using Ct scan, abnormality are detected in sagittal plane or coronal plane with the help of reconstruction in the scan obtain in the computer. Characterizing hepatic lesions using different imaging tests is frequently challenging. The good standard is histology, but because biopsy is an intrusive procedure, it is never feasible. The most popular imaging technique for assessing focal liver lesions is computed tomography (CT); nevertheless, the liver's intricate blood supply makes it difficult to find the best contrast-enhanced CT protocol for identifying and characterizing focal hepatic lesions. The majority of primary and secondary liver neoplasms obtain 80–95% of their blood supply via the hepatic artery, despite the fact that the liver receives 70% of its blood supply from the portal vein and 30% from the hepatic artery. Due to the prevalence of benign focal liver lesions like focal nodular hyperplasia, haemangiomas, and cysts, characterisation of the leions is essential.[2]

Introduction of TPCT

Triple-Phase Computed Tomography of the liver is essential in view of the dual blood supply of the liver TPCT allows characterization of all liver's lesion and closed to pathological correction by invasive imaging alone. It is the imaging technique that involves taking three consecutive Ct scans after injecting contrast media, each phase includes different aspects of blood flow and tissue enhancement. a triphasic spiral CT technique was developed to image the entire liver in arterial, portal, and equilibrium phases.6,7 Although current search shows that MRI has a comparable rate CT is the best imaging method for identifying and categorizing localized liver lesions, nonetheless, because of its quick availability and quick scanning time.8–10. Recent research has also shown that using arterial phase imaging in addition to portal venous imaging improves lesion detection, particularly when hypervascular neoplasms such hepatocellular carcinoma are present. Numerous investigations have been conducted globally about the use of triphasic CT scans in identifying and distinguishing between benign and malignant tumors.[5]

Challenges faced during the TPCT:

The primary challenges faced during a triple-phase computed tomography (CT) scan include: optimizing contrast injection timing for accurate phase capture, managing patient motion artifacts, differentiating subtle lesion characteristics in different phases, minimizing radiation dose due to multiple scans, potential variability in image interpretation by radiologists, and considering patient factors like kidney function when administering contrast; all of which can impact the diagnostic accuracy of the procedure, particularly when evaluating liver lesions.

Contrast injection timing:

Accurately capturing the arterial, portal venous, and delayed phases requires precise timing of contrast injection, which can be challenging due to variations in patient anatomy and blood flow dynamics.

Motion artifacts:

Patient movement during the scan can significantly degrade image quality, especially in the liver where breathing can cause substantial motion.

Lesion characterization:

Differentiating between benign and malignant lesions based on subtle differences in enhancement patterns across the different phases can be challenging, especially for small or poorly defined lesions.

Radiation dose:

Performing multiple phases in a single CT scan increases the overall radiation dose to the patient, necessitating careful optimization of scan parameters to minimize exposure.

Inter-observer variability:

Interpretation of the imaging findings can vary between radiologists, which can affect the consistency of diagnosis.

Patient factors:

Patients with impaired kidney function may require special considerations when administering contrast due to the potential for nephrotoxicity.[10]

Potential solutions to overcome these challenges:

Bolus tracking technology:
Utilizing automated bolus tracking software to optimize contrast injection timing for each phase.

Breath-holding techniques:
Patient instructions to hold their breath during image acquisition to minimize motion artifacts.

Advanced image post-processing:
Utilizing dedicated software to enhance image quality and differentiate subtle lesion characteristics.

Dose reduction techniques:
Optimizing scan parameters, such as field of view and slice thickness, to minimize radiation dose while maintaining diagnostic quality.

Standardized reporting protocols:
Establishing clear criteria for reporting findings to improve consistency in interpretation. [11]

Phases of Triple Phase Computed Tomography:

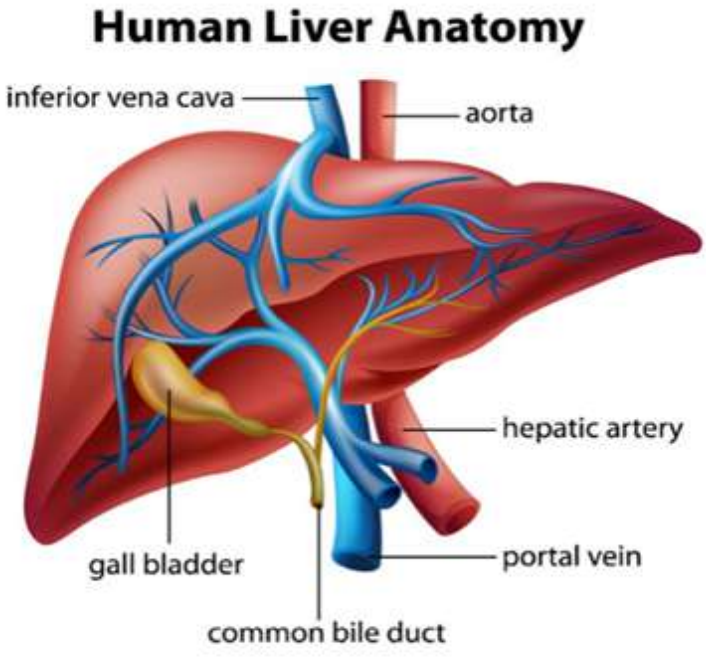
Arterial Phase: bolus tracking 18-25sec, it is taken immediately after contrast injection, highlighting arterial blood flow.

Portal Phase: take on 45sec, showing portal venous blood flow and liver enhancement.

Venous Phase: take on 65sec, shows blood vessels in different stages of liver pathologies.

General anatomy of Liver

Liver is the largest gland in the body it reddish brown in colour highly vascular and weight about 1.5 kg in adults. It connects with the endocrine and gastrointestinal frameworks by supporting absorption and digestion. The liver is the capacity area for fat-dissolvable nutrients and handles cholesterol homeostasis. It stores iron and copper. It assumes a part in hematology with coagulating component and protein combination. [7]



Position of liver

It occupies the right hypochondrium and extends lateral surface into the epigastrium and left hypochondrium.
Situated opposite to the left side in the body under lower ribs.
Liver → 4 lobes → 8 segments → Lobules → Acini
Lots of blood supply to the liver: oxygenated blood and Nutrition.[15]

Blood supply of liver

Right and left hepatic artery: Oxygenated blood pumped by the heart- 25% of blood supply.
Hepatic Vein: RHV, LHV, MHV directly drains into the IVC And then into heart
Portal Vein: brings the nutrients and blood from the small Intestine. 75% of blood supply.[13]

Segments of liver

- 1 – Caudate lobe (posterior side).
- 2 and 3 – left lateral side.
- 4 – Left medial.
- 5 and 8 – right anterior side.
- 6 and 7 – right posterior side.[10]

Contrast we are using in TPCT

- Iodinated contrast – Non-ionic – Omnipaque.
- Serum Creatinine and GFR.
- Contrast dose – 1ml/kg (80-100ml).
- Rate of injection – 3.5/sec, IV Cannula – 20 gauge.
- CT – Reduce the contrast dose. Arterial Phase – Timing and Rate.
- Venous Phase – Total iodine dose[17]

CT without contrast (Plane)

This scan is made without administration of iv contrast agent, a primary indication for abdominal scans without contrast media is the detection of liver problem, condition of internal structure organ of the body like spleen, pancreas, aorta, stomach.[12]

- Survey image done
- Locator: Arch of aorta.
- ROI set: Descending aorta.
- Bolus tracking– 0-10sec
- Portal phase – 15-20sec
- Venous phase – 25-30sec
- Delayed – 5min

Liver arterial phase 1

This test is made approximately 20-30 seconds after the management of IV evaluation agent. The evaluation agent remains withinside the arteries, and a few inner organ shape is beginning to take in the agent. This test segment is specifically suitable for comparing arteries and detecting hyper vascular abnormalities. Example Hyper vascular metastases within side the liver

Liver Portal phase 2

When the normal liver parenchyma strengthens the most, hypovascular tumours are found in the portal venous phase. In a comparably highly dense liver, these hypovascular tumours will appear as hypodense lesions. This scan might take up to 60 second.[19]

Liver Venous phase (Equilibrium phase) 3

Tumors become prominent in this phase, which occurs around 10 min post contrast administration, and which either lose or wash out their contrast quicker than normal liver parenchyma. To the typical liver, these tumours will become either hyper dense or hypo dense.[15]

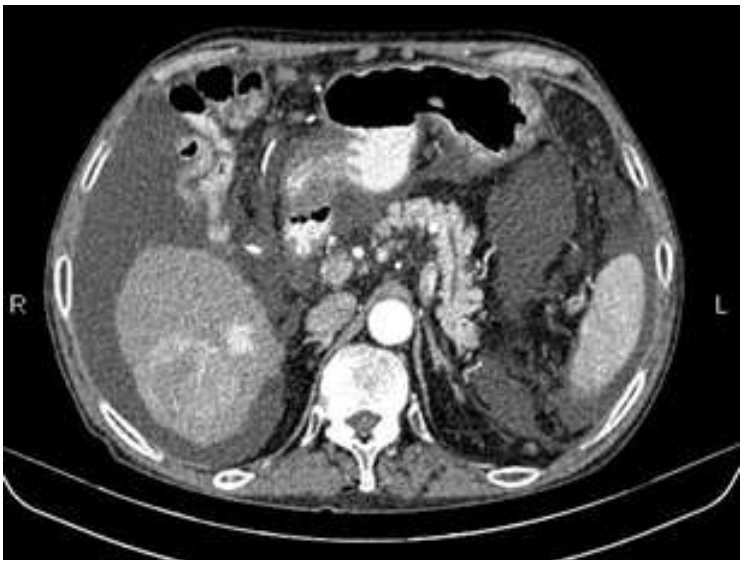
Delayed Phase 5-10 Minutes

5–10 Minutes post bolus investigation. Wash out of contrast occurs in all abdominal tissues, which is also referred to as the "wash out phase" or "equilibrium phase." With the exception of fibrotic tissue, which has a poor late wash out and will become comparatively thick as compared to normal tissue.

After the procedure patient care

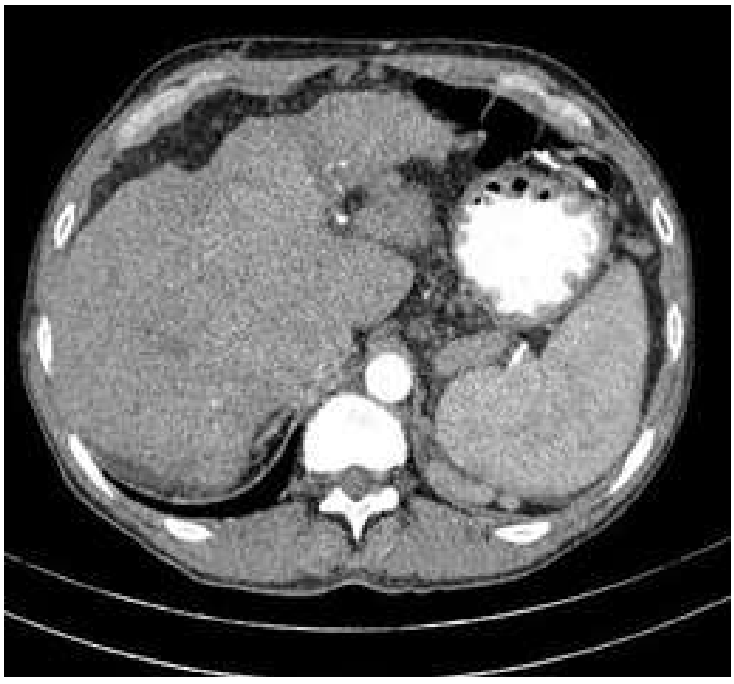
Patient is asked to stay in the hospital after the procedure.
Patient is ask to drink plenty of water so that the dye flushes out from the body.
Patient is monitered for 24 hrs after the procedure [16].

Some Pathologies detected by TPCT:



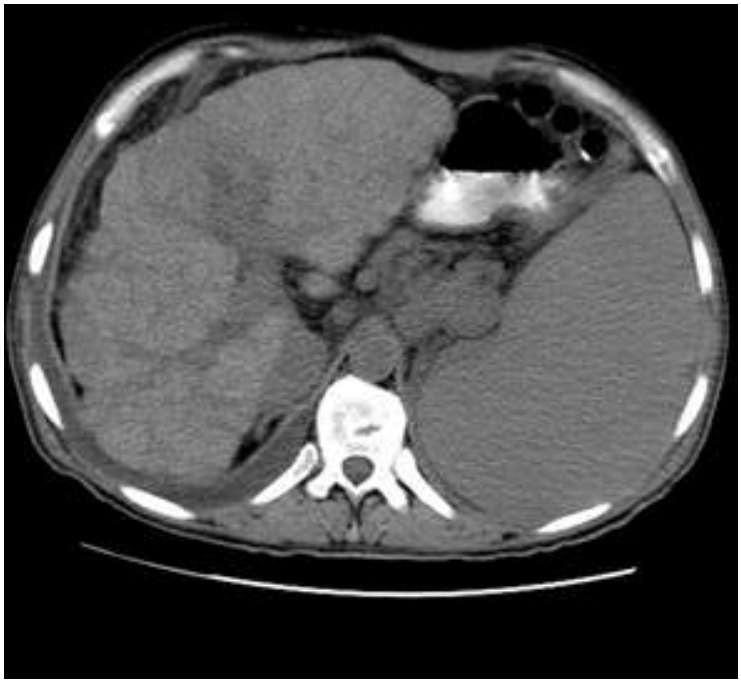
Hepatocellular carcinoma [HCC]

- There is severe abdominopelvic ascites.
- Cirrhosis is implied by the liver's atrophic state and uneven edges.
- Hepatocellular carcinoma is suggested by the presence of at least three hypervascular lumps in the liver with delayed washout. Some perigastric and distal paraesophageal collateral veins that are compatible with portal hypertension are observed along with the recanalization of the umbilical vein and falciform ligament vascular structures.



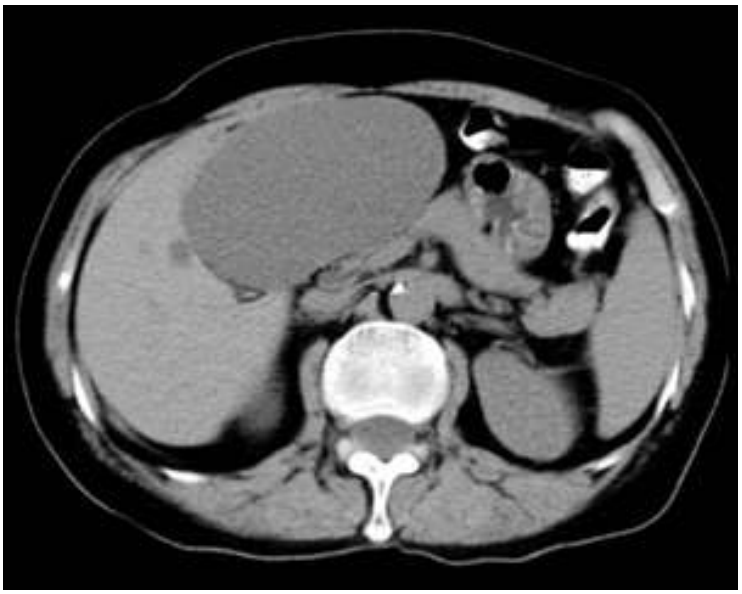
Liver cirrhosis

- The liver's uneven borders and diverse parenchyma are indicative of cirrhosis. There were no visible localized lesions in the liver parenchyma.
- There are numerous dilated collateral veins in the abdominal spaces, especially near the perisplenic areas.
- The perihepatic area contains a small amount of free fluid.
- The cephalocaudal height of the enlarged spleen is 16 cm.

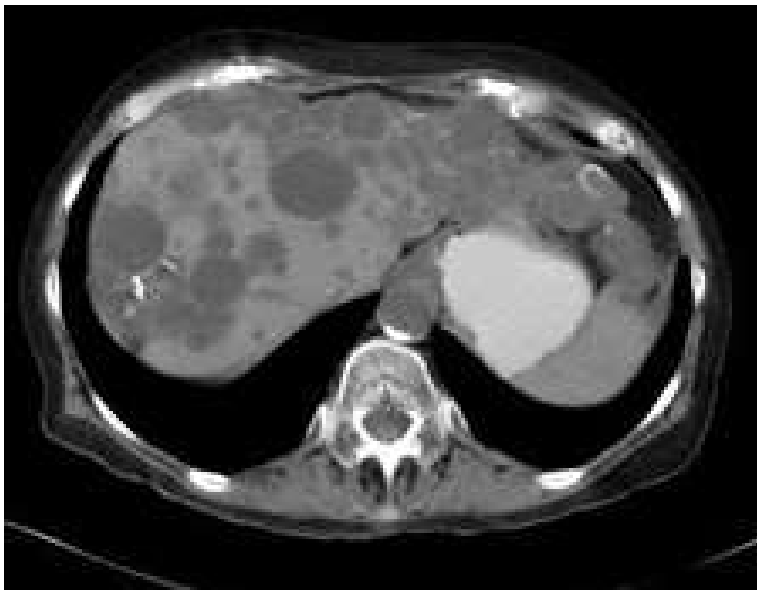


Chronic hepatitis B

- According to a triphasic liver CT scan, the liver exhibits increased density and uneven parenchyma and nodular surface, which is indicative of cirrhosis.
- During the arterial phase, no increasing nodule was observed to indicate HCC.
- Huge splenomegaly is seen. Distended and engorged paraumbilical veins, which are seen radiating from the umbilicus across the abdomen to join the systemic veins indicative of severe portal hypertension.



Large cystic lesion in the left lobe of the liver.



Polycystic liver lesion

Conclusion

TPCT is very effective technique for the detection of hepatic lesion as the above some pathologies are discussed related to hepatic lesions. It includes the three phases Arterial Phase, bolus tracking 18-25sec, it is taken immediately after contrast injection, highlighting arterial blood flow. portal Phase, take on 45sec, showing portal venous blood flow and liver enhancement. Venous Phase, take on 65sec, shows blood vessels in different stages of liver pathologies. By using Ct scan, abnormality are detected in sagittal plane or coronal plane with the help of reconstruction in the scan obtain in the computer. It is a standardized procedure for the detection and characterization of a large variety of benign and malignant liver lesions. This contributes to the decrease in liver disease patients' rates of death and morbidity. Due to its ability to acquire images at the peak enhancement of the liver parenchyma with a single breath hold, spiral computed tomography has become the method of choice for regular liver examination. Multiphase liver computed tomography is made possible by rapid data acquisition, which also enables successive scanning of the entire liver at various intervals following the injection of the iodinated contrast material.

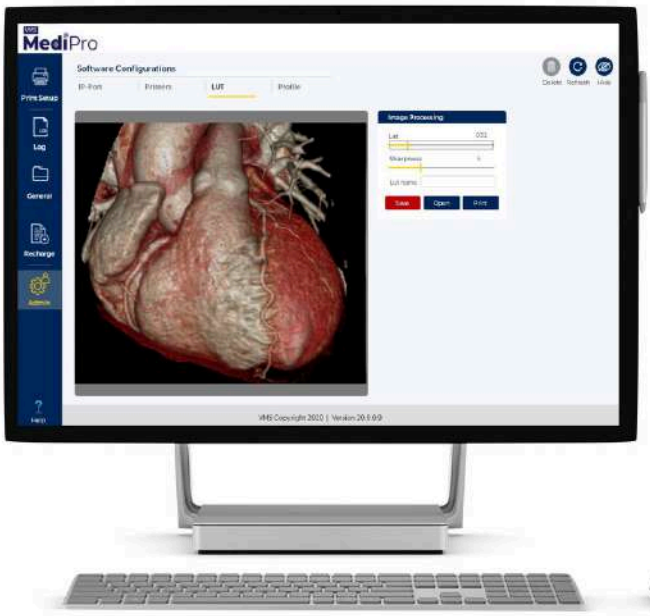
Most metastases to the liver are hypovascular and consequently are best detected during the portal venous phase. Hypervascular primary malignancies (e.g., hepatocellular carcinomas) and certain metastases have a proportionately greater hepatic arterial blood supply and, as a result, may be visible only on hepatic arterial phase images.

Reference

- Méndez-Sánchez N, Villa AR, Chávez-Tapia NC, Ponciano-Rodriguez G, Almeda-Valdés P, González D, et al. Trends in liver disease prevalence in Mexico from 2005 to 2050 through mortality data. Annals of Hepatology
- Javed IF, Rukhsana JF. Prevalence of hepatocellular carcinoma in Pakistan in liver cirrhosis: An experience in NWFP. J Coll Physicians Surg Pak 2000; 2:54-
- Yaqoob J, Bari V, Usman M U, Munir K, Mosharaf F, Akhtar W. The evaluation of hepatocellular carcinoma with biphasic contrast enhanced helical computed tomography scan J Pak Med
- Schwartz LH, Gandras EJ, Colangelo SM, Ercolani MC, Panicek DM. Prevalence and importance of small hepatic Lesions Found at CT in Patients with cancer. Radiology
- Karhunen PJ. Benign hepatic tumours and tumour-like conditions in men. J Clin Pathol
- Bonaldi VM, Bret PM, Reinhold C, Atri M. Helical computed tomogram of liver, value of an early hepatic arterial phase Radiology
- Francis IR, Cohan RH, McNulty NJ, Platt JF, Korobkin M, Gebremariam A, et al. Multidetector CT of the liver and hepatic neoplasms: Effect of multiphasic imaging on tumor conspicuity and vascular enhancement. AJR Am J Roentgenol
- Ichikawa T, Saito K, Yoshioka N, Tanimoto A, Gokan T, Takehara Y et al. Detection and characterization of focal liver lesions: a Japanese phase III, 574 J Pak Med Assoc
- multicenter comparison between gadoxetic acid disodium enhanced magnetic resonance imaging and contrast enhanced computed tomography predominantly in patients with hepatocellular carcinoma and chronic liver disease.
- Hammerstingl R, Huppertz A, Breuer J, Balzer T, Blakeborough A, Carter R et al. Diagnostic efficacy of gadoxetic acid (Primovist)-enhanced MRI and spiral CT for a therapeutic strategy: comparison with Intraoperative and histopathologic findings in focal liver lesions..
- Soyer P, Sirol M, Fargeaudou Y, Duchat F, Hamzi L, Boudiaf M, et al. Differentiation between true focal liver lesions and psudolesions in patients with fatty liver: evaluation of helical CT criteria.
- Van Leeuven MS, Noordzij J, Feldberg MA, Hennipman AH, Doorneewaard H. Focal Liver lesions; characterization with triphasic computed tomography Radiology
- Szklaruk J, Silverman PM, Chamsangavej C. Imaging in the diagnosis, staging, treatment and surveillance of hepatocellular carcinoma. AJR Am J Roentgenol.
- Iannaccone R, Piacentini F, Murakami T, Paradis V, Belghiti J, Hori M, et al. Hepatocellular carcinoma in patients with non-alcoholic fatty liver disease: helical CT and MR imaging findings with clinical-pathologic comparison. Radiology
- Iannaccone R, Laghi A, Catalano C, Rossi P, Mangiapane F, Murakami T, et al. Hepatocellular carcinoma, role of unenhanced and delayed phase multi detector row helical computed tomography in patients with cirrhosis.
- Foley WD, Mallisee TA, Hohenwalter MD, Wilson CR, Quiroz FA, Taylor AJ. Multiphase hepatic computed tomography with a multirow detector computed tomography scanner. AJR Am J Roentgenol
- Oliver JH 3rd, Baron RL, Federle MP, Rockette HE Jr. Detecting hepatocellular carcinoma, value of unenhanced or arterial phase computed tomography imaging or both used in conjunction with conventional portal venous phase contrast enhanced computed tomography imaging.
- AJR Am J Roentgenol 1996; 167: 71- 7. Miller FH, Butler RS, Hoff FL, Fitzgerald SW, Nemcek AA Jr, Gore RM. Using triphasic helical computed tomography to detect focal hepatic lesions in patients with neoplasms. AJR Am J Roentgenol
- Vallls C, Andia E, Rocca Y, Cos M, Figueras J. Computed tomography in hepatic cirrhosis and chronic hepatitis. Semin Ultrasound, CT
- Sheafor DH, Frederick MG, Paulson EK, Keogan MT, DeLong DM, Nelson RC. Comparison of unenhanced, hepatic arterial-dominant and portal venous dominant phase helical CT for the detection of liver metastases in women with breast carcinoma

VMS MediPro™

VMS®



Secure. Seamless. Smart. MediPro

The Most Intuitive DICOM Solution

The VMS MediPro DICOM Solution offers a holistic, end-to-end management option. It is ideally-suited for Hospitals, Diagnostic centres with MRI, CT-Scan, Endoscopic, Sonography, etc. looking to adopt new digital imaging technologies or radiology centres with few per-day exposures.

It provides easy integration to all digital modalities and maintains a perfect balance between image quality and convenience. Most importantly, it provides signi□cant costs reduction as well as helps minimise the environmental impact on a daily basis.

VMS MediPro is an advanced, DICOM-to-Windows printing solution with a host of rich features.

- It offers multi-modality connectivity and supports four different Windows-based printers at one time.
- For fast printing, it can be con□gured to send prints to the next available idle printer in rotation.
- Suitable for Pre-Natal Diagnostic Technique (PNDT) prints.
- Enhance print quality by applying linear DICOM Look-Up Tables (LUTs).
- Handles both Greyscale and colour prints at a time.

Vinod Medical Systems Pvt Ltd.
Corporate Office: 119, Omkar - The Summit Business Bay, 1st Floor, B. L. Bajaj Road, Near W. E. H Metro station, Andheri (E), Mumbai - 400 093. Tel: +91 022 26820517 / 18

Registered Office: Kripa Kunj, B1 - 2, Sai Nagar, Near Railway Crossing, Raipur - 492 009. India. Tel: +91 771 4214400 / 21
Email: medipro@vinodmedical.com

vinodmedical.com I 1800 202 1988 I vmscart.com

Estimation of Standard Liver Volume with Computed Tomography and Comparison of Finding with Ultrasonography

Aadil Hussain Bhat, Assistant Professor, Global Group of Institutes, Amritsar, Punjab.
Irfan Ahmad Malla, Radiology Technologist, Government Medical College, Jammu & Kashmir.
Zubair Ul Islam, Shakir Nisar Bhatt, Assistant Professor, Maulana Azad National Urdu University, Hyderabad.

Abstract
As a crucial metric for assessing liver function, getting ready for surgery, and tracking the course of the disease, an accurate estimate of liver volume is necessary in a variety of research and clinical settings. Liver volume is frequently measured using two imaging modalities: CT and ultrasonography. This study compares the precision of CT and ultrasonography in determining conventional liver volumes. A thorough literature analysis was conducted in order to find pertinent studies that compared CT and ultrasonography for the assessment of liver volume. The search encompassed pertinent scholarly articles published between 2010 and 2023 in addition to online databases. Studies that reported liver volume measurements using both CT and ultrasonography were included in the analysis, and there was sufficient data for comparison. The chosen study findings showed that liver volume may be estimated using both CT and ultrasonography. Accurate liver segmentation and volume assessment are made possible by CT imaging, which produces high-resolution, three-dimensional pictures. However, CT is more costly than ultrasonography and involves ionising radiation. On the other hand, ultrasonography is affordable, widely accessible, and non-invasive. It offers dynamic liver volume assessment and real-time imaging. However, ultrasonography has limitations, including reduced accuracy in detecting liver disorders, operator dependency, and limited penetration in obese people. Despite the benefits of ultrasonography, computed tomography is currently the preferred method for routinely measuring liver volume because of its greater accuracy, dependability, and capacity to record detailed anatomical data. All things considered, more study is required to more accurately assess the effectiveness of CT and US in predicting typical liver volume.

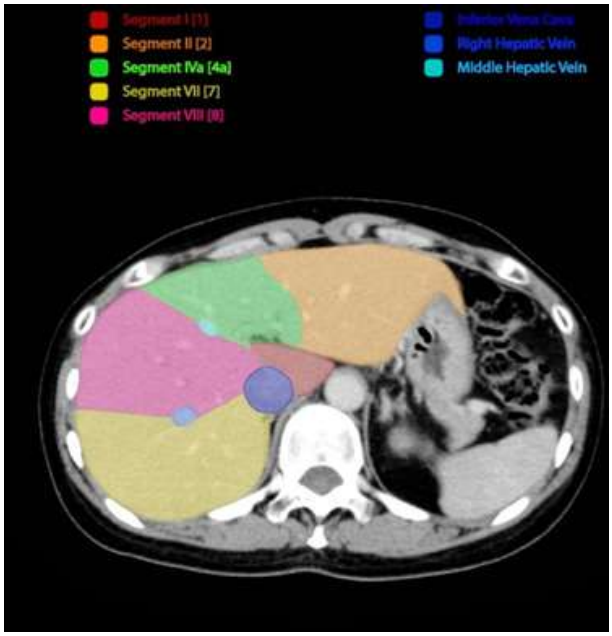
Keywords: computed tomography, ultrasonography, liver volume, and liver segmentation

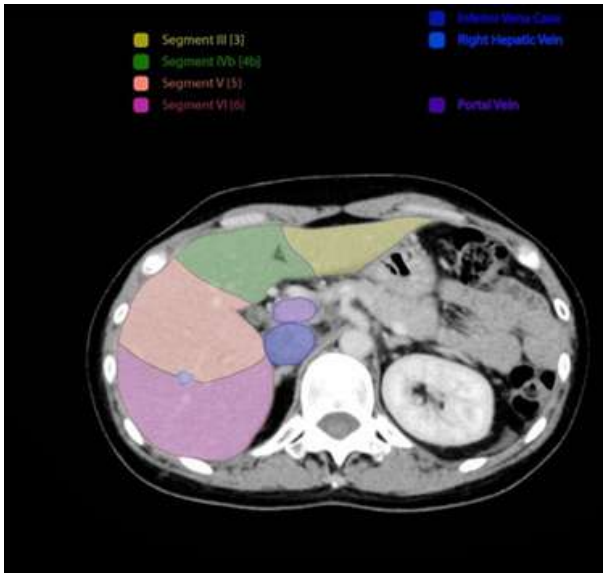
Introduction

A computerised X-ray imaging system known as "computed tomography," or CT, uses a narrow X-ray beam that is directed at the patient and quickly rotates around the body to produce signals that the machine's computer interprets to produce cross-sectional images, or "slices." Since these slices can give medical practitioners far more comprehensive information than traditional X-rays, they are frequently referred to as tomographic images. A three-dimensional (3D) image of the patient can be easily created by digitally "stacked" slices that the machine's computer has acquired over time. This makes it possible to identify suspected tumours or anomalies as well as basic features. [1] Ultrasound (US) is an imaging method that uses high-frequency sound pulses to describe tissue. It is a useful and adaptable medical imaging technique that typically offers an extra or distinct assessment of tissues, particularly when contrasted with other modalities like CT or conventional radiography. Sound waves travel in liquids as longitudinal waves, with particle motions in the medium parallel to the direction of the sound wave's propagation. Through variations in pressure, sound waves physically transfer their energy to particles. Regions with high pressure and density are called "compressions," whereas those with low pressure and density are called "rarefactions." The frequency of the sound waves employed in medical ultrasound is millions of cycles per second, or megahertz, or MHz[2]

Computed tomography's function in normal liver volume

We can assess the liver volume noninvasively using the computed tomography (CT) liver volumetry technique. The fundamental concept behind this technique is simple, and it has been documented since the 1970s. By measuring the area of each cross-sectional picture, computing the area by the slice





interval to obtain the slice volume, and adding the slice volumes to determine the overall liver volume, this method can be used

to calculate the liver's volume (Fig 1). Before a living liver transplant, the liver volumes of donors can be measured using this technique.[3] The preoperative volumetric evaluation of the liver prior to liver transplant surgery commonly uses CT volumetry. By physically tracing the hepatic outlines and measuring the liver area on each axial section at a slice thickness of 10 mm, CT volumetry was traditionally performed. Automated and semi-automated approaches were used despite the long computation times of manual methods. The goal was to assess the effectiveness of manual CT volumetry with a slice thickness of 20 mm by comparing the results of total liver volume with a slice thickness of 10 mm and the two approaches using real graft weight.[4] An accurate measurement of liver capacity is crucial in many medical circumstances. In order to provide appropriate medical care and lower the risk of postoperative hepatic failure, it is crucial to ascertain the donor organ size and future liver volume residual in patients admitted for liver surgery (liver lobe resection or liver transplantation).[5] CT has grown in popularity due to its rapid acquisition time, enhanced spatial resolution, durability, and ease of use.[6]

Ultrasound's function in normal liver volume

The liver is usually evaluated during a normal abdominal ultrasonography. Basic linear measurements of the liver from a plane along the mid-clavicular line were typically used to calculate ultrasound measures of liver size.[7] Cut-off values were then used to distinguish between normal and abnormal liver size because there is a growing demand for a straightforward, easy, valid, and dependable way to measure the liver using 2D ultrasound and a reference value to distinguish between a liver with hepatomegaly and a normal liver. Three basic ultrasonography measurement planes are included in the set: the anteroposterior diameter, the right lobe's dome-to-tip diameter, and the liver's third measurement in the midline sagittal plane.[8] Ultrasound examination of liver size is accessible,

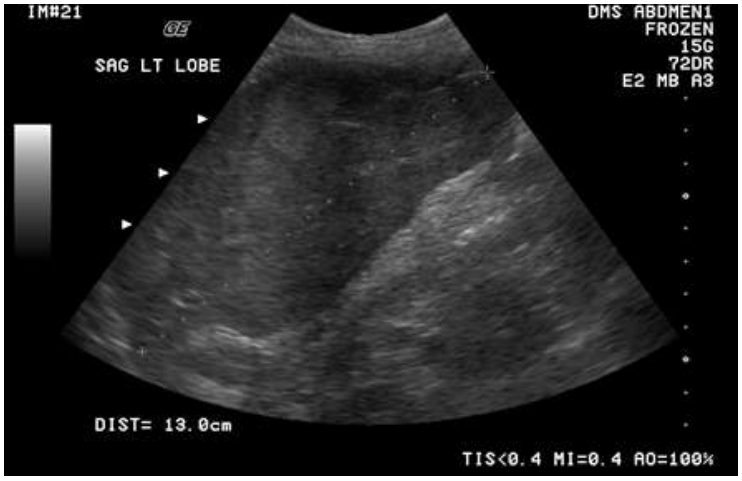


Figure 2 Normal anatomy of liver in ultrasound

affordable, and comparable to a quick imaging method that doesn't need ionising radiation (Fig 2). Simple linear ultrasound measures of the liver are also simple to execute. However, those measurements are restricted since they only offer dimensions data at a single location within the liver's right lobe.[9] A quick, low-cost, and real-time method for determining the size of an adult liver is sonography. As smaller, more portable, and less expensive ultrasound devices become more generally available, specialist office and bedside 2D ultrasound is growing in popularity as a point-of-care diagnostic evaluation. Computed tomography (CT) is currently the gold standard for figuring out the size and volume of the liver. Sonography does provide several major advantages than CT, though, such as allowing the patient to avoid radiation exposure and providing regular liver size estimations as needed. Nowadays, many doctors primarily use the percussion method to measure liver size during physical examinations.[10]]

The liver's anatomy

The liver is a big organ located in the upper right abdominal quadrant. It is a multipurpose supporting organ of the digestive system that performs a number of vital tasks, such as bile production, protein synthesis, detoxification, and nutrition storage. It weighs approximately 1.5 kg, making it the largest gland in the human body. It assists in maintaining essential physiological processes and maintains constant communication with a number of other organs. The right, left, caudate, and quadrate lobes make up the liver. visceral and diaphragmatic surfaces (Fig 3). Ligaments include the falciform, coronary, left triangular, venous, and circular ligaments. Fissures and recesses include the hepatorenal recess, subphrenic recess, and porta hepatis (central fissure).[11]

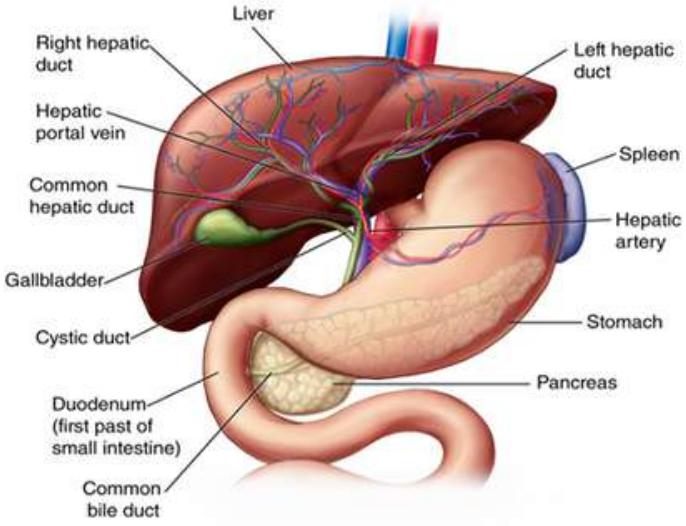


Figure 3 Anatomy of liver

Segmental anatomy

The Couinaud classification of hepatic anatomy divides the liver

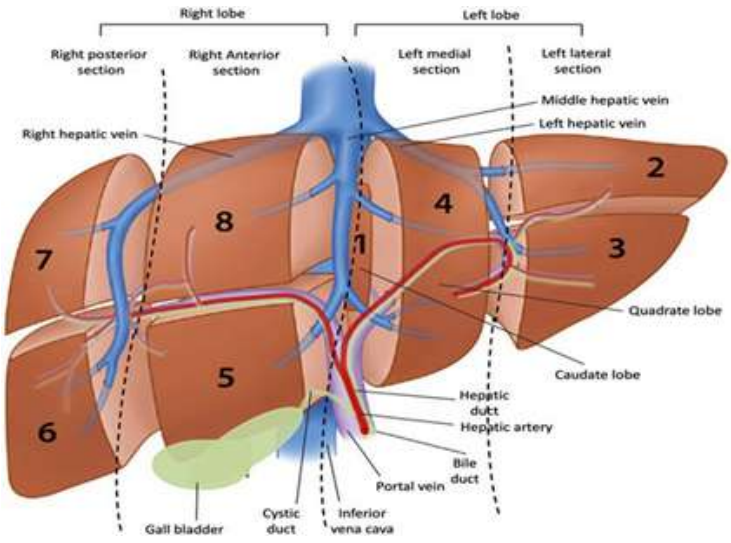


Figure 4 Segmented anatomy of liver

into eight functionally separate parts. The liver is made up of "four sectors," "eight segments," "two lobes" (right and left), and "two hemi livers." The planes of the three hepatic veins (portal

fissures or scissurae) divide the four sectors; the falciform ligament divides the two lobes; Cantlie's line divides the two hemi livers; and an imaginary transverse plane that passes by the portal vein bifurcation divides the eight segments.[12](Fig-4) Every section has its own vascular intake, outflow, and biliary drainage. The bile duct, hepatic artery, and portal vein branches are located in the centre of each section.[13] Vascular outflow is provided by hepatic veins at each segment's edges. Names or numbers are used to identify the segments. The segments are numbered anticlockwise, starting with Segment I (the caudate lobe). The left hemiliver has segments II through IV, while the right hemi liver contains segments V through VIII.[12]

Discussion

The results of this investigation provide credence to the use of CT densitometry as an extra instrument for gauging the extent of steatosis in NAFLD. Liver volume increases when hepatosteatosis progresses, according to the positive linear relationship between liver size and volume. CT offers precise volumetric measurements and is especially useful for assessing the density and shape of the liver. Conversely, USG is widely accessible, non-invasive, and reasonably priced, and it provides crucial information regarding the staging of steatosis. A thorough assessment of hepatosteatosis is made possible by the combination of CT and USG strengths, which leads to better treatment options and follow-up methods.[13] The broad availability, low cost, and absence of ionising radiation exposure are some benefits of using 2D US for liver volume measurement. These characteristics make it a good choice for situations needing frequent volume evaluations, medical follow-up, or routine evaluation of liver volumes over time. Its clinical use is further enhanced by the ease of applying the developed prediction equation to calculate liver volumes and perform 2D US measurements. However, there are a number of disadvantages to using 2D US to measure liver volume.[14] For instance, measurement variability may arise from relying on the skill and knowledge of the operator. Second, more research should be done on how patient-specific variables and body habituation affect the precision of 2D US measurements. Both USG and CT are suitable modalities for assessing localised hepatic anomalies, according to the study's findings.[15] USG and CT have similar specificity and sensitivity, with CT showing higher accuracy in uncommon situations. USG is very useful for follow-up examinations. During this conversation, we emphasised the importance of imaging-based volumetry, particularly computed tomography (CT). We will examine the technical elements that result in precise volumetric measurements as well as the approaches that affect their precision. The capacity of CT volumetry to produce finely detailed, high-resolution liver anatomical pictures is one of its primary advantages. Because CT images have strong soft tissue contrast, liver margins can be accurately identified and volumes can be calculated. This is particularly true when morphological changes brought on by liver disorders like cirrhosis or tumours affect liver volume.[16] According to the review-based analysis, the most effective method for determining the standard liver volume is computed tomography (CT). The liver may be precisely divided into different slices thanks to CT's higher spatial resolution. CT is widely regarded as the gold standard in clinical practice, and its accuracy and reliability have been thoroughly assessed in liver volumetry based on CT. Additionally, CT scans may reveal incidental lesions or anomalies that could impair liver function.

Despite the fact that ultrasonography (US) is widely used, non-invasive, and radiation-free, it has drawbacks that reduce its accuracy in measuring liver volume. Operator variation and varied methods can lead to incompatible findings. Furthermore, deeper liver segments and obese patients may be difficult to spot on an ultrasound, which reduces the tool's ability to reliably measure liver volume.

Summary

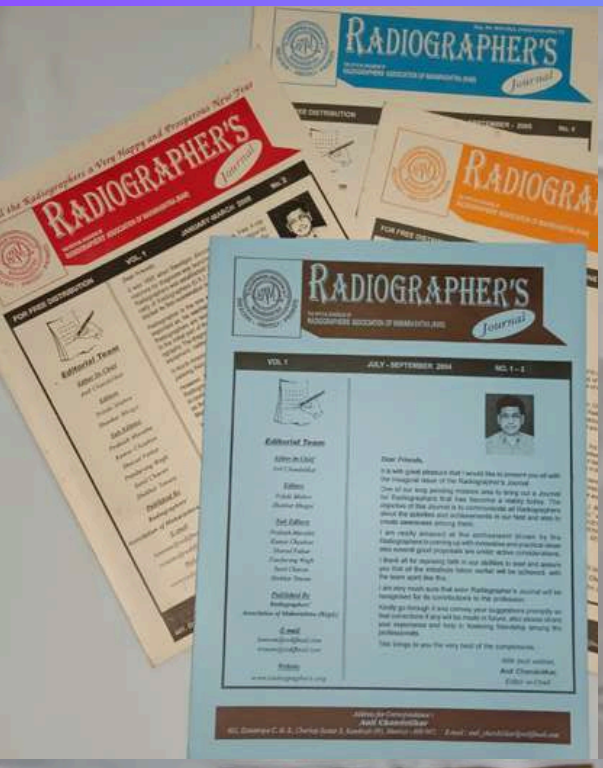
Two commonly used imaging techniques to assess liver volume are computed tomography (CT) and ultrasound. High-resolution, three-dimensional pictures produced by CT imaging enable precise liver segmentation and volume estimations. It is more expensive and uses ionising radiation, though. On the other hand, ultrasonography is affordable, accessible, and non-invasive. It is suitable for measuring dynamic hepatic volume and offers real-time imaging. However, ultrasonography has disadvantaged such operator reliance, limited penetration in obese patients, and decreased accuracy when hepatic problems are present. Ultrasonography can be a useful alternative to computed tomography (CT), which is the gold standard for evaluating liver volume. This is particularly true in settings with limited resources or when repeated measurements are required. A combination of these techniques, utilising the special qualities of each method, might provide a comprehensive assessment of liver volume. Further investigation and technological developments are needed to improve the precision and usability of liver volume measurement with CT and ultrasonography.

Conclusion

In conclusion, computed tomography is still the suggested modality for routine liver volume measurement despite the benefits of ultrasonography because of its greater accuracy, dependability, and capacity to record detailed anatomical information. All things considered, more study is required to more accurately assess the effectiveness of CT and US in predicting typical liver volume.

References

1. Computed tomography (CT). (n.d.). Retrieved May 16, 2023, from National Institute of Biomedical Imaging and Bioengineering website: https://www.nibib.nih.gov/science-education/sciencetopics/computed-tomography-ct
2. Jones, J., & Morgan, M. (2014). Ultrasound (introduction). In Radiopaedia.org. Radiopaedia.org.
3. Hori, M., Suzuki, K., Epstein, M. L., & Baron, R. L. (2011). Computed tomography liver volumetry using 3-dimensional image data in living donor liver transplantation: effects of the slice thickness on the volume calculation. https://doi:10.1002/lt.22419
4. Haberal, M., Bayramoglu, M., Kirnap, M., Coskun, M., & Haberal, M. (2018). Manually computed tomography liver volumetry: Can it be done faster? Transplantation, 102(Supplement7),S898.https://doi:10.1097/01.tp.0000543995.73966.e6.
5. Hagen, F., Mair, A., Bitzer, M., Bösmüller, H., & Horger, M. (2021). Fully automated whole-liver volume quantification on CT-image data: Comparison with manual volumetry using enhanced and unenhanced images as well as two different radiation dose levels and two reconstruction kernels. PloS One, 16(8), e0255374.
6. Gotra, A., Sivakumaran, L., Chartrand, G., Vu, K.-N., Vandenbroucke-Menu, F., Kauffmann, C., ... Tang, A. (2017). Liver segmentation: indications, techniques, and future directions. Insights into Imaging, 8(4), 377–392. https://doi:10.1007/s13244-017- 0558-1.
7. Izranov, V. A., Ermakov, A. V., Martinovich, M. V., Kazantseva, N. V., & Stepanyan, I. A. (2018). Current possibilities of liver volume estimation in diagnostic ultrasound (ex vivo study). International Journal of Radiology & Radiation Therapy, 5(5), 62–65. https://doi:10.15406/ijrrt.2018.05.00180.
8. Ain, P. S., Roy, U. K., Sen, K., Ray, D., & Pal, J. (2021). Variability of standard liver volume by 2D ultrasound: A cross-sectional study from eastern India. Journal of Clinical and Diagnostic Research: JCDR. https://doi:10.7860/jcdr/2021/47353.14716.
9. Farghaly, S., Makboul, M., & Shehata, M. R. (2019). Two-dimensional ultrasound: can it replace computed tomography in liver volume assessment? The Egyptian Journal of Radiology and Nuclear Medicine, 50(1). https://doi:10.1186/s43055-019-0073-0.
10. Childs, J. T., Esterman, A. J., Phillips, M., Thoirs, K. A., & Turner, R. C. (2014). Methods of determining the size of the adult liver using 2D ultrasound: A systematic review of articles reporting liver measurement techniques. Journal of Diagnostic Medical Sonography: JDMS, 30(6), 296–306. https://doi:10.1177/8756479314549070.
11. Mytilinaios, Dimitrios. Arteries of the Stomach, Liver, and Spleen. 2023.
12. Sharma, Malay, et al. —Stepwise Evaluation of Liver Sectors and Liver Segments by Endoscopic Ultrasound.|| World Journal of Gastrointestinal Endoscopy, vol. 10, no. 11, 2018, pp. 326–339, https://doi:10.4253/wjge.v10.i11.326.
13. Liver - Segmental Anatomy.|| Radiologyassistant.Nl, https://radiologyassistant.nl/abdomen/liver/segmental-anatomy. Accessed 17 May 2023.
14. Bora, A., Alptekin, C., Yavuz, A., Batur, A., Akdemir, Z., & Berköz, M. (2014). Assessment of liver volume with computed tomography and comparison of findings with ultrasonography. Abdominal Imaging, 39(6), 1153–1161. https://doi.org/10.1007/s00261- 014-0146-5
15. Cerit, M., Şendur, H. N., Cindil, E., Erbaş, G., Yalçın, M. M., Cerit, E. T., Allahverdiyeva, S., Oktar, S. Ö., & Yücel, C. (2020). Quantification of liver fat content with ultrasonographic attenuation measurement function: Correlation with unenhanced multidimensional computerized tomography. Clinical Imaging, 65, 85–93 https://doi.org/10.1016/j.clinimag.2020.04.028
16. Aparna, Y. V. R., Kallepally, A. K., & Vardhan, D. A. K. (2021). A comparative diagnostic ability between ultrasound and computed tomography in the evaluation of focal liver lesions. International Journal of Health and Clinical Research, 4(6), 255–257. https://www.ijhcr.com/index.php/ijhcr/article/view/1261



Advertising in Radiographers' Journal

Advertise your business or market your product on "Radiographers' Journal" - monthly ebulletin.

Radiographers' Journal is circulated electronically to thousands of Radiographers across the globe and posted on Social media platforms.

Monthly Tariff for Advertisement

- Full page - Rs. 3000/-
- Half page - Rs. 1500/-
- Quarter page. - Rs. 1000/-

For **yearly subscription of advertisement 50% discount in above charges**

To book your advertisement call on **+91 9322035920**