**Role of CT Scan and MRI in Cancer Diagnosis: A Comparative Review of Imaging Modalities for Precision Medicine**

**Abstract**

Cancer is one of the most lethal diseases in the current scenario all over the world. Early detection may lead to better treatment and recovery. Imaging modalities such as Magnetic resonance imaging (MRI) and Computed tomography (CT) are two modern diagnostic imaging techniques that are helpful in tumor diagnosis. However, CT imaging uses ionizing radiation and soft tissue contrast is its significant limitation. In contrast, MRI provides excellent soft tissue differentiation, multiplanar imaging capabilities, and functional imaging techniques such as diffusion-weighted imaging and spectroscopy, which are increasingly valuable in characterizing tumors and guiding therapy. The method of cancer diagnosis using CT or MRI, can provide precise information about the lesion's location, size, shape, and structural changes in the surrounding tissues. Cancer staging is precisely done on positron emission tomography (PET) but the staging of cancer is possible through CT scan and MRI up to some extent, which is helpful before starting any treatment. It provides adequate treatment depending on location, size, and type of tumor. CT scan is generally preferred in the diagnosis of abdominal and calcified lesions, while MRI is better for peripheral and central nervous system (CNS) lesions.Precision in cancer diagnosis increases the probability of opting and executing a successful treatment. Recent advances such as dual-energy computed tomography (DECT), magnetic resonance spectroscopy (MRS), Positron emission tomography-computed tomography (PET-CT), and Positron emission tomography-magnetic resonance imaging (PET-MRI) have increased the precision of cancer diagnosis. ASL (arterial spin labeling), an advanced MRI technique, helps diagnose people who are allergic to contrast. It increases image acquisition resolution, allowing for even more accurate and precise diagnosis and prognosis. Also, the qualitative interpretation of cancer imaging might be greatly enhanced by the integration of artificial intelligence (AI) in radio imaging techniques. Improving the proportion of patients diagnosed with early-stage cancer is a key priority of the World Health Organisation. Screening programs have improved survival in many tumor groupings, but risk stratification and patient selection remain major obstacles. This review highlights their complementary roles and the potential of multimodal imaging strategies to enhance diagnostic accuracy and improve clinical outcomes.

**Keywords:** Cancer diagnosis, Computed Tomography, Magnetic Resonance Imaging, Precision medicine

**1. Introduction**

In 2022, approximately 1.4 lakh cases of cancer were reported in India (Sathishkumar et al., 2022). 23 major cancers became the causes of about 12.85 million deaths between 2000 and 2019 in India (Shaji et al., 2023). The stage of cancer at the time of diagnosis has a significant impact on the patient's chances of better recovery; therefore, early detection is very crucial (Bhat et al., 2024; Neal et al., 2015). Early cancer detection depends on several factors, including screening the at-risk population, patients, and healthcare providers, and the ability to spot warning signs (Bhat et al., 2024; Zameer et al., 2025). The applications of diagnostic techniques are to distinguish cancer from other conditions and accurately identify the tumor’s location and extent (Loud & Murphy, 2017). The first approach, using CT or MRI, can give very detailed information on the location, size, shape, and structural alterations of the lesion in the surrounding tissues (De Witte & Mariën, 2013). Modalities such as CT and MRI imaging are used for the detection and staging of cancers, which is an important aspect before starting the treatment of cancer. Another technique is MRS, which helps to analyze the chemical composition of any tumor (Glunde et al., 2011). It is based on the MRI principle and is used for patients whose biopsy is a life-threatening challenge, such as a CNS tumor. CT or MRI-guided biopsy of the specific tumor is recommended to get cells for further closer analysis. An incorrect biopsy may lead to misdiagnosis and wrong treatment (Guedes et al., 2024). MRI, CT scan, and Ultrasonography modalities are frequently used for biopsy guidance. Guidance ensures the correct biopsy and also reduces the risks of complications. CT scan is specifically utilized in lung biopsies to ensure accuracy throughout the process and to prevent pneumothorax and is also used in bone biopsy (Rindy & Chambers, 2025). The application of technology like CT scans and MRI at the point-of-care to guide clinical treatment choices is the foundation of precision medicine in cancer care (Ghasemi et al., 2016). This makes it possible to forecast customized therapies that are best suited for certain patients with greater accuracy and efficiency (Ho et al., 2020).

**2. CT scan in cancer diagnosis**

CT scan refers to a modality that uses a beam of X-ray to scan a patient. The X-ray tube rotates circularly (360°) around the patient to produce a detailed cross-sectional image (Patel & De Jesus, 2025a). Tomography means sectional imaging, this sectional image is stacked over one another and can be reconstructed into 3D images using various techniques, such as Shaded Surface Display (SSD) Volume Rendering Technique (VRT), and Maximum Intensity Projection (MIP) (Hermena & Young, 2025). After the completion of the reconstruction of all the slices, the CT scan image helps in the identification of basic structures (liver, spleen, kidney, etc.) as well as tumor and other abnormalities. CT scan is a fast modality and used as an emergency or fast diagnosis modality in some cases like stroke, hemorrhage, and trauma, since early diagnosis of these cases may be lifesaving (Patel & De Jesus, 2025b). A CT scan can quickly rule out either an ischemic or hemorrhagic stroke (Campbell & Khatri, 2020). Additionally, CT imaging is used as a screening tool for detecting abdominal tumors or lesions (D.-W. Kim et al., 2011). Barium sulfate (BaSO4) and Iodine compounds are used as contrast agents in CT scans due to their high radiopacity. Contrast-enhanced CT (CECT) is a technique in which a contrast agent is administered intravenously (IV) to visualize the vessels, organs, other tissues, and pathologies (tumors) more clearly. The enhancement pattern of a tumor helps to rule out the tumor between benign and malignant and also determines the type of tumor (Millet et al., 2011). The organs including the stomach, liver, kidneys, spleen, and bowel are well differentiated and visible on CT scans. CT imaging can determine the location, size, and type of cancer. The whole abdomen can be scanned within a few seconds via CT scan modality and that’s the reason it is quite suitable for multiphase abdominal scanning such as triple phase abdomen scan and angiography. Some cases including hemangioma and hepatic cell carcinoma (HCC) cannot be diagnosed clearly without multiphase scanning (Bialecki & Di Bisceglie, 2005). CT scan is appreciable in detecting early-stage cancer. Additionally, a CT scan can reveal metastases (Mets) in other organs including the liver or lymph nodes that surround the original tumor (Raj et al., --). The information obtained about size, location, invasion, and type of tumor are very precise, CT scans can be very helpful in staging cancer (Prasad et al., 2014). The tumor can be staged easily following the TNM (Tumor-lymph node and metastasis) system. It visualizes the size of the tumor, lymph nodes around the primary tumor, and metastasis. Cancer staging using the TNM system is summarised in **Fig. 1**. One of the major issues with CT imaging is the repeated use of ionizing radiation which is harmful to the body. (Brower & Rehani, 2021). It is also quite possible that some abnormalities cannot be seen on CT scans because sometimes it does not differentiate between adjacent tissues and thus further modalities are required to confirm the diagnosis (Shah & Rojas, 2022).



**Fig. 1.** Showing TNM system used in cancer staging. T (Tumor) is graded from T0 to T4 depending on the size of the tumor, N (Nodes) is graded from N0 to N3 depending on lymph node involvement, and M (Metastasis) is graded from M1 to M2 depending on the absence and presence of metastasis.

**3.** **MRI in cancer diagnosis**

MRI is another important imaging modality used in radiodiagnosis. MRI works on the nuclear magnetic resonance (NMR) phenomenon (Kaunitz, 2018). NMR was first described by Bloch and Purcell in 1945 (Shampo et al., 2012). MRI acquires images through a radiofrequency (RF) pulse in the presence of a strong magnetic field (Hore, 2017). When an RF pulse is given to the patient in the presence of a strong magnetic field, it disturbs the alignment of protons by passing the energy of the RF pulse to the protons present in tissues by resonance (transfer of energy from one body to another when they both are at same energy level). Protons in the tissue aligned themselves in parallel and anti-parallel directions. When the RF pulse switches off the protons get back to the equilibrium position and release energy in the form of signals (raw data) for image formation (Pai et al., 2025). Raw data is converted into a meaningful image using Fourier transformation (Aibinu et al., 2008). MRI shows better tissue contrast and spatial resolution than CT scans. MRI has been proven a better modality in cases of cervix cancer, bladder cancer, CNS cancer, and extremity masses (eg; sarcoma) (Alemu et al., 2023; Re et al., 2023; Wasa et al., 2010). MRI ensures breast cancer diagnosis after breast ultrasonography and even adds more detailed information in the final diagnosis (Gilbert & Pinker-Domenig, 2019). Diffusion Weighted Imaging (DWI) is an important sequence in the diagnosis of any tumor, which is based on Brownian movement (random motion of particles) (Baliyan et al., 2016). It gives an estimation of proton movement within any tissue or pathology, such as a tumor. It provides detailed information about cellularity and cell membrane integrity, which reflects the function of tumor cells (Messina et al., 2020). It can differentiate a malignant tumor and a benign tumor and also estimate the tumor's grade, and offer a therapy response (Messina et al., 2020). Apart from this, for contrast-enhanced MRI (CEMRI), a gadolinium-based contrast agent is used to observe the enhancement pattern within the tumor, which further helps in the characterization of the tumor (Gruber et al., 2017)Similar to a CT scan, the TNM method can be used in MRI for cancer staging. The stages can be classified as the first, second, third, and fourth using TNM classification, as explained in **Fig. 2**. One of the major advantages of MRI is that it has better tissue resolution than any other modality (Thakur et al., 2023). It provides better soft tissue resolution in small field of view (FOV) area scanning, which is not possible in CT imaging. As above mentioned MRI uses a magnetic field and radiofrequency waves for image acquisition, there is no risk of radiation hazards and scans can be repeated as many times as required for follow-up (Thakur et al., 2023). Monitoring ongoing treatment through follow-up scans is crucial for the patient to minimize treatment side effects and inhibit the recurrence of the tumor (Teke Kısa & Emir, 2021). Despite all of the benefits, the cost and accessibility of the MRI modality make it difficult to utilize. MRI artifacts also play a significant role in making it challenging (Krupa & Bekiesińska-Figatowska, 2015). fMRI with Arterial Spin Labeling (ASL) can assess cerebral blood flow (CBF) in narcoleptic patients, giving insights into regional brain dysfunction (Akram et al., 2025; Yadav et al., 2025).

**A diagram of a cancer patient

Description automatically generated with medium confidence**

**Fig. 2.** Depicts the classification of different stages of cancer using the TNM method.

**4. Advances in CT scan and MRI technologies for cancer detection**

Advances in CT scan and MRI technologies provide superior safety, dependability, and high resolution for the diagnosis, treatment, and management of complicated patients of cancer (Hussain et al., 2022). DECT, CT Perfusion, single photon emission computed tomography-CT (SPECT-CT), and PET-CT are some advances in CT scan technology. DWI, MRS, Magnetic Resonance Perfusion (MR Perfusion), and PET-MRI are some advances in MRI. These techniques facilitate the development of novel, accurate imaging devices with improved sensitivity, resolution, and specificity (Hussain et al., 2022). DECT uses two different X-ray energies to acquire images simultaneously (lower energy of 80 kV and higher energy of 120 kV) at different angles (Forghani et al., 2017). The use of dual-energy beam settings enhances tissue contrast, thus providing more accurate and reliable tumor characterization (Foti et al., 2024). Additionally, this program can identify and eliminate chemical compounds such as metals, calcium, and iodine-based on their atomic number (Yu et al., 2012). This helps to rule out many problems in tumor characterization such as identifying even a minimal amount of iodine or calcium in any lesion, which is possible due to low-energy photon acquisition. The perfusion imaging technique helps to assess the flow of blood within the microvasculature of the tumor (Aziz et al., 2022). It provides information of angiogenesis and micronecrosis (S. H. Kim et al., 2016; Zameer et al., 2025). This detailed blood flow information within a tumor increases the accuracy of tumor characterization or identification and tumor grading, thus leading to a more reliable diagnosis. Perfusion can be done through both modalities CT and MRI, but generally preferred for MRI because of its high tissue contrast and high resolution (Thakur et al., 2023). PET is a nuclear medicine imaging technology that is nowadays also used in combination either with CT or MRI. This hybrid technology provides a more precise and accurate image with high resolution to diagnose subtle lesions or minimal early-stage activity related to cancer (Bashir et al., 2015). In this technology, the diagnosis is done comparatively considering both scans which decreases the chance of misdiagnosis and even early-stage cancer can be detected easily. When it comes to identifying axillary and extra-axillary nodal metastases, PET-CT and PET-MRI are both more sensitive than MRI. For distant metastases, PET-CT is more effective in detecting lung metastases, but PET-MRI is more effective in detecting liver and bone metastases (AL-Jahdali et al., 2012; Zhang et al., 2023). MRS is a technique based on chemical shift which requires a homogenous magnetic field during the image acquisition (Tognarelli et al., 2015). It is an advanced non-invasive technique that is used to assess the chemical composition of a tumor (Tognarelli et al., 2015). It helps to draw graphs that show peaks of different chemicals such as choline, N-acetyl aspartate, creatine, and Myo-inositol. Diagnosis is made by comparing the composition of different chemicals in the acquired graph with the normal chemical composition in the tissue. As an example, a high choline peak may be a sign of glioma or other malignancies as choline increases with an increase in cell membrane production (Verma et al., 2016). MR spectroscopy and MR perfusion together help in differentiating a malignant and benign tumor (Hasan et al., 2019).

**5. CT and MRI in precision medicine**

The focus on early diagnosis and individualized therapies, precision medicine is revolutionizing medical practices and has a beneficial effect on diagnostic radiology (Johnson et al., 2021). Precision medicine refers to the tailoring of medical treatment which means customizing or personalizing treatment based on the characteristics of each patient such as their genetics, lifestyle, and environment, instead of one type of treatment for all. For example, using genetic testing to determine the most effective therapy for a patient (Wang & Wang, 2023). It helps in adjusting the appropriate dose of medicine based on a person’s metabolism. This minimizes therapy's adverse effects and lowers costs by focusing on preventive or therapeutic actions. Oncology has made substantial use of CT, MRI, and PET to aid in diagnosis and direct therapy (Ghasemi et al., 2016). Images can give comprehensive details regarding the structural and functional characteristics of tumors. With the development of technology over the past decades, oncology has evolved into a diverse area that enables the development of customized treatment plans for cancer patients as well as the more accurate assessment of their response to therapy (Pulumati et al., 2023).

**6. Clinical Implications and Future Directions**

Clinically, a variety of imaging techniques, such as CT and MRI, are utilized to identify primary tumor and lymph node metastases in cancer (Luo et al., 2020). CT imaging is widely used for many clinical diagnoses. Its non-invasive benefits and clinical use in tumors and other possible diagnoses cannot be overlooked (Chacko & Ankri, 2024). CT scan best diagnose the calcified tumor (Zulfiqar et al., 2020). Some silent disorders can be discovered at an early stage and can be treated simply before they become severe (Neugut et al., 2019). The human body is not affected by MRI exposure since it acquires images using magnetic fields (Ghadimi & Sapra, 2025). It can do both whole-body and local scanning, which is safer and more sophisticated. Additionally, it offers more diagnostic anatomical features than CT, and the images have more textural information overall (Alorainy et al., 2024). As a result, comparing the benefits and drawbacks of CT and MRI is difficult. A case-by-case analysis is required for this. The most prevalent method of radiographic disease assessment is visual evaluation, which can be further interpreted by complex computational studies (Bi et al., 2019). Artificial intelligence (AI) has the potential to significantly improve the qualitative interpretation of cancer imaging by skilled clinicians (Koh et al., 2022). This includes the ability to volumetrically delineate tumors over time, extrapolate the tumor's biological course and genotype from its radiographic phenotype, predict clinical outcomes, and evaluate the effects of disease and treatment on nearby organs. AI has the potential to automate the first steps in image interpretation and change the clinical workflow of radiography detection, management choices about the administration of an intervention, and follow-up observation to a pattern that has not yet been imagined (Bi et al., 2019).

**Conclusion**

Even though cancer might be fatal or have a bad prognosis, a proper precise, and early diagnosis proves to help ensure a high probability prognosis. The first-line modalities that are used after suspecting any lesion are Ultrasonography, CT, and MRI. However, because CT and MRI give a three-dimensional image, they are more accurate in diagnosing conditions than ultrasound. CT and MRI show very clear contrast enhancement within the lesion, which helps to determine the type and staging of the tumor by using the TNM method. Staging and type of tumor is an important aspect in cancer treatment, PET-CT enables much more comprehensive cancer staging. However, contrast can occasionally result in allergic reactions and may even be the cause of nephrogenic systemic fibrosis (NFS). Therefore, before administering contrast, the renal function test (RFT) must be normal to prevent NFS. In case RFT is not normal, DWI is utilized to partially replace the need for contrast-enhanced imaging for extracting information about the tumor. CT scans use iodine-based contrast (Iohexol), whereas MRI uses gadolinium-based contrast for the enhancement of tissues and tumors. By enabling early diagnosis, routine screening, treatment evaluations, judging the effectiveness of therapy, and preventing cancer recurrence, these imaging technologies are crucial to precision medicine. Advances in technology like PET-CT, PET-MRI, and MRS have drastically improved precision medicine.

**Disclaimer (artificial intelligence)**

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of manuscripts.

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