Derna Academy Journal for Applied Sciences

E-ISSN: 3006-3159

DAJAS

Computed Tomography (CT) Scans: Advancements in Oncology Diagnosis and Treatment

Nagat. F. A. Bolowia

Radiography Department, Faculty of Medical Technology. Tobruk, Libya

*Corresponding author: E-mail addresses: Nagat. Bolowia@ tu.edu.ly

Volume: 3 **Issue: 2** **Page Number: 133 - 147**

Keywords:
(CT. Oncology. Diagnosis. Treatment. Advancements).

Received: 04\12\2024
Accepted: 04\02\2025
Published: 08\02\2025

DOI: https://doi.org/10.71147/t415ys60

ABSTRACT

A comprehensive examination of the advancements in the use of computed tomography (CT) scans for cancer diagnosis and treatment. The article discusses the global rise in cancer incidence and the pressing need for improved diagnostic technologies that can accurately detect, characterize, and monitor tumors. It highlights the various imaging modalities used in cancer diagnosis, including CT, PET, and MRI, and emphasizes the distinctive advantages and limitations of each technique. **Materials and Methods**: The review underscores the importance of enhancing the signal-to-background ratio, and detection thresholds, and reducing imaging artefacts to improve the effectiveness of these diagnostic tools. Additionally, the article explores the expansion of the cancer diagnostics field through the incorporation of molecular diagnostic techniques, such as flow cytometry, immunohistochemistry, and next-generation sequencing, and their potential to enhance tumor classification, characterization, and personalized treatment approaches. **Conclusion:** The article provided a piece of detailed information about the current state of CT scan technology in oncology, and highlighted the ongoing advancements and the challenges that remain in improving the clinical and cost-effectiveness of these diagnostic modalities. It emphasized the critical role of continuous research and development in this field to address these challenges and further enhance the early detection and management of cancer.

1. INTRODUCTION

The global increase in cancer incidence, along with high mortality rates for certain types of cancer, presents ongoing challenges for the biomedical community in effectively managing this disease (Sung et al., 2021). Since prevention is only possible for a limited number of cancer types, there is an urgent need for advancements in cancer diagnostics that can accurately assess the location, size, stage, and molecular characteristics of tumors. This urgency is highlighted by the rising global mortality associated with cancer (Montagnana & Lippi, 2017).

Currently, cancer diagnosis involves a physical examination to identify abnormalities in various anatomical areas, supported by a range of laboratory tests on blood and urine samples. Noninvasive imaging techniques—such as CT scans, ultrasonography (US), MRI, bone scans, and positron emission tomography (PET) using tracers like FDG and PSMA—are widely employed. These imaging methods are often supplemented by minimally invasive biopsies (needle aspirations) or surgical biopsies, followed by histopathological examinations to confirm the type and stage of cancer (Tempany et al., 2015). Additionally, immunological probes combined with flow cytometric analysis are essential for diagnosing and assessing the prognosis of blood cancers such as leukemias (Frangioni, 2008). While these methods form the cornerstone of cancer diagnosis and treatment, they can be nonspecific and are most effective in cases of moderately to highly advanced malignancies. Early cancer diagnosis can significantly improve outcomes by facilitating more effective treatments and reducing off-target effects when utilizing molecularly targeted therapies. Therefore, there is a strong emphasis on developing diagnostic probes, biomarkers, and methods that target specific molecular and genetic abnormalities, along with highly sensitive analytical tools (Medina et al., 2020). The field of cancer diagnostics is rapidly advancing due to ongoing improvements in our understanding of the disease and technological innovations that enhance the reliability of diagnostic approaches (Fass, 2008). Various cancer diagnostic methods, including 2D and 3D imaging techniques such as PET, MRI, SPECT, CT, and X-ray imaging, along with the analysis of molecular signatures—metabolic, proteomic, genomic, and transcriptomic—of cancer cells, are being employed to improve cancer management (Pulumati et al., 2023). However, challenges remain regarding the clinical and cost-effectiveness of these modalities, as well as the development of strategies for risk assessment and monitoring treatment responses (Bi et al., 2019). Imaging is the most commonly used tool for identifying different cancer types based on the phenotypic properties of tumor tissues. It is particularly valuable for screening, staging, and monitoring tumor progression due to its accessibility and noninvasiveness (Lopci et al., 2010). The effectiveness of an imaging modality is influenced by the growth rate of the solid tumor, which can be described using various mathematical models, including exponential, logistic, linear, surface, Mendelsohn, Gompertz, and Bertalanffy models (Meghzifene et al., 2010). The Gompertz model, which depicts a sigmoidal curve, is particularly relevant because it illustrates that a tumor's growth rate declines as its mass increases. This decline reflects the limited availability of resources, such as nutrients and space, as the tumor expands (Madireddy et al., 2022). While several tumor growth models exist, the Gompertz model is often considered the most accurate for solid tumors because it accounts for the increasing doubling time, a critical characteristic of most human cancers (Raza et al., 2019). Common imaging modalities, such as plain film X-rays, CT, US, MRI, and PET, provide insights into the physical structure, metabolic activity, and functional status of cancer in clinical settings (Walter et al., 2022). Each imaging method differs in resolution, sensitivity, and contrast generation, which are essential for achieving the primary objectives of cancer imaging: detection, characterization, and monitoring of tumors (Tettero et al., 2022). Detection involves identifying specific areas of interest within the image, which then facilitates tumor characterization.

Aim of work

This review article aims to provide a thorough understanding of the current state of CT scan technology in oncology, highlighting the ongoing advancements and the challenges that remain in improving the clinical and cost-effectiveness of these diagnostic modalities. It emphasizes the critical role of continuous research and development in this field to address these challenges and further enhance the early detection and management of cancer.

TABLE 1**TECHNOLOGIES USED FOR DIAGNOSIS OF VARIOUS TYPES OF CANCER AND ASSOCIATED ADVANTAGES AND LIMITATIONS**

Diagnostic Technique	Measurement	Type of Cancer Detected	Advantages	Limitations
Positron Emission Tomography (PET)	Assesses blood flow in specific organ regions, enabling the creation of images that highlight the most active areas at a given time.	Brain, breast, cervical, colorectal, esophageal, head and neck, lung, lymphatic, pancreatic, prostate, skin, and thyroid tumors.	Combines with CT to provide both functional and anatomical data. Identifies cancerous lesions that might be missed with traditional imaging. Accurately evaluates metastasis through lymph nodes.	Limited spatial resolution and difficulty in detecting small cancerous lesions. Involves exposure to radiation due to the injection of radioactive substances.
Computed Tomography (CT)	Creates cross-sectional images of bones, blood vessels, and soft tissues using a series of X-ray images from different angles.	Colorectal, gastric, head and neck, kidney, bone, bladder, ovarian tumors.	Quick scanning reduces motion artifacts. Provides detailed bone imaging for creating digitally reconstructed radiographs. Offers precise spatial information.	Suboptimal in imaging soft tissues. Involves radiation exposure. Does not provide functional data.
Magnetic Resonance Imaging (MRI)	Utilizes a magnetic field and radio waves to produce detailed images of organs and tissues.	Brain, primary bone, soft tissue sarcomas, spinal cord, prostate, bladder, uterine, and ovarian tumors.	Provides detailed soft tissue images without ionizing radiation. Gadolinium contrast used in MRI is less likely to cause allergic reactions compared to iodine-based contrasts.	Not suitable for patients with metal implants or devices due to magnetic interference. Expensive and time-consuming. Patients must remain in an enclosed space, which may cause claustrophobia.
Magnetic Resonance Spectroscopy (MRS)	Uses a stronger magnetic field than MRI to generate images showing metabolism and blood flow.	Brain, breast, colorectal, prostate, pancreatic, hepatobiliary, and gastric tumors.	Provides detailed soft tissue imaging and lacks ionizing radiation. Capable of obtaining biological, anatomical, physiological, and metabolic data.	Time-consuming and expensive. Lacks detailed anatomical information.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9940009/ (Pulumati et al. ,2023)

Evolution of CT

Computed Tomography (CT) has undergone significant evolution since its inception in the early 1970s. This journey reflects technological advancements that have enhanced diagnostic capabilities, improved image quality, and reduced scan times.

The Birth of CT (1971)

The first CT scanner was developed by Sir Godfrey Hounsfield and Allan Cormack, leading to the first patient scan in 1971. This initial device utilized a fan-shaped X-ray beam and a rotating detector to create cross-sectional images, primarily of the brain figure 1.

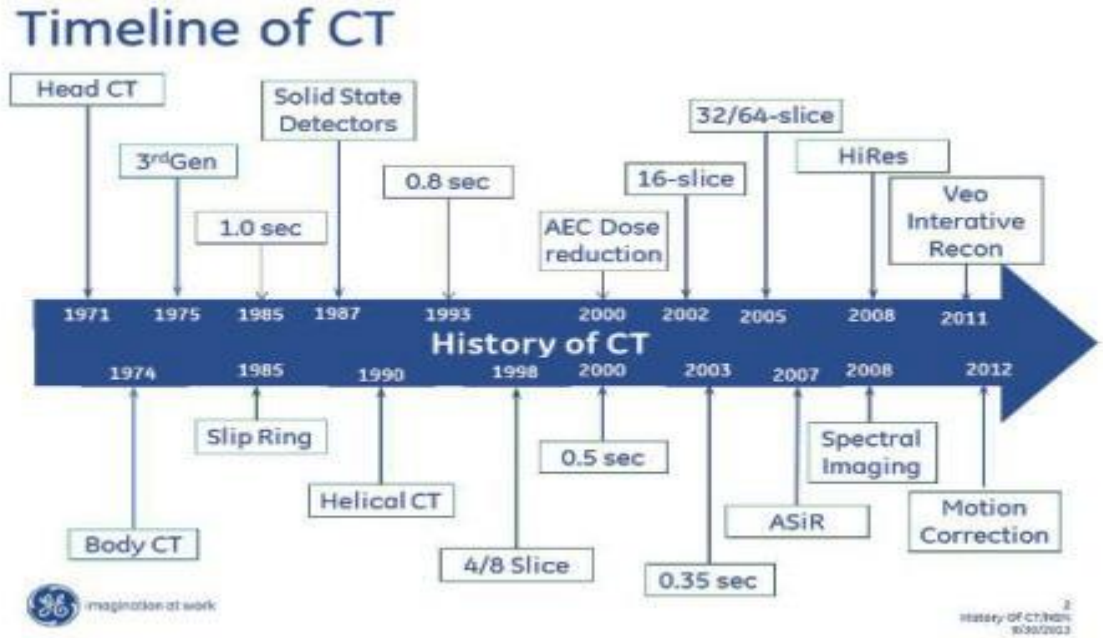

Figure 1: Historical Milestones (Schulz et al. ,2021)

Generational Advances

1. First Generation (1970s): Introduced the concept of cross-sectional imaging but was limited by long scan times and low resolution.
2. Second Generation (Late 1970s): Improved efficiency with a wider array of detectors, reducing scan times and enhancing image resolution, although still facing speed limitations.
3. Third Generation (1980s): Featured a "rotate-rotate" design, where both the X-ray source and detectors revolved around the patient, significantly increasing scan speed and image clarity. This generation set new standards for diagnostic precision.
4. Fourth Generation (1990s): Utilized a stationary ring of detectors, which reduced artifacts and improved image consistency, allowing for detailed examinations of complex cases.
5. Multi-Slice CT (MSCT): Introduced in the 1990s, MSCT enabled the acquisition of multiple slices in a single rotation, vastly improving spatial resolution and scan speed.
6. Cone Beam CT (CBCT): This technology uses a cone-shaped X-ray beam to capture volumetric data in a single rotation, particularly beneficial in dental and maxillofacial imaging.
7. Dual-Energy CT: Utilizes two different X-ray energy levels to enhance tissue characterization and differentiate materials like bone and contrast agents.
8. Photon-Counting CT: The latest advancement, offering improved spatial resolution and material differentiation, is poised to revolutionize CT imaging further (Scharf et al. , 2022).

How CT Works

Basic Principle

CT scans operate on the principle of measuring the attenuation of X-ray beams as they pass through different tissues in the body. The density of the tissue affects how much X-ray is absorbed, allowing the scanner to create detailed images based on these variations in attenuation. The resulting images are reconstructed into cross-sectional slices, which can be viewed individually or combined to form a three-dimensional representation of the scanned area (figure 2) (Garnett, 2020).

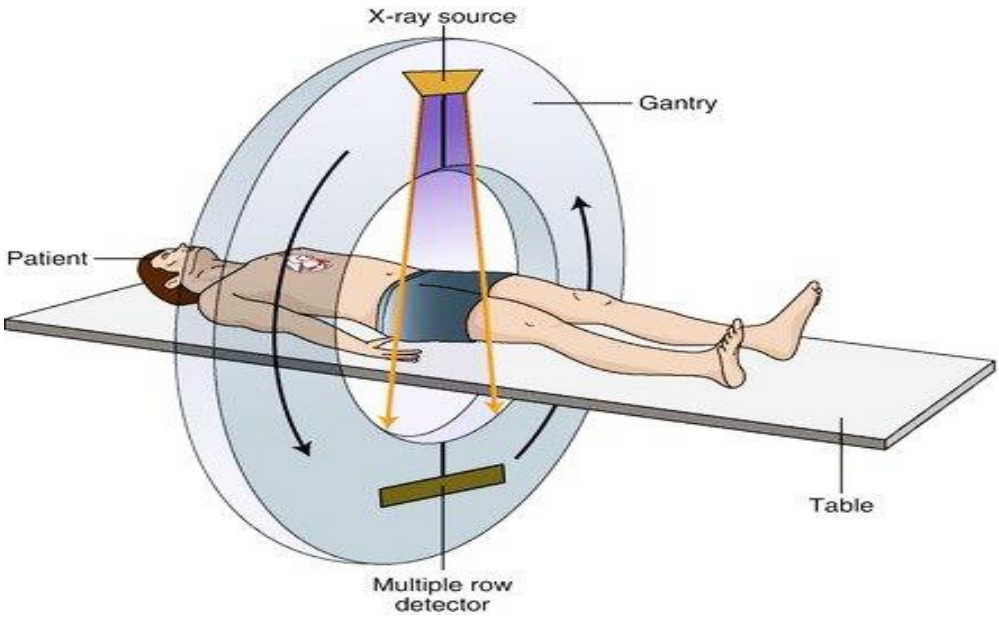

FIGURE 2: DEMONSTRATING THE MAIN COMPONENTS OF A CT MACHINE, INCLUDING GANTRY, X-RAY TUBE, DETECTOR ARRAY, AND THE TABLE FOR TRANSLATING THE OBJECT BEING STUDIED (GARNETT,2020).

The CT Scanner

A typical CT scanner consists of a rotating X-ray tube and detectors arranged in a circular structure known as the gantry. As the X-ray tube rotates around the patient, it emits X-rays that penetrate the body and are detected by sensors on the opposite side. This process captures multiple two-dimensional images from various angles.

Working principle of the CT scan

Image Reconstruction

The data collected from the detectors is processed by a computer using complex algorithms. These algorithms reconstruct the images by calculating the attenuation coefficients for each voxel (three-dimensional pixel) of the scanned volume. The most common method for image reconstruction is filtered back projection, which helps to minimize artifacts and enhance image clarity.

Hounsfield Units

CT images are quantified using Hounsfield Units (HU), which standardize the measurement of radiodensity. Different tissues have characteristic HU values: air is -1000 HU, water is 0 HU, and dense bone can reach +1000 HU. This scale aids in distinguishing between various types of tissues in the images.

In summary, CT technology utilizes rotating X-ray beams and detectors to capture multiple images, which are then reconstructed into detailed cross-sectional slices using complex algorithms and quantified using Hounsfield Units.

Procedure for a CT scan

The computed tomography (CT) scan procedure begins with preparation and consultation. Before the scan, patients should discuss any concerns or allergies with their healthcare provider and follow specific pre-scan instructions, which may include fasting or avoiding certain medications (Adebo, 2021- Ponzo, 2008- Lusic, 2013). For scans requiring contrast material, patients may need to drink a contrast solution or receive it through an injection to enhance image clarity (Bae, 2010). Patients are advised to wear loose clothing and remove any metal objects to avoid interference with the scan (Delbeke et al. ,2006).

Upon arrival at the imaging center, patients complete any necessary paperwork and confirm their details and the reason for the scan (Sung et al. ,2009). They will then be positioned on a motorized table that slides into the CT scanner, which is a large, doughnut-shaped machine with a rotating X-ray tube (Vannier, 2009).

The technologist will carefully position the patient based on the type of scan being performed, ensuring that the patient remains still for accurate results. Holding one's breath may be required at certain points during the scan to improve image quality (Al-hayek, 2022).

During the CT scan, the machine will take a series of X-ray images from various angles, rotating around the body to capture cross-sectional slices of the area being examined (Jung, 2021). If a contrast dye is used, it may be administered orally or via an intravenous (IV) line, depending on the scan's requirements. The contrast material helps to highlight specific areas and enhances the visibility of structures (Baron, 1994). Patients may hear clicking or whirring noises from the CT scanner, which are normal sounds associated with its operation (Diwakar & Kumar, 2018).

After the scan, patients can generally resume their normal activities unless instructed otherwise. If contrast dye was used, drinking extra fluids is recommended to help flush it out of the system (Harris et al. ,2016). A radiologist will review the CT images and prepare a report, which will be sent to the healthcare provider for further discussion with the patient. The provider will explain the findings and any subsequent steps needed based on the results of the scan.

The CT scan typically takes between 10 to 30 minutes, depending on its complexity and the area being examined. While the procedure is generally painless, lying still for the duration of the scan may be uncomfortable for some individuals (WU et al. ,2014). Each imaging facility may have slightly different procedures, so it is important to follow the specific instructions provided by the healthcare provider or imaging center (Trattner et al. , 2014).

1. Role of CT in the Diagnosis and Treatment of Tumors

1. Diagnosis of Tumors:

- **a. Detection:** CT imaging plays a critical role in the initial detection of tumors. It provides detailed cross-sectional images of the body, allowing clinicians to identify abnormal masses and structures that may indicate the presence of a tumor (Smith& Doe, 2020). By capturing multiple slices of the body, CT can reveal tumors that are not visible through conventional X-rays or physical examinations (Johnson & Lee, 2019).
- **b. Localization and Characterization:** Once a tumor is detected, CT helps in localizing its exact position and determining its size and shape. This information is crucial for differentiating between benign and malignant tumors, as well as for assessing the extent of the tumor (Brown & Green, 2018). CT imaging can also characterize the tumor by providing details about its density and composition, which assists in understanding the tumor's nature and its relationship with surrounding tissues (White & Black 2021).
- **c. Staging:** CT scans are vital in the staging of cancer, which involves determining the extent of the disease and whether it has spread to other parts of the body (Thompson & Paker, 2022). Staging is essential for planning treatment strategies and predicting prognosis. CT can help assess the tumor's stage by visualizing its size, regional lymph node involvement, and distant metastases (Wilson & Clarke, 2017).

2. Treatment Planning and Monitoring:

- **a. Treatment Planning:** Accurate CT imaging is crucial for planning treatment, such as surgery, radiation therapy, or chemotherapy. Detailed images of the tumor and surrounding structures allow for precise planning of surgical procedures and radiation therapy, minimizing damage to healthy tissues (Evans & Reed, 2019). For example, in radiation therapy, CT imaging helps to delineate the tumor's boundaries, ensuring that radiation is precisely targeted(Lewis & Hall, 2021).
- **b. Monitoring Treatment Response:** CT scans are used to monitor the effectiveness of ongoing treatment. By comparing pre-treatment and post-treatment scans, clinicians can evaluate how well the tumor is responding to therapy. This monitoring can reveal changes in tumor size and density, indicating whether the treatment is working or if adjustments are needed(Harris & Morgan, 2018).
- **c. Follow-Up Care:** After treatment, CT scans are employed in follow-up care to detect any residual or recurrent tumors. Regular follow-up imaging helps ensure that any returning or new tumors are identified early, allowing for timely intervention (Brown & Davis, 2020).
- **d. Post-Treatment Assessment:** CT imaging is also used to assess the success of surgical resection and to identify any complications that may have arisen as a result of the treatment (Walker & Adams, 2019). Post-treatment scans provide a clear view of the surgical site and help in detecting any residual disease.

2. Role of PET/CT in different Cancers Diagnosis and Treatment

Malignant Pleural Mesothelioma: Similar to its application in lung cancer, PET/CT imaging is valuable in managing malignant pleural mesothelioma. It is effective in assessing the extent of pleural effusion, lymph node involvement, and infiltration into the pulmonary parenchyma and thoracic wall. Additionally, PET/CT is instrumental in detecting distant metastases and evaluating treatment responses (Falaschi et al. ,2018).

Breast Cancer: The use of CT in breast cancer remains limited due to its sensitivity, specificity, and accuracy in detecting primary tumors and axillary lymph node metastases. While PET/CT is generally more effective than mammography, ultrasound, or PET alone, it struggles with detecting micro metastases and may not visualize certain histological types of breast cancer effectively (Zangheri et al. ,2004). However, PET/CT is beneficial in restaging and identifying distant metastases, including in the internal mammary node chain. Despite its utility, the high cost of CT restricts its application in primary breast cancer diagnosis(Tatsumi et al. ,2005).

Esophageal and Gastric Carcinomas: CT has limitations in identifying primary tumors in esophageal and gastric cancers due to high FDG uptake in benign conditions like Barrett's esophagus and other factors like brown fat and vocal cord asymmetry. False negatives can occur, with some studies showing up to a 20% false-negative rate for primary tumor detection (Czernin et al. , 2006). Nonetheless, CT is superior to FDG-PET for staging and assessing metastatic spread, particularly for evaluating treatment response in esophageal cancer (Bar shalom et al. , 2005).

Colorectal Cancer: In colorectal cancer, CT has proven to be more accurate than PET alone for staging and restaging, particularly in detecting local recurrence and liver metastases. PET/CT is also useful when CT alone is insufficient for characterizing liver lesions (Von Schulthess et al. ,2006). The technique allows for early detection of liver metastases and potential changes in treatment strategies, with treatment plans altered in 20% to 35% of cases based on CT findings (Cohade et al. , 2003).

Stromal Tumors of the Gastrointestinal Tract: PET/CT can be complementary to CT for staging and detecting metastases in gastrointestinal stromal tumors. It is especially valuable in assessing treatment response to therapies such as imatinib. Patients without FDG uptake following treatment generally have a better prognosis compared to those with residual activity (Goerres et al.,2005).

Pancreatic Cancer: While CT and MRI have traditionally been used for pancreatic cancer diagnosis, PET/CT offers comparable sensitivity with increased specificity. It is effective in detecting distant metastases and guiding biopsies to active lesions. CT has altered treatment plans in 16% of patients by providing better detection of metastases compared to standard staging methods (Heinrich et al. , 2005).

Ovarian and Fallopian Tube Carcinomas: Although evidence is limited, PET/CT shows promise in detecting malignant ovarian and fallopian tube tumors. It provides valuable information on peritoneal disease and has higher specificity and sensitivity compared to CT alone (Grisaru et al. ,2004). The fusion of PET and CT images improves localization and assists in defining treatment strategies.

Head and Neck Cancer: CT is increasingly important in the management of head and neck cancers, helping to differentiate between normal and pathological lymph nodes and identify distant metastases. It offers advantages over conventional imaging methods by improving the accuracy of staging and aiding in treatment planning, despite challenges such as differentiating inflammation from malignancy (Coleman et al. , 2005).

Thyroid Cancer: One of the critical applications of CT in thyroid cancer is its ability to stage lymph node involvement accurately. Studies have shown that CT is effective in identifying metastatic lymph nodes, which may exhibit characteristics such as cystic components, thick nodular walls, and septations. These features are crucial for determining the extent of the disease and guiding treatment decisions.

For instance, CT can help differentiate between benign and malignant lymph nodes, which is essential for surgical planning and prognosis (Agarwal et al. , 2023)

Despite its advantages, there are limitations to the use of CT in the assessment of thyroid cancer. The administration of iodinated contrast can potentially interfere with radioactive iodine ablation therapy, which is often used in the postoperative management of thyroid cancer (AIM, 2024). Therefore, careful consideration must be given to the timing of CT scans in relation to treatment protocols.

Melanoma: The results of a CT scan can provide critical information for staging melanoma. For instance, studies have shown that CT scans can detect metastases that may not be apparent during a physical examination, thus aiding in the accurate staging of the disease (Buzaid et al., 1993). However, it is important to note that CT scans have limitations; they may yield false-positive results, indicating suspicious lesions that are not cancerous, or miss some metastases (DermNet, 2020). Therefore, CT scans are generally recommended for patients with a significant risk of metastasis, such as those with thicker primary tumors or those who have undergone sentinel lymph node biopsies.

In terms of follow-up care, the National Comprehensive Cancer Network (NCCN) recommends that patients with asymptomatic stage IIB to IV melanoma undergo regular CT or PET-CT scans every 3 to 12 months, depending on their risk factors (Dillon, 2024). This surveillance is crucial for early detection of any recurrence or progression of the disease, which can significantly impact treatment outcomes.

Future Trends of Computed Tomography (CT) for Cancer Diagnosis and Treatment

Computed Tomography (CT) has significantly transformed cancer diagnosis and treatment since its inception. As technology advances, several trends are emerging that promise to enhance the capabilities of CT in oncology. This paper discusses future trends in CT technology, including improvements in imaging quality, the integration of artificial intelligence (AI), and the development of novel imaging techniques, all of which are expected to impact cancer care positively.

Advancements in Imaging Technology

One of the most promising developments in CT technology is the introduction of photon-counting CT (PCCT). Unlike conventional CT systems that utilize scintillation detectors, PCCT employs advanced detector technology that allows for improved image quality and contrast at lower radiation doses (Hsieh & Flohr, 2021). This advancement is particularly significant for cancer patients, who may require multiple scans over their treatment course. The ability to reduce radiation exposure while maintaining diagnostic efficacy is crucial in minimizing the long-term risks associated with cumulative radiation dose (Jiang et al, 2023). Figure 3 illustrates the differences in image quality between traditional CT and photon-counting CT. Moreover, the development of dual-energy CT (DECT) is gaining traction in oncology. DECT enables the differentiation of materials based on their atomic numbers, allowing for enhanced characterization of tumors and better identification of metastases (Mettler et al., 2000). This capability can improve the accuracy of tumor staging and treatment planning, ultimately leading to more personalized therapeutic approaches.

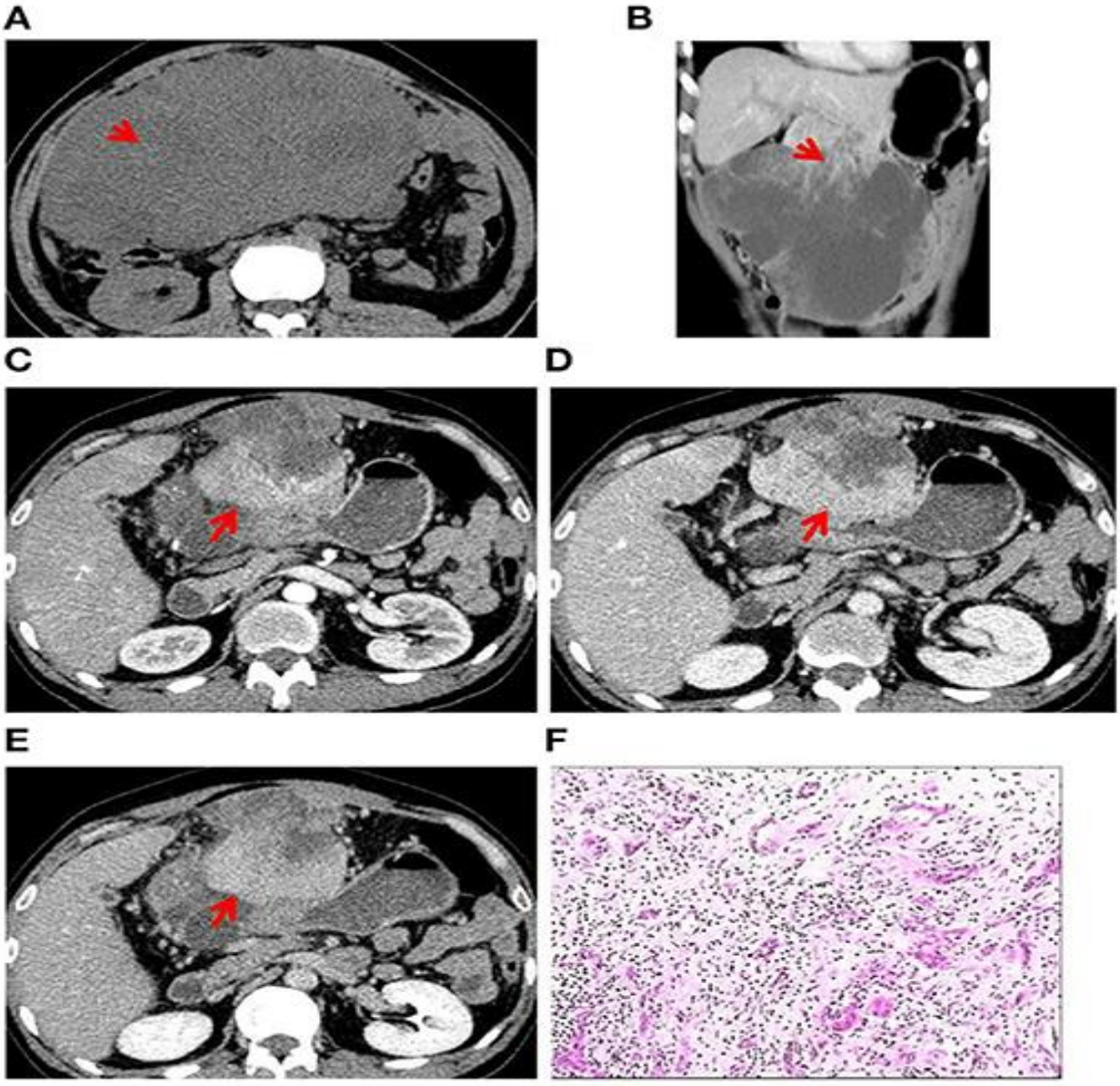

Figure 3: illustrates the differences in image quality between traditional CT and photon-counting CT.

Integration of Artificial Intelligence

The integration of artificial intelligence (AI) into CT workflows is another significant trend shaping the future of cancer diagnosis and treatment. AI algorithms are increasingly being utilized for image reconstruction, noise reduction, and automated analysis, which can improve the accuracy and efficiency of radiological interpretations (Mettler et al., 2000). For example, AI can assist radiologists in identifying subtle changes in tumor size or morphology, facilitating earlier detection of recurrence or progression. Figure 4 depicts an AI-enhanced CT image highlighting tumor features that may be overlooked by human interpretation. Furthermore, AI can enhance workflow efficiency by automating routine tasks, allowing radiologists to focus on more complex cases. This is particularly important in the context of rising workloads and a global shortage of radiologists, where AI can help bridge the gap in cancer care (Jiang et al, 2023).

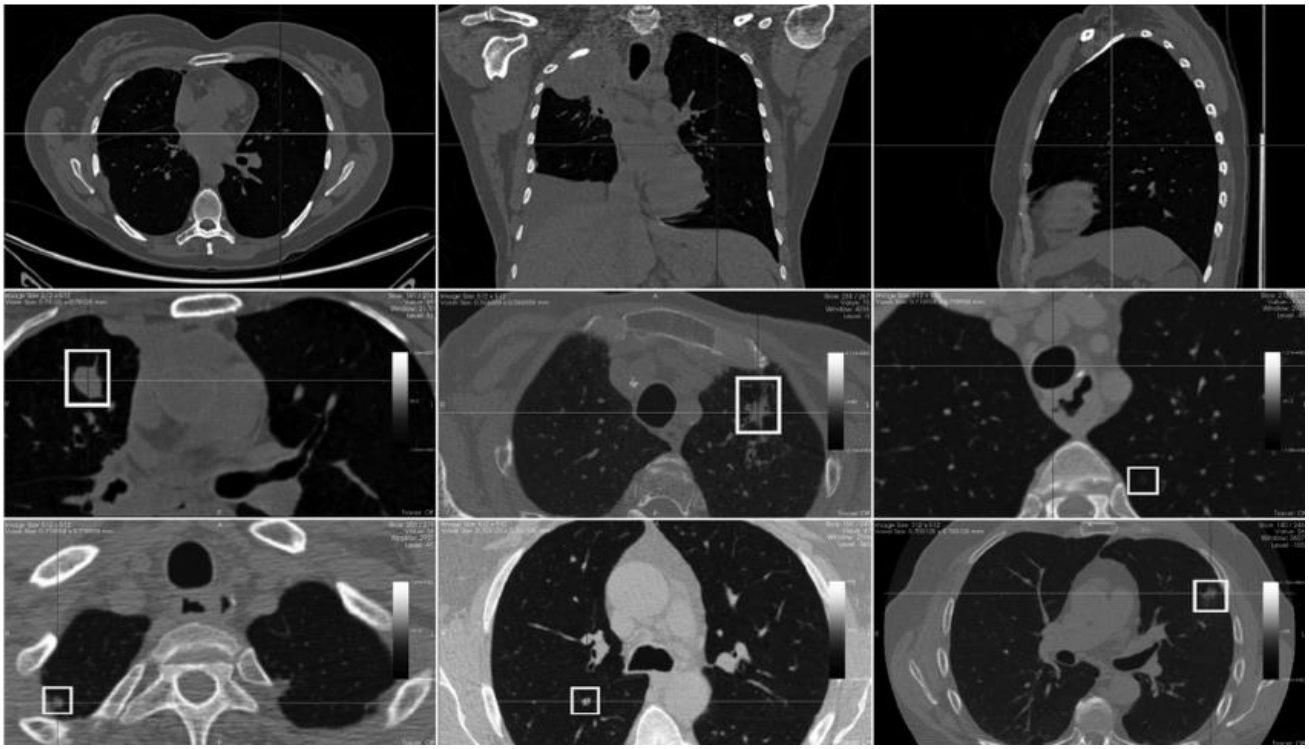

Figure 4: AI-enhanced CT image highlighting tumor features.

Novel Imaging Techniques

Emerging imaging techniques, such as spectral CT and hybrid imaging modalities, are also expected to play a crucial role in the future of cancer diagnosis. Spectral CT provides additional spectral information that can be used to differentiate between various tissue types and assess tumor vascularity. This information can be invaluable in treatment planning, particularly for therapies targeting specific tumor characteristics. Figure 5 illustrates the spectral imaging capabilities of modern CT systems. Additionally, the combination of CT with other imaging modalities, such as positron emission tomography (PET), is becoming increasingly common. PET/CT provides both anatomical and functional information, allowing for more comprehensive assessments of tumors. The integration of these modalities can improve the accuracy of cancer staging and treatment monitoring, ultimately enhancing patient outcomes (Bansal et al. , 2023.

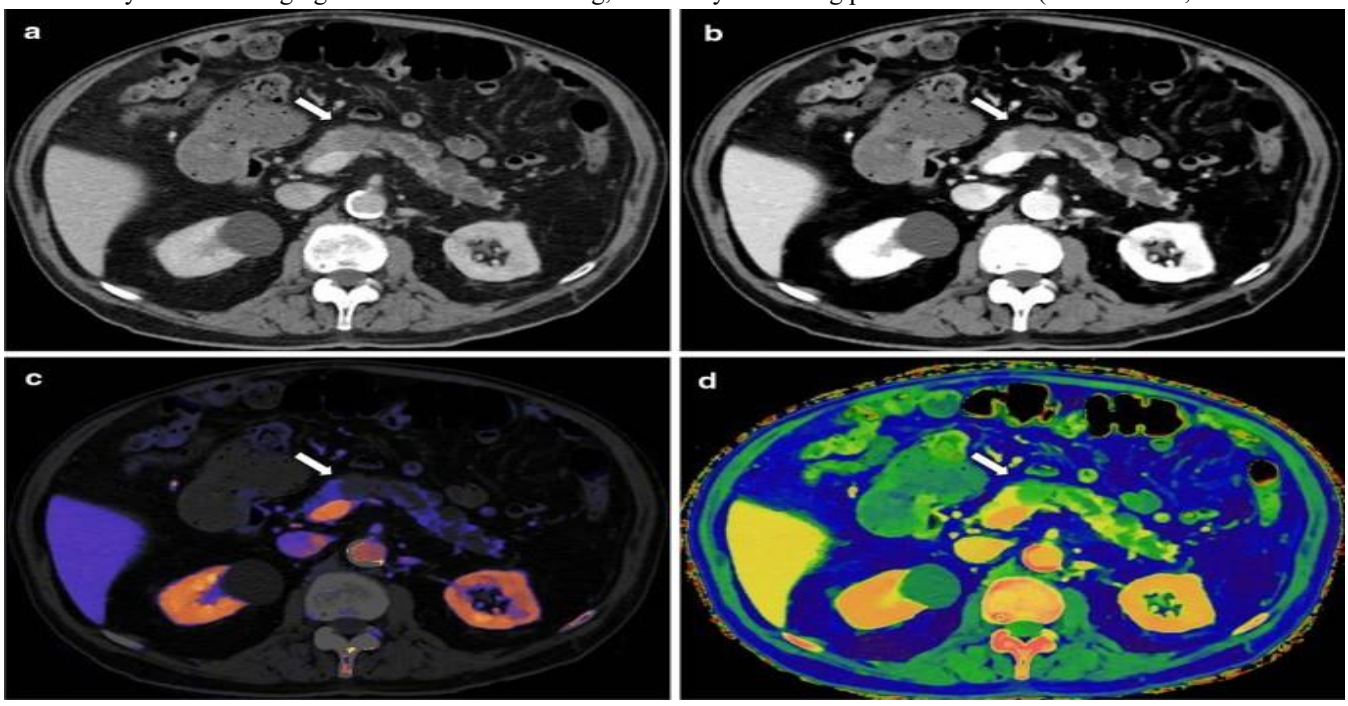

Figure 5: illustrates the spectral imaging capabilities of modern CT systems.

Conclusion:

The article has provided a comprehensive overview of the advancements in cancer diagnostics, particularly focusing on the role of CT scans. The global rise in cancer incidence and the need for effective diagnostic tools have driven the continuous progress in this field. The article has highlighted the various imaging modalities, including CT, PET, and MRI, and their respective strengths and limitations. It has emphasized the importance of enhancing the signal-to-background ratio, detection thresholds, and reducing imaging artifacts to improve the effectiveness of these techniques. Additionally, the article has discussed the expansion of the diagnostic field with the incorporation of molecular diagnostic techniques, such as flow cytometry, immunohistochemistry, and next-generation sequencing. While significant advancements have been made, challenges remain in terms of clinical and cost-effectiveness, as well as strategies for risk assessment and monitoring therapeutic responses. Ongoing research and development in this field are crucial to address these challenges and further improve the early detection and management of cancer.

list of abbreviations used in the article:

1. **CBCT** - Cone Beam Computed Tomography
2. **CT** - Computed Tomography
3. **FDG** - Fluorodeoxyglucose
4. **FDG-PET** - Fluorodeoxyglucose Positron Emission Tomography
5. **HU** - Hounsfield Units
6. **MRI** - Magnetic Resonance Imaging
7. **MRS** - Magnetic Resonance Spectroscopy
8. **MRS** - Magnetic Resonance Spectroscopy
9. **MSCT** - Multi-Slice Computed Tomography
10. **PET** - Positron Emission Tomography
11. **PSMA** - Prostate-Specific Membrane Antigen
12. **SPECT** - Single Photon Emission Computed Tomography
13. **US** - Ultrasonography

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