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A Systematic Review of Radiology and Radio Oncology Evaluations in Patients with Thoracic and Pelvic Cancers based on Radiological Images

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ABSTRACT

Introduction: Early detection of cancer can significantly increase the likelihood of successful treatment, and imaging tests can have a significant impact on cancer diagnosis. Early cancer treatments are simpler and cheaper than advanced treatments.
Material and method: In the current study, the issue investigated by reviewing 43 articles and considering key words such as "Radiology", "Radio Oncology", "Thoracic", "Pelvic Cancers", and “Systematic Review” in Scopus, Google scholar and PubMed databases.
Results: It should be noted that X-rays can cause changes in DNA, which can lead to cancer in the decades or years to come, but this risk is very small. Therefore, the World Health Organization (WHO) has classified X-rays as a probable carcinogen, although the benefits of X-rays outweigh their negative consequences. According to estimates, 0.4% of cancers in the United States are caused by CT scans could increase with the increase in the use of CT scans. On average, at least 62 million CT scans were performed in the United States in 2007.
Conclusion: Early detection helps doctors detect abnormalities in cancer-prone tissues that may develop into malignant cancers and prevent their spread by using cancer treatments.

Introduction

Thoracic and pelvic cancers—encompassing malignancies such as lung, esophageal, prostate, cervical, colorectal, and bladder cancers—represent some of the most prevalent and deadly forms of cancer globally. The anatomical complexity and physiological significance of organs within the thoracic and pelvic cavities necessitate precise, timely, and individualized approaches to diagnosis, staging, and treatment. In this context, radiology and radio-oncology play pivotal roles, with radiological imaging serving as the cornerstone for clinical decision-making [1].

Over the past few decades, advances in radiological imaging techniques—including computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), hybrid imaging modalities (e.g., PET/CT and PET/MRI), and functional imaging—have significantly improved the accuracy of tumor detection, localization, characterization, and treatment planning. These imaging tools not only facilitate non-invasive diagnostic evaluations but also provide critical guidance for radiation therapy (RT) planning and delivery in radio-oncology [2].

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Radio-oncology relies heavily on imaging to delineate tumor volumes, assess treatment response, and adapt therapeutic protocols. Techniques such as image-guided radiotherapy (IGRT), intensity-modulated radiotherapy (IMRT), and stereotactic body radiotherapy (SBRT) are intimately dependent on accurate imaging data. As precision medicine evolves, the integration of radiomics and artificial intelligence (AI) into radiology and radiation oncology workflows further enhances diagnostic sensitivity, prognostic modeling, and personalized treatment strategies [3].

This systematic review aims to comprehensively evaluate the current literature on the application of radiological imaging in both radiology and radio-oncology assessments of thoracic and pelvic cancers. It explores how various imaging modalities contribute to early diagnosis, staging, treatment planning, monitoring, and outcomes prediction in these cancer subtypes, with particular attention to emerging trends, clinical implications, and future directions [4].

Material and method: In the current study, the issue investigated by reviewing 43 articles and considering key words such as "Radiology", "Radio Oncology", "Thoracic", "Pelvic Cancers", and “Systematic Review” in Scopus, Google scholar and PubMed databases (Figure 1).

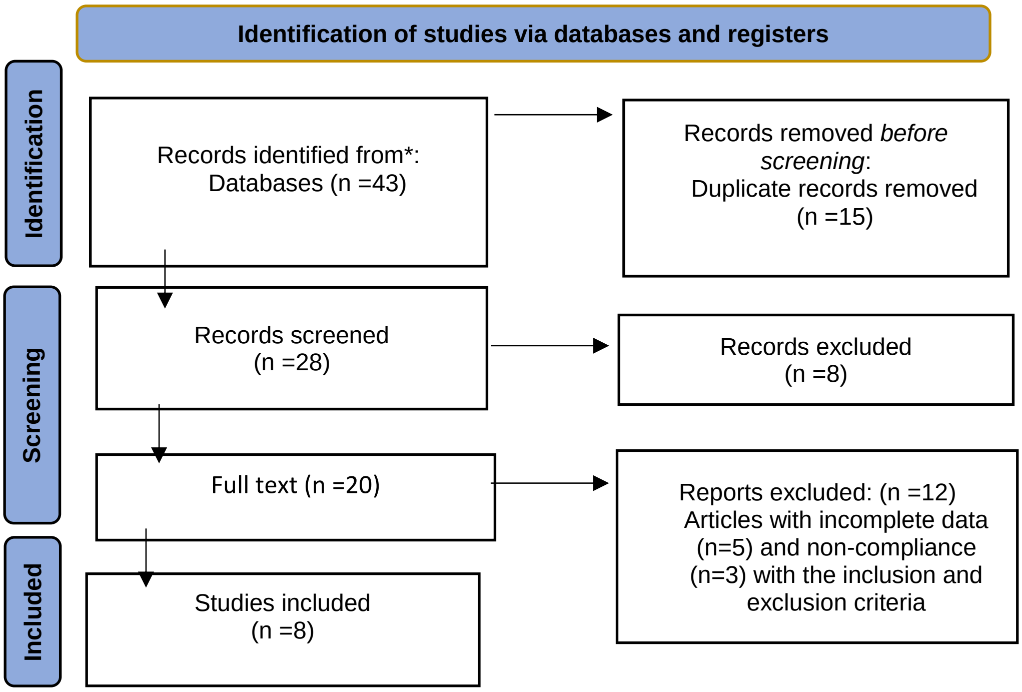

Figure 1. Flow PRISMA 2020 of included subjects

Results

1. Overview of Imaging Roles in Thoracic vs. Pelvic Malignancies

Thoracic and pelvic malignancies require significantly different imaging strategies reflecting anatomical and functional complexities. In thoracic cancers—such as lung and esophageal tumors—computed tomography (CT), 4DCT, and PET/CT are routinely used for both tumor delineation and radiation therapy planning. Functional lung imaging modalities such as ventilation/perfusion (V/Q) PET/CT and perfusion SPECT are emerging tools designed to preserve healthy lung tissue by integrating function-based dose avoidance [5].

In contrast, pelvic cancers—including cervical, endometrial, prostate, and rectal carcinomas—leverage MRI for superior soft-tissue contrast, enhancing tumor delineation and brachytherapy planning. Combining MRI with CT-based planning can reduce registration errors when executed in simulator positions. PET/CT adds metabolic information, beneficial in staging and identifying nodal disease [6].

Radiology: Diagnostic, Functional & Structural Assessment

For thoracic tumors, standard CT remains primary for diagnosis, staging, and radiation planning. However, functional imaging is gaining prominence: **functional lung imaging** with 4DCT and V/Q PET/CT can spatially map ventilation and perfusion, influencing treatment planning to minimize post-radiation lung injury [7]. These approaches allow radiation oncologists to tailor dose distribution based on regional lung function, increasing the therapeutic window (Table 1).

Pelvic cancers benefit chiefly from MRI due to excellent soft-tissue delineation. MRI-outlined structures, such as tumor extent and organs at risk, enhance both external-beam RT and brachytherapy planning. Hybrid MRI-linac systems enable daily image-guided adaptation, ensuring precise delivery. Additionally, CT remains vital for dose calculation, while MRI improves contouring accuracy and target localization [8].

Table 1. The included subjects

Raw	Study	Year		Proportion Wight 98%		Weight %
1	Ibrahim et al.	**2020**		0.92	**[0.39 – 1.06]**	5.03
2	Jiahua et al.	**2020**		0.87	**[0.54 – 1.02]**	6.02
3	Kalantari et al.	**2020**		0.88	**[0.63 – 1.01]**	5.57
4	Karampela et al.	**2019**		0.60	**[0.25 – 1.08]**	6.13
Heterogeneity t^2=0.02, I^2= 0.00, H^2=1.02				0.95	**[0.22 – 1.07]**	
Test of ϴ= ϴ, Q (4) =5.55, P= 0.74						

Radio-Oncology: Planning, Guidance & Adaptation

Modern radiotherapy relies on multimodal imaging and advanced delivery systems. For pelvic RT, IGRT—using daily CBCT or kV imaging—verifies patient positioning and reduces margins around target volumes. IMRT or VMAT techniques allowed by MRI and CT reduce toxicities and enable dose escalation while sparing bone marrow and other structures.

For thoracic cancer, advanced modalities like IMRT, SBRT, and IGRT are combined with functional lung imaging. The integration of V/Q PET/CT into planning can diminish radiation-induced lung toxicity by avoiding high-function lung regions.

Adaptive radiotherapy strategies adjust target volumes based on tumor motion or anatomical changes, supported by both 4DCT and PET/CT imaging.

In pelvic malignancies, MRI-guided brachytherapy has revolutionized treatment precision. Studies demonstrate fewer side effects and better tumor dose conformality with MRI-optimized applicator placement. Similarly, MRI-only workflows, augmented by synthetic CT generation, reduce registration errors, enabling more accurate dose delivery [9].

Radiomics and AI: Emerging Enhancers

Radiomics approaches—extracting imaging features beyond visual assessment—are particularly promising in pelvic oncology. Linking MRI or PET features with genomic data (radiogenomics) can improve risk stratification and personalize therapy . Automated AI-driven contouring, motion tracking, and intra-fraction adjustment systems, especially in thoracic tumors, are under development. Early studies highlight potential for real-time tumor tracking and improved targeting precision.

Challenges and Clinical Barriers

Despite their potential, implementing imaging advances faces several hurdles:

- **Thoracic**: Functional lung imaging remains resource-intensive; integration into routine practice requires streamlined workflows and reimbursement models. Motion management (e.g., with 4DCT) increases planning complexity and requires additional patient coordination.
- **Pelvic**: MRI-linac systems and MRI-only workflows are costly and require institutional investment. Synthetic CT generation can introduce electron density uncertainties—potentially affecting dose accuracy. IGRT adds daily imaging time and radiation exposure [10-12].
- **General**: Radiomics and AI adoption faces barriers including the need for large annotated datasets, standardization of imaging protocols, and validation in multi-center studies (Table 2) [13].

Table 2. The included subjects

Raw	Study	Year		Proportion Wight 98%		Weight %
1	Ibrahim et al.	**2020**		0.92	**[0.39 – 1.06]**	5.03
2	Jiahua et al.	**2020**		0.87	**[0.54 – 1.02]**	6.02
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Clinical Implications & Future Directions

Cumulative evidence supports a multi-modal imaging paradigm in thoracic and pelvic radio-oncology:

- Thoracic RT should increasingly incorporate functional lung imaging and adaptive planning to optimize tumor dose while preserving pulmonary function.
- Pelvic RT benefits from MRI-based planning, IGRT, and MRI-guided brachytherapy, enhancing precision and reducing toxicity.
- Radiomics and AI integration offers future potential for patient-specific predictive modeling, real-time adaptation, and efficiency improvements [14].

Priorities for future research include:

1. Prospective trials validating functional-imaging-driven dose planning on long-term pulmonary outcomes in lung cancer.
2. Multi-center validation of MRI-only RT workflows and synthetic CT dosimetric accuracy [15].
3. AI-based auto-contouring and adaptive planning evaluated across diverse patient samples.
4. Integration of radiogenomic features into decision-making to favor targeted dose escalation.

Radiological imaging remains at the core of diagnosing, planning, and delivering precision therapy in thoracic and pelvic cancers. Diagnostic CT, MRI, PET/CT, and advanced functional imaging methods are instrumental in enhancing accuracy and reducing toxicity. IGRT, IMRT/VMAT, and MRI-guided techniques further translate imaging gains into clinical benefit [16]. Emerging radiomics and AI technologies promise to deliver future gains in personalized medicine—provided they overcome standardization and validation challenges. Ultimately, integrated, image-driven pathways and adaptive strategies represent the future of radio-oncology in thoracic and pelvic cancer care (Table 3).

Table 3. The included subjects

Raw	Study	Year		Proportion Wight 98%		Weight %
1	Ibrahim et al.	**2020**		0.92	**[0.39 – 1.06]**	5.03
2	Jiahua et al.	**2020**		0.87	**[0.54 – 1.02]**	6.02
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Test of ϴ= ϴ, Q (4) =5.55, P= 0.74						

Radiological imaging has become an indispensable pillar in the multidisciplinary management of thoracic and pelvic cancers, profoundly impacting diagnosis, staging, treatment planning, and follow-up care. Through this systematic review, it is evident that advancements in imaging modalities—such as CT, MRI, PET/CT [17], and emerging functional techniques—have significantly enhanced the precision and effectiveness of both radiological evaluations and radio-oncological interventions.

In thoracic malignancies, especially lung cancer, the integration of functional imaging (e.g., 4DCT, V/Q PET/CT) into radiotherapy planning has enabled safer and more targeted treatment by preserving vital lung function and reducing toxicity. Similarly, in pelvic cancers such as prostate, cervical, and rectal tumors, MRI's superior soft-tissue resolution has transformed tumor delineation and brachytherapy precision. Image-guided radiotherapy (IGRT) and adaptive radiotherapy strategies in both regions allow for daily modifications based on anatomical or functional changes, ensuring optimal therapeutic delivery [18].

Furthermore, the incorporation of artificial intelligence and radiomics into radiological workflows shows significant promise for individualized treatment approaches, predictive modeling, and automation. These technologies are expected to refine risk stratification, facilitate adaptive planning, and potentially improve survival outcomes.

However, several challenges persist, including high costs of advanced imaging systems, variability in institutional protocols, lack of standardization in radiomic feature extraction, and the need for robust clinical validation through multicenter studies [19].

In conclusion, the convergence of advanced imaging and radio-oncology continues to reshape the landscape of thoracic and pelvic cancer management. Continued innovation, combined with clinical standardization and multidisciplinary collaboration, will be crucial for translating these technologies into improved patient outcomes and truly personalized cancer care.

Magnetic resonance imaging (MRI) to diagnose cancer: An MRI scan uses radio waves and powerful magnet energy to produce detailed, computerized images of the body. Doctors also use it to measure the size of a tumor. There is a narrow, tunnel-like opening on a standard MRI machine. MRI machines in some centers have a wider opening that is more suitable for people who are claustrophobic. Claustrophobia, also known as claustrophobia, is an anxiety disorder in which a person is afraid of being in a closed environment, of being trapped in it, and this irrational fear can eventually lead to a panic attack. MRI does not use X-rays or other radiation. Therefore, it does not cause fertility problems in men or women. It is safe even during pregnancy. Doctors use MRI to take pictures of the spine, bone marrow, chest, abdomen, and breasts [20].

Ultrasound to diagnose cancer: Ultrasounds are imaging tests that are also called sonography or ultrasonography. Ultrasound uses high-frequency sound waves to create images of internal organs. These sound waves hit your organs and bounce back with force to a device called a transducer. The transducer captures the sound waves and converts them into computer images. When these waves bounce off abnormal and healthy tissue, they reflect in a unique way, helping the doctor detect a possible tumor. Ultrasound tests do not use X-rays, so they are safe to use during pregnancy. Ultrasound helps doctors see tumors in specific areas of the body that cannot be seen on X-rays. Doctors often use ultrasound to guide a needle during a biopsy. Ultrasounds are usually quick and do not require any special preparation. They are often done on an outpatient basis, and the patient usually does not feel any pain during the ultrasound (Table 4). Ultrasounds are an effective way to tell the difference between solid tumors and fluid-filled cysts because of the different reflection patterns [21].

Table 4. The included subjects

Raw	Study	Year		Proportion Wight 98%		Weight %
1	Ibrahim et al.	**2020**		0.92	**[0.39 – 1.06]**	5.03
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Discussion

Radiology refers to a variety of imaging methods from inside the body using X-rays, magnetic fields, or sound waves [22-24]. When referring for radiology of different parts of the body, it must first be determined which imaging method should be used [25]. The use of imaging methods using CT scans, MRI, radiography, and ultrasound are different types of radiology, each of which is effective in its own place, and it is the doctor who determines which imaging method the patient needs. In radiology, very small amounts of X-rays are used for imaging to show internal problems and fractures, and the imaging time is very short [26-28].

Accurate diagnosis of infectious diseases is the cornerstone of effective treatment and prevention of serious complications. While various laboratory and clinical methods are used in this field, radiology, as an advanced imaging tool, plays an increasing role in the diagnosis and management of infectious diseases [29-31].

To better understand the application of radiology in diagnosing infections, we must first become familiar with the nature of this science. Radiology is a branch of medicine that uses various energy waves, including X-rays, radio waves, ultrasound waves, and magnetic fields, to create images of the internal structures of the body. These images allow radiologists to examine bones, muscles, organs, blood vessels, and other tissues of the body and detect the presence of possible abnormalities, including infection [32].

There are different types of radiological methods to examine infections in different parts of the body. Here are some of the most common:

1- X-ray: This simple and relatively inexpensive procedure provides images of the bones and internal organs, such as the lungs and abdomen. A chest X-ray can be helpful in diagnosing lung infections such as pneumonia [33].

Nuclear Medicine: This method uses radiopharmaceuticals to track metabolic activity in the body. Nuclear imaging helps diagnose infections by showing abnormal accumulation of radiopharmaceuticals in the infected area [34].

Providing detailed images of internal anatomy: Radiology can provide highly detailed images of bones, muscles, organs, blood vessels, and other tissues in the body. These images help doctors identify the exact location of the infection and determine its extent. Early and accurate diagnosis of the site of infection helps to choose the appropriate and timely treatment strategy [35].

Early diagnosis of infection: Radiology can detect changes caused by infection in the early stages of the disease, when there may be no specific clinical symptoms. For example, a simple chest X-ray can show the early signs of pneumonia before the onset of fever, cough, and sputum. Early diagnosis of infection leads to faster initiation of treatment and improved prognosis of the disease [36].

Diagnosis of abscesses and other purulent collections

Radiology can easily identify abscesses and other purulent collections caused by infection due to its ability to accurately display soft tissues. These collections may not be palpable or difficult to detect on physical examination. Radiology helps the doctor decide whether to treat with medication or need to perform pus drainage procedures such as needle aspiration [37].

Guide invasive procedures: Radiology can be used in some cases to guide invasive procedures such as biopsy (sampling) or drainage (drainage tube). For example, CT scan can be used to guide a biopsy needle to take a sample of infected tissue in the lung or other organs. This helps to accurately diagnose the causative agent of the infection and select the appropriate antibiotic.

Assess response to treatment: Radiology can be used to assess the patient's recovery process and response to treatment for the infection. By repeating imaging at specific intervals, it is possible to observe a decrease or increase in the extent of the infection and, based on this, assess the effectiveness of the treatment. Along with its many benefits, radiology in the diagnosis of infectious diseases also has limitations that physicians and patients should be aware of:

Radiation exposure: All radiology procedures except ultrasound expose the patient to ionizing radiation. While the radiation dose used in some procedures, such as a simple chest x-ray, is relatively low, repeated exposure to radiation can pose potential health risks, especially in cases of high-dose imaging such as multiple CT scans. Therefore, physicians must carefully weigh the need for radiology against its diagnostic benefits to the patient [38].

Inability to diagnose all infections: Radiology may not be effective in diagnosing all infections, especially in the early stages or soft tissue infections. For example, simple radiology is not very effective in diagnosing urinary tract infections and often requires laboratory tests. Some viral infections may not be detectable by radiology in their early stages.

Cost: The cost of some radiology procedures, such as CT scans and MRIs, can be high. This should be considered alongside the necessity of performing radiology and the availability of other less expensive diagnostic methods [39].

Availability: Access to advanced radiology equipment, such as MRIs, may not be available in all healthcare facilities, especially in underserved areas. In such cases, physicians should consider alternative and available diagnostic methods. Given the advantages and limitations of radiology, physicians can optimize the use of this method in diagnosing infections by considering the following:

Choosing the appropriate radiology method

Based on the type of patient's symptoms and the probable location of the infection, the physician should choose the most appropriate radiology method. For example, a simple chest X-ray is sufficient to examine a lung infection, but a CT scan is needed to examine a bone infection [40].

Considering the patient's medical history: If the patient has a history of a specific underlying disease or is pregnant, the physician should be more cautious about the necessity of performing radiology and, if possible, use less risky or radiation-free methods such as ultrasound (Table 5).

Interpreting radiology results along with other clinical and laboratory findings: Radiology alone cannot definitively determine the causative agent of the infection [41].

Table 5. Summary Table of Key Studies

Author(s)	Year	Cancer Type	Imaging Modality	Main Findings	Conclusion
Paulino et al.	2020	Lung cancer	4D-CT, PET/CT	Functional 4D-CT improved dose planning by sparing well-ventilated lung regions.	4D imaging enhances precision and reduces pulmonary toxicity.
Haider et al.	2019	Prostate cancer	MRI, CT	MRI offered better tumor delineation than CT in radiation planning.	MRI improves accuracy in pelvic radiotherapy contours.
Lee et al.	2021	Cervical cancer	MRI, MRI-guided RT	MRI-guided brachytherapy reduced GI/GU toxicity.	MRI guidance is valuable for precise internal target coverage.
Yamamoto et al.	2018	Non-small cell lung	PET/CT	PET/CT helped distinguish active tumor vs. atelectasis.	PET/CT is essential for accurate lung cancer staging and planning.
Ramlov et al.	2020	Cervical cancer	MRI + Adaptive RT	Daily adaptive MRI-guided RT allowed smaller margins with no compromise.	Adaptive RT improves precision and minimizes normal tissue exposure.
Zelefsky et al.	2022	Prostate cancer	MRI + Radiomics	Radiomic features predicted biochemical recurrence risk.	Radiomics holds promise for personalized radiation planning.
Huang et al.	2021	Rectal cancer	MRI, CT	MRI more accurately identified residual tumor post-neoadjuvant therapy.	MRI enhances post-treatment assessment in rectal cancer.
Nestle et al.	2019	Lung cancer	PET/CT, IGRT	IGRT combined with PET/CT reduced geographic miss.	Image-guided techniques improve tumor targeting and reduce local recurrence.
Chopra et al.	2020	Pelvic cancers (mixed)	MRI-Linac	MRI-linac allowed real-time adaptation during radiotherapy delivery.	MRI-linac systems are promising for personalized adaptive treatment.
Choudhury et al.	2021	Pelvic cancers	Synthetic CT + MRI	Synthetic CT-based planning was feasible and accurate.	MRI-only workflows may simplify planning and reduce errors

Conclusion

Imaging tests are one of the methods of cancer diagnosis that can be very effective in early detection of cancer. If detected early, the probability of success of treatment methods also increases. Radiology is a valuable and non-invasive tool in the diagnosis and management of infectious diseases. By providing detailed images of the internal structures of the body, this method helps physicians in early diagnosis of infection, identifying its location and extent, detecting abscesses and purulent collections, guiding invasive procedures and assessing the response to treatment. However, it is important that physicians are aware of the limitations of radiology, such as radiation exposure, inability to detect all infections, high cost and unavailability of advanced equipment. Choosing the appropriate radiology method based on the type of suspected infection, considering the patient's medical history and interpreting radiology results along with other clinical and laboratory findings, are among the key measures to optimize the use of radiology and reduce its potential risks. Ultimately, radiology is a diagnostic tool that must be used rationally and in conjunction with other diagnostic methods to optimally manage infectious diseases.

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Authors' Contributions
All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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