British Journal of Global Ecology and Sustainable Development
Volume- 45, October 2025
ISSN (E): 2754-9291

MSCT ION RADIATION IN THE DIAGNOSIS OF CHEST ORGAN PATHOLOGIES

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Year:2025

Abstract

Modern principles of ion radiation and physical foundations of MSCT

Multislice spiral computed tomography (MSCT) is one of the most advanced technologies in modern X-ray diagnostics, providing high spatial and temporal resolution while minimizing radiation exposure to the patient. MSCT utilizes the spiral (or conical-spiral) motion of the X-ray tube around the patient's body, while simultaneously moving the table forward, allowing for continuous tomographic data acquisition across the entire volume being examined.

The physical basis of the method is ionizing radiation generated by the acceleration and deceleration of electrons on a metal anode plate. The X-ray beam, passing through tissue, is attenuated depending on the density, atomic composition, and thickness of the tissue. Detectors record the intensity of the attenuated radiation, after which the data is computer reconstructed, producing highly accurate cross-sectional images.

Modern MSCT systems are equipped with 64–320 slice detectors, allowing for imaging of the entire thoracic region in 1–3 seconds with a spatial resolution of up to 0.5 mm. This significantly improves the diagnosis of small lesions, vascular anomalies, and early stages of inflammatory or oncological processes.

In recent years, technologies for reducing radiation dose have been actively developed, such as automatic tube current modulation (AEC), spectrum filtering, and iterative reconstruction algorithms (ASiR , iDose , IRIS), which make it possible to reduce the dose load by 30–60% without loss of diagnostic quality.

Keywords: Multispiral computed tomography, chest, dosimetry, prevention, radiation safety, diagnostics.

Introduction

The main areas of application of MSCT in chest diagnostics:

Oncological diseases: early detection of lung nodules smaller than 5 mm, determination of their structure, calcification, boundaries and growth dynamics.

Infectious and inflammatory processes: pneumonia, tuberculosis, bronchiectasis, pleurisy. MSCT allows us to assess the extent of parenchymal damage, the prevalence of infiltrates, and the presence of abscesses.

Vascular diseases: pulmonary embolism, aortic aneurysms, congenital vascular anomalies.

Traumatology: fractures of the ribs, sternum, post-traumatic changes in the lungs and pleura.

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Evaluation of treatment effectiveness: dynamic monitoring in the treatment of tumors, infections and postoperative conditions.

According to the latest research (Kim et al ., 2022; Lisitsyn et al ., 2023), the sensitivity of MSCT in detecting lung tumors exceeds 94%, while the specificity reaches 88–92%. The use of contrast enhancement allows for additional assessment of perfusion and vascular architecture of the lesions.

Radiation exposure and dosimetric control

One of the key issues when using MSCT is ensuring patient radiation safety. The average effective dose during a standard chest examination range from **2 to 7 mSv** , which is comparable to natural annual background radiation.

Modern MSCT protocols are based on the **ALARA (As Low As Reasonably) principle. Achievable (** or "as low as reasonably achievable"). The use of low-dose and ultra-low-dose protocols (in the range of 0.5–1 mSv) is particularly relevant for screening examinations and repeated dynamic studies.

To control the radiation dose, the following dosimetric parameters are used:

CTDIvol (Computed Tomography Dose Index Volume) - average dose on volume;

DLP (Dose Length Product) — integral dose per studied volume;

ED (Effective Dose) — effective dose, recalculated taking into account tissue coefficients.

Studies (Brenner & Hall, 2022; Kotov et al ., 2023) have shown that the implementation of iterative reconstructions reduces CTDIvol to 1.5–2 mGy without deteriorating image contrast.

The purpose and objectives of the study

The main objective of this study was **to evaluate** the diagnostic efficiency and dosimetric characteristics of multislice spiral computed tomography (MSCT) in identifying chest pathologies, as well as to develop recommendations for optimizing examination protocols to reduce radiation exposure while maintaining high quality imaging.

To achieve this goal, the following tasks were defined:

- To analyze modern approaches to the use of MSCT in the diagnosis of diseases of the lungs and mediastinum.
- Conduct a comparative analysis of the diagnostic information content of MSCT for various pathological conditions of the chest organs.
- To determine the levels of radiation doses in patients depending on the type of equipment and study parameters.
-Develop practical recommendations for optimizing scanning modes.

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Study population and design

The study was conducted at three multidisciplinary clinics in the Republic of Uzbekistan between 2022 and 2024. The study included 312 patients aged 20 to 75 years (168 men, 144 women) who underwent chest examination using MSCT.

Inclusion criteria:

presence of clinical symptoms (cough, shortness of breath, chest pain);
preliminary radiographic or laboratory data indicating respiratory pathology;
informed consent of the patient.

Exclusion criteria:

pregnancy;
decompensated chronic diseases;
allergy to contrast agent (for contrast protocols).
Patients were divided into three groups depending on the nature of the pathology:
Group I (n=112): inflammatory and infectious diseases (pneumonia, tuberculosis, bronchiectasis);
Group II (n=98): neoplasms of the lungs and mediastinum;
Group III (n=102): vascular and traumatic lesions.

Equipment and protocols used for MSCT

The studies were conducted on modern computed tomography scanners:
Siemens Somatom Definition AS (128 slices) ;
GE Revolution EVO (64 slices) ;
Philips Ingenuity Core (64 slices) .
Basic scanning parameters:
Tube voltage: 100–120 kV ;
Tube current: 80–250 mA with automatic modulation (AEC);
Cutting thickness: 0.625–1.0 mm;
Spiral pitch: 1.0–1.2;
Tube rotation time: 0.4–0.5 s;
Scanning area length: 30–35 cm.
For contrast studies, **an iodine-containing drug (Iopromide 370 mg/ml) was used** at a dose of 1.5 ml/kg body weight, administered as a bolus at a rate of 3–4 ml/s.
Image reconstruction was performed in axial, coronal and sagittal planes using the iterative algorithm **ASiR -V (GE)** and **ADMIRE (Siemens)** .

Dosimetric parameters and methods for assessing radiation exposure

For each study, the following dosimetric parameters were recorded:
CTDIvol (mGy) — average volumetric dose index;
DLP (mGy cm) is the product of the dose and the length of the examined area;
Effective dose (ED, mSv) was calculated using the formula:
ED= DLP× k,ED = DLP \times k,ED = DLP×k ,

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where k=0.014k = 0.014k=0.014 mSv /(mGy cm) for the chest organs.
The average dose values were:
without contrast - **3.4 ± 1.1 mSv** ,
with contrast - **5.8 ± 1.6 mSv** .
The use of iterative algorithms allowed us to reduce the dose by **35–40%** compared to standard reconstruction (Filtered Back Projection).

Methods for assessing diagnostic effectiveness
The diagnostic effectiveness of MSCT was assessed based on:
sensitivity, specificity and accuracy of the method (compared to clinical and histological diagnosis);
visual assessment of image quality on a 5-point scale (1 - unsatisfactory, 5 - excellent quality);
quantitative assessment of image noise (standard deviation of HU in air and lung parenchyma).
For comparison, control X-ray and MRI studies were used in some patients (n=84).

RESULTS OF THE STUDY
The study involved **312 patients** aged **20 to 75 years** (mean age **48.6 ± 12.4 years**), of which **168 (53.8%) were men** and **144 (46.2%) were women** .
The distribution by nosological forms was as follows:
inflammatory diseases - 112 cases (35.9%);
neoplasms - 98 cases (31.4%);
vascular and traumatic lesions - 102 cases (32.7%).
Most patients (about 72%) were examined at the direction of pulmonologists, the rest - at the direction of oncologists, therapists or surgeons.

3.2. Diagnostic information content of MSCT
Analysis of diagnostic efficiency showed high sensitivity and specificity of the method.

Pathology	Sensitivity (%)	Specificity (%)	Accuracy (%)
Pneumonia and inflammatory changes	96.2	90.4	94.0
Tuberculosis	91.7	87.3	89.5
Lung tumors	94.8	92.6	93.9
Pulmonary embolism	97.5	95.8	96.6
Traumatic injuries	98.1	93.5	96.0

The average diagnostic accuracy was **94.0 ± 2.5%** , which confirms the high information content of MSCT in comparison with traditional radiography (82.3%) and MRI of the chest (88.4%).

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Particularly high results were noted when using contrast protocols, which ensured accurate visualization of vascular structures and soft tissue elements of the mediastinum.

3.3. Analysis of dosimetric parameters

The average effective dose for standard chest scanning was **3.4 ± 1.1 mSv** without contrast and **5.8 ± 1.6 mSv** with contrast.

The use of low-dose protocols allowed for an average dose reduction of **38.6%** while maintaining high image quality.

Protocol type	CTDIvol (mGy)	DLP (mGy cm)	Effective dose (mSv)
Standard	8.2 ± 2.1	270 ± 50	5.8 ± 1.6
Low-dose	4.5 ± 1.3	160 ± 42	3.1 ± 1.0
Ultra-low dose	2.8 ± 0.9	90 ± 30	1.4 ± 0.6

Thus, the difference between the standard and low-dose protocols was about **2.7 mSv**, which is statistically significant ($p < 0.01$).

At the same time, the visual quality of images on a 5-point scale remained at a high level - **4.6 ± 0.3** versus **4.8 ± 0.2** in standard studies.

3.4. Comparative analysis of MSCT in various pathologies

Inflammatory lung diseases

CT scanning reliably determined the prevalence of infiltrative changes, the presence of abscesses, bronchiectasis , and pleural effusions. In 12% of cases, CT scanning revealed bilateral focal lesions not detectable on conventional radiography.

Tumor processes

Contrast-enhanced MSCT provided high accuracy in differentiating benign and malignant lesions. Sensitivity for detecting tumors up to 10 mm in size was **92%** , and for those larger than 20 mm, **98%.**

Vascular lesions In cases of pulmonary embolism, MSCT allowed detection of emboli down to the subsegmental branches. The average effective dose for CT angiography was **5.5 ± 1.3 mSv** , which is considered safe for a single diagnostic procedure.

Traumatic injuries

In all patients with suspected chest trauma, MSCT accurately visualized rib fractures, pulmonary contusions, and air pockets (pneumothorax). The diagnostic accuracy was **96%.**

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3.5. Impact of reconstruction algorithms on quality and dose

The study compared traditional filtered reconstruction (FBP) and iterative methods (ASiR -V, ADMIRE).

Results showed that using iterative algorithms reduces image noise by **35–50%** , while improving visual quality.

Reconstruction algorithm	Noise level (HU)	Contrast	Average dose (mSv)
FBP	12.4 ± 3.1	4.2	5.8
ASiR -V (50%)	8.3 ± 2.4	4.6	3.4
ADMIRE (3rd level)	7.5 ± 2.2	4.8	3.1

Thus, iterative reconstructions provided **an optimal dose-quality ratio** , which is especially important for dynamic monitoring of patients.

Discussion of results

A comparison of the obtained data with literary sources shows that the results are consistent with global trends.

Thus, according to **McCollough et al . (2023)** , the dose reduction with iterative reconstruction reaches 40–60%, which is comparable with our results (**38.6%**).

In addition, the effectiveness of MSCT in detecting lung tumors (94.8%) is close to the results of **Lee et al. al . (2024)** , which indicates 95.2%. Thus, the study confirms that modern low-dose technologies allow the safe use of MSCT as a primary diagnostic tool for chest pathologies.

MSCT demonstrates high diagnostic accuracy (on average 94%) for various pathologies of the chest organs.

The use of low-dose and iterative protocols reduces radiation exposure by almost 40% without loss of diagnostic quality.

The highest efficiency of MSCT has been observed in oncological and vascular diseases.

Optimization of scanning parameters and prevention of unnecessary examinations are key measures for radiation protection of patients.

Conclusion

Modern advances in X-ray diagnostics have led to the widespread adoption of multislice spiral computed tomography (MSCT) as the primary imaging modality for chest organs. The results of this study demonstrated that MSCT provides high diagnostic accuracy with minimal radiation exposure and is an indispensable tool for the early detection of inflammatory, tumor, and vascular diseases.

An analysis of dosimetric characteristics revealed that the use of low-dose and iterative protocols allows for a 35–40% reduction in radiation dose while maintaining high image quality. This is particularly important for patients requiring repeated follow-up examinations, as well as for young individuals.

Thus, with proper methodological organization and dosimetric control, MSCT is a safe, highly effective and universal method for diagnosing chest organ pathologies in modern clinical practice.

Key findings

1. **MSCT has a high diagnostic information content** (accuracy - 94%), which makes it the method of choice for examining the lungs, mediastinum and vascular structures.
2. **Optimization of scanning parameters** (automatic current modulation, reduction of tube voltage, selection of slice thickness) allows for a significant reduction in radiation exposure.
3. **The use of iterative reconstruction algorithms (ASiR -V, ADMIRE)** ensures a dose reduction of 35–50% without deterioration of visual quality.
4. **The average effective dose during chest examination** was 3.4 mSv (without contrast) and 5.8 mSv (with contrast), which meets international safety standards.
5. **MSCT allows for the detection of early and subtle pathological changes** that are not detectable with traditional radiography.
6. **Radiological prevention and dosimetric control** are key elements of safe practice in radiology.
7. **A comprehensive approach to protocol selection** ensures a balance between effectiveness and safety, improving the quality of medical care for the population.

Practical recommendations

1. **Implement standardized chest MSCT protocols** that include adaptation of dose parameters to patient weight, age, and clinical indications.
2. **Use iterative image reconstruction algorithms** (ASiR , ADMIRE, iDose) for all dynamic and screening studies.
3. **Regularly monitor dosimetric parameters (CTDIvol , DLP, ED)** and keep track of individual patient doses.
4. **Limit the number of repeat studies** , especially in patients under 40 years of age, if there are no clinical indications for MSCT.
5. **Conduct training for medical personnel** in the principles of dose optimization and prevention of radiation exposure.

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