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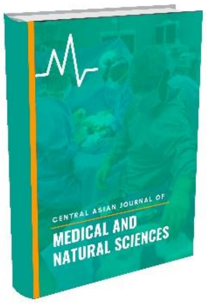

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Respiratory computed tomography

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ABSTRACT: Over the past 20 years, X-ray computed tomography (CT) has become one of the most important methods for diagnosing respiratory diseases. This is due to the high accuracy of the method in identifying pathological changes in organs and tissues of the chest cavity. The use of CT has made it possible to replace traditional radiopaque techniques such as bronchography, pneumomediastinography, diagnostic pneumothorax, etc. In those medical institutions where CT is an available research method, linear tomography is practically not used.

Key words: computed tomography, magnetic resonance imaging, angiography

Introduction

In most clinical situations, radiation diagnostics of respiratory pathology can be limited to plain radiography and CT. If necessary, these techniques are supplemented by isotopic and ultrasound examinations or magnetic resonance imaging (MRI). Transthoracic puncture or transbronchial biopsy under fluoroscopy is used to verify changes in the chest cavity. Punctures can also be performed under the guidance of echography or CT. Along with modern bronchological and functional methods, the complex of radiation studies allows you to obtain comprehensive information about the state of the respiratory system.

The meaning of the CT method is to perform three sequential actions: scanning the object with a thin fan-shaped X-ray beam; registration of attenuated X-ray radiation by detectors that allow converting the energy of radiation quanta into electrical pulses; constructing a two-dimensional halftone image of a transverse (axial) cut of the investigated area. The technical details are detailed in the respective manuals.

Like any X-ray method, CT examination is associated with exposure to the body of ionizing radiation. The radiation dose for a standard CT scan is comparable to the dose for linear tomography of the lungs and is 5-8 mSv. In modern devices equipped with automatic exposure correction programs, the dose can be reduced by 1.5-2 times. When using high-resolution CT (HRCT), when thin (1-2 mm) tomographic sections are performed at a distance of 10-20 mm from each other, the dose is 2-3 mSv. In special protocols of the so-called low-dose CT scan, intended for screening lung pathology, primarily bronchogenic cancer, the radiation dose is comparable to the usual plain radiograph and is equal to 0.2-0.4 mSv. These same protocols are often used today for the initial scanning of patients with already known pathology.

Indications for CT of the chest

It is customary to highlight some general indications for CT scan of the chest cavity organs, most of which involve differential diagnosis of changes detected by conventional radiography or fluorography. Such indications, in particular, include:

• pathological formation (obvious or suspected) in the chest cavity, including the lungs, mediastinum, pleura and chest wall;

• enlargement of the lymph nodes of the mediastinum and roots of the lungs (obvious or suspected);

• lobar and segmental infiltrates in the lung, the nature of which is unclear on the basis of plain radiography;

• common bilateral changes in the lungs (obvious or suspected), including in interstitial lung diseases;

• pleural effusion of unknown origin;

• trauma and injury to the chest.

In principle, any doubts about the correct interpretation of X-ray data are a serious argument in favor of performing CT [6]. In some cases, CT can also be performed with a normal X-ray picture in order to search for pathological changes that are invisible on plain radiographs, for example:

• staging of malignant tumors: bronchogenic cancer, malignant lymphomas;

• possible pathological formation in the mediastinum in patients with myasthenia gravis;

• emphysema in patients with spontaneous pneumothorax;

• bronchiectasis and endobronchial tumors in patients with hemoptysis;

• interstitial lung diseases in patients with impaired respiratory function and clinical symptoms;

• thromboembolism of the pulmonary artery in the presence of spiral scanning technology and the possibility of CT angiography.

In a number of foreign countries, CT is beginning to be used as a screening method for bronchogenic cancer instead of radiography and fluorography. It is well known that CT can reliably detect pathological lesions in the lungs of 5 mm or more, while X-ray and fluorography - from 10 mm. At the same time, the detectability of small formations in the lungs at CT does not depend on a number of negative “X-ray” factors (physical and technical conditions of the image, interposition of bone structures, correct patient positioning, etc.). In one of the largest studies in this area, the use of CT in the examination of the risk group revealed foci in the lungs in 23.3% of patients. lesions, while on radiography, foci were found only in 7%. Lung cancer was detected on CT in 27 cases (2.7%), of which 26 tumors were resectable, and 23 (85%) had stage I, and 19 of 23 lesions (75%) in stage I were not visible on radiographs. Other researchers also obtained comparable data.

The use of modern low-dose spiral CT protocols made it possible to reduce patient exposure to a level comparable to plain radiography. However, the question of the fundamental feasibility of screening lung cancer using radiation research methods remains a subject of discussion to this day. It is unclear whether these programs can actually reduce the death rate of lung cancer patients, or whether such costly programs will prove economically viable.

CT examination techniques

Any diagnostic CT scan of the chest cavity is a series of tomograms of the area being examined. It focuses on the study of lung tissue, airways, mediastinum, pleura and chest wall. In the initial study, tomograms are performed from the apex to the diaphragmatic sinuses, with the thickness of the tomographic layer and the distance between the layers being 8-10 mm. This technique allows you to study the entire volume of the chest cavity using slices adjacent to each other (adjacent slices), without missing a significant pathology. If pathology is detected on a series of primary (native) tomograms, special techniques can be used to clarify the nature of changes associated with the introduction of contrast agents, a decrease in the thickness of the tomographic layer, an exhalation study, etc.

Currently, it is customary to distinguish two main technologies of CT examination: step-by-step (sequential) and spiral [6, 8]. Step-by-step technology involves stopping the X-ray tube after each rotation, during which the table with the patient moves to the next position, and the patient has the opportunity to inhale and hold his breath for the next rotation. This technology is the main and only one on the devices manufactured before the mid-1990s. In later modifications, step-by-step CT continues to be used to study the brain, especially in the area of the skull base, bones of the facial skeleton, large joints, as well as for high-resolution CT of the lungs.

High resolution CT

HRCT is a step-by-step scanning option and consists in performing three technological steps: reducing the thickness of the tomographic layer to 1-2 mm, targeted reconstruction of the studied part of the chest cavity, and using a special high-resolution imaging algorithm. All three actions are aimed at increasing the spatial resolution as much as possible. The technique is designed to study the most subtle changes in the lung tissue at the level of the anatomical elements of the secondary pulmonary lobule and acini.

HRCT is currently used to diagnose interstitial lung diseases, emphysema, and bronchiectasis. Assessment of interstitial lung diseases at HRCT allows to significantly narrow the differential diagnostic range, to objectively speak about the activity of the inflammatory process, to choose the optimal place and type of biopsy, if necessary. In some cases, HRCT manages to get as close as possible to the histo-specific diagnosis, in particular, in sarcoidosis, lymphangioleiomyomatosis, histiocytosis, and lymphogenous carcinomatosis.

Important indications for HRCT are spontaneous pneumothorax and hemoptysis in the absence of changes on plain radiographs. The main cause of spontaneous pneumothorax is emphysema, in the detection of which HRCT has undeniable advantages over any other diagnostic methods. In patients with hemoptysis and a normal chest x-ray, HRCT should be preceded by bronchological examination. This tactic allows you to confidently detect both endobronchial tumors and bronchiectasis, which are invisible during bronchoscopy. An important finding during HRCT in such patients is areas of pulmonary tissue imbibition with blood, which indicates the localization of the source of bleeding even before bronchoscopy.

The study of the fine anatomical structure of the lung tissue is closely related to the processes of ventilation and blood circulation (perfusion). The state of the lung tissue with impaired ventilation in patients with obstructive changes is studied under conditions of expiratory CT. With this technique, HRCT is performed at the height of the delayed expiration. In zones of impaired bronchial patency, equal in volume to individual lobules, sometimes segments and even lobes, when examining on exhalation, areas of increased airiness are revealed - air traps.

In patients with acute and, especially, chronic thromboembolism of the pulmonary arteries (PE), there is a redistribution of blood from areas with obliterated vessels to areas with preserved blood flow. As a result, the density of normal lung tissue increases due to excess perfusion, which reflects They are in the presence of uneven or mosaic perfusion in the form of alternating areas of low and high density. This picture may resemble obstructive changes, but when examining on exhalation, the density of the lung tissue increases in all areas.

The role of HRCT in the study of interstitial lung diseases has long remained insufficiently understood. As a rule, such a study was performed with insufficiently obvious changes on radiographs or with a discrepancy between radiological and clinical data.

Indications and protocols for high-resolution CT

Indications

Obvious changes on the radiograph - diffuse infiltrative process Normal or nearly normal radiograph, suspected diffuse infiltrative process

Suspected or apparent bronchial disease

Protocols

Inspiratory HRCT, table pitch 10-20 mm Inspiratory HRCT, table pitch 10-20 mm. Additional cuts in prone position, table pitch 30-40 mm. Inspiratory HRCT, table pitch 10 mm

Additional images

Expiratory HRCT, table pitch 30-40 mm - in case of suspected exogenous allergic alveolitis.

Maximum intensity projections (STS MIP) - for suspected miliary focal changes.

Expiratory CT, table pitch 20-30 mm - in case of suspicion of diseases of the small bronchi.

Narrowing of the electronic window to detect emphysema or areas of swelling in the pathology of the small bronchi.

Minimum Intensity Projections (STS minIP) to detect minimal mosaic patterns.

expand and specify the indications for HRCT:

• detection of diffuse changes in the lungs in patients with a normal or almost normal x-ray picture;

• narrowing of the differential diagnostic range in case of nonspecific changes on radiographs up to the establishment of a histo-specific diagnosis;

• assessment of the reversibility of changes in the lungs;

• study of patients with unexplained obstructive changes;

• assessment of patients with hemoptysis;

• determination of the type and location of lung biopsy.

The most commonly used scanning protocols in typical clinical situations are shown in the table. In addition to the listed group of diseases, HRCT can be used to clarify the data of spiral scanning, which is widely used to assess single rounded formations in the lungs or local (lobar and segmental) infiltrative changes. However, most of the pathological processes in the lung tissue, trachea and large bronchi, vessels of the chest cavity, in the mediastinum, pleura and chest wall should be studied using spiral CT.

Spiral CT

Spiral scanning technology, in contrast to step-by-step, assumes continuous rotation of the X-ray tube while continuously moving the table with the patient through the gantry window. As a result, the trajectory of the X-ray beam projected onto the human body takes the form of a spiral. The main advantage of the spiral technology is a sharp acceleration of the scanning process as a result of elimination of the time intervals between individual rotations of the X-ray tube. Examination of the chest can be performed with one breath hold, for 10-20 s, which is especially important for the study of the respiratory system.

The result of a spiral scan is a single continuous data set about the area of interest. Unlike step-by-step CT, this array is not divided into separate fragments (tomograms) by discrete X-ray tube rotation cycles. With the help of special mathematical programs from this data array, images can be obtained in any plane, both two-dimensional and three-dimensional, three-dimensional. The advent of multilayer CT has further expanded the scope of virtual technology based on isotropic imaging. The essence of multilayer CT is the use of several rows of detectors instead of one. In this case, one tomographic layer can be divided into several tomograms. These new capabilities have eliminated the most important disadvantage of CT compared to MRI, which was to obtain informative tomographic images only in the axial plane.

CT angiography

The need for contrasting vessels in CT examinations of various anatomical areas arises due to the insufficient contrast resolution of the method. The differences in the X-ray density of blood flowing through the vessels, the walls of the vessels and most soft tissue structures, with the exception of adipose tissue, are insignificant. Without the introduction of a contrast agent (CV), it is not possible to distinguish blood in the lumen of the vessel from the vessel wall, to reveal a narrowing of the internal lumen due to thrombus formation, as well as thickening, stratification or damage to the vascular wall.

With a native CT examination of the chest cavity, only the outer contours of the vessel are clearly visible, and only if it is surrounded by adipose tissue of the mediastinum or air-containing lung tissue. The layers of fat in the mediastinum are insufficiently expressed in children, adolescents, persons with an asthenic constitution, which significantly complicates evaluates the vessels. Even greater difficulties arise in the presence of soft tissue formations in the mediastinum, the root of the lung or lung tissue, in the area of which the vessels are not visualized.

Attempts to use CT to assess vascular pathology of the chest cavity have been made since the mid-1970s. In this case, intravenous drip was used, and subsequently also a bolus injection of CV into the ulnar vein, during which from 2 to 5-7 tomographic sections were performed per minute. Abroad, this CT technique has become standard in the study of patients with neoplasms.

With spiral CT angiography, scanning is performed at the time of injection of 80-100 ml of CV into a peripheral vein at a rate of 2-4 ml / s. The circulation time of CV through the large vessels of the chest cavity or any other anatomical region is limited to several tens of seconds. If scanning is possible during this time interval, it becomes possible to see the inner lumen of the vessels filled with contrasting blood.

CT angiography combines all the advantages of CT itself with the capabilities of conventional angiography. It can be performed even on an outpatient basis, since anesthesia and complex intravascular interventions are not required.

CT angiography has acquired the greatest clinical significance in the staging of malignant tumors of the thoracic cavity (bronchogenic cancer, malignant lymphomas), in the diagnosis of pulmonary embolism, assessment of thoracic aortic aneurysms and vascular malformations in the lungs and mediastinum.

In patients with cancer, CT angiography can reliably reveal the narrowing and deformation of the vessels of the mediastinum and the roots of the lungs during their invasion by a primary tumor or altered lymph nodes. The most reliable results were obtained in the presence of changes in the vena cava, large pulmonary arteries and veins. Narrowing of these vessels or deformation of their contours by adjacent tumor masses are objective signs of invasion of the vascular wall. These data are of great importance in planning surgical or radiation treatment.

It is more difficult to determine if the tumor has grown into the thoracic aorta. Only a few patients have a clear deformation of the lumen of the vessel due to the ingrowth of a pathological formation. In other patients, the involvement of the aorta in the tumor process can be judged only on the basis of indirect signs. The most important of these are the adherence of tumor masses to the vessel for more than 3 cm in the longitudinal direction or annular coverage of the vessel by the tumor for more than 1/2 of its diameter.

PE is one of the most difficult diagnostic problems. For a long time, her diagnosis was based on plain chest X-ray, perfusion scintigraphy and, if necessary, pulmonary angiography. This algorithm has undergone major revisions in recent years. It has been established that spiral CT angiography can reveal up to 98% of emboli in the main, lobar and segmental arteries.

In the late 1990s, the difficulties of detecting changes in subsegmental pulmonary arteries were actively discussed. When using relatively thick tomographic layers, changes in these vessels were usually missed, which worsened the overall indicators of the information content of the method. However, with the advent of devices in which the time of one rotation of the X-ray tube became less than 1 s, this problem was solved. An increase in the scanning speed made it possible to reduce the thickness of the tomographic layers to 3-5 mm and to dramatically improve the image quality of the subsegmental arteries.

A number of studies have shown that the use of spiral CT angiography in combination with ultrasound scanning of the veins of the lower extremities as the first and only method for assessing pulmonary vessels is the most accurate, shortest and cheapest algorithm for diagnosing pulmonary embolism. Vascular and complex malformations in most patients with X-ray examination resemble a tumor or inflammatory process. The use of CT angiography makes it possible to reliably establish the presence of vascular malformation, its localization and topographic-anatomical relationships with the surrounding structures and, on this basis, radically change the treatment tactics. Three-dimensional transformation programs are especially important here. An important advantage of CT angiography over traditional pulmonary angiography is the ability to simultaneously assess the state of the lung tissue around the malformation zone.

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