Ultrasound Method for Pleural Punctures in The Diagnosis and Treatment of Exudative Pleuritis

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Abstract. The World Health Organization warns that the conditions for the spread of infectious diseases increase when the level of vaccination of the population falls. In order to prevent fatal cases, it becomes a question of timely diagnosis. The article examines issues related to medical care, diagnosis, and pharmacotherapy of exudative pleurisy. The advantages and features of ultrasound diagnostics are mentioned. The ultrasound method in the diagnosis and treatment of exudative pleurisy was studied. The effectiveness of ultrasound diagnostics in lung diseases has been proven. The optimal method of performing pleural punctures with the help of ultrasound control in exudative pleurisy has been developed. It is noted that a significant advantage of ultrasound diagnostics is the absence of X-ray exposure. It was concluded that the implementation of the program of medical guarantees in the provision of medical care to patients with exudative pleurisy will contribute to the improvement of the quality of diagnostics, the use of ultrasound methods to optimize the system of legal relations "doctor-patient-pharmacist".

Keywords: ultrasound method, pleural punctures, diagnosis, treatment, patient, exudative pleuritis, liquid, pleural cavity, pleural effusion.

Introduction. The World Health Organization warns about the level of vaccination coverage of the population. When it drops by several percent, there are conditions for the spread of infectious diseases [1-5]. Today, the life and health of every person and patient depends on preventive measures:

- ✓ personal hygiene rules;
- ✓ health of the respiratory system;
- ✓ personal safety to avoid breast injuries;
- ✓ rules for timely referral to doctors regarding infectious conditions for prescribing pharmacotherapy;
- ✓ procedures for regular medical examinations, vaccinations, prevention of chronic and concomitant health disorders in accordance with ICD-11 [6-17].

Note that, according to the Ministry of Health of Ukraine, from March 4 to 10, 2024, 146,953 citizens (85,064 of whom were children) fell ill with influenza, COVID-19 and other acute respiratory viral infections, and 4 202 patients [6, 7, 18]. In order to prevent fatal cases, it becomes a question of timely diagnosis [19]. We note that pleurisy is inflammation of the pleura with the formation of fibrin on its surface or the accumulation of effusion in the pleural cavity [20-26]: Pleural effusion (Fig. 1) means the accumulation of pathological fluid in the pleural cavity during inflammatory processes (exudates) or when the ratio between hydrostatic pressure in capillaries and colloid-osmotic pressure of blood plasma (transudate) [27, 28].

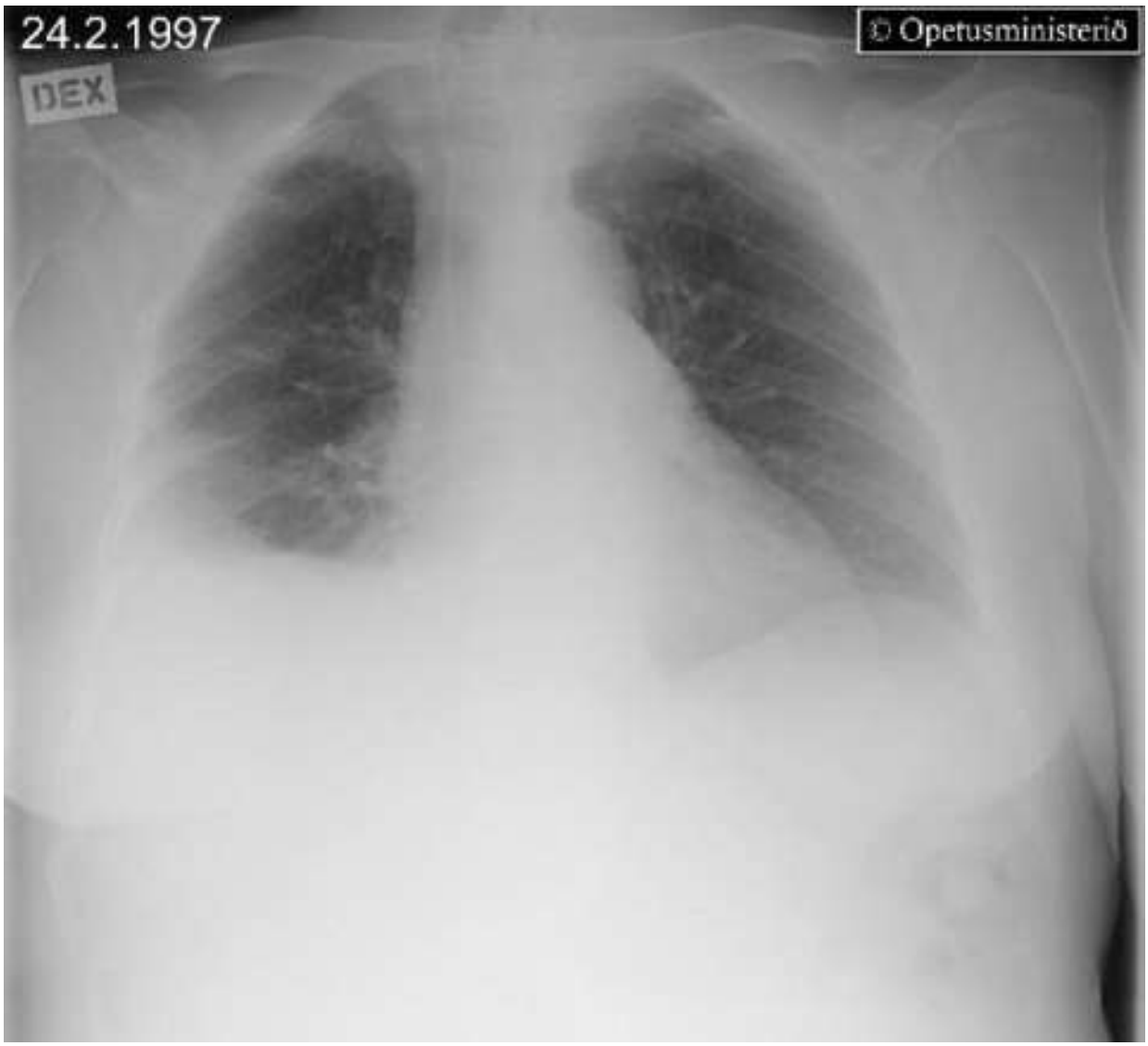

Fig. 1. Pleural effusion in a cancer patient. Abundant pleural fluid on the right side. The patient has metastatic pancreatic carcinoma.

In the United States, pleural effusion is a common respiratory disease. Every year, 1.5 million new cases are diagnosed, of which 500,000 are attributed to congestive heart failure, 150,000 to malignant neoplasms [29].

Etiological factors of exudative pleurisy are:

- bacterial or viral infections;
- chest injuries;
- tumors;
- autoimmune diseases (type 1 diabetes, hyperthyroidism, inflammation of the thyroid gland, systemic lupus erythematosus).

Allergic pathology can cause pleural effusion disease. No less often, the inflammatory process is associated with respiratory tract infections (pneumonia), heart failure, and 150,000 - malignant neoplasms [29].

So far, about 50 nosologies have been identified that can lead to the occurrence of pathological fluid in the pleural cavity [30]. Regarding the etiological factors that lead to the occurrence of exudative pleurisy, tuberculous lesions of the lungs and pleura, nonspecific inflammatory processes [31] and autoimmune pathologies are distinguished. At the same time, malignant neoplasms can cause the appearance of pathological fluid in the pleural cavity [32, 33]. Inflammation of the liver and pancreas can lead to the phenomenon of exudative pleurisy, and traumatic lesions of the chest organs can be accompanied by exudative pleurisy [34-36].

Symptoms of pleurisy: cough, pain in the chest during breathing, difficulty breathing (dyspnea), increased temperature, fever (in some cases). Problematic questions regarding medical care, diagnostics, and pharmacotherapy require further research into exudative pleurisy.

The purpose of the study was to establish the effectiveness of the ultrasound method in the diagnosis and treatment of exudative pleurisy.

The use of this study when performing pleural punctures may have advantages or disadvantages compared to the X-ray method. The authors decided to solve the task of developing the optimal method of performing pleural punctures using ultrasound control in exudative pleurisy.

Materials and methods. The experimental base of research - the department of ultrasound diagnostics of the Communal Non-Commercial Enterprise of the Lviv Regional Council Lviv Regional Phthisiopulmonology Clinical Treatment and Diagnostic Center is equipped with modern ultrasound equipment from Siemens, Philips, Aloka, Toshiba. This allows for a wide range of ultrasound examinations to diagnose endocrine, hepatobiliary, urological, mammalogical, and gynecological pathologies [37, 38]. Ultrasound diagnostics is the acquisition of objective data on the state of organs or systems, their functions, which allows detecting pathology even before the onset of clinical manifestations and makes it possible to treat the disease in the early stages.

The study of the article is a fragment of the research works of the department of phthisiology and pulmonology of Danylo Halytsky Lviv National Medical University - Department of phthisiology and pulmonology "Study of clinical, radiological and laboratory features of diagnosis and course of chronic obstructive pulmonary diseases and bronchial asthma in broncho-obstructive syndrome in patients with tuberculosis or pneumonia" and "Study of the features of the clinical course, prevention and treatment of chemoresistant tuberculosis in children and adolescents" (state registration number 0120U002141, implementation period 2020-2024) and Lviv Medical Institute LLC on the topic "Improving the system of drug circulation during pharmacotherapy on the basis of evidence-based forensic pharmacy, organization, technology, biopharmacy and pharmaceutical law" (state registration number 0120U105348, implementation period 2021-2026).

Results and discussion. Advantages of ultrasound diagnostics include:

- absolute safety for the patient (absence of radiation exposure, non-invasiveness);
- high sensitivity and specificity of the received data;
- research of blood flow parameters in real time;
- possibility of dynamic monitoring;
- speed and at the same time high informativeness of the examination.

The clinic carries out two types of ultrasound diagnostics using sensors for external and internal cavity (rectal, vaginal) examination.

Today, our specialists perform the following types of ultrasound diagnostics (Fig. 2):

Ultrasound diagnosis of lungs and pleural cavity	Echocardiography (ultrasound diagnostics of the heart and its structural elements)
Ultrasound diagnosis of abdominal organs	Dopplerography (investigation of the state of blood vessels)
Ultrasound diagnosis of pelvic organs	Intracavitary (transvaginal) ultrasound examination of a woman's genitals
Ultrasound diagnosis of joints	Folliculometry (assessment of the condition of the ovaries)
Ultrasound diagnostics of the retroperitoneal space	Echohydrotubation (estimation of fallopian tube patency)
Ultrasound diagnostics of the neck and thyroid gland	Transrectal ultrasound diagnostics for examination of internal genital organs in men
Ultrasound diagnosis of lymph nodes	Ultrasound diagnosis of pregnant women
Ultrasound diagnosis of mammary glands	3D examination of the state of the fetus

Ultrasound diagnostics of organs of the male reproductive system	Ultrasound diagnostics of the veins of the lower extremities
All types of ultrasound diagnostics for children	

Fig. 2. Types of ultrasound diagnostics.

Modern ultrasound examination is a highly informative method of diagnosing the condition of human internal organs. It is based on the ability of human body tissues to reflect ultrasound waves. After scanning individual parts of the body, such a signal is processed and appears on the monitor in the form of a specific image that makes it possible to assess the condition of the examined tissues.

Before conducting ultrasound diagnostics, doctors give certain recommendations regarding preparation for the examination:

- giving up bad habits on the eve of the examination;
- restriction in the consumption of flour, fatty and fried food a few days before the diagnosis;
- mandatory bowel cleansing;
- consultation with a doctor regarding the expediency of taking medications;
- notification of the doctor about the endoscopy the day before, if such an examination really took place;
- filling the bladder (drinking water before the examination) during the examination of the genital organs.

Ultrasound diagnostics has several significant advantages that make this method of diagnosis the most convenient and informative in terms of diagnosing the state of internal organs:

- diagnosis is quick and does not take much time;
- the examination does not require special preparation;
- ultrasound is absolutely safe for the human body and cannot cause any disturbances;
- ultrasound diagnostics is highly effective;
- diagnosis can be performed on patients of all age groups.

In clinical practice, pleural punctures are widely used for diagnostic and therapeutic purposes in the presence of fluid in the pleural cavity. These manipulations make it possible to clearly differentiate hydrothorax from inflammatory exudative processes by performing Rivalt's test [39, 40].

Cytological and immunocytochemical examination of the fluid itself from the pleural cavity in other nosologies of inflammatory and immune genesis is uninformative. Therefore, doctors can predict (suspect) the detection of a specific tubercular process with an increased level of lymphocytes in the exudate. Tuberculosis mycobacteria or malignant cells in the exudate are extremely rare. Revealed, for example [41]:

- the red color of the exudate is most often inherent in a malignant process or pulmonary embolism;
- light yellow color of the pleural fluid can be caused by specific, non-specific inflammatory processes, autoimmune pathology.

Performing pleural punctures should be clearly defined by the location and depth of needle insertion. As you know, the injection point is the upper edge of the lower rib along the 7th and 8th intercostal lines, linea axillaris posterior or linea scapularis. It is quite problematic to establish the injection site, especially in cases of limited exudative pleurisy, periscissuritis or during control examinations after performing pleural punctures.

Traditionally, X-ray examination is carried out. When repeated, a significant radiation load is possible, both on the patient and on the doctor. This procedure is performed with the patient standing in the X-ray room. Pleural punctures according to planned indications are performed in the dressing room or procedure room with the patient in a sitting position. In this situation, the projection of the location of the exudate on the chest wall can change significantly. Difficulties may arise when performing the indicated manipulation. This is especially true for relatively small exudates limited in size. This indicates that the x-ray method has a number of significant

disadvantages. The ultrasonic method of detecting fluid in the pleural cavity is devoid of the above-mentioned disadvantages [42].

Thus, the ultrasound method is becoming increasingly widespread and used in the diagnosis of exudative pleurisy in the differentiation between exudates and transudate (Fig. 3) [36, 43-46].

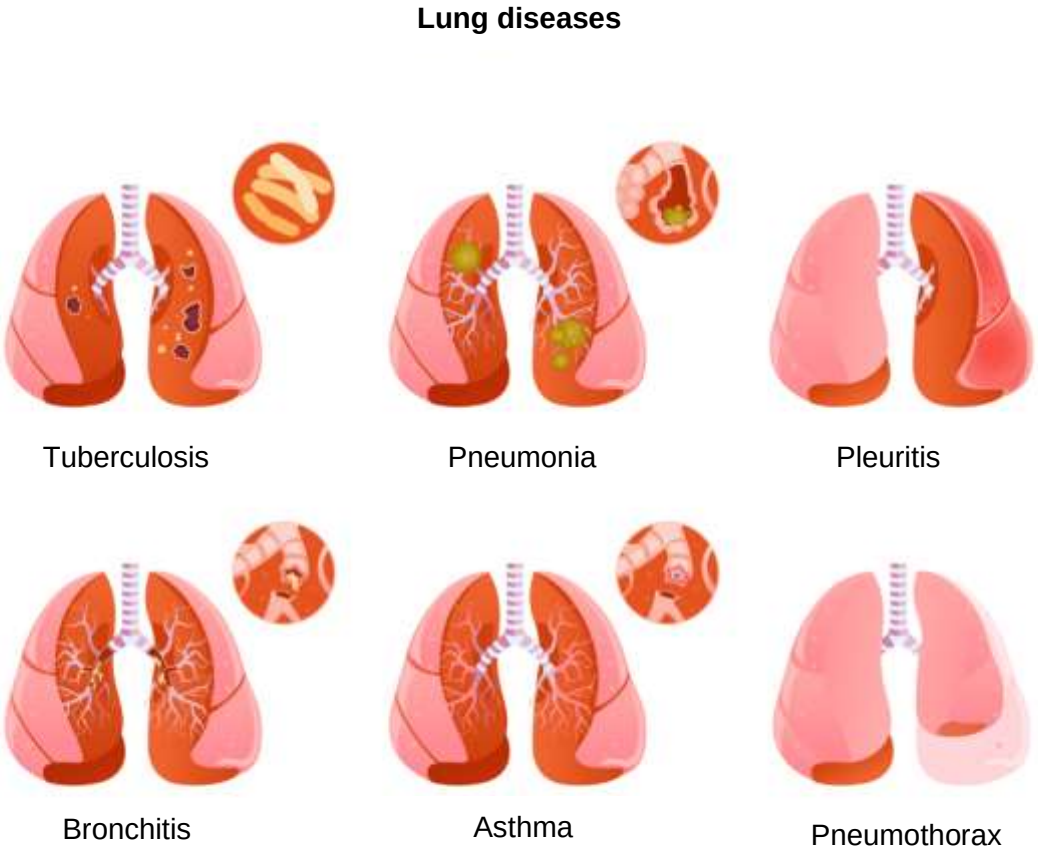

Fig. 3. Lung diseases (tuberculosis, pneumonia, pleuritis, bronchitis, asthma, pneumothorax).

Literary sources indicate that when using this study, a very small amount of fluid in the pleural cavity can be detected - up to 20 ml. In addition, performing pleural punctures to remove fluid from the pleural cavity under ultrasound control increases the efficiency of this procedure to 97% [47]. The minimum amount of fluid in the pleural cavity, which can be detected by X-ray, is more than 200 ml [48-50].

The authors of the article consider it essential that with limited exudative pleuritis, periscissuritis, it is possible to very clearly establish a point for pleural cavity puncture. Accordingly, carry out successful evacuation of the pleural contents. Also, ultrasound diagnostics in exudative pleurisy helps to clearly detect the presence of pleural effusions [32].

The authors performed pleural punctures according to the standard technique with the patient in a sitting position. The procedure was mainly performed in the dressing room of the thoracic department. Occasionally, in the procedure room of the therapeutic department. A 20 ml Luer syringe and standard pleural puncture needles were used.

First, local anesthesia was performed with a 0.5% solution of Procaine (Novocaine) or a 2% solution of Lidocaine at a certain point on the chest wall. Layer-by-layer infiltrative anesthesia of the soft tissues of the chest wall was performed. Later, a puncture needle connected to a luer syringe was inserted into the pleural cavity. The rule to perform a pleural puncture along the upper

edge of the lower rib in order to prevent damage to the intercostal artery was always strictly followed.

Later, when the patient was holding his breath during exhalation, a rubber adapter was connected between the puncture needle and the syringe and the contents of the pleural cavity were removed.

An Alpinion ecube 12 ultrasound device with a nozzle for lung research was used to detect fluid in the pleural cavity, establish the pleural puncture point, and monitor the effectiveness of the performed pleural puncture. Ultrasound examination for the presence of fluid content in the pleural cavity was carried out according to standard methods.

In order to establish the point of pleural needle injection, patients also underwent fluoroscopy of the lungs. This diagnostic procedure was carried out in an X-ray room. The patient's position is standing under the X-ray machine. The doctor who later performed the punctures was also in the X-ray room.

During the study, the authors analyzed the results of diagnosis, pharmacotherapy and treatment of 1015 patients with exudative pleurisy who were in hospital treatment. All patients were conditionally assigned to 2 groups. The first group included 317 patients. In the first group, the ultrasound method of research was performed for the purpose of diagnosis. The second group included 698 patients who underwent a fluoroscopic examination. Each of the groups had two subgroups (A – patients with exudative pleurisy and B – patients with limited exudative pleurisy). In the first group (317 people), in subgroup A there were 293 patients with exudative pleurisy, in subgroup B – 24 patients with limited exudative pleurisy. In the second group (698 people), respectively, there were 642 patients in subgroup A and 56 patients in subgroup B (Fig. 4).

1,015 patients with exudative pleuritis	
The first group of 317 patients	The second group of 698 patients
Ultrasound method of examination	X-ray examination method
Subgroup A – patients with exudative pleurisy 293 patients	Subgroup A – patients with exudative pleurisy 642 patients
Subgroup B – patients with limited exudative pleurisy 24 patients	Subgroup B – patients with limited exudative pleurisy 56 patients

Fig. 4. Results of diagnosis, pharmacotherapy and treatment of patients with exudative pleuritis who were in hospital treatment.

In case of exudative pleuritis, pleural punctures were performed at standard points (VII-VIII intercostals along the linea axillaris posterior). After the maximum release of exudate to the vacuum, radiography or ultrasound diagnostics were performed, respectively, to determine the presence of fluid content in the pleural cavity.

The results of diagnostic and therapeutic pleural punctures in patients with exudative pleurisy under radiological control were analyzed. With an average and large amount of exudate, shadowing with an upper oblique Demoiseot line or with a straight line (if there is air in the pleural cavity) was radiologically determined. The shading extended to the diaphragm. With a small amount of exudate, shadowing was observed in the costophrenic sinuses.

Ultrasound diagnosis of free fluid in the pleural sinuses revealed its presence, fibrin threads and heterogeneous echo structures (small mobile hyperechoic inclusions). In case of fibrinous exudative pleuritis, layering of fibrin on the pleura was detected. The pleura was, as a rule, thickened, with an uneven contour, had a homogeneous structure and increased echogenicity.

There were no technical difficulties or problems when performing pleural punctures under X-ray control in the specified situations. In order to control the effectiveness of pleural punctures after the evacuation of fluid from the pleural cavity, X-ray control is not always sufficient. In cases of fluid removal "to a vacuum", radiologically, it is not always possible to detect the presence of fluid in the pleural cavity, if the amount of this exudate was from 30 to 50 ml. As you know, the

minimum amount of fluid in the pleural cavity, which is detected radiologically, is more than 200 ml.

The results of the effectiveness of pleural punctures under X-ray and ultrasound control are presented in Fig. 5.

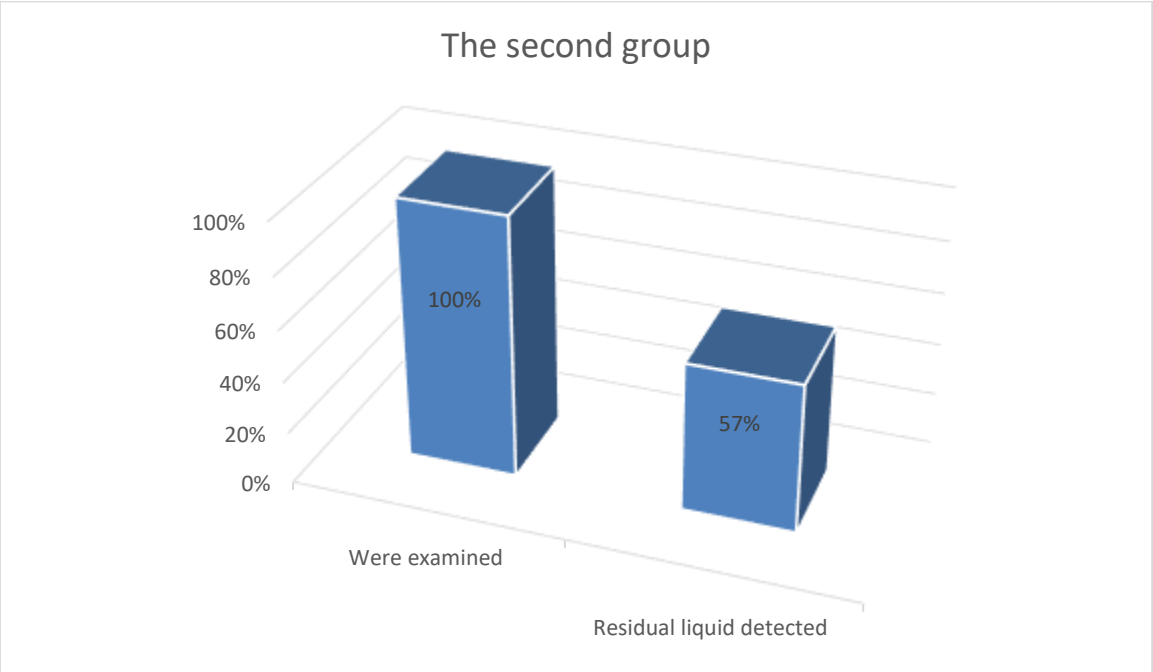

Fig. 5. Results of effectiveness of pleural punctures under X-ray and ultrasound control.

The following information was received:

- ✓ 314 patients of the second group (100%) underwent ultrasound diagnosis after a negative X-ray result of the presence of fluid in the pleural cavity;
- ✓ in 179 cases (57%), from 30 to 50 ml of residual fluid in the pleural cavity was detected. This confirms that the x-ray method, which was used as a control after pleural punctures in patients with exudative pleurisy of the second group, is insufficiently informative. And, on the contrary, the teaching of ultrasound diagnostics in this case is effective.

Limited exudative pleurisy in patients of the 2nd group was determined radiographically in the form of clearly limited rounded shadows of different sizes. In 48 cases (85.7%), these limited pleuritis were located "parietal" near the costal pleura.

With an interlobular location, limited exudative pleurisy had the appearance of disc-shaped, oblong, elongated shading. The radiographic method of examination of the chest organs was performed by doctors in the radiology room. The patient stood in front of the device screen. Puncture of the pleural cavity was performed in the dressing room with the patient in a sitting position. In connection with this, there was a change in the location of limited exudative pleurisy.

With the size of limited shadows up to 3 cm during fluoroscopic control, pleural puncture was not effective in 15 cases (27%). This required ultrasound diagnostics in the room of the dressing room. In all cases, repeated pleural puncture was effective.

When performing fluoroscopy, it is necessary to take into account the radiation load on both the patient and the doctor. On average, during a one-time X-ray examination, the radiation load on the patient was 1.5 millisieverts.

If we take into account that pleural puncture, according to the rules, also requires a control fluoroscopy, then the radiation exposure for one patient is 3 millisieverts. Performing a pleural puncture under ultrasound control is safe in terms of radiation exposure.

Optimizing the system of legal relations "doctor-patient-pharmacist" with the help of the medical guarantee program will contribute to the improvement of the quality of diagnostics, the

use of ultrasound methods in the provision of medical care, and the pharmaceutical provision of patients with exudative pleurisy [51-53].

Conclusions. Problematic issues regarding medical care, diagnosis, and pharmacotherapy of exudative pleurisy are emphasized. The advantages and features of ultrasound diagnostics are mentioned. The ultrasound method in the diagnosis and treatment of exudative pleurisy was studied. The effectiveness of ultrasound diagnostics in exudative pleurisy has been proven. The optimal method of performing pleural punctures with the help of ultrasound control in exudative pleurisy has been developed. It is substantiated that performing pleural punctures for the evacuation of pleural contents under ultrasound control has advantages over radiological control in the diagnosis and treatment of limited exudative pleurisy. It is noted that a significant advantage of ultrasound diagnostics over fluoroscopic diagnostics is the absence of X-ray exposure. In the course of the study, it was noted that there is no reliable difference between ultrasound and fluoroscopic examination in pleural punctures of medium and large exudative pleurisy. It was concluded that the implementation of the program of medical guarantees in the provision of medical care to patients with exudative pleurisy will contribute to the improvement of the quality of diagnostics, the use of ultrasound methods to optimize the system of legal relations "doctor-patient-pharmacist". The availability of pharmaceutical care and pharmacotherapy for patients with exudative pleurisy requires further investigation.

Conflict of interests. The authors confirm that they are the authors of this work and have approved it for publication. The authors also certify that the obtained clinical data and research were conducted in compliance with the requirements of moral and ethical principles based on medical and pharmaceutical law, and in the absence of any commercial or financial relationships that could be interpreted as a potential conflict of interest.

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Ethical approval. Ethical clearance was obtained from the administration of the Danylo Halytsky Lviv National Medical University. Permission statement for conducting the experiments was received from the administration of the Danylo Halytsky Lviv National Medical University. Before any data collection, the main purpose of the study was clearly explained to each department (concerned personnel).

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