Ultrasound Examination of the Lung Focal Lesions: Topical and Differential Diagnosis during Thoracoscopic Operations
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Summary
The most frequent indications for thoracoscopic operations are lung focal lesions. But their success is limited by weak intraoperative topical diagnosis. That is why part of these operations switch to open ones. This article is devoted to thoracoscopic ultrasound examination during such type of interventions, which aimed at two main goals. The first one is to localize the pathology and its proximity to large blood vessels and bronchi. And the second one is to determine the nature of the disease. Both of these issues allow the surgeon to optimize the order (model) of operation and significantly improve its result. This article provides with the method of thoracoscopic ultrasonography and presents the specific ultrasound pictures of normal collapsed lung tissue and different types of pathology such as tuberculomas, hamartomas, peripheral cancer, metastasis, etc.

Introduction
During last years thoracoscopic operations become widely used [1–5]. The most frequent indications for thoracoscopic operations are lung focal lesions. Though the routine use of roentgenography and CT examinations before the operation give an important information about the location and other characteristics of lung focal lesion. But the results of all these examinations are not enough informative to choose the correct treatment tactics and the way and method of the endoscopic operation. The differential diagnosis of the lung focal lesions before the operation, even using spiral CT with contrast enhancement, gives only orientational information, that’s why the only correct tactics for the lung focal lesions is resection of the focal lesion with histological examination of the lesion [1].

One of the factors, that doe’s not allows to use thoracoscopic operation of lung focal lesions more widely in clinical practice, is the problem of topological diagnostics. The mane amount of the operations, which began as thoracoscopic operation, is finally ended as thoracotomy, because of the limited abilities of the intraoperative revision and because it is impossible to find out pathological lesion using only instrumental revision of the lungs. The search of the lung focal lesions during thoracoscopic revision becomes difficult because of the deformation of lung’s volume as a result of the lung’s collapse.

The method of the intraoperative ultrasound examination of the lung focal lesions during thoracoscopic operation was worked out in Surgery Institute named after A.V. Vishnevsky of Russian Academy of Medical Sciences. We were the first in the world to brought the method into clinical practice began with year 1995 [2–5]. Until this time we couldn’t find any articles in the scientific literature devoted to the problem of use of the intraoperative ultrasound examination of the lungs (IOUS).

The first goal of ultrasound examination was to localize the focal lesions for definition of lung resection border and detection of foreign bodies. Another important goal of the ultrasound examination was an attempt to determine the nature of the disease and to learn semiotics of different focal lesions and to work out the differential diagnosis.

The method IOUS was made to the patients with such lung focal lesions as: hamartomas, tuberculomas, carcinoid, peripheral cancer and metastasis.

Mane part of the patients had solitar focal lesions. The size of these lesions was between 5 and 26 mm. Focal lesions were located subpleural and also deep in the lung tissue. In some cases the small focal lesions were located close to the lung’s root and very close to large blood vessels and bronchi. This fact mainly increases the importance of precision diagnostics for modeling of the lung resection

Method
The ultrasound examination of the lungs was made using a special guided multi frequency endoscopic convex probe, which was put into the pleural cavity by 10–11 mm thoracoport (fig. 1). During scanning frequencies 6,5 and 7,5 MHz were usually used.

We used B-mode, color Doppler imaging and PW-mode.
For the more effective ultrasound examination of the lung tissue it is necessary to have a fully collapsed lung. The collapse of the lung was achieved by method of separate intubation, disconnection of lung, aspiration from the bronchi and instrumental palpation in the zone of interest. The criterion of full collapse of the lung and its freedom from the air (that makes it possible to exam the lung tissue deeply) is coloring the lung in a special blue color. For achieving acoustic penetration of the lung it is necessary to disconnect the lung for 10–35 min. For achieving the main goals of the study it is necessary repeat ultrasound scanning of the lungs many times (fig. 2).

The first step of the study was to detect focal lesions. After that the model of lung resection was made, the aim of this procedure is to achieve correct volume of the operation and the best functional results of the resection (fig. 3). Scanning is made under imposition of a suture apparatus on the tissue for control of the focal lesion position according the cutting line of the tissue every time before imposition of next cassette. After the resection of the lung it is necessary to scan the rest part of the lung in the zone of seam to confirm the absence of the focal lesions. This is very important in the case of numerous tuberculomas.
The ultrasound examination of the lungs was effective in 91% of all cases. The detection of the lung focal lesions allows modeling the borders of marginal and wedge-shaped (V-shaped) resections with best functional results. In all cases there were no atelectasis or zones of hypoventilation detected by roentgenographic examination after the operation.

In 9% of the cases the study was not informative because it was impossible to achieve the full lung collapse with the best acoustic penetration of the organ. The reason of this situation was impossibility to make separate ventilation because of low saturation during breathing by means of one lung. In these cases thoracotomy with palpation examination and resection of the lung was fulfilled.

Normal echographic picture of the lungs
The echographic picture of the lungs is mainly depended upon the degree of the collapse. Making the ultrasound examination of the lungs during full lung collapse, we get the ultrasound picture, which is close to the picture of the parenchymal organ with vessels and structures with high acoustic density – bronchi. During the ultrasound examination fully collapsed lung looks like parenchymal organ, being an acoustic penetrated medium (fig. 4). In color Doppler imaging and PW-mode lung’s arteries and veins have intensive high-velocity blood flow with special phases. Bronchi – is a structure, containing air, and are visualized as areas with high acoustic density. A tissue with high density and very low ultrasound penetration characterizes the ultrasound picture of full lung collapse. In this case it is possible to detect and study lung
focal lesions located not only subpleural, but in the depth of not more than 5–10 mm as well (fig. 5).

Ultrasonographic semiotics of lung focal lesions

Analysis of all the study materials, connected with the results of urgent and planned histological studies, made it possible for us to work out ultrasound semiotics of some lung focal lesions. Among all lung focal lesions, detected by IOUS, the largest group was the patients with hamartochondromas and tuberculomas. The most common structure of tuberculomas is low acoustic density in comparison with adjoining lung tissue; they may have contour regular or irregular contour (fig. 6 and 7). However tuberculomas are those lung focal lesions that have very wide polymorphism, and this fact is displayed in variety of the ultrasonographic picture. Among all studied tuberculomas there were different types of contents: homogeneous fluid–pus (fig. 5), and dense caseous masses. In some cases tuberculomas had a concentric structure (fig. 8).

There were also tuberculomas with “tissue” echographic structure, in these cases the main differential sign of tuberculomas in comparison with chondromas were irregular contour of tuberculomas, that is the sign of involving of the adjoining lung tissue in the pathological process (fig. 9). The vessels of tuberculomas are not detected by color Doppler imaging. Another type of the lung focal lesions, that was diagnosed often, was a focal lesion with histological picture of hamartochondroma. In all cases chondromas had round form, precise and regular contour, sometimes with a thin capsule, “tissue” acoustic structure (fig. 10–12). In some cases...
Chondromas had calcium inclusions that was seen by the ultrasound as small areas of high-density tissue. The detection of such kind of lung focal lesions when they were located subpleural made it possible in some cases to fulfill enucleation of these focal lesions.

(Fig 16)

During the ultrasound examination of the tumor focal lesions, that were metastasis, it was found out that the acoustic density of these focal lesions was higher in comparison with collapsed lung tissue. These focal lesions during ultrasound scanning looked like hyperechogenic areas with precise but often irregular contour (fig. 13, 14). Sometimes it was possible to detect blood flow by color Doppler imaging in the areas with the size more than 2 cm (fig. 15).

During the ultrasound examination carcinoid tumor of the lungs looked like focal lesion with complicated structure – there were solid zones and cyst zones (fig. 16).

In the cases of peripheral cancer focal lesions had anomalous form and irregular contour. However the number of studied tumors of the lungs was too small to make a full description of the characteristics of the ultrasound picture of these tumors (fig. 17, 18).

Foreign body in the lungs – a bullet, which stayed in the lung for more than 2 months, wasn't detected during visual and instrumental revision. During scanning acoustic density of the bullet was higher in comparison with adjoining lung tissue with mild perifocal tissue reaction (fig. 19). Another case of foreign body – a piece of metal, had very high acoustic density during scanning, as it was expected (fig. 20). The abilities of the differential diagnostics of lung focal lesions established by the study, no doubt, are very interesting. However in our days this method of the diagnostics can't be a guide for choosing surgical tactics, but it has an academically interest. Unconditionally, worked out and presented here topical and differential diagnostics is only the first step in development methods of widely used intraoperative examination in thoracoscopic surgery in the cases of lung and mediastinum diseases.

(Fig 17)
(Fig 19)

The role of our differential diagnostics is limited this time. Unconditionally, it is impossible to plan treating tactics without the results of histological study.

Now the differential diagnostics makes it possible to decide a problem and choose enucleation in the cases of not deeply located hamartomas or to escape from this procedure and to make resection in cases, where we suspect malignant tumors or tuberculosis. That's why ultrasound scanning is very important not only in the cases of deep location of the lung focal lesion to define the topic, but also in the cases of subpleural pathology. Today the ultrasound scanning of the lungs is the only method of intraoperative diagnostics, which allows planning and fulfilling the operations of lung focal lesions in thoracoscopic variant. Of course there are some technological limitations in using of the described method, the efficacy of the method is not 100%. One of the problems, which are necessary to decide, is the time of lung collapse, necessary to establish the correct acoustic penetration of the organ. On our point of view, the use of isolated short-time ventilation of the operating lung with the inert gas – xenon or helium (these gases disperse quickly and without any harm to the organism) – has many good prospects. It is necessary for achieving the quick and full lung collapse, restoration of the acoustic penetration of the lung tissue and for the high efficacy of the ultrasound examination of the lungs.

(Fig 20)

But already today in the main part of the cases with focal lesions located in the depth of lung tissue, ultrasound examination is the method, which determine the success of the operation in thoracoscopic variant.

Detailed topical diagnosis of lung focal lesions allows optimizing the order (model) of lung resection and significantly improving its functional results.

The abilities of the differential diagnosis of lung focal lesions by their echographic signs open a new page in the diagnostics of lung diseases.
Bibliography