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THE CAPABILITIES OF COMPUTED TOMOGRAPHY AND MAGNETIC RESONANCE IMAGING IN ASSESSING THE LOCAL INVASION OF LUNG CANCER

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The purpose of the study was an assessment the diagnostic capabilities of computed tomography and magnetic resonance imaging in evaluating the local invasion of lung cancer. 320 patients with lung cancer who were hospitalized from 2010 to 2013, were observed. The mean age of the patients was 52.3 ± 0.3 years (35 to 75 years). Computed tomography and magnetic resonance imaging were performed to detect cancer invasion. The specificity, sensitivity, and accuracy of the methods were calculated. The most reliable signs of cancerous invasion of the pleura were such as the presence of "tumor-pleural" paths, as well as thickening of the pleura at the border of contact with the tumor for more than 3 cm ($r=0.787$ and $r=0.705$, respectively). In determining the signs of cancerous invasion of the chest wall, CT demonstrated high sensitivity of 86.9 % and accuracy of 76.8 %, but low specificity (49.0 %). MRI was characterized by high sensitivity (75 %), accuracy (70 %), but low specificity (50 %). According to obtained results we can recommended both computed tomography and magnetic resonance imaging for detection of local cancer invasion. **Key words:** lung cancer, radiation diagnostic methods, pleural invasion, regional metastases

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МОЖЛИВОСТІ КОМП'ЮТЕРНОЇ ТОМОГРАФІЇ ТА МАГНІТНО-РЕЗОНАНСНОЇ ТОМОГРАФІЇ В ОЦІНЦІ МІСЦЕВОЇ ІНВАЗІЇ РАКУ ЛЕГЕНЬ

Метою дослідження стала оцінка діагностичних можливостей комп'ютерної томографії та магнітно-резистивної томографії у визначенні локальної інвазії раку легень у прилеглі органи та тканини грудної клітки. Під наглядом перебувало 320 хворих на рак легень, які перебували на стаціонарному лікуванні з 2010 по 2013 роки. Середній вік хворих становив $52,3 \pm 0,3$ року (від 35 до 75 років). Усіх пацієнтів обстежили за допомогою комп'ютерної томографії та магнітно-резонансної томографії. Розраховано специфічність, чутливість та точність методів дослідження. Найбільш достовірними ознаками ракової інвазії плеври були такі, як наявність «пухлинно-плевральних» шляхів, а також потовщення плеври на межі контакту з пухлиною більше 3 см ($r=0,787$ та $r=0,705$ відповідно). Комп'ютерна томографія характеризувалася високою чутливістю 86,9 % та точністю 76,8 %, але низькою специфічністю (49,0 %). Магнітно-резонансна томографія продемонструвала високу чутливість (75 %), точність (70 %), але досить низьку специфічність (50 %). Згідно з отриманими результатами ми можемо рекомендувати як комп'ютерну томографію, так і магнітно-резонансну томографію для виявлення місцевої ракової інвазії.

Ключові слова: рак легень, променеві методи діагностики, інвазія плеври, регіональні метастази

Lung cancer (LC) is one of the leading cause of cancer-related death in the world [2, 12]. According to report of Global Cancer Observatory, owned by the World Health Organization/International Agency for Research on Cancer, there were more than 2.2 million new cases of lung cancer in 2020 [11]. If identified at an early stage, surgical resection of LC offers a favourable prognosis, with 5-year survival rates of 70–90 % for small, localized tumours (stage I) [9]. Unfortunately, most patients (about 75 %) already have advanced disease at the moment of confirmation of diagnosis (stage III/IV) [15] and despite significant developments in the oncological management of late stage LC over recent years, survival remains poor. The UK Office for National Statistics reported that patients diagnosed with distant metastatic disease (stage IV) had a 1-year survival rate of just 15–19 % compared with 81–85 % for stage I [8].

The exact determination of the clinical stage of lung cancer is still relevant, since the choice of treatment method depends on it [14]. Certain difficulties are presented not only by the exact characterization of the state of the lymph nodes of the mediastinum, but also the invasion of the tumor in neighboring tissues (pleura, chest wall, etc.) [4]. Computed tomography (CT) reveals an increase in all groups of mediastinal lymph nodes [13]. There is a point of view that magnetic resonance imaging (MRI) does not provide additional information about the state of the mediastinal lymph nodes in comparison with CT, since both methods are based on measuring the diameter [2, 7].

In this regard, the importance of determining the diagnostic capabilities of such modern and informative methods as computed tomography and magnetic resonance imaging for assessing the prevalence of the process can have an invaluable impact on the timeliness of diagnosis and largely determine the choice of treatment method in patients with LC.

The purpose of the study was to provide an assessment of the diagnostic capabilities of computed tomography and magnetic resonance imaging in evaluating the invasion of lung cancer in adjacent organs and tissues of the chest.

Materials and methods. In total, 320 patients with lung cancer were hospitalized at the National Oncological Center of the Ministry of Health of the Republic of Azerbaijan, the City Oncological Dispensary of Baku, as well as at the Department of Oncology of the Azerbaijan Medical University in the period from 2010 to 2013. The main contingent of patients was aged 35 to 75 years. The mean age of the patients was 52.3 ± 0.3 years.

Central lung cancer was diagnosed in 214 (66.9 %) patients, and peripheral form in 106 (33.1 %) patients. The vast majority of the examined (72.8 %) had III and IV stages of the disease. According to the results of histological examination, squamous cell carcinoma of varying degrees of differentiation was found in 170 (53.1 %) patients, adenocarcinoma in 114 (35.6 %), and small cell carcinoma in 36 (11.3 %) patients.

CT scanning (n=45) was performed on a “Bright Speed” CT scanner (USA). The tomography time was 4–5 seconds; the tomography step was chosen depending on the volume of the formation (usually it ranged from 4 to 9 mm), and the thickness of the resulting section was 2–8 mm. When analyzing CT, the main attention was paid to such signs as the anatomical shape of the tumor formation, the establishment of its specific localization, the size of the tumor, the state of the bronchial lumen, the transition of the tumor to individual anatomical structures of the mediastinum and the wall of the chest cavity.

MRI scanning (n=30) was carried out on a “Magnetom Open” tomograph (Siemens, Germany), which has a resistive magnet with a magnetic field strength of 0.2 T. The placement and orientation of the slices were carried out according to the median images in the sagittal and frontal projections in the PS sequence in T1 mode (TR–250 ms, TE–40 ms). Then transverse tomography was performed in the PS sequence in T1 mode (TR–500 ms, TE–35 ms), which made it possible to obtain slices. Both T1 and T2 weighted images were evaluated. The areas of examination were determined by the localization of the tumor and possible ways of its metastasis. If necessary, this volume of research was supplemented by obtaining an image of the object under study in longitudinal projections (frontal and sagittal).

The research results were processed by the methods of parametric and nonparametric statistics using standard statistical processing packages (Statgraphic, CricketGraph). The correlation of semiotic features for determining the prevalence of the tumor process was performed using a non-parametric rank criterion proposed by Spearman. The significance of differences in signs between groups was determined using the chi-squared test. The correlation coefficient was calculated using the Pearson formula for parametric indicators of communication, taking into account a small sample. To assess the diagnostic effectiveness of the studied methods, indicators such as sensitivity (N), specificity (S) and accuracy (T) were determined, as well as the positive predictive value (PPV) and the negative predictive value (NPV).

Results of the study and their and discussion. In the process of work, we encountered certain difficulties. In cases of development of atelectasis on CT, it is not always possible to determine the size of the tumor formation and separate the primary tumor focus from regional metastases in the lymph nodes. Not always CT made it possible to determine the germination of the tumor on the walls of the chest cavity.

Studying computed tomograms in patients with subpleural localization of peripheral cancer, we were able to identify a number of signs that, in our opinion, can be taken as criteria indicating the involvement of the pleura in the tumor process: 1) thickening of the pleura over 4–3 mm, 2) thickening of the pleura at the border of contact with the tumor with a length of more than 3 cm, 3) uneven contours of the pleura at the level of the tumor, 4) the appearance of “tumor-pleural” paths, 5) the disappearance of extrapleural adipose tissue, 6) retraction of the pleura at the border with tumor, 7) the presence of an obtuse angle between the tumor formation and the pleura.

Thanks to the above criteria, with the help of CT, we were able to detect cancerous invasion of the pleura in 41 (91.1 %) cases. The spread of the tumor to the pleura in 29 (64.4 %) cases was proved by the results of surgical intervention.

The most reliable signs of cancerous invasion of the pleura were such as the presence of “tumor-pleural” paths, as well as thickening of the pleura at the border of contact with the tumor for more than 3 cm.

Statistical processing of the results showed a very good correlation of these signs (the correlation coefficient was 0.787 and 0.705, respectively).

At the same time, the leading signs of cancerous invasion of the visceral pleura were a combination of the following symptoms – the detection of “tumor-pleural” paths, unevenness and retraction of the pleura at the border with the tumor formation, as well as visualized thickening of the pleura itself. In 84.4 % of cases, tumor paths leading to the pleura detected on CT scan are a reflection of tumor invasion of the

lymphatic vessels, i.e. this picture is the result of cancerous lymphangitis. Information about the diagnostic information content of CT in determining cancerous invasion of the pleura is shown in table 1.

Table 1

Diagnostic indices of CT value in determining the signs of cancerous invasion of the pleura

Diagnostic indices of the method	%
Sensitivity	82.2
Specificity	24.7
Accuracy	58.6
Positive predictive value	61.2
Negative predictive value	52.3

In our observations, a true positive result was established in 22 cases, a true negative result in 5 cases, a false positive result in 14 cases, and a false negative result in 4 cases.

Thus, CT has high sensitivity and accuracy in determining the signs of cancerous invasion of the pleural sheets.

Due to the high resolution of the method and the absence of a summative effect, CT makes it possible not only to assess the state of the pleura itself, but also to determine the state of the tumor adjacent to it. Unfortunately, low specificity reduces the value of the method in determining signs of pleural invasion.

According to the results of CT, cancerous invasion of the chest wall was detected in 10 (83.3 %) of 12 patients in whom this symptom was established by surgery. Moreover, a rather high level of correlation ($r=1.000$) and the reliability of conjugation of such a feature as destruction of the ribs were revealed. CT made it possible to identify destruction phenomena not only in the spongy substance of the ribs, but also their location in the cortical layer, and also to clearly identify changes located in the soft tissues of the intercostal spaces (correlation coefficient 0.822). In 7 (58.3 %) of 12 patients, CT data on cancerous invasion of the walls of the chest cavity were confirmed by surgical intervention data. Only in one case, overestimation of CT data was allowed in identifying signs of cancerous invasion of the chest wall, and it was associated with expansive tumor growth.

The diagnostic information content of CT in determining the signs of cancerous invasion of the chest wall was characterized by the following indicators: sensitivity 86.9 %, specificity 49.0 %, accuracy 76.8 %, positive predictive value 81.9 %, negative predictive value 59.7 %. In our observations, a true positive result was found in 7 patients, a true negative result in 2 patients, a false positive result in 2 patients, and a false negative result in 1 case.

The analysis of our material shows that CT has a high potential in detecting signs of cancerous invasion of the chest wall, especially in accurately establishing the stage of T2 and T3, and this makes it possible to accurately plan the extent of surgical intervention. The low percentage of false positives appears to be related to the resolution limits of CT.

When studying the possibilities of MRI in assessing the local spread of peripheral cancer to adjacent organs and tissues of the chest, we took into account both the results of previous studies and CT data. The analysis of MRI data in determining the spread of the tumor to the pleural sheets and soft tissues of the chest wall was based on such signs as: 1) the disappearance of extrapleural adipose tissue; 2) destruction of the ribs and the transition of the tumor to the soft tissues of the intercostal spaces; 3) a significant thickening of the pleura and a change in its normal configuration at the border of contact with the tumor formation.

With the help of MRI, it was most often possible to identify such a symptom as a change in the thickness of the pleura (26.7 %), but unfortunately, the correlation of this symptom with the results of surgical intervention was very low. More reliable MRI-signs of cancerous invasion were such symptoms as thickening of the pleura at the border of its direct contact with the tumor for more than 4 cm, and retraction - retraction of the pleura at the border with the tumor (the correlation coefficient of which was 0.829 and 1.00000, respectively). In assessing cancerous invasion of the chest wall, such signs as the disappearance of extrapleural adipose tissue and the presence of an additional shadow in the intercostal spaces and beyond had a fairly high correlation coefficient with the results of surgical intervention.

With the help of the above criteria, by means of MRI we managed to detect cancerous invasion of the pleura in 20 (66.7 %) patients, and the transition of the tumor process to the chest wall in 7 (23.3 %) cases. At the same time, the transition of the cancerous process to the pleura and chest wall tissues was confirmed by the results of surgical intervention – in 16 (53.3 %) and 8 (26.7 %) cases, respectively.

According to the analysis of our material, during MRI, the main signs of cancerous invasion of the visceral pleura were its thickening, a change in its normal shape, and retraction at the border of the contact

between the pleura and the tumor formation. These symptoms were found in 56.7 % of cases. The most reliable signs of cancerous invasion of the parietal pleura were such signs as thickening of the pleura over a considerable extent at the site of its direct contact with the tumor formation, smoothing of the angles between the pleura and the tumor formation, as well as the absence of a radio signal of the required intensity according to T1, coming from the extrapleural adipose tissue. Unfortunately, it should be noted that even when the above signs of cancerous invasion of neighboring structures were detected, the number of false positive results was 3.3 % of cases, and this was due to reactive changes in the pleura itself.

The most reliable and reliable sign of cancerous invasion of the soft tissues of the chest wall is the disappearance of extrapleural adipose tissue at the border of direct contact of the tumor formation with the pleura. Based on the results of MRI studies and the data of the operation, it can be firmly asserted that the identification of these symptoms indicates a high risk of the cancer process spreading to the anatomical structures of the chest wall.

In our observations, in 7 (23.3 %) cases, the signs of cancerous invasion of the wall of the chest cavity, revealed by MRI – studies, were fully confirmed by the operation data. Tumor infiltration of the intercostal muscles had a high intensity signal compared to unaffected muscles. Only in one case, with the help of MRI, we failed to detect superficial destruction of the rib, and this error was associated not so much with the resolution of the method, but with an unsuccessfully chosen projection and the corresponding cut. False-positive results were associated with the presence of residual effects of previous inflammatory diseases of the lung and pleura.

Information on the diagnostic effectiveness of MRI-studies in determining the signs of cancerous invasion of the pleura and chest wall are given in table 2.

Table 2

Diagnostic efficacy of MRI in identifying signs cancerous invasion of the pleura and chest wall

Diagnostic indices of the method	%
Sensitivity	75
Specificity	50
Accuracy	70
Positive predictive value	85.7
Negative predictive value	33.3

In our observations, a true positive result was established in 18 cases, a false positive result in 6 cases, a true negative result in 3, and a false negative result in 3 patients.

As can be seen from this table, MRI – the study has both high sensitivity and accuracy in determining the signs of cancerous invasion of the pleura and chest wall. MRI, along with the detection of signs of cancerous invasion, makes it possible to record changes in radio signals at the border of direct contact between the pleura and the tumor. Unfortunately, the low specificity of the method does not make it possible to accurately state that the identified changes are always associated with cancerous infiltration. As our experience shows, the most common cause of false-positive MRI results are changes in the pleura itself due to previous inflammatory diseases.

Analysis of our material indicates that in peripheral lung cancer, MRI is especially important for establishing T3 and T4 descriptors, that is, if necessary, to determine the extent of the tumor to neighboring tissues.

Thus, both CT and MRI are highly sensitive and accurate in detecting cancerous invasion of the pleura. This conclusion coincides with the opinion of a number of authors (Laryukov AV; Goldstraw P et al.), who indicated that both methods are quite informative. Unfortunately, the low specificity of both research methods does not always make it possible to judge accurately their true nature based on the identification of these signs [2, 9]. Trufanov GE, et al., in their work described the difficulties in the differential diagnosis of pneumonia or an infiltrative (pneumonia-like) form of bronchioloalveolar lung cancer [5].

Compared to MRI, CT has greater potential for early detection of minimal rib destruction. In turn, due to the ability of MRI to register changes in the radio signal at the contact boundary of the tumor formation and neighboring structures, it makes it possible to better visualize the cancerous infiltration of the soft tissues of the chest wall [10]. This is also noted by Bebezov BKh, et al., who point to the advantage of MRI in detecting invasion into the mediastinal organs [1].

The percentage of false conclusions, in our opinion, is mainly associated with the limits of these methods, as well as with the wrong choice of the required slice, and with MRI and the corresponding projection.

Based on the data we obtained, we consider it appropriate to use CT or MRI, depending on the goals of diagnosis, and in each specific case to decide on the choice of method in a complex manner. Lyakhov AS et al. has a different opinion, they consider MRI as an alternative to CT in cases of intolerance to iodine-containing X-ray contrast agents and do not belong to the category of the most informative methods in the detection and differential diagnosis of focal lung lesions [3]. Although, as proved in our study, MRI has a fairly high sensitivity and accuracy in this matter.

Interestingly, Frolova IG considers it most expedient to use X-ray computed tomography of the lungs and mediastinum after traditional radiography, and if invasion of large vessels and pericardium is suspected, it is better use magnetic resonance imaging [6].

Conclusion

1. In determining the signs of cancerous invasion of the chest wall, CT was characterized by the following indicators: high sensitivity (86.9 %) and accuracy (76.8 %), while the specificity of the method is low (49.0 %).

2. The diagnostic information content of MRI in determining cancerous invasion of the chest wall and pleura is characterized by high sensitivity (75 %), accuracy (70 %), but rather low specificity (50 %)

3. Both computed tomography and magnetic resonance imaging are highly informative in the detection of cancer invasion in assessing the spread of lung cancer to adjacent organs and tissues of the chest, which gives reason to recommend them as the main methods in establishing the above signs.

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