ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LIX, N 1, 2 SECTIO D 2004

2nd Department of Radiology, Skubiszewski Medical University of Lublin

MAREK PASŁAWSKI, KONRAD KRZYŻANOWSKI,
JANUSZ ZŁOMANIEC, JACEK GWIZDAK

Morphological characteristics of malignant solitary pulmonary nodules

The solitary pulmonary nodule is a common radiologic abnormality, which is often detected incidentally. It is defined as focal, round or oval areas of increased opacity in the lung which are caused by a variety of disorders, including neoplasm, infection, inflammations, and vascular and congenital abnormalities (2).

Most of the solitary pulmonary nodules are benign, but up to 30%–40% of them are malignant (2)

The main goal of the radiologic evaluation of suspected solitary pulmonary nodules is to differentiate benign from malignant lesions as accurately as possible (2).

The aim of the study was the assessment of the morphological characteristics of the malignant solitary pulmonary nodules.

MATERIAL AND METHODS

Material comprises a group of 35 patients with malignant solitary lung nodule, in which CT examination was performed. The scanning was performed before and after administering 100 ml of contrast agents, from lung apices to the level of the diaphragm. The scan collimation was 10 mm. The scanning was performed with patients in a supine position, at full inspiration. Additional expiratory scans were obtained to reveal and assess possible emphysema peripheral to the lesion. The sizes of the nodules, margins, internal characteristics, contrast enhancement and morphology of surrounding structures were evaluated.

RESULTS

In four patients the diameter of nodule was less than 2 cm (Fig. 1). In 31 patients the nodules were larger than 2 cm. The margins of nodules were irregular and spiculated in 26 patients (Fig. 2). In four patients the nodules have lobulated margins (Fig. 3). In five cases the nodules have well-defined, smooth margins. The 23 nodules were inhomogeneous, with focal areas of lower density, suggesting the necrosis inside the nodules (Fig. 4).

Calcifications were found in three cases (Fig. 5). In seven patients nodules were peripheral, and infiltrated the pleura, with thickening of it and the presence of the pleural effusion.

In 31 patients the nodules show intense enhancement after administering the contrast agents, and the density increased more than 20 HU (Fig. 6 A, B). In four patients the increase in density after administering the contrast agents was less than 20 HU.

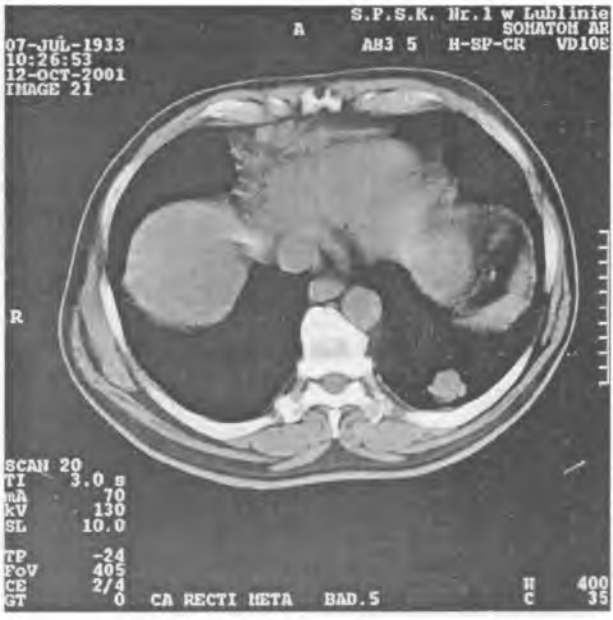

Fig. 1. A small solitary pulmonary nodule, in the peripheral part of the left lung

Fig. 2. Irregular, spiculated margins of the pulmonary nodule, with long spicules reaching the pleura

Fig. 3. Irregular, lobulated margins suggesting asymmetrical growth of the nodule. Infiltration of the chest wall

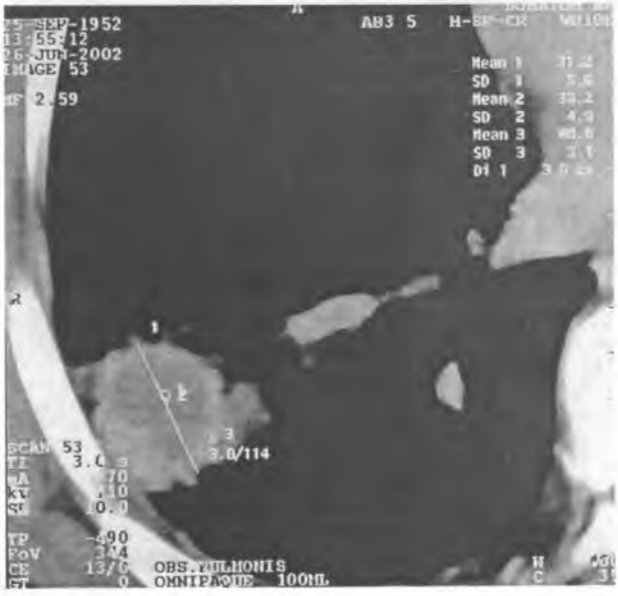

Fig. 4. Inhomogeneous density of the lung nodule, with focal areas of lower density, suggesting the necrosis inside the nodule. Thickened parenchymal band leading the lesion. Infiltration of the pleura

Fig. 5. Focal, irregular calcifications visible inside the lung nodule. Spicules reaching the pleura

DISCUSSION

The solitary pulmonary nodule is still a very important diagnostic problem. The most important thing is to determine if the nodule is benign or malignant. Several imaging modalities may be used in evaluation of the solitary pulmonary nodule. They include plain radiographs, computed tomography, PET.

Plain radiography is not a precise diagnostic method in evaluating the solitary pulmonary nodule. Usually it must be supplemented with CT. However a lot of solitary pulmonary nodules are still detected incidentally on plain radiographs.

Computed topography enables precise evaluation of the solitary pulmonary nodule. Morphologic evaluation of the solitary pulmonary nodule is very important. Small size of the nodule suggests the benign process. Up to 80% of benign nodules are below 2 cm in diameter. But 15% of small nodules below 1 cm and up to 42% of nodules smaller than 2 cm are malignant (2, 7).

Nodule margins are important in differentiating benign and malignant nodules. Smooth, well--defined margins are typical of benign nodules. However, about 20% of malignant nodules have well--defined margins. Lobulated margins imply uneven growth, associated with malignancy. But up to 25% of benign nodules have also lobulated margins (2, 6, 8).

Irregular and spiculated margins, especially with associated distortion of adjacent vessels are typical features of malignant nodules, especially if the spicules extend to the visceral pleura (2, 6).

An internal characteristic of the nodule is important in determining whether the nodule is benign or malignant. Homogeneous attenuation is seen on thin-section CT in 55% of benign and 20% of malignant nodules. Small, focal low-attenuation regions and air bronchograms within a nodule are typical of bronchoalveolar carcinoma. Cavitation is seen in both malignant and benign nodules. The benign cavitary nodules usually have smooth, thin walls. Thick, irregular walls are typical of the malignant process. Wall thickness less than 4 mm is typical of benign lesions. Most malignant cavitary nodules have more than 16 mm in wall thickness. The presence of intranodular fat, easily seen in CT, is typical of hamartromas (2, 6, 8).

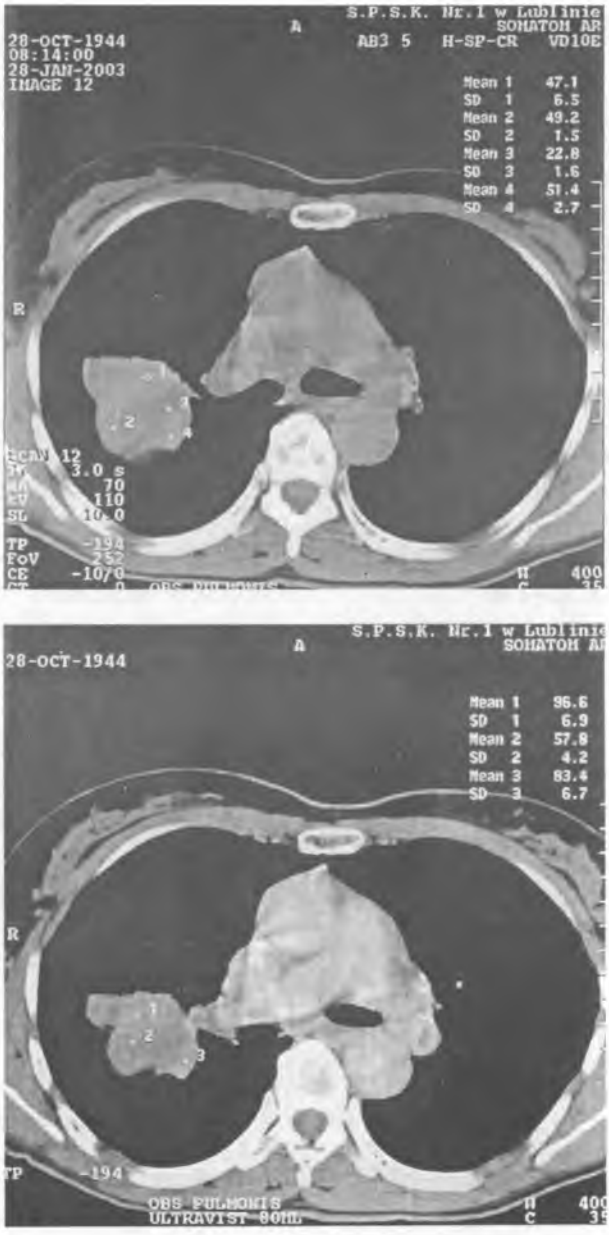

Fig. 6. The pulmonary nodule before (A) and after administering contrast agent (B) showing intense increase in density from 22-51 HU to 57-96 HU

Calcifications are frequent in benign nodules. They may be diffuse, central, laminated or popcorn--like. The first three types of calcifications are typical of inflammatory lesions, the popcorn-like calcifications are typical of hamartromas. Unfortunately calcification may be also found in malignant changes, and diffuse, irregular amorphous calcifications suggest the malignant process (2, 6).

The bronchus sign and vessel sign (bronchus or bronchioles leading to the nodule, and pulmonary vein leading to the nodule and contact with the lesion) are the characteristic features of malignant lesions (6).

The presence of the perifocal emphysema or atelectasis in the adjacent lung parenchyma, or in the periphery of the nodule is suggestive for malignant lesion (6). Retraction and thickening of the visceral pleura close to the solitary pulmonary nodule also suggest malignancy (6, 8). Involvement of vessels is typical of malignant changes, especially if three or more pulmonary vessels are involved in the process (8).

Contrast enhanced CT is very helpful in differentiation of malignant and benign nodules. It has been suggested that blood flow in malignant nodules is different than in benign ones. The degree of enhancement after administering contrast agents is related to the vascularity of nodules. Nodular enhancement of less than 15 HU is typical of benign nodules, while enhancement of more than 20 HU suggests the malignant lesion (3, 6, 7).

Also metabolic activity of the nodule may be evaluated in PET. Increased metabolism is typical of malignant lesions, permitting differentiation of benign and malignant nodules. But bronchoalveolar carcinoma may demonstrate low uptake of the radionuclide (3, 4, 6). For bronchoalveolar carcinoma the angiogram sign is typical, which is defined as linear, high attenuation of pulmonary vessels visible after administering contrast material within the nodule, of lower attenuation (5).

The growth rate is a helpful factor in determining the malignancy of the nodule. The doubling time (time in which the nodule double its volume) is much lower for malignant nodules than for benign ones. The doubling time for malignant nodules is less than 400 days (3). For nodules smaller than 5 mm the doubling time up to 180 days is considered typical of malignancy, while doubling time longer than 400 days suggested benign nodules (9).

Volumetric assessment using multislice CT detectors is much more accurate than in standard helical CT. It is possible to reveal the changes in the volume of the nodule within 30 days, with accuracy of 1 mm^3 (5, 9).

The metastases strongly resembled benign lesions in term of size and edge type, and inflammatory pseudotumors closely resemble the malignant solitary pulmonary nodule (6).

CONCLUSIONS

The solitary pulmonary nodule is an important diagnostic problem. The main goal of the imaging is determining whether the lesion is malignant or not. The assessment of morphological characteristics of the nodule is very helpful in the diagnostic process. Large nodule size, irregular, spiculated margins, inhomogeneous density of nodule thick walls in cavitary nodules suggest the presence of the malignant lesion. Smooth, well-defined margins, homogeneous density or the presence of diffuse, laminated, central or popcorn-like calcifications suggest benign nodule. Unfortunately there is a kind of overlapping, and some benign nodules may show features typical of malignancy, and some malignant lesion may appear benign, based on morphologic characteristics. Morphologic characteristics in computed tomography is however helpful in differentiation of benign from malignant nodules.

REFERENCES

1. Akata S. et al.: CT scanning of bronchioloalveolar carcinoma: specific appearances. Lung Cancer 12, 221, 1995.
2. Erasmus J. et al.: Solitary pulmonary nodules: Part I. Morphologic evaluation for differentiation of benign and malignant lesions. Radiographics, 20, 43, 2000.
3. Erasmus J. et al.: Solitary pulmonary nodules: Part II. Evaluation of the indeterminate nodule. Radiographics, 20, 59, 2000.
4. Haberkorn U., Schoenberg S.: Imaging of lung cancer with CT, MRT and PET. Lung Cancer, 34, S13, 2000.
5. Naidich D., Rusinek H.: Multislice low-dose CT for early lung cancer detection: Current status and future applications. Oncology, 68, 9, 2000.
6. Seemann M. et al.: Differentiation of malignant from benign solitary pulmonary lesions using chest radiography, spiral CT and HRCT. Lung Cancer, 29, 105, 2000.
7. Swensen S. J.: Functional CT: Lung nodule evaluation. Radiographics, 20, 1178, 2000.
8. Takanashi N. et al.: The diagnostic accuracy of a solitary pulmonary nodule, using thin--section high resolution CT: A solitary pulmonary nodule by HRCT. Lung Cancer, 13, 105, 1995.
9. Yankelevitz D. et al.: Small pulmonary nodules: Volumetrically determined growth rates based on CT evaluation. Radiology, 217, 251, 2000.

SUMMARY

The solitary pulmonary nodule is a common radiologic abnormality, which is often detected incidentally. It is defined as focal, round or oval areas of increased opacity in the lung which are caused by a variety of disorders, including neoplasm, infection, inflammations, and vascular and congenital abnormalities. Most of the solitary pulmonary nodules are benign, but up to 30%–40% of them are malignant. The main goal of the radiologic evaluation of suspected solitary pulmonary nodules is to differentiate benign from malignant lesions as accurately as possible. The aim of the study was the assessment of the morphological characteristics of the malignant solitary pulmonary nodules. Large nodule size, irregular, spiculated margins, inhomogeneous density of nodule thick walls in cavitary nodules suggest the presence of the malignant lesion. Smooth, well-defined margins, homogeneous density or the presence of diffuse, laminated, central or popcorn-like calcifications suggest the benign nodule. Diffuse, irregular amorphous calcifications suggest the malignant process. Unfortunately there is a kind of overlapping, and some benign nodules may show features typical of malignancy, and some malignant lesions may appear benign. Morphologic characteristics in computed tomography is however helpful in differentiation of benign from malignant nodules.

Charakterystyka morfologiczna złośliwych guzków płuc

Pojedynczy guzek płuca jest zmianą radiologiczną, która jest często wykrywana przypadkowo. Zmiana jest definiowana jako ogniskowy, okrągły lub owalny obszar zwiększonej gęstości płuc. Może być spowodowana przez różne procesy, nowotwory, infekcje, zapalenia, zmiany naczyniowe i zmiany wrodzone. Większość pojedynczych guzków płuca to zmiany łagodne, ale w 30-40% są to zmiany złośliwe. Głównym zadaniem oceny radiologicznej podejrzanych pojedynczych guzków płuc jest stwierdzenie, czy zmiana jest łagodna, czy złośliwa z największym możliwym prawdopodobieństwem. Celem pracy była analiza cech morfologicznych typowych dla złośliwych pojedynczych guzków płuc. Duży rozmiar guzka, nieregularne spikularne granice, niejednorodna gęstość guzka czy grube,

nieregularne ściany guzków jamistych sugerują obecność procesu złośliwego. Gładkie, dobrze zarysowane granice, jednorodna gęstość czy obecność zwapnień rozsianych, blaszkowatych, centralnych lub w kształcie "pop-cornu" sugerują obecność guzka łagodnego. Rozsiane, nieregularne, amorficzne zwapnienia sugerują proces złośliwy. Niestety, obrazy te często się nakładają i niektóre zmiany łagodne wykazują cechy typowe dla zmian złośliwych, a guzki złośliwe mogą wyglądać jak zmiany łagodne. Ocena morfologiczna pojedynczych guzków płuc w tomografii komputerowej jest jednak pomocna w różnicowaniu guzków łagodnych i złośliwych.