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ORIGINAL ARTICLE

Assessment of 64-slice spiral computed tomography with perfusion weighted imaging in the early diagnosis of ground-glass opacity lung cancer

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Summary

Purpose: *To evaluate the use of the 64-slice spiral computed tomography (CT) with perfusion-weighted imaging in the early diagnosis of ground-glass opacity lung cancers.*

Methods: *412 patients with ground-glass opacities found by conventional CT scan in our hospital, and deemed highly suspected of being lung cancers, were enrolled in the study between February of 2012 and February of 2015. Sixty four-slice spiral CTs with perfusion-weighted imaging were carried out on all patients, and the latest nodular contrast analysis software, MPR2D, 3D reconstruction technology, MIP technology and perfusion scanning technology were used to analyze lesion types, density, blood supply, peripheral signals, doubling time and tissue perfusion characteristics. This was repeated after one month, and the final pathologic diagnosis was used as a reference.*

Results: *There were 350 (84.95%) patients who were ultimately diagnosed with lung cancer. The main lesion type of lung cancer was quasi-circular, the average CT density was 56.7±5.4 HU, bronchial arterial enhancement increased in the nodule, peripheral signals were mainly irregular burrs, and the average doubling time was 1.2±0.3 s. Comparing these parameters with the ones in the non-cancer group, the differences found were with statistical significance ($p<0.05$). Importantly, tissue perfusion parameters of blood flow, blood volume, mean transit time and permeability surface in the lung cancer group were all significantly higher than those in non-cancer group ($p<0.05$).*

Conclusion: *From the findings in our study, we propose that 64-slice spiral CT with perfusion-weighted imaging can be used to diagnose ground-glass opacity lung cancer early, by taking into account variables such as lesion type, density, blood supply, peripheral signals, doubling time and tissue perfusion characteristics.*

Key words: *ground-glass opacity, lung cancer, perfusion-weighted imaging, 64-slice spiral CT*

Introduction

Lung ground-glass opacities are caused by changes in the lung parenchyma that result in blurry areas of decreased translucency, through which vascular and bronchial structures are still discernible. With the wide application of high resolution CT (HRCT) technology and the popularization of multi-detector CT (MDCT), more and more ground-glass opacities are detected in patients suffering from a multitude of pathologies, and the differential diagnosis can be challenging [1,2]. Apart from the non-neoplastic lesions such as inflammatory disorders and hemorrhages that can be manifested as ground-glass opacities, many neoplastic lesions can manifest themselves

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in this manner, such as peripheral adenocarcinoma, bronchoalveolar carcinoma, atypical adenomatous hyperplasia and lymphoma [3]. Up until now few studies have focused on the use of CT scans for the differential diagnosis of this lesion type in cancer. In the present study the new technology of spiral CT was evaluated as a means of distinguishing lung cancer from other ground-glass opacity lesions.

Methods

Patient information

412 patients with ground-glass opacities found by conventional CT scan and highly suspected of being lung cancers were enrolled in the study. All the patients were treated in our hospital between February of 2012 and February of 2015. There were 256 male and 156 female patients, their ages ranged from 37 to 68 years, with an average of 52.4±13.6 years. Exclusion criteria were: 1) Patients who had malignant tumors in other organs, pulmonary tuberculosis, chronic pneumonia or chronic obstructive pulmonary disease; 2) Patients presenting serious dysfunction of the heart, liver and/or kidney, and allergic reactions to contrast agents; 3) Non-compliant patients or patients who refused to take part in the research.

Experimental methods

After obtaining the approval of the Ethics Committee of our hospital and the informed consent of patients and their families, 64-slice spiral CT with perfusion-weighted imaging was carried out on all patients. The latest nodular contrast analysis software, MPR2D, 3D reconstruction technology, MIP technology and perfusion scanning technology were all brought into play to analyze lesion types, density, blood supply, peripheral signals, doubling time and tissue perfusion characteristics. This was repeated one month later, and the final pathologic diagnosis was used as the reference standard for the diagnosis of cancer.

The principles of perfusion-weighted imaging rely on the radioactive tracer dilution and central volume principles of nuclear medicine. Cine perfusion scan mode (continuous axial acquisition) affiliated to the CT machine is used for the perfusion scan protocol. All the patients in our study underwent inspected breathing training sessions in order to ensure that different imaging results due to diverse respiratory patterns were minimal. Patients were trained to perform a deep inhalation at the end of each expiration. Conventional CT scanning was carried out at the chest level, the thickness of the scan slices was 2.5mm, and the interslice thickness was 0.625 mm. The location of ground-glass opacity was determined to obtain morphological features of the lesions, and the dataset was then transferred to a workstation for nodule analysis. Then cine perfusion scan mode affiliated to the CT machine was used for perfusion scanning, the thickness of the perfusion slice was 5 or 2.5 mm, and there were 8 slices taken. The coverage area of the Z axle included all lesions, and a whole tumor perfusion scan was carried out. The method of 1-20 s, 28-48 s, 56-76 s, 84-104 s discontinuous breathing scan was employed during the scanning. Fifty ml of the contrast agent iopronide (Bayer Pharma AG, Munich, Germany) were administered at a flow rate of 5 ml/s. The body tumor perfusion software package was used to analyze lesions, and the four perfusion parameters of blood flow (BF), blood volume (BV), mean transit time (MTT) and permeability surface (PS) of the lesions were obtained. The processes followed for each scan review were the same employed for the initial diagnosis: two high-level technicians carried out before and after comparative analyses respectively.

Statistics

Data were analyzed using the SPSS 19.0 statistical software. Parametric results were expressed as mean±standard error, and one-way ANOVA was used for comparison among groups. Enumeration data were represented by percents, x^2 test was adopted for comparison among groups, and a $p<0.05$ was considered to be statistically significant.

Results

Comparisons of lesion types, density, blood supply, peripheral signals and doubling time

Pathology results confirmed a diagnosis of cancer in 350 patients (84.95%), with 164 patients having central type and 186 having peripheral type cancers, while 43 patients had only benign lesions and 19 had inflammatory lesions. The main lesion type of lung cancer was quasi-circular; the average CT density value was relatively high, and could be further increased with the extension of time. Bronchial arterial enhancement was increased in nodules, peripheral signals were mainly irregular burrs, the average doubling time was relatively short, and could be further shortened with the extension of time. Compared with the non-cancer group, the differences were with statistical significance ($p<0.05$; Table 1).

Comparisons of tissue perfusion parameters of blood flow, blood volume, mean transit time and permeability surface

The two scans showing tissue perfusion parameters of blood flow, blood volume, mean transit time and permeability surface in the lung cancer group resulted all in significantly higher values than those in the non-cancer group, and all

Table 1. Comparisons of lesion types, density, blood supply, peripheral signals and doubling time

Groups	*CT scan*	*Lung cancer group (N=350)*	*Non-cancer group (N=62)*	*x^2*	*p value*
Type	First time	Quasi-circular: 301 cases (86.0%)	Complex: 55 cases (88.7%)	5.627	0.036
	Second time	Quasi-circular: 311 cases (88.9%)	Complex: 53 cases (85.5%)	5.768	0.034
Average CT density value (HU)	First time	56.7±5.4	25.4±4.6	6.625	0.016
	Second time	58.5±6.2	23.2±4.3	6.732	0.014
Blood supply	First time	273 (78.0%)	9 (14.5%)	7.103	<0.001
	Second time	281 (80.3%)	7 (11.3%)	7.238	<0.001
Peripheral signals	First time	Irregular burrs: 308 cases (88.0%)	Relatively Smooth: 57 cases (91.9%)	8.614	<0.001
	Second time	Irregular burrs: 316 cases (90.3%)	Relatively Smooth: 59 cases (95.2%)	8.437	<0.001
Doubling time (s)	First time	1.2±0.3	3.5±0.7	6.827	0.027
	Second time	0.8±0.2	3.7±0.8	6.923	0.023

Values are means ± standard error

Table 2. Comparisons of tissue perfusion parameters of blood flow, blood volume, mean transit time and permeability surface

Groups	*CT scan*	*Lung cancer group (N=350)*	*Non-cancer group (N=62)*	*x^2*	*p value*
Blood flow (ml/s)	First time	13.4±2.3	3.6±0.4	5.627	0.029
	Second time	14.2±2.5	3.4±0.3	5.839	0.026
Blood volume (ml)	First time	5.6±1.3	1.3±0.4	4.748	0.037
	Second time	5.8±1.2	1.1±0.2	4.923	0.034
Mean transit time (ms)	First time	23.4±3.6	4.7±1.2	6.626	0.025
	Second time	25.6±3.2	4.3±1.1	6.349	0.027
Permeability surface	First time	35.4±6.6	10.2±3.1	6.137	0.029
	Second time	36.6±5.8	10.4±3.3	6.602	0.031

Values are means±standard error

differences were statistically significant ($p<0.05$; Table 2).

Discussion

Modern imaging technologies, especially the development of CT perfusion technology and PET-CT, can provide morphological, functional and molecular metabolic information, for the diagnosis, staging and monitoring of lung cancers. Since CT perfusion-weighted imaging can accurately portrait the micro-vessel changes of tissue angiogenesis in the living organism, it can be used to assess the biological activity of a tumor [2].

The comparisons of ground-glass opacities have been studied through CT values, as well as through the changes of a differential index [3]. Other researchers carried out comparative analyses looking at manual measurements of diameter, volume and mass of pulmonary ground-glass nodules, in order to find a method for identifying the changes of malignant ground-glass nodules with the passing of time [4-7]. Yamagushi et al. studied the aspects of type, size, marginal type, interface, internal structure and adjacent structure of ground-glass opacity lesions, and some basic conclusions pointing to the feasibility of such an approach were obtained [8].

CT with perfusion-weighted imaging technology is a kind of economic quantitative technique with no need for radionuclides, spatial and time resolutions of images are high, few factors confound its results and only a short imaging time is required. Perfusion weighted imaging technology has huge advantages in the research of hemodynamic state of tissues and organs, and its effectiveness and reproducibility have been verified by basic studies and clinical applications [9,10]. Currently, pulmonary CT with perfusion-weighted imaging is one of the most convenient, effective and efficient tools for quantitatively studying blood perfusion in the lung. Furthermore, high-density and high-spatial resolution anatomical images can also be obtained, rendering this type of CT scanning a very promising technique in medical diagnostics [11].

This study used an innovative body tumor perfusion software package to carry out the perfusion survey of pulmonary ground-glass opacities and the resulting perfusion values were found to be revealing of the type of subsequent pathological confirming diagnosis. This type of analysis has not been applied in previous reports [12]. Also, this is the first time the software from the General Electric (GE) Company has been used in a nodule comparative analysis, and the MIP software (GE Company) was used to study ground-glass opacities for the first time. We stress the importance of respiration training of the patients, since currently the CT machine cannot be connected to a respiratory gating monitor to align the scanning sequence with the respiration patterns. Equally, the selection of periods of time should be repeatedly fumbled through trial tests, because the discontinuous breathing scan will inevitably lose scan data of some periods of time. Undoubtedly, more studies are needed to determine the perfusion scan threshold value and the selection of perfusion layer of regions of interest completely depends on the experience of the operators, which can lead to inconsistencies.

In conclusion, 64-slice spiral CT with perfusion-weighted imaging can be used in the early diagnosis of lung cancer ground-glass opacities by detecting lesion types, density, blood supply, peripheral signals, doubling time and tissue perfusion characteristics that will differ significantly in non-cancerous lesions.

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Conflict of interests

The authors declare no confict of interests.

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