Added value of SPECT/spiral CT versus SPECT or CT alone in diagnosing solitary skeletal lesions

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Solitary skeletal lesions, benign, malignant, SPECT/spiral CT

Summary

Aim: The aim of this study was to investigate the added value of SPECT/spiral CT versus SPECT or CT alone in the differential diagnosis of solitary skeletal lesions. Methods: This was a retrospective study on a total of 69 patients who had a solitary skeletal "hot spot" that could not be definitively diagnosed using planar scintigraphy. Thus, SPECT/spiral CT was performed on the indeterminate lesions. SPECT, CT and SPECT/spiral CT images were independently interpreted by two experienced doctors who have both identification of CT and nuclear medicine. Each lesion was graded on a 4-point diagnostic scale (1: benign, 2: likely benign, 3: likely malignant, 4: malignant). The final diagnosis of each lesion was based on pathological confirmation after surgery within 3 weeks of the bone scan. Results: Final diagnoses based on the pathological results revealed that 43 of the 69 patients were diagnosed with malignancy, and the remaining 26 patients were diagnosed as having benign lesions. For SPECT and CT scans, both of the reviewers rated 55.1 % (38/69) and 37.7 % (26/69) of lesions as equivocal, with the help of SPECT/CT, 33.3 % (23/69) of lesions were rated as equivocal. The diagnostic accuracies of SPECT, CT alone and SPECT/CT were 66.7 % (46/69) ,82.6 % (57/69) and 85.5 %(59/69), respectively. The kappa scores for the degree of agreement between SPECT, CT alone or SPECT/CT with pathological results were 0.185 ($p = 0.054$) , 0.612 ($p < 0.001$) and 0.671 ($p < 0.001$), respectively. Conclusion: Compared with SPECT or imaging alone, SPECT/spiral CT imaging was more accurate and valuable in the differential diagnosis of solitary skeletal lesions and resulted in significantly fewer equivocal findings.

Schlüsselwörter
Solitäre Skelettläsionen, benigne, maligne, SPECT/Spiral-CT

Zusammenfassung

Ziel: In dieser Studie sollte der Zusatznutzen der SPECT/Spiral-CT gegenüber SPECT oder CT alleine für die Differenzialdiagnose solitärer Skelettläsionen untersucht werden. Methoden: An der retrospektiven Studie nahmen insgesamt 69 Patienten mit einem solitären „Hot Spot" im Skelett teil, der mittels planarer Szintigraphie nicht abschließend diagnostiziert werden konnte. Daher wurden die unklaren Läsionen mittels SPECT/Spiral-CT dargestellt. Die SPECT-, CT- und Spiral-CT-Aufnahmen wurden von zwei erfahrenen Ärzten mit Qualifikationen in CT und Nuklearmedizin unabhängig voneinander befundet. Jede Läsion wurde mit einer diagnostischen 4-Punkte-Skala klassifiziert (1: gutartig; 2: wahrscheinlich gutartig; 3: wahrscheinlich bösartig; 4: bösartig). Die Läsionen wurden innerhalb von 3 Wochen nach den Skelettaufnahmen operativ entfernt und anhand der pathologischen Beurteilung endgültig diagnostiziert. Ergebnisse: Als endgültige Diagnose auf der Basis der pathologischen Ergebnisse ergab sich bei 43 der 69 Patienten ein maligner Befund, bei den verbleibenden 26 Patienten wurden die Läsionen als benigne diagnostiziert. In den SPECT- bzw. CT-Aufnahmen beurteilten beide Gutachter 55,1 % (38/69) und 37,7 % (26/69) der Läsionen als nicht eindeutig, mithilfe des SPECT/Spiral-CT waren noch 33,3 % (23/69) der Läsionen unklar. Die diagnostische Genauigkeit von SPECT oder CT alleine und SPECT/CT lag bei 66,7 % (46/69), 82,6 % (57/69) bzw. 85,5 % (59/69). Die Kappa-Scores als Maß für die Übereinstimmung von SPECT und CT alleine bzw. SPECT/CT mit den pathologischen Befunden waren jeweils 0,185 ($p = 0.054$), 0,612 ($p < 0,001$) und 0,671 ($p < 0,001$). Schlussfolgerung: Die Darstellung mittels SPECT/Spiral-CT lieferte für die Differenzialdiagnose solitärer Skelettläsionen genauere und wertvollere Ergebnisse als SPECT oder Bildgebung alleine sowie signifikant weniger unklare Befunde."

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Bone scintigraphy is high sensitive, making it a useful clinical screening method to many pathologic conditions (9). Compared with planar scintigraphy, single-photon emission computed tomography (SPECT) offers improved the sensitivity for bone scanning, however, the revealed anatomical detail is inadequate (1, 8). But it is less specific because not only malignant bone lesions, but also many benign conditions, including degenerative diseases, infections, and benign bone tumours exhibit increased uptake of radiotracer (12).

Especially for solitary bone lesions, differential diagnosis of benign and malignant lesions is very difficult. The specific diagnosis of a bone disease is based on the location, matrix change, appearance of soft-tissue around the bone lesion, and the growth rate of a lesion, all of which can be obtained from diagnostic computed tomography (CT) scans. Fused SPECT/CT images can be obtained with integrated SPECT/CT scanners, and in these images, anatomical features are well recognized by CT, which combines the diagnostic power of morphological changes of diagnostic-quality CT with that of abnormal metabolism of SPECT within lesions, improving the diagnostic accuracy of bone disease imaging (5, 15, 18–22). The aim of this study was to evaluate the added value of SPECT/spiral CT versus SPECT or CT alone in diagnosing solitary skeletal lesions

Materials and methods

Patients

From April 2008 to September 2015, 32146 patients underwent bone scintigraphy. Among them, 17516 patients underwent SPECT/CT with equivocal skeletal lesions in the Department of Nuclear Medicine, Zhongshan Hospital, Fudan University. This study was retrospective and the patients were selected if the following criteria were both met:

- The patient only had a solitary skeletal "hot spot" that could not be definitively diagnosed using planar scintigraphy and these spots had been further evaluated with SPECT/CT.
- Histological verification had been completed as part of the patient's clinical management.

Tab. 1 Location of bone lesions in 69 patients.

region	number of lesions
cervical	2
thoracic vertebra	12
lumbar	10
sacrum	7
sternum	3
clavicle	2
scapula	2
humerus	3
rib	5
ilium	7
femur	12
patella	1
tibia	3

A total of 69 patients (42 men and 27 women, mean age: 46.8 ± 18.5 years, age range: 12–83 years) were investigated. Patients selected for our study included 19 patients who underwent surgical operation or chemotherapy for extraskeletal malignancies, while others had no history of extraskeletal malignancies, with bone lesions showed by other imaging studies such as X-ray, CT or MRI but without diagnosis and surgery before bone scintigraphy.

Patients with histories of skeletal malignancies, trauma, fracture and surgery were excluded. The locations of bone lesions are listed in ▶Tab. 1. The final diagnosis of each lesion was based on pathological confirmation after surgery within 3 weeks from the time of the bone scan.

This study was approved by the Institutional Review Board of Zhongshan Hospital, Fudan University. All patients provided written informed consent before the enrollment in the study.

Bone scintigraphy

Whole-body planar scintigraphy was performed approximately 3–6 hours after intravenous injection of about 1110 MBq (30 mCi) Tc-99m-MDP with a three-detector gamma camera (Prism-IRIX, Marconi Medical Systems, Cleveland, OH, USA) equipped with a low-energy, high-resolution, parallel-hole collimator. For planar whole-body scintigraphy acquisition, counts from the 20% energy windows at 140 keV were acquired in a 256 × 1024 matrix.

SPECT/spiral CT

Based on the findings of undetermined foci from planar whole-body scintigraphy, the patients underwent SPECT/spiral CT scanning (Philips Precedence with 16-slice diagnostic CT [Philips, Medical System, Bothell, WI, USA]). The camera heads were equipped with a low-energy, high-resolution, parallel-hole collimator.

Each SPECT scan was acquired with the indeterminate finding from the initial planar whole-body scan included in the center of the field of view. For SPECT acquisition, counts from the 15% energy window at 140 keV were acquired in a 64 × 64 matrix. A CT scan with the same field of view as the SPECT scan was acquired. The following CT parameters were used:

- 120 kV,
- 160 mAs,
- 400 mm field of view, and
- 5 mm collimation.

The SPECT raw data were reconstructed into transaxial, coronal, and sagittal slices using reconstruction software (Astonish; Philips San Jose, CA, USA). For all fused images, the accuracy of the matching of internal anatomic landmarks visible on both CT and SPECT was checked. Both SPECT and CT were performed with the patients stably lying supine and breathing shallowly. No misregistration exceeding 2 mm was found.

Image analyses

All images were independently interpreted by two experienced nuclear medicine physicians who have identifications of both CT and nuclear medicine physician qualifications. To minimize recall bias, the reviewers read planar and SPECT images first and interpreted CT 3 weeks later, and