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Application of SPECT Combined with CT and MRI in Malignant Tumors Clinical Value in the Diagnosis of Bone Metastasis

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Abstract

Introduction: Bone is the most common site of hematogenous metastasis of malignant tumors. Patients with bone metastasis can have a series of bone related adverse events, which seriously affect the quality of life and survival time of patients. Imaging examination is the main means of clinical diagnosis and evaluation of bone metastasis. **Aim of the Work:** To evaluate the value of single-photon emission computerized tomography (SPECT) combined with CT and MRI in the diagnosis of bone metastasis of malignant tumors. **Subjects and Methods:** Eighty patients with bone metastasis from malignant tumors who were admitted to Affiliated Hospital of Chengde Medical College were selected from March 2019 to June 2021. They underwent bone scan with SPECT imaging, CT and MRI separately. The distribution of bone metastasis from primary tumors as well as efficacy of the above three detection methods for bone metastasis was analyzed. **Results:** A total of 464 lesions were detected by SPECT and CT in the same scanning field, with SPECT detection rate of 92.5% (429/464) and CT detection rate of 77.8% (361/464) ($P < 0.05$). In addition, 143 lesions were detected by SPECT beyond the same scanning field. A total of 321 lesions were detected by SPECT and MRI in the same scanning field, with SPECT detection rate of 95.6% (307/321) and MRI detection rate of 82.6% (265/321) ($P < 0.05$), and nother 286 lesions were detected by SPECT beyond the same scanning field. In all, 259 lesions were detected by CT and MRI scans in the wild same scanning field. The detection rate was 71.4% (185/259) for CT, and 95.7% (248/259) for MRI ($P < 0.05$). The ensitivity, specificity and accuracy of SPECT imaging combined with CT and MRI were higher than single SPECT imaging, CT and MRI ($P < 0.05$). **Conclusion:** SPECT may be the preferred screening modality for uspected bone me-

tastases, and when combined with CT and MRI, it can clarify the regional distribution of bone metastasis from malignant tumors and improve the sensitivity, specificity and accuracy of diagnosis with high clinical significance.

Keywords

Bone Scan with SPECT Imaging, Malignant Bone Metastases, Computed Tomography, Magnetic Resonance Imaging

1. Introduction

The definition of bone metastases is that tumors in any part of the body metastasize to the bone through various ways and continue to grow [1]. All tumor patients may have bone metastases [2]. The incidence of bone metastasis in breast [3], prostate [4], lung, thyroid [5] and kidney cancer is more than 90%. The most common sites of bone metastases in China are spine, ribs, pelvis and femur. The clinical manifestations are systemic consumption symptoms, metastatic pain and pathological fractures [6]. With the rapid development of imaging technology, the value and significance of imaging examination for early detection of bone metastases are gradually emerging. At present, the commonly used clinical examination methods include X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and single photon emission computed tomography (SPECT). The imaging data of 80 cases of malignant tumor with bone metastasis were compared and analyzed to explore the application value of SPECT, CT and MRI in the diagnosis of bone metastasis.

2. Subjects and Methods

Eighty patients with bone metastasis from malignant tumors who admitted to Affiliated Hospital of Chengde Medical College were selected from March 2019 to June 2021. The research method was approved by the hospital ethics committee. The patients and their families were informed and signed the informed consent. Inclusion criteria: 1) patients with tumor history were confirmed by pathological examination or clinical diagnosis; 2) plane bone imaging was positive for the first time. Exclusion criteria: 1) contraindications of CT, MRI and SPECT; 2) patients with chronic organ failure; 3) psychiatric patients; 4) patients with contrast medium allergy; 5) patients with severe liver and kidney function and bone marrow dysfunction; 6) survival time < 3 months.

To analyze the regional distribution of bone metastases and the accuracy of SPECT bone imaging combined with CT and MRI in the diagnosis of bone metastases. 1) SPECT bone imaging: infinia dual probe SPECT instrument with a low-energy high-resolution collimator provided by GE company of the United States was used. After intravenous injection of 99 mTc methylene diphosphate (99 mTc MDP) for 20 - 25 mci, the patient drank 600 - 1000 ml water, and the bladder was emptied after 3 hours, and performed anterior posterior and

posterior anterior whole-body bone imaging at a speed of 15 cm/min. Then the whole body bone imaging was performed at a speed of 15 cm/min. 2) CT examination: discovery hd750 multi-slice spiral CT provided by GE company of the United States was used, with layer thickness of 5 - 10 mm, and soft tissue window and bone window were used for observation. 3) MRI examination: discovery MR750 3.0 nuclear magnetic resonance produced by GE company in the United States, conventional spin back sequence was used for cross-sectional, coronal and sagittal T1WI and T2WI imaging. 4) Image analysis and result judgment: the diagnosis was made by more than two experienced radiologists and nuclear medicine doctors. The gold standard for the diagnosis of bone metastasis is histopathological examination, but it is unrealistic to perform puncture biopsy for each patient. The diagnostic criteria for bone metastases used in this study are [7]: 1) bone metastases confirmed by pathological examination. 2) There are two or more imaging methods to diagnose bone metastases. 3) After follow-up for more than 6 months, the lesions increased or decreased after anti-tumor treatment. Those who met one of the three conditions were diagnosed as bone metastases.

3. Results

Table 1: This table shows the patient ranged age 30 - 80 with mean 60.23 ± 9.56 and median 60.3.

Table 2: This table shows the number of primary tumors.

Table 3: Distribution area of bone metastasis of malignant tumor.

Table 4: Comparison of detection rate of bone metastasis by SPECT, CT and MRI: a total of 464 lesions were detected by SPECT and CT in the same scanning field, with SPECT detection rate of 92.5% (429/464) and CT detection rate of 77.8% (361/464). In addition, 143 lesions were detected by SPECT beyond the same scanning field. A total of 321 lesions were detected by SPECT and MRI in the same scanning field, with SPECT detection rate of 95.6% (307/321) and MRI detection rate of 82.6% (265/321), and nother 286 lesions were detected by SPECT beyond the same scanning field. In all, 259 lesions were detected by CT and MRI scans in the wild same scanning field. The detection rate was 71.4% (185/259) for CT, and 95.7% (248/259) for MRI.

Table 5: Comparison of SPECT bone imaging, CT and MRI in the diagnosis of bone metastases: the sensitivity, specificity and accuracy of SPECT combined with CT and MRI were significantly higher than those of SPECT bone imaging, CT or MRI alone.

Table 1. Demographic characteristics of patients.

Age (years)	Statistics
Range	30 - 80
Mean ± SD	60.23 ± 9.56
Median	60.3

Table 2. Number of primary tumors.

primary tumors	Number of cases
lung cancer	26
breast cancer	22
prostate cancer	17
nasopharyngeal carcinoma	3
esophageal cancer	4
rectal cancer	2
liver cancer	2
renal carcinoma	1
gastric cancer	1
colon cancer	1
cervical cancer	1

Table 3. Distribution area of bone metastasis caused by malignant tumor.

Distribution area of bone metastasis	Number of cases	Number of lesions
spine	63	166
ribs	48	155
pelvis	32	113
chest (sternum, clavicle, scapula)	21	80
limbs	17	72
skull	9	21

Table 4. Comparison of detection rate of bone metastasis.

Inspection items	Detection rate of metastatic site	X^2
SPECT CT	92.5%# 77.8%	39.36
SPECT MRI	95.6%# 82.6%	28.48
CT MRI	71.4%# 95.8%	69.86

#$P < 0.05$.

Table 5. Comparison of SPECT, CT and MRI in the diagnosis of bone metastases (%).

Inspection items	sensitivity	specificity	accuracy
SPECT	92.6	70.8	79.5
CT	83.8	88.7	86.5
MRI	90.6	89.2	89.5
Combination of three inspections	98.7	92.5	95

Sensitivity = number of true positives/(number of true positives + number of false negatives) × 100%; Specificity = true negative number/(true negative number + false positive number) × 100%; Accuracy = standard deviation/arithmetic mean of calculation results × 100%.

4. Discussion

The incidence of malignant tumor metastasis to bone is so high, but many patients have no symptoms of bone pain. In this study, 80 patients with bone metastasis of malignant tumor, 46 cases had no obvious symptoms of bone pain and 34 cases had obvious symptoms of bone pain. The main ways of metastasis of malignant tumors were hematogenous dissemination, lymphatic metastasis and local infiltration. Most tumor cells were transferred to the bone system through blood dissemination, and a few tumor cells were directly transferred to the bone through soft tissue. Some scholars believed that red bone marrow was suitable for the reproduction of tumor cells in hemodynamics and biochemistry, so it had become the preferred site for tumor cell metastasis [8], and more than 90% of bone metastases were located in the axial bone with more red bone marrow [9]. The results of this study showed that most bone metastases were located in the axial bone and the proximal end of the long bones of the limbs with more red bone marrow. Bone metastases occurred in the spine, ribs, pelvis, chest, limbs and skull. Among them, the incidence of spinal metastases was high, which might be related to Batson venous plexus. Batson theory believed that the spinal venous plexus was connected with the thoracic, abdominal and pelvic venous plexus, where the blood flow was slow and there was no venous valve obstruction. When the thoracic and abdominal pressure increases due to respiratory movement, the tumor cells directly retrograde into the spine through the spinal venous plexus. This study also showed that the most common sites of spinal metastases were thoracic vertebrae, lumbar vertebrae, sacral vertebrae and cervical vertebrae, which was considered to be related to the fact that the primary tumors were mostly in the chest and abdomen.

SPECT is one of the most commonly used methods for the diagnosis of bone metastasis of malignant tumors, which uses radionuclide technetium labeled methylene bisphosphonate (99 m Tc MDP) as imaging agent to display the difference of radioactive concentration in image form by single photon emission tomography [10]. SPECT showed that most bone metastases were multiple and asymmetric radioactive concentrated foci, and a few osteolytic metastases showed cold areas of radioactive defects. SPECT has a high sensitivity to early metastases, which is half a year or even a year earlier than X-ray examination. In addition, SPECT can examine the whole body bone at one time, which greatly reduces the possibility of missed diagnosis. SPECT is also used to assist the localization of radiotherapy and evaluate the curative effect [11].

CT is sensitive to detect the destruction of bone cortex, but intramedullary metastases without bone cortex destruction which often shows small low-density lesions in the medullary cavity, is easy to miss diagnosis [12]. The important value of CT is to evaluate the uncertain lesions in SPECT, and can accurately detect the location, diameter and shape of the lesions. In this study, bone metastases showed 3 forms: osteogenic type, osteolytic type and mixed type. Bone metastases of prostate cancer mostly showed osteogenic type. Bone metastases of liver

cancer mostly showed osteolytic type, and bone metastases and osteolytic types were mostly seen in lung cancer and breast cancer. CT can show the surrounding situation, blood supply and adjacent soft tissue of the metastasis which is helpful to judge whether there are complications of malignant tumor bone metastasis, such as pathological fracture, spinal cord compression and so on. CT can also help to identify benign and malignant vertebral compression, whether there is involvement of vertebral appendages, whether it breaks through bone to form soft tissue mass, etc. [12]. Bone metastases of malignant tumors start from bone marrow. The occurrence of intramedullary metastases will lead to changes in bone marrow fat and water content in varying degrees.

MRI is very sensitive to the changes of fat and water content, and MRI has high spatial resolution, which is of great value in the early diagnosis of bone metastases. In this group of data, most of the MRI positive cases showed long T1 and long T2 signals. MRI detected more early intramedullary metastases than SPECT and CT. This study showed that the detection rate of bone metastases by MRI was higher than that by SPECT and CT. In reality, MRI scanning range was limited, which was difficult to check the whole body's bone condition, and it was easy to be affected by artifacts caused by breathing and heart beat movement, resulting in missed diagnosis of rib and thoracic vertebral lesions. In this study, the sensitivity, specificity and accuracy of SPECT bone imaging combined with CT and MRI were significantly higher than those of SPECT, CT or MRI alone.

In conclusion, SPECT can be used as a preliminary screening method for bone metastases. Combined with CT and MRI, SPECT can clarify the regional distribution of bone metastases of malignant tumors, improve the sensitivity, specificity and accuracy of diagnosis, and has high clinical value.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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