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Clinical applications of SPECT/CT in assessment of bone lesions in POEMS syndrome

Yaqin Hou¹, Zhilian Zhao¹, Haiqin Zhang¹, Le Guan¹, Ze Li¹, Tianbin Song¹ and Jie Lu^{1,2*} 

Abstract

Purpose Retrospectively analyse the ^{99m}Tc-MDP SPECT whole-body bone scan in POEMS syndrome to explore its clinical value.

Methods Twenty-four untreated patients with pathologically confirmed POEMS syndrome were included in the study. 24 of them underwent ^{99m}Tc-MDP SPECT whole-body bone scan, 24 underwent CT examination and 18 patients underwent X-ray examination in different parts. Features of bone lesions in ^{99m}Tc-MDP SPECT, and X-ray, CT were analysed. Three experienced radiologists read the images and gave diagnosed results for bone lesions.

Results Of the 24 POEMS syndrome patients, three types of bone lesions were found: osteosclerotic lesions, osteolytic lesions and mixed lesions, of which the most common type was osteosclerotic. 54.16% (13/24) patients were found bone lesions by SPECT; 44.44% (8/18) patients underwent X-ray and 62.50% (15/24) patients underwent CT were detected bone lesions. We compared the difference of the X-ray, CT and SPECT scans of the bone lesions by chi-square and found that there was no difference ($P=0.51$) in detection of bone lesions among the three methods.

Conclusion ^{99m}Tc-MDP SPECT wholebody bone scan also useful in evaluating patients with suspected POEMS syndrome. We can use it as a supplement examination of the CT in the confirmation of one minor diagnostic criterion for POEMS syndrome: bone lesions.

Keywords ^{99m}Tc-MDP SPECT, Computed tomography (CT), X-ray, POEMS syndrome

POEMS syndrome is a rare plasma cell disorder (Dispenzieri 2023, Jurczynszyn et al. 2023). This acronym, which was coined by Bardwick in 1980 (Bardwick et al. 1980), refers to the features of the syndrome: polyradiculoneuropathy, organomegaly, endocrinopathy, monoclonal plasma cell disorder and skin changes. However, there are other important features not included in the POEMS

acronym, including papilledema, extravascular volume overload, sclerotic bone lesions, thrombocytosis/erythrocytosis (PEST) (Warsame et al. 2017). The major criteria for the syndrome are polyradiculoneuropathy, clonal plasma cell disorder (PCD), sclerotic bone lesions, elevated vascular endothelial growth factor, and the presence of Castleman disease (Dispenzieri 2023). Bone lesions are not only very important for diagnosing and evaluating POEMS syndrome, but also crucial for administering appropriate treatments (Ali and Qazilbash 2021, Jurczynszyn et al. 2023). Osteosclerosis is a unique feature and one of the major diagnostic criteria of this disease (Khwaja et al. 2023, Genicon et al. 2022). Otherwise, whether the lesion is isolated or multiple determines whether the patient should accept systematic chemotherapy or focal radiation (Khwaja et al. 2023), so imaging

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plays a vital role in accurately diagnosing POEMS syndrome and determining the treatment approach. How to confirm the presence and number of bone lesions is very important. Dispenzieri recommended skeletal CT and/or PET/CT for bone lesions (Dispenzieri 2023). In comparison to the conventional methods of CT or X-ray, SPECT offers distinct advantages and is deemed necessary for the detection of bone lesions in POEMS syndrome. Given that the bone lesions associated with POEMS syndrome can manifest in various parts of the skeleton, a whole-body bone scan is imperative for comprehensive assessment. Firstly, ^{99m}Tc -MDP SPECT bone scans provide a panoramic view of the entire skeletal system in a single examination, a practicality that is often unattainable with whole-body skeletal CT scans in most hospitals. Secondly, SPECT entails a lower radiation dose in contrast to whole-body skeletal CT, enhancing its safety profile. Furthermore, the ^{99m}Tc -MDP SPECT bone scans exhibit excellent sensitivity, enabling the detection of bone lesions at an earlier stage compared to X-ray and CT scans. However reports of ^{99m}Tc -MDP SPECT bone scans for the diagnosis of POEMS syndrome are scarce. In this study, we analyse the ^{99m}Tc -MDP SPECT whole-body bone scan in POEMS syndrome to explore its clinical value.

1 Materials and methods

1.1 Subjects

A total of 24 cases (6 female and 18 male; mean age $\pm$ SD 52.79 ± 11.24 years, age range 23–73 years) admitted to our hospital from November 2012 to January 2020 with a diagnosis of POEMS were included in this retrospective study. The POEMS diagnostic criteria revised by the 2017 Mayo Clinic Criteria were used in this study (Khawaja et al. 2023). All the patients went to the hospital because of peripheral neuropathy. Relevant medical history, including electromyography, found peripheral nerve damage, and physical examination found skin pigmentation, and physical examination did not find either tumor and trauma. All patients underwent ^{99m}Tc -MDP SPECT whole-body bone scan, 24 patients underwent CT examination and 18 underwent X-ray examination in different parts to detect bone lesions. All the examinations were completed before treatment.

1.2 ^{99m}Tc -MDP SPECT study

^{99m}Tc -MDP SPECT whole-body bone scans were acquired after the patient had fasted for 2–5 h after intravenous administration of ^{99m}Tc -MDP 740 MBq. The patient was instructed to drink 500–1000 ml water 1 h after intravenous tracer administration. The patient must remove any things like watches and rings or other metals worn on the body and void the bladder before

the scanning procedure. ^{99m}Tc -MDP SPECT images were obtained using combined SPECT/CT (GE Discovery NM/CT 670). All scans were acquired in step-by-step and antero-posterior mode. The emission scan was obtained in the craniocaudal direction, from the top of the skull to the feet. The matrix was 256×1024 , window width was 20%, zoom was 1.0 and the speed was 15 cm/min.

1.3 X-ray and CT study

The X-ray scanning was acquired by SIEMENS Ralco. The CT scanning was acquired by SIEMENS Flash or SIEMENS Sensation; the slice thickness was 5 mm or 1.25 mm, the voltage was 120 kV and the current was from 120 to 350 mA.

1.4 Imaging analysis

Each X-ray and CT image was independently analyzed by three senior radiologists, resulting in a Kappa value of 0.85. Similarly, the ^{99m}Tc -MDP SPECT whole-body bone scan images were independently analyzed by three experienced nuclear medicine physicians, yielding a Kappa value of 0.97. In instances of differing opinions, consensus was reached through joint readings or consultation with more authoritative experts. It was considered high metabolism if the lesion showed increased uptake of ^{99m}Tc -MDP, which also meant hot spot, and decreased uptake was considered low metabolism, meaning cold spot.

1.5 Statistical analysis

Statistical analysis was performed using SPSS software (version 21.0; IBM SPSS, Inc.). All data were expressed as mean $\pm$ SD. The agreement consistency analysis was expressed using Kappa value. A probability value of 0.05 was considered statistically significant.

2 Results

2.1 Subjects' characteristics

The results of all 24 patients who underwent ^{99m}Tc -MDP SPECT bone scan, X-ray and CT are shown in Table 1. The CT examination primarily focuses on the Chest (71.00%) and Abdominal (67.00%), whereas the X-ray examination primarily concentrates on the Head (63.00%) and Pelvic (67.00%).

2.2 ^{99m}Tc -MDP SPECT whole-body bone scan imaging characteristics

The ^{99m}Tc -MDP SPECT whole-body bone scan found that 13 (13/24, 54.16%) cases of the POEMS patients showed positive bone lesion. Which mainly included three types: the hot lesion (sclerotic bone lesion) means the focal bone lesion showed increased uptake of the

Table 1 Summary of results from 24 patients who underwent SPECT, X-ray and CT

Examination method	Cases and rate
^{99m} Tc-MDP SPECT bone scan	24/24 (100.00%)
Head CT	3/24 (13.00%)
Chest CT	17/24 (71.00%)
Abdominal CT	16/24 (67.00%)
Pelvic CT	5/24 (21.00%)
Head X-ray	15/24 (63.00%)
Chest X-ray	6/24 (25.00%)
Thoracolumbar X-ray	10/24 (42.00%)
Pelvic X-ray	16/24 (67.00%)
Knee joint X-ray	2/24 (8.00%)

tracer (Fig. 1A), the cold lesion (lytic bone lesion) indicates decreased uptake of the tracer (Fig. 1B), and the mixed lesion means both of the aforementioned types (Fig. 1C). The bone lesions are summarised in Table 2. The distribution of bone lesions in ^{99m}Tc-MDP SPECT

whole-body bone scan imaging reveals that sclerotic bone lesions predominate (41.67%), followed by lytic bone lesions (8.33%) and mixed bone lesions (4.17%).

In this study, we had 4 patients with POEMS syndrome, who underwent regional SPECT/CT bone tomography scan after the whole-body SPECT bone scan. We got three kinds of information about the lesions: the metabolism change (the SPECT tomography image), the density image (the CT image) and the fusion image (the SPECT tomography image combined with the CT image) (Fig. 2).

2.3 CT and X-ray imaging characteristics

The CT imaging found that 15 cases (15/24, 62.50%) of the POEMS patients showed positive bone lesion (Table 2). The sclerotic bone lesions (50.00%) surpass lytic bone lesions (16.67%) and mixed bone lesions (8.33%). Beside the bone lesions, the CT imaging also can give the features of organomegaly and extravascular volume overload (Fig. 3), which are summarised in Table 3. Organomegaly reveals lymphadenopathy (58.33%) as the

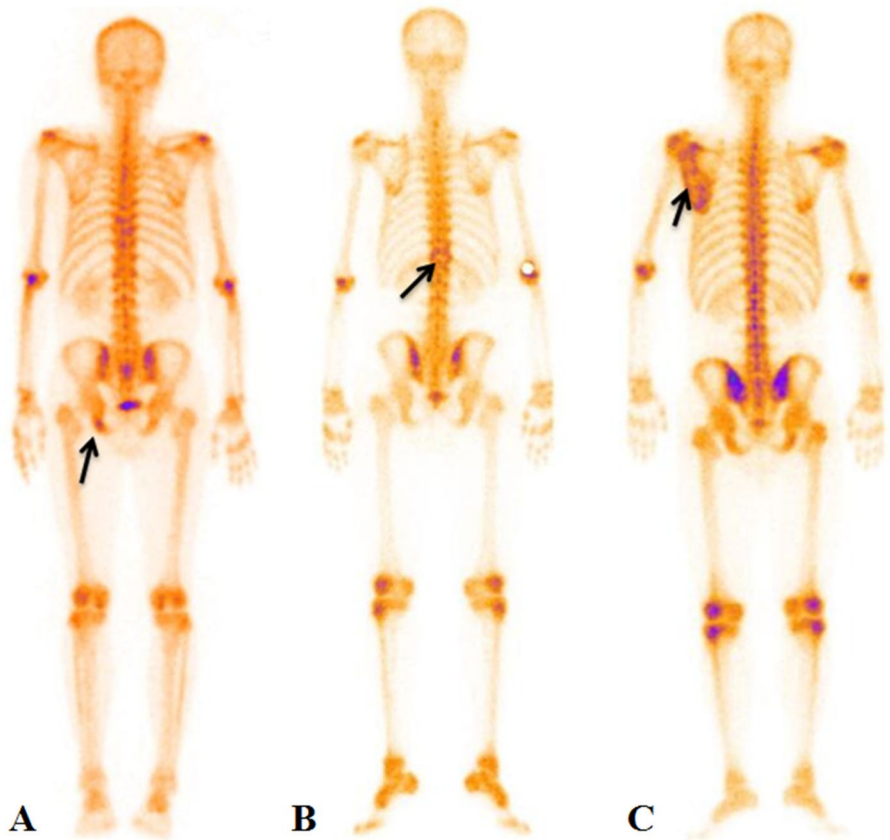


Fig. 1 ^{99m}Tc-MDP SPECT whole-body bone scan. **A** A 63-year-old man with POEMS syndrome who complained of peripheral neuropathy for 6 months. The ^{99m}Tc-MDP SPECT whole-body bone scan (post) shows the left ischium hot lesions (black arrow). **B** A 23-year-old man with POEMS syndrome who complained of skin changes for 8 months and peripheral neuropathy for 2 months. The ^{99m}Tc-MDP SPECT whole-body bone scan (post) shows the 12th thoracic vertebra cold lesions (black arrow). **C** A 29-year-old man with POEMS syndrome who complained of peripheral neuropathy for 7 months. The ^{99m}Tc-MDP SPECT whole-body bone scan(post) shows the left scapula mixed lesions

Table 2 The features of bone lesion in 24 patients with POEMS syndrome

Bone lesions	SPECT	CT	X-ray
Sclerotic	41.67% (10/24)	50.00% (12/24)	33.33% (6/18)
Lytic	8.33% (2/24)	16.67% (4/24)	16.67% (3/18)
Mixed	4.17% (1/24)	8.33% (2/24)	5.56% (1/18)
Multiple	41.67% (10/24)	41.67% (10/24)	16.67% (3/18)
Solitary	12.50% (3/24)	20.83% (5/24)	27.78% (5/18)

most prevalent, followed by splenomegaly (50.00%) and hepatomegaly (33.33%). Extravascular volume overload exhibits pleural effusion (41.67%) as the highest, followed by pericardial effusion (33.33%) and peripheral edema (33.33%) over ascites (20.83%).

The X-ray imaging found that 8 cases (8/18, 44.44%) of the POEMS patients showed positive bone lesion (Fig. 4),

which is summarised in Table 3. The sclerotic bone lesions (33.33%) predominate over lytic bone lesions (16.67%) and mixed bone lesions (5.56%).

2.4 X-ray vs. CT vs. SPECT in bone lesions

Of these three methods, X-ray revealed bone lesions in 44.44% (8/18) of patients, CT revealed bone lesions in 62.50% (15/24) of patients and SPECT found bone lesions in 54.16% (13/24) of patients. In the three types, osteosclerosis produced the largest number of bone lesions. We compared the X-ray, CT and SPECT images of the bone lesions by chi-square and found that there was no difference (Jurczynsyn et al. 2023)=1.34,P=0.51) among the three methods.

Among the 24 patients, SPECT showed 13 positive and 11 negative results, while CT showed 15 positive and 9 negative results. Combined SPECT and CT analysis

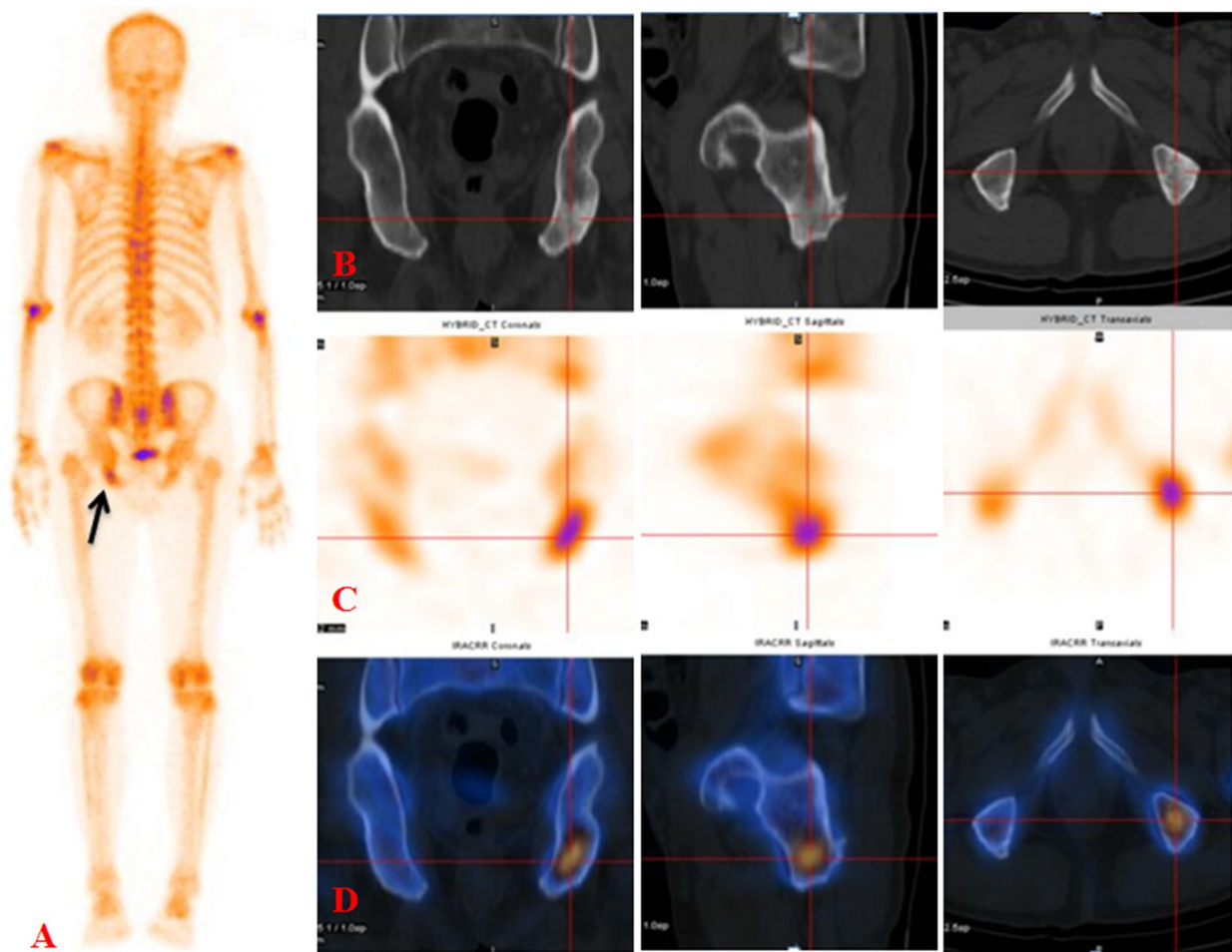


Fig. 2 Pelvis regional ^{99m}Tc-MDP SPECT/CT bone tomography scan. A 63-year-old man with POEMS syndrome who underwent the ^{99m}Tc-MDP SPECT whole-body bone scan (post) had left ischium hot lesions (A, black arrow). In an added regional SPECT/CT scan of the pelvis (B, C, D), the SPECT/CT tomographic images (C) showed high metabolism in the left ischium. The CT images (B) showed sclerotic bone lesions in the same position as the fusion images (D)

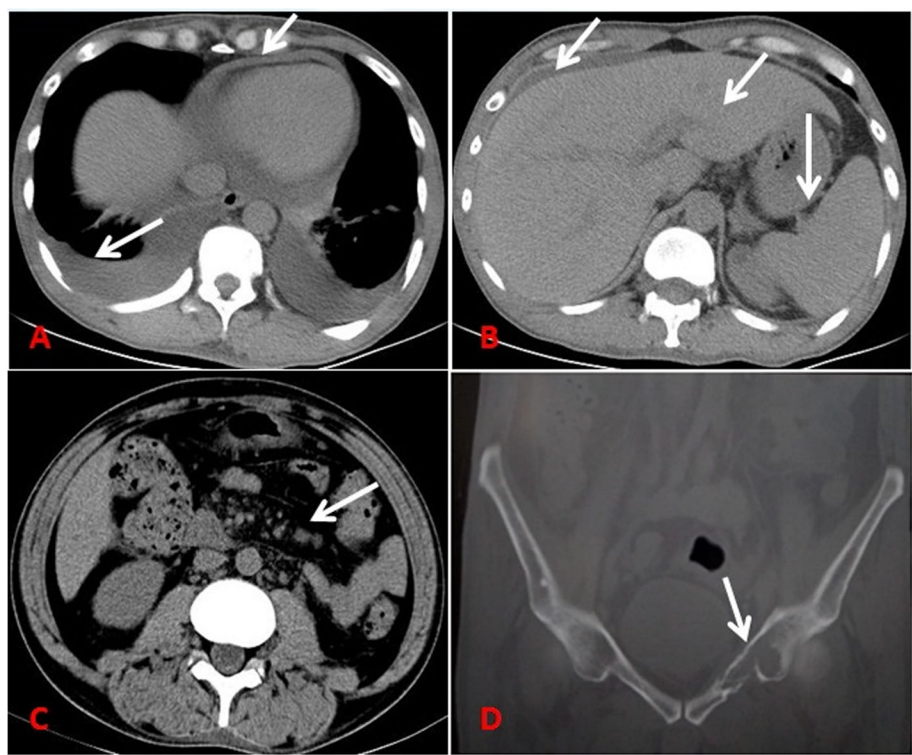


Fig. 3 CT imaging illustrating bone lesions, organomegaly and extravascular volume overload. The CT scan shows the pleural effusion and pericardial effusion (Fig. 1A, white arrow); the ascites, hepatomegaly and splenomegaly (Fig. 1B, white arrow); the lymphadenopathy (Fig 1C, white arrow); the bone lesions (Fig 1D, white arrow)

Table 3 CT imaging features of 24 patients with POEMS syndrome

Characteristics	Detection rate
Extravascular volume overload	
Pleural effusion	41.67% (10/24)
Ascites	20.83% (5/24)
Pericardial effusion	33.33% (8/24)
Peripheral edema	33.33% (8/24)
Any of above	50.00% (12/24)
Two of above	8.33% (2/24)
Three of above	16.67% (4/24)
All of above	12.50% (3/24)
Organomegaly	
Hepatomegaly	33.33% (8/24)
Splenomegaly	50.00% (12/24)
Lymphadenopathy	58.33% (14/24)
Any of above	70.83% (17/24)
Two of above	37.50% (9/24)
All of above	16.67% (4/24)

revealed 18 positive and 6 negative results. Discrepancies between SPECT and CT diagnoses were noted, with a Kappa value of 0.03, indicating a lack of coincidence in bone lesion detection for POEMS syndrome.

Referencing CT diagnosis results, among the 15 positive cases, two exhibited complete coincidence in the location of bone lesions between SPECT and CT, six showed SPECT identifying more lesions than CT, and seven showed SPECT identifying fewer lesions than CT. For the nine negative cases, six displayed complete coincidence in the location of bone lesions between SPECT and CT, three showed SPECT identifying more lesions than CT, and none showed SPECT identifying fewer lesions than CT. ROC analysis (Fig. 5) demonstrated an area under the curve of 0.844, with a *p*-value of 0.006.

3 Discussion

POEMS syndrome, also known as osteosclerotic myeloma, is a rare paraneoplastic syndrome resulting from an underlying plasma cell disorder (Kim 2022). The diagnosis of POEMS is made in accordance with a synthesis of clinical and laboratory features, which suggests a multi-systemic disorder (D’Sa et al. 2022). Among the diagnostic criteria, organomegaly, extravascular volume overload and sclerotic bone lesions may be detected by imaging

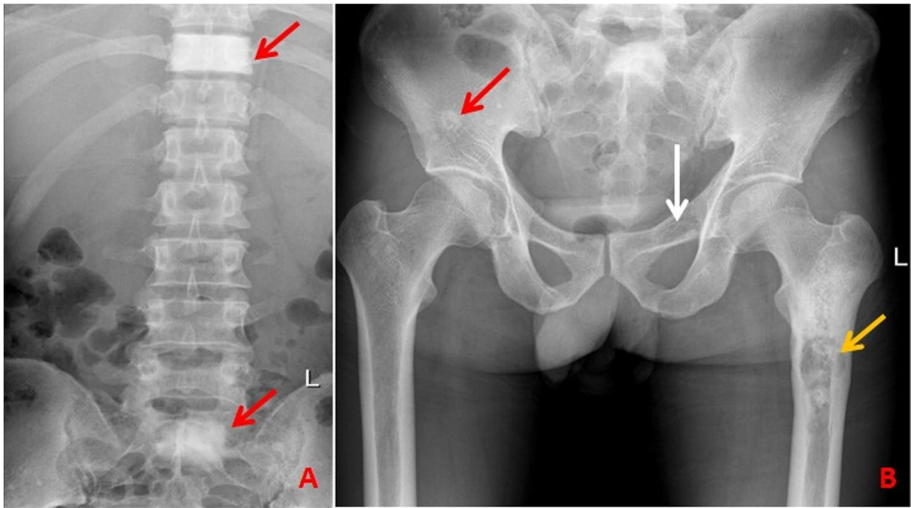


Fig. 4 X-ray imaging depicting three types of bone lesions. **A** The lumbar X-ray shows the 11 thoracic vertebral and sacral vertebral osteosclerosis (red arrow). **B** The pelvis X-ray shows the sclerotic (red arrow), lytic (white arrow), and mixed (yellow arrow) bone lesions

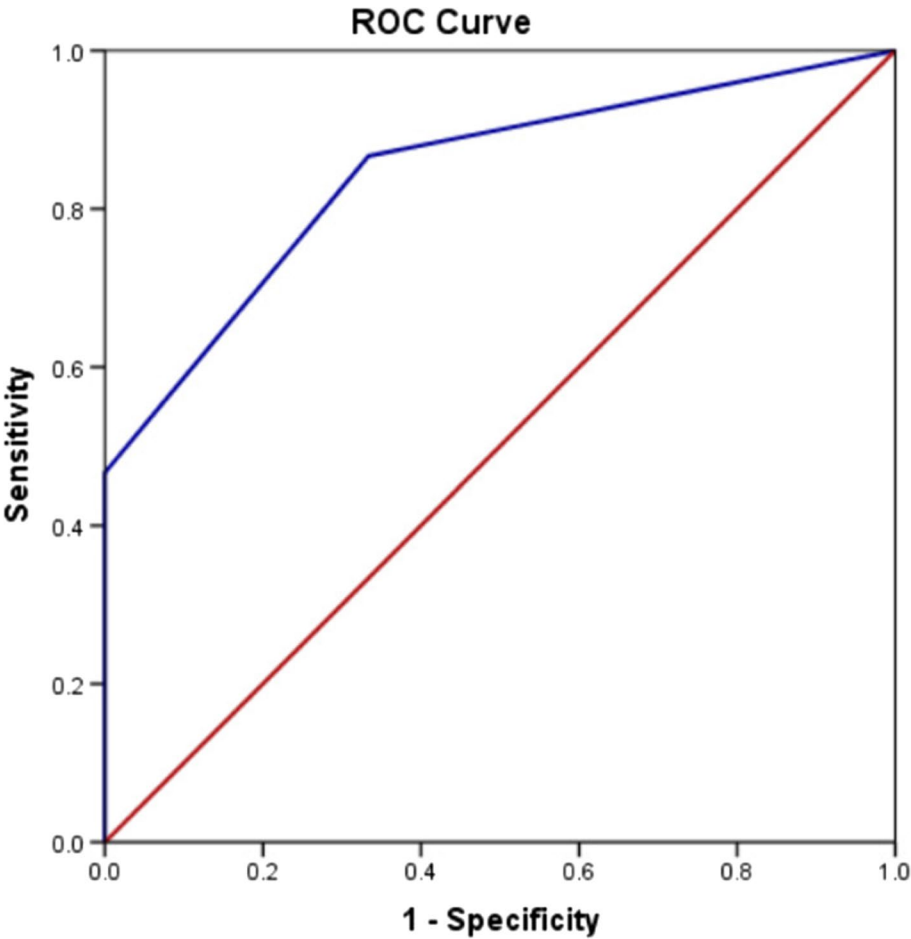


Fig. 5 The ROC curve of the SPECT annlysis result base on CT

modalities. This study retrospectively analysed the imaging features of 24 patients with POEMS syndrome who underwent X-ray, CT and ^{99m}Tc -MDP SPECT whole-body bone scans. All of them were examined by SPECT and CT, but 18 scans were performed with X-ray.

Bone lesions of POEMS occur in about 95% of patients in the United States (Dispenzieri 2007) and 27%–46% in Chinese patients (Cui et al. 2011, Wang et al. 2019). In our study, bone lesions were found by X-ray in 44.44% (8/18) of the patients, 62.50% (15/24) by CT, and 54.17% (13/24) by SPECT, which was equal to those recently found by PET/CT (Pan et al. 2015). X-ray and CT are important and preferred checking methods for bone lesions of POEMS, but CT could detect more and smaller bone lesions than X-ray. In this paper, only 16.67% (3/18) showed multiple bone lesions in X-ray, but 41.67% (10/24) in CT. Bone windows of whole-body CT images are often used for the diagnosis of osteosclerotic lesions in POEMS syndrome (Glazebrook et al. 2015, Shi et al. 2016). In addition, the Mayo Clinic recommended CT body bone windows and/or PET/CT to evaluate sclerotic bone lesions thoroughly for a patient with POEMS syndrome to define a baseline that can be used for future assessments (Dispenzieri 2023).

In addition to the conventional methods, ^{99m}Tc -MDP SPECT is also widely used to detect bone lesions, especially in metastatic tumours of bone. Now, hardly any researchers refer to ^{99m}Tc -MDP SPECT bone scans for diagnosis of bone lesions in POEMS syndrome. As a whole-body bone scan modality, ^{99m}Tc -MDP SPECT has great advantages for evaluating bone lesions. Its excellent sensitivity makes it useful in screening for generalised bone abnormalities (Gnanasegaran and Ballinger 2014, Huellner and Strobel 2014). The tracer uptake in bone primarily reflects osteoblastic activity but also depends on skeletal vascularity. With the development of image technology, hybrid SPECT/CT could obtain diagnostic-quality CT and SPECT images in the same time. Therefore, we can not only know the anatomic sites but also the perfusion and metabolism of the lesions after SPECT/CT scanning and, often earlier than X-ray and CT found lesions (Abikhzer et al. 2016, Palmedo et al. 2014). The patients who underwent regional SPECT/CT bone tomography scan after the whole-body SPECT bone scan, could get three kinds of information about the lesions: the metabolism change (the SPECT tomography image), the density image (the CT image) and the fusion image (the SPECT tomography image combined with the CT image). The SPECT scans had high sensitivity but low specificity. In usual clinical work, we always add the SPECT/CT local bone tomography scan only after we find lesions in whole-body bone scans.

Bone lesions of POEMS can be confused with benign bone islands, non-ossifying fibromas, aneurysmal bone cysts, and fibrous dysplasia (Dispenzieri et al. 2003;

Rajkumar et al. 2006). Some lesions are lytic with a sclerotic rim, whereas others are densely sclerotic, and still others have a mixed, soap-bubble appearance. Most benign bone islands show no uptake of ^{99m}Tc -MDP.

We found that bone lesions of POEMS have three types: osteosclerotic lesions, osteolytic lesions and mixed lesions. X-ray, CT and SPECT all show osteosclerotic lesions most. This finding is similar to the results of Wang F (Wang et al. 2016). The osteosclerotic lesions in CT correspond to high metabolism in SPECT, and the osteolytic lesions correspond to low metabolism. The osteosclerotic lesions on CT without ^{99m}Tc -MDP uptake may be due to the inactive stage of these lesions or to lesions smaller than 1 cm.

Other features, such as organomegaly and extravascular volume overload, are apparent only on CT, which are the minor criteria of POEMS syndrome. In this study, we found that 70.83% of patients had organomegaly, including hepatomegaly (33.33%), splenomegaly (50.00%) and lymphadenomegaly (58.33%). A summary of frequencies of POEMS syndrome findings based on large retrospective series by the Mayo Clinic in 2017 showed that the proportions of hepatomegaly, splenomegaly and lymphadenomegaly were 24%–78%, 22%–70% and 26%–74%, respectively (Dispenzieri 2017). Besides these three, the Mayo Clinic also thought that Castleman's disease was one kind of organomegaly. Castleman's disease is a rare lymphoproliferative disorder, which can range from simple B-symptoms to various autoimmune phenomena to POEMS syndrome (Dispenzieri et al. 2003, Thajeb et al. 1989). Extravascular volume overload most commonly appears as oedema (24%–89%) (Dispenzieri 2017), yet pleural effusion, ascites, and pericardial effusions are also common. However, our study shows pleural effusion (41.67%) as the most common.

4 Conclusions

^{99m}Tc -MDP SPECT wholebody bone scan also useful in evaluating patients with suspected POEMS syndrome. We can use it as a supplement examination of the CT in the confirmation of one minor diagnostic criterion for POEMS syndrome: bone lesions.

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Authors' contributions

Yaqin Hou and Jie Lu contributed to the concept and study design. Yaqin Hou and Ze Li were responsible for patient management. Yaqin Hou, Zhilian Zhao, Haiqin Zhang, Le Guan, Tianbin Song contributed to data acquisition and analysis. Yaqin Hou, and Jie Lu drafted the manuscript, tables and figures. Yaqin Hou, Zhilian Zhao, Tianbin Song and Jie Lu revised the manuscript and the important intellectual content. Jie Lu contributed to critical revision of the manuscript. All authors approved the final version.

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Availability of data and materials

The data and material of this paper is not public.

Declarations

Ethics approval and consent to participate

The subjects provided written informed consent for the study protocols, which were approved by the ethics committee of Xuanwu Hospital and conducted in accordance with the Declaration of Helsinki.

Consent for publication

All the authors declare that they consent for publication.

Competing interests

The authors declare that they have no competing interest.

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References

- Abikhzer G, Srouf S, Keidar Z, et al. Added value of SPECT/CT in the evaluation of benign bone diseases of the Appendicular skeleton. *Clin Nucl Med*. 2016;41(4):e195-199.
- Ali T, Qazilbash MH. POEMS syndrome: A multisystem clonal disorder. *Eur J Haematol*. 2021;106(1):14–8.
- Bardwick PA, Zvaifler NJ, Gill GN, et al. Plasma cell dyscrasia with polyneuropathy, organomegaly, endocrinopathy, M protein, and skin changes: the POEMS syndrome. Report on two cases and a review of the literature. *Medicine (Baltimore)*. 1980;59(4):311–22.
- Chong ST, Beasley HS, Daffner RH. POEMS syndrome: radiographic appearance with MRI correlation. *Skeletal Radiol*. 2006;35(9):690–5.
- Cui RT, Huang XS, Shi Q, et al. POEMS (polyneuropathy, organomegaly, endocrinopathy, M-protein and skin changes) syndrome in China. *Intern Med J*. 2011;41(6):481–5.
- Dispenzieri A, Kyle RA, Lacy MQ, et al. POEMS syndrome: definitions and long-term outcome. *Blood*. 2003;101(7):2496–506.
- Dispenzieri A. POEMS syndrome. *Blood Rev*. 2007;21(6):285–99.
- Dispenzieri A. POEMS syndrome: Update on diagnosis, risk-stratification, and management. *Am J Hematol*. 2023;98(12):1934–50.
- D'Sa S, Khwaja J, Keddie S, et al. Comprehensive Diagnosis and Management of POEMS Syndrome. *Hemasphere*. 2022;6(11).
- Dispenzieri A. POEMS syndrome: 2017 Update on diagnosis, risk stratification, and management. *Am J Hematol*. 2017;92(8):814–29.
- Genicon C, Guilloton L, Pavic M, Le Moigne F. Skeletal lesions in POEMS syndrome. *Joint Bone Spine*. 2022;89(4).
- Glazebrook K, Guerra Bonilla FL, Johnson A, et al. Computed tomography assessment of bone lesions in patients with POEMS syndrome. *Eur Radiol*. 2015;25(2):497–504.
- Gnanasegaran G, Ballinger JR. Molecular imaging agents for SPECT (and SPECT/CT). *Eur J Nucl Med Mol Imaging*. 2014;41(Suppl 1):S26-35.
- Huellner MW, Strobel K. Clinical applications of SPECT/CT in imaging the extremities. *Eur J Nucl Med Mol Imaging*. 2014;41(Suppl 1):S50-58.
- Jurczyszyn A, Olszewska-Szopa M, Vesole D. POEMS Syndrome-Clinical Picture and Management. *Current Knowledge Clin Lymphoma Myeloma Leuk*. 2023;23(8):575–82.
- Khwaja J, D'Sa S, Lunn MP, Sive J. Evidence-based medical treatment of POEMS syndrome. *Br J Haematol*. 2023;200(2):128–36.
- Kim YR. Update on the POEMS syndrome. *Blood Res*. 2022;57(S1):27–31.
- Palmedo H, Marx C, Ebert A, et al. Whole-body SPECT/CT for bone scintigraphy: diagnostic value and effect on patient management in oncological patients. *Eur J Nucl Med Mol Imaging*. 2014;41(1):59–67.
- Pan Q, Li J, Li F, et al. Characterizing POEMS Syndrome with 18F-FDG PET/CT. *J Nucl Med*. 2015;56(9):1334–7.
- Rajkumar SV, Dispenzieri A, Kyle RA. Monoclonal gammopathy of undetermined significance, Waldenström macroglobulinemia, AL amyloidosis, and related plasma cell disorders: diagnosis and treatment. *Mayo Clin Proc*. 2006;81(5):693–703.
- Shi X, Hu S, Luo X, et al. CT characteristics in 24 patients with POEMS syndrome. *Acta Radiol*. 2016;57(1):51–7.
- Thajeb P, Chee CY, Lo SF, et al. The POEMS syndrome among Chinese: association with Castleman's disease and some immunological abnormalities. *Acta Neurol Scand*. 1989;80:492–500.
- Wang F, Huang X, Zhang Y, et al. Bone lesions in Chinese POEMS syndrome patients: imaging characteristics and clinical implications. *Peer J*. 2016;4.
- Wang Y, Huang LB, Shi YH, et al. Characteristics of 1946 cases of POEMS syndrome in Chinese subjects: a literature-based study. *Front Immunol*. 2019;10:1428.
- Warsame R, Yanamandra U, Kapoor P. POEMS Syndrome: an Enigma. *Curr Hematol Malig Rep*. 2017;12(2):85–95.