A Comparison of Accuracy of Planar and Evolution SPECT/CT Bone Imaging in Differentiating Benign from Metastatic Bone Lesions

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Objective: *To compare sensitivity, specificity, accuracy and diagnostic confidence in the differentiation between benign and metastatic bone lesions on whole body planar bone scintigraphy and Evolution SPECT/CT.*
Material and Method: *Eighty diagnosed or suspected cancer patients with indeterminate lesions on planar scintigraphy were recruited in the present prospective study. Additional whole body Evolution SPECT/CT was performed after whole body planar scintigraphy. All lesions on both imagings were categorized into 5 categories; definitely metastasis, probably metastasis, indeterminate, probably benign and definitely benign. The diagnosis of each lesion was confirmed by follow-up imaging, pathological findings or clinical follow-up for at least 6 months.*
Results: *Detected lesions on planar scintigraphy and Evolution SPECT/CT imaging were 442 and 477 lesions, respectively. The sensitivity, specificity and accuracy of planar scintigraphy and Evolution SPECT/CT imaging in the diagnosis of metastatic lesions were 27% (95% CI: 13.8, 44.1), 63.2% (95% CI: 58.5, 67.7), 60%, and 97.3% (95% CI: 85.8, 99.9), 100% (95% CI: 96.4, 100) and 99.8%, respectively. Indeterminate lesions on planar scintigraphy were 34.2% (151 lesions from total 442 lesions, which 135 of these 151 indeterminate lesions or 89.4% were located in axial skeleton). Evolution SPECT/CT images were able to characterize all indeterminate lesions.*
Conclusion: *Differentiation of benign and metastatic lesions by Evolution SPECT/CT images has superior diagnostic performance and diagnostic confidence over the planar scintigraphy. Thus, Evolution SPECT/CT images should be considered in characterization of indeterminate lesions on planar scintigraphy, especially in the axial skeleton.*

Keywords: *Bone scan, planar scintigraphy, Evolution SPECT/CT, bone metastases*

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Nowadays, planar whole body bone scintigraphy still plays a major role in detecting bony metastasis in cancer patients because it provides a whole-body detection with high sensitivity at reasonable price. However, its major disadvantage is relatively low specificity. The most problematic area is axial skeleton at which a 2D imaging technique, like planar imaging, has limitation in anatomical localization. Owing to this, SPECT, a 3D imaging and SPECT/CT, a fusion between functional and anatomical imaging have been developed and widely used[1-5]. Among imaging techniques of bone scintigraphy, SPECT/CT imaging has been proved to give the highest accuracy[6-11] and diagnostic confidence[6,9-13]. But the major drawback of this 3D imaging is a time-consuming procedure. With this reason, a new technique named Evolution SPECT has been developed to decrease imaging time with comparable imaging quality or even better[14,15]. The purpose of the presented study was to compare

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diagnostic performance of planar imaging, which is a conventional technique with Evolution SPECT/CT in differentiating benign from metastatic bone lesions on the basis that acquisition time of whole body imaging of these two techniques are not much different.

Material and Method

From April to December, 2012, 80 diagnosed or suspected cancer patients (41 men and 39 women; age 20-80 years, mean age 59.3 years) with indeterminate lesions on planar scintigraphy or severe pain incompatible with findings on planar scintigraphy underwent bone scintigraphy in the Division of Nuclear Medicine, Department of Radiology, Faculty of Medicine Siriraj Hospital were enrolled into the present prospective study. There were 22 breast cancer patients, 20 prostate cancer patients, 10 head and neck cancer patients, 6 non-small cell lung cancer patients, 4 patients with suspected malignancy due to pathological fracture and 18 patients with other malignancies. Of 86 initially included patients, 6 patients were excluded from the study due to unwilling to join, under 18 years of age and unable to lay down longer than 10 minutes. The protocol was approved by the Siriraj Ethics Committee for Human Experiment and a written informed consent was obtained from each subject.

Planar scintigraphy acquisition

Whole body planar scintigraphy was done routinely on anterior and posterior positions 3 hours following intravenous administration of 20 mCi ^{99m}Tc-methylene diphosphate by using double-headed-gamma cameras (Infinia™ Hawkeye and Discovery NM/CT 670 by GE Healthcare and Symbia T and Symbia E of Siemens Medical Solution) performed with low-energy high resolution. Images were collected with a zoom factor of 1 and 256 x 1024 matrix size. Imaging time for anterior and posterior whole body was15-20 minutes and spot images-anterior and posterior pelvis with lateral skull was 10-15 minutes. Total imaging time per patient was approximately 30 minutes.

Planar scintigraphy interpretation

After completion of routine planar scintigraphy, all detectable lesions were classified into 5 categories by the consensus of 2 nuclear medicine physicians. Anterior superior iliac spine (ASIS) was used as a reference for intensity of radiotracer uptake as it usually showed the highest uptake on normal bone scan.Criteria for each category were described as followed.

Category 1, definitely a metastatic lesion referred to a lesion with radiotracer uptake greater than the ASIS located in a typical site of metastasis (e.g. spines) or demonstrated highly specific patterns of bony metastasis (e.g increased radiotracer uptake along a rib).

Category 2, probably a metastatic lesion referred to a lesion that did not perfectly match to the criteria of definitely metastatic lesion but had high tendency of being metastatic lesion (e.g. a focal radiotracer uptake with intensity less than that in the ASIS and located in a typical site of metastasis).

Category 3, an indeterminate lesion is a non-diagnostic pattern due to overlapping characteristics between benign and metastatic lesion (e.g. a single bony lesion at spine, rib or skull).

Category 4, probably a benign lesion referred to a lesion that did not perfectly match to the criteria of definitely benign lesion but had high tendency of benign lesion (e.g. a lesion in a typical site of degenerative change with radioactivity greater than that in the ASIS).

Category 5, definitely a benign lesion referred to a lesion with radiotracer uptake less than or equal to ASIS located around a joint or involved both sides of a joint (e.g. radiotracer uptake at vertebral end plate).

Whole body Evolution SPECT/CT acquisition

After interpretation of the planar scintigraphy, if there was any indeterminate lesion (category 3) or a leading symptom of severe low-back pain incompatible with imaging findings, the additional whole body Evolution SPECT/CT imaging (vertex to mid-thigh) was done. SPECT data were collected in step-and-shoot mode, 6 degree per step with 360 degree rotation, 128 x 128 image matrix size and acquiring 15 sec per view. Images were reconstructed with an ordered subset expectation maximization (OSEM) iterative reconstruction algorithm and high-frequency noise was decreased with post-reconstruction Butterworth filtering (cutoff 0.48 cycle per pixel; order 10) on a computer workstation (Xeleris, GE healthcare). Non-contrast enhanced CT scanning (120 Kv, 20 mA) was

performed in the helical mode with slice thickness of 3.75 mm. and a matrix size of 512. Imaging time of Evolution SPECT from vertex to mid-thigh was about 22.5 minutes (7.5 minutes per bed x 3 beds). Average imaging time, including whole body CT scan of the same region was approximately 25 minutes.

Whole body Evolution SPECT/CT interpretation

Lesions were also classified into 5 categories by the consensus of 2 nuclear medicine physicians and a diagnostic radiologist. Criteria for each category were described as followed:-

Category 1, definitely a metastatic lesion referred to a lesion with radiotracer uptake greater than the ASIS located in a typical site of metastasis on SPECT images. Findings indicated metastatic lesion on CT scan were osteolytic lesion with or without soft tissue mass, a sharply delineated osteoblastic lesion, or a lesion with asymmetric increased density of bone marrow.

Category 2, probably a metastatic lesion referred to a lesion that did not perfectly match to the criteria of definitely a metastatic lesion but had high tendency of being metastatic lesion (e.g. multifocal radioactivity with intensity equal to the ASIS located in a relatively typical site of metastasis without corresponding abnormality on CT scan).

Category 3, an indeterminate lesion is non-diagnostic due to overlapping characteristics between benign and metastatic lesion (e.g. a single bony lesion at spine, rib or skull without abnormal findings on CT scan).

Category 4, probably a benign lesion referred to a lesion that did not perfectly match to the criteria of definitely benign lesion but had high tendency of being benign lesion (e.g. a single lesion in the appendicular skeleton without corresponding abnormality on CT scan).

Category 5, definitely a benign lesion referred to a lesion with radiotracer uptake less than or equal to the ASIS located around the joint or involved both sides of joint on SPECT images. Findings indicated a benign lesion on CT scan were sclerotic change with spondylophytes and disk space narrowing, subchondral cyst and osteophyte.

Confirmation of diagnosis

The reference standard tests used for confirmation of diagnosis were as followed; 1) the follow-up imaging done at least 6 months after performing the bone scintigraphy. Follow-up studies included CT scan, MRI, plain radiograph interpreted by non-participating diagnostic radiologist and bone scintigraphy interpreted by non-participating nuclear medicine physician, 2) the result of the Evolution SPECT/CT corresponding with clinical findings, 3) histopathological report, and 4) findings from clinical follow-up for at least 6 months.

Image data analysis

Data were analyzed based on the diagnosis of each lesion and each patient. Lesions in categories 1 and 2 were summed up as metastatic lesions and categories 4 and 5 were summed up as benign lesions. Lesions without reference standard test were excluded from being analyzed on lesion-based analysis. Diagnostic performance of planar scintigraphy and Evolution SPECT/CT imaging in differentiating metastatic and benign lesions were presented in form of sensitivity, specificity and accuracy. On patient-based analysis, all 80 patients were categorized to conclusive or inconclusive group on each imaging technique. Conclusive group consisted of 2 subgroups; 1) bone metastasis - referred to a patient with category 1 and 2 lesion and 2) no bone metastasis - referred to patient whose all lesions were in category 4 and 5. The inconclusive group included a patient who had category 3 lesion without category 1 lesion.

Results

Of total 499 retrieved lesions from 80 patients, there were 477 lesions that reference standard tests were available for comparison. The rest 22 lesions did not have reference standard test, therefore, they were excluded from analysis. There were 442 lesions detected on the planar scintigraphy and 477 lesions detected on Evolution SPECT/CT. There were 35 missed lesions on planar scintigraphy, which 3 of them were metastasis (Fig. 1 and 2). Lesions in each category on planar scintigraphy and Evolution SPECT/CT were shown in Table 1.

In differentiation between benign and metastatic lesions, sensitivity, specificity and accuracy of the planar scintigraphy were 27% (10/37 lesions, 95%

Table 1. Detected lesions on planar scintigraphy and Evolution SPECT/CT in each category

Categories	Definitions	No. of lesions planar	No. of lesions Evolution SPECT/CT
1	Definitely metastatic lesion	6	35
2	Probably metastatic lesion	7	1
3	Indeterminate lesion	151	0
4	Probably benign lesion	56	1
5	Definitely benign lesion	222	440
	Total	442	477

Table 2. Diagnostic performance of planar scintigraphy and Evolution SPECT/CT imageson lesion-based analysis

Technique	Sensitivity	Specificity	Accuracy
planar	27% 10/37 lesions (95% CI: 13.8, 44.1)	63.2% 278/440 lesions (95% CI: 58.5, 67.7)	60% 288/477 lesions
Evolution SPECT/CT	97.3% 36/37 lesions (95% CI: 85.8, 99.9)	100% 440/440 lesions (95% CI: 96.4, 100)	99.8% 476/477 lesions

Table 3. Detected axial skeletal lesions on planar scintigraphy and Evolution SPECT/CT in each category

Categories	Definitions	No. of Lesions planar	No. of Lesions Evolution SPECT/CT
1	Definitely metastatic lesion	4	31
2	Probably metastatic lesion	5	1
3	Indeterminate lesion	135	0
4	Probably benign lesion	50	1
5	Definitely benign lesion	99	289
	Total	293	322

CI: 13.8, 44.1), 63.2% (278/440 lesions, 95% CI: 58.5, 67.7) and 60% (288/477 lesions), respectively whereas that of Evolution SPECT/CT imaging were 97.3% (36/37 lesions, 95% CI: 85.8, 99.9), 100% (440/440 lesions, 95% CI: 96.4, 100) and 99.8% (476/477 lesions), respectively. Indeterminate lesions on planar scintigraphy were 151 from 442 lesions (34.2%). All of these were able to be categorized on Evolution SPECT/CT imaging (Table 2).

Detection of axial skeletal lesions on planar scinitgraphy were 293 lesions while Evolution SPECT/CT was able to demonstrate all 322 lesions. On planar scintigraphy, there were 135 from 293 lesions that were regarded as indeterminate (46.1%) but on Evolution SPECT/CT imaging, there was no indeterminate lesion (Table 3).

On patient-based analysis, 3 patients were diagnosed as conclusive group (bone metastasis subgroup) and there were 77 inconclusive patients on planar scintigraphy. With Evolution SPECT/CT imaging, an inconclusive group decreased to 13 patients and the number in metastatic group increased to 15 patients (Table 4 and 5).

Table 4. Patient-based diagnosis on planar scintigraphy compared to reference standard test

Diagnosis on planar*	Reference standard test			Total
	Metastasis	Inconclusive#	Benign	
Conclusive				
- Metastasis	3	0	0	3
- No metastasis+	0	0	0	0
Inconclusive	16	5	56	77
Total	19	5	56	80

*Patient-based diagnosis based on all detectable lesions in each patient
#Available reference standard tests were unable to determine nature of the lesions
+No metastasis subgroup was none as patients included into this study must have at least one indeterminate lesion on planar scintigraphy

Table 5. Patient-based diagnosis on Evolution SPECT/CT imaging compared to reference standard test

Diagnosis on Evolution SPECT/CT*	Reference standard test			Total
	Metastasis	Inconclusive#	Benign	
Conclusive				
- Metastasis	15	0	0	15
- No metastasis	1	0	51	52
Inconclusive	3	5	5	13
Total	19	5	56	80

*Patient-based diagnosis based on all detectable lesions in each patient
#Available reference standard tests were unable to determine nature of the lesions

Discussion

Increased radiotracer uptake on planar scintigraphy is non-specific and precise anatomical localization is somewhat limited. This causes differentiation between benign and metastatic lesions sometimes problematic. To overcome this limitation, SPECT/CT imaging has been introduced and become widely used later on. Superiority of diagnostic performance of SPECT/CT imaging over planar scintigraphy has been proved by many studies and it is regarded as a promising technique[6,9-13]. However, it is impossible to perform whole body SPECT/CT imaging routinely for several reasons. Firstly, planar scintigraphy is efficient for detection of bone metastasis in majority of patients. Secondly, patient would receive additional radiation exposure from low-dose CT scan. With this reason, SPECT/CT imaging usually limits to area of suspicion instead of whole body imaging. Lastly, conventional SPECT/CT imaging is a time-consuming process. Subsequently, the Evolution SPECT/CT imaging has been developed to shorten acquisition time from 15 minutes/bed to 7-10 minutes/bed[14,15].

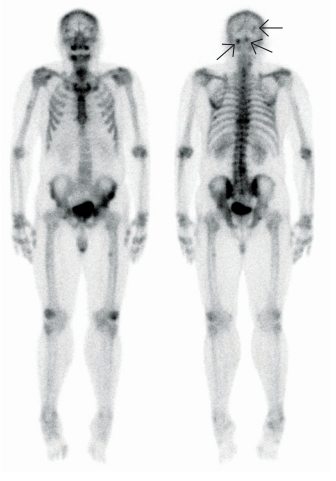
Diagnostic performance of the whole body Evolution SPECT/CT imaging was better than planar scintigraphy. According to the present study, missed lesions on planar scintigraphy were 35 lesions. All of these were detected on Evolution SPECT/CT imaging with 32 lesions considered as benign and the rest 3 lesions were bone metastases. For 3 missed lesions on planar scintigraphy; the first one was a subcentimeter osteolytic destruction without abnormal radiotracer uptake on both planar and Evolution SPECT at right parietal bone in a suspected recurrent prostate cancer patient. The second was a bony lesion at skull without evidence of bony destruction in a diffused large B-cell lymphoma patient (Fig. 1).The last lesion was a small osteolytic destruction at the right pedicle of L3 vertebra in a non-small cell lung cancer patient whose planar

scintigraphy showed only bony metastases at T6 and T7 vertebra (Fig. 2).

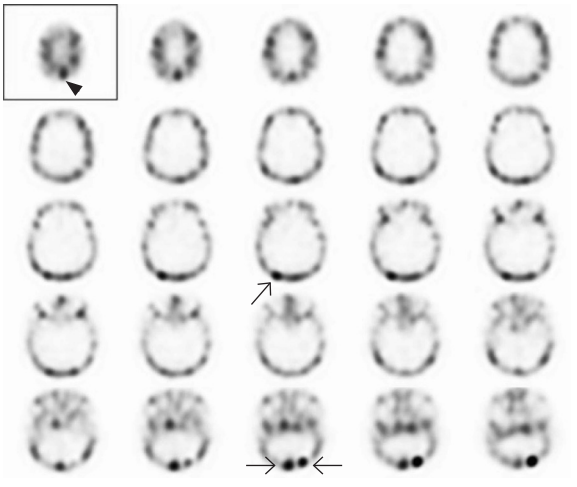
Mechanism of MDP uptake is well-known to be more sensitive than detection of structural change. Therefore abnormal bony lesion detected on the whole body bone scan with normal finding on anatomical imaging is possible. In the present study, planar scintigraphy and SPECT/CT images of one nasopharyngeal cancer patient showed abnormal radiotracer uptake at right sided nasal cavity extended to right pterygoid plate without definite bony destruction. This lesion was suspected to be local invasion. A month later, the staging CT scan revealed local invasion of the primary tumor into nasal cavity with destruction of nasal septum, right maxillary sinus, right ethmoidal sinus, right sphenoidal sinus and right pterygoid plate. These findings confirmed the diagnosis on planar scintigraphy and SPECT/CT images and proved ability of whole body bone scan in early detection as well. (Fig. 3). However, this lesion was regarded as missed diagnostic lesion because the affected bony structure on the staging CT scan, which was also a reference standard test, was more extensive than that on planar scintigraphy and Evolution SPECT/CT.

Of total 151 indeterminate lesions on planar scintigraphy, 135 lesions (89.4%) were located in the axial skeleton. All of these were able to be demonstrated with SPECT/CT imaging. These findings showed the usefulness of SPECT/CT imaging in differentiating the causes of axial skeletal lesions (Fig. 4). Moreover, SPECT/CT imaging also provides additional information. Old fracture in a patient with a single bony lesion at rib, chronic sinusitis in a patient with nasopharyngeal cancer and large myoma uteri in a patient whose planar scintigraphy showed irregular shaped bladder due to compression effect were examples.

The sensitivity, specificity and accuracy of Evolution SPECT/CT in the present study were 97.3%, 100% and 99.8%, respectively. These were similar to the other studies[6,10], but the results of planar scintigraphy were rather low. While Strobel et al[10] reported sensitivity, specificity and accuracy of planar scintigraphy as high as 82%, 94% and 91%, respectively, our planar scinigraphy had extremely low sensitivity of only 27%, and both specificity and accuracy were also not high (63.2% and 60%). The best explanation about discordant results was the difference of the study design. All lesions in the study by Strobel et al were categorized as benign or metastasis and none was

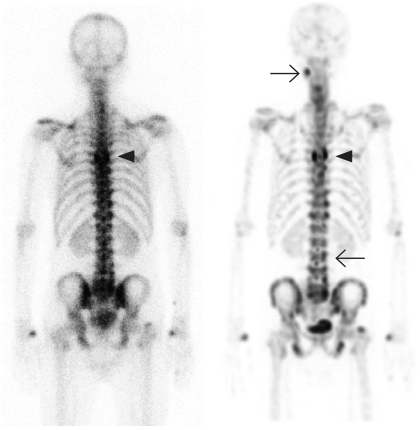


(a)



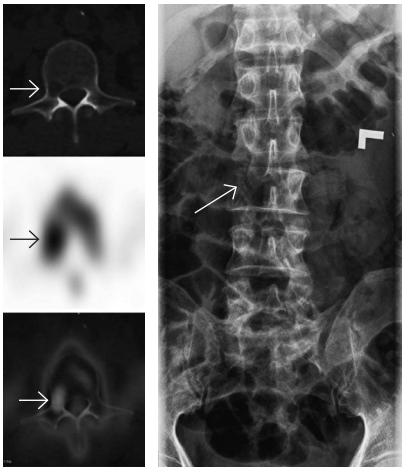
(b)

Fig. 1 (a) Planar scintigraphy of a diffused large B-cell lymphoma patient with paraparesis due to spinal metastases showed 3 abnormal foci of radiotracer uptake at occipital and right parietal region (arrow). Abnormal radiotracer uptake were also detected at posterior aspect of left 8th rib, multiple levels of the spine, left scapula, right humeral shaft, right acetabulum and left sided pelvic bones. (b) Axial views of Evolution SPECT showed multiple foci of radiotracer uptake at skull. One of them was not demonstrated on planar scintigraphy (arrowhead).



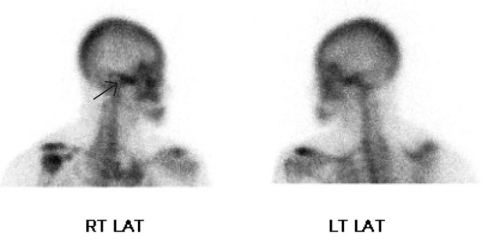
(a) (b)

Fig. 2 (a) Posterior view whole body planar scintigraphy of a non-small cell lung cancer patient showed increased radiotracer uptake at T6 and T7 vertebra (arrowhead) corresponding with bony destruction on Evolution SPECT/CT imaging (not shown). Radiotracer uptake at posterior end of several ribs and lateral aspects of lumbar vertebrae represented degenerative process were also demonstrated. (b) Posterior view whole body Evolution SPECT showed similar findings as planar scintigraphy with better resolution. Additional findings of a focal uptake at cervical vertebra and slightly prominent uptake at right lateral aspect of L3 vertebra were also detected (arrow).



(c) (d)

Fig. 2 (c) Additional bony lesions on Evolution SPECT were seen as osteophyte at C3 vertebra (not shown) and an osteolytic destruction of right pedicle and right lateral aspect of L3 vertebra (arrow) on SPECT/CT imaging. (d) An osteolytic lesion at L3 vertebra was clearly observed on plain radiograph in 3 months later.



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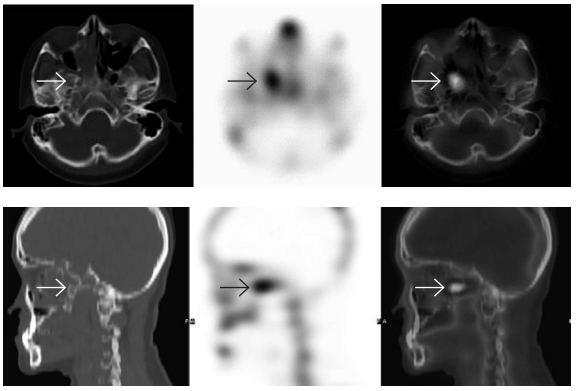
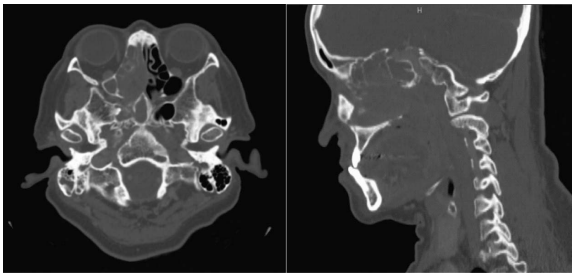


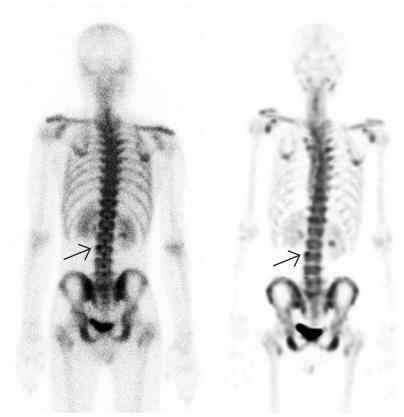
(b)

Fig. 3 (a) Lateral skull of planar scintigraphy of a patient with nasopharyngeal cancer showed increased radiotracer uptake at right sided skull base (arrow) and right maxillary sinus without definite evidence of bony destruction on SPECT/CT imaging (b).



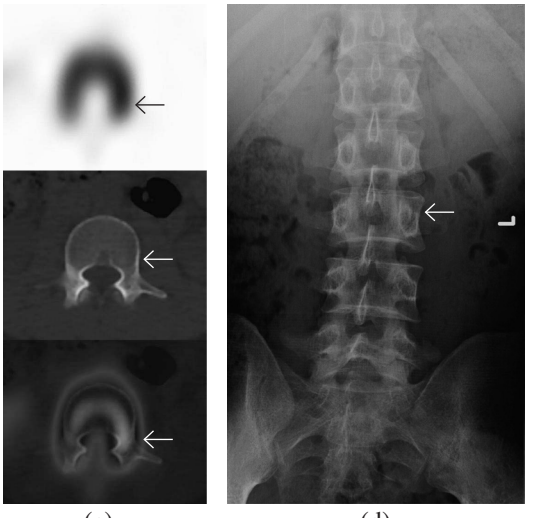
(c)

Fig. 3 (c) Staging CT scan performed a month later showed a large soft tissue mass with bony destruction at adjacent medial wall of right maxillary sinus, right ethmoid sinus, inferior wall of sphenoid sinus, medial aspect of right pterygoid plate and right nasal septum.



(a) (b)

Fig. 4 Posterior whole body planar scintigraphy (a) and Evolution SPECT (b) of a patient with malignant mediastinal germ cell tumor showed focal radiotracer uptake at left lateral aspect of L3 vertebra (arrow).



(c) (d)

Fig. 4 (c) Evolution SPECT/CT images revealed slightly increased radiotracer uptake at left pedicle of L3 vertebra without definite bony destruction. (arrow) This lesion was concluded as probably a metastatic lesion. (d) Plain radiograph performed 2 months later demonstrated an osteolytic lesion at left pedicle of L3 vertebra (arrow).

indeterminate. Using this method, all lesions were included into analyzing processes. In contrast to our study, there was a number of indeterminate lesions, especially on planar scintigraphy. Inclusion of these lesions from analytical process causes the sensitivity, specificity and accuracy of planar scintigraphy extremely low.

Utsunomiya et al[9] demonstrated increment of diagnostic confidence gained with SPECT/CT imaging when compared to the planar scintigraphy and separated set of scintigraphy and CT scan. Their results were similar to ours. Diagnostic confidence was significantly increased with Evolution SPECT/CT imaging. Decrease of 151 indeterminate lesions on planar scintigraphy to none on Evolution SPECT/CT imaging in our study can be implied that Evolution SPECT/CT imaging improved diagnostic confidence by eliminating all indeterminate lesions.

Conclusive lesions on Evolution SPECT/CT imaging in our study were accounted for 100% which was a relatively high proportion as compared to 85-92% in other studies[6,11,12,16].The main reason of different result may be from categorization of the lesions. Instead of using 3 categories like the others, category of probably a benign lesion and probably a metastatic lesion were added to total of 5 categories. Categorization with this strategy may lead to decreased proportion of indeterminate lesions because some indeterminate lesions may be placed in probably categories in lieu. When all probably lesions were considered as indeterminate lesions, conclusive rate was slightly decreased to 99.6%.

Another cause that may have an impact on high conclusive rate of Evolution SPECT/CT imaging was initial low proportion of indeterminate lesions. Percentage of inconclusive lesions on planar scintigraphy was only 34.2% in our study whereas the study by Helyar et al[12], for example, was over 70%. Thus, higher conclusive rate in our study was understandable.

The results of patient-based analysis showed better diagnostic performance of Evolution SPECT/CT than planar scintigraphy. From total 17 bony metastatic and 2 probably bony metastatic patients, 3 and 15 patients were correctly diagnosed on planar scintigraphy and Evolution SPECT/CT imaging, respectively. Conclusive rate on planar scintigraphy was also significantly lower than that of Evolution SPECT/CT (3.8 vs 83.8%). However, patients recruited into the present study must have at least 1 indeterminate lesion on planar scintigraphy. Inconclusive rate of planar scintigraphy was therefore not surprisingly high. In addition, the classification method might be a cause. Bony metastatic patients referred to patients with one or more definitely metastatic lesions, patient

with benign bony lesions referred to patient with all definitely benign lesions and inconclusive patients were the rest who have probably benign or probably metastatic or indeterminate lesion. Thus, inconclusive group must be the largest one.

The strength points of the present prospective study were recruitment of patients with several types of malignancy and the number of total lesion as high as 499 lesions. SPECT/CT imaging technique used in the present study was not only Evolution technique which shorten acquisition time but SPECT/CT imaging was also performed as whole body image, from vertex to mid-thigh. With this reason, our study was actually a comparison between whole body imaging techniques whereas the other studies only performed SPECT/CT imaging over the suspicious area. Hence whole body SPECT/CT imaging could help revealing bony metastasis missed by planar scintigraphy and also provides other abnormalities apart from the skeleton. Our study had several limitations as well. There were 22 inconclusive lesions excluded from analytical process. Histopathological confirmation for all included lesions were not available but best conclusion for each lesion was made by using imaging follow-up and/or clinical follow-up with median time of 161 days. Lastly, proportion of metastatic lesions in our study were relatively low as compared to a huge number of benign lesions. This may not fully demonstrate ability of Evolution SPECT/CT imaging in diagnosis of metastatic lesion.

Conclusion

Differentiation of benign and metastasis lesions on Evolution SPECT/CT images has superior diagnostic performance and diagnostic confidence to that of planar scintigraphy. Therefore, Evolution SPECT/CT images should be considered to characterize indeterminate lesions, especially in the axial skeleton.

What is already known on this topic?

Planar whole body bone scintigraphy is an imaging of choice for detection of bony metastasis although it has relatively low specificity, especially for axial skeleton. With this reason, SPECT/CT, a fusion imaging has been developed to render this limitation. However, SPECT/CT still has disadvantage as the SPECT images is a time-consuming procedure. Thus, Evolution SPECT has been introduced later to decrease scanning time with preservation of imaging quality[14,15].

Many studies have revealed additional value of SPECT/CT imaging as compared to planar scintigraphy[6-13] in the corresponding area. In Thailand, comparison of whole body planar and SPECT/CT imaging has never been performed. With the Evolution technique, imaging time of whole body planar scintigraphy is not much different to that of whole body Evolution SPECT/CT. Therefore, comparison of diagnostic performance of both imaging may be useful to clinical practices.

What is this study adds?

This study proved that whole body Evolution SPECT/CT imaging does not only provide an excellent diagnostic performance in differentiating between benign and metastatic lesions but also reveals additional findings that are useful for definite diagnosis. Moreover, when using Evolution SPECT/CT as a whole body scan, scanning time of this technique is not much different to that of whole body planar scintigraphy, but it provides a superior performance. Therefore, results of this study may lead to change of routine imaging technique from whole body planar scintigraphy to the higher quality image with nearly equal scanning time, the whole body Evolution SPECT/CT imaging.

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Potential conflicts of interest

None.

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การเปรียบเทียบความถูกต้องของการถ่ายภาพกระดูกทั่วตัวด้วยเทคนิค planar และ Evolution SPECT/CT เพื่อวินิจฉัยแยกรอยโรคที่ไม่ใช่มะเร็งกับรอยโรคที่เป็นการแพร่กระจายของมะเร็งมายังกระดูก

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วัตถุประสงค์: *เพื่อเปรียบเทียบความไว ความจำเพาะ ความถูกต้อง และความมั่นใจในการวินิจฉัยแยกรอยโรคที่ไม่ใช่มะเร็ง กับรอยโรคที่เป็นการแพร่กระจายของมะเร็งมายังกระดูกในการถ่ายภาพกระดูกทั่วตัวด้วยเทคนิค planar และ Evolution SPECT/CT*

วัสดุและวิธีการ: *ผู้ป่วยมะเร็งหรือสงสัยว่าเป็นมะเร็ง 80 รายที่พบรอยโรคที่ไม่สามารถวินิจฉัยได้ในภาพถ่ายกระดูกทั่วตัวด้วยเทคนิค planar จะถูกนำเข้ามาในการศึกษาแบบ prospective ผู้ป่วยแต่ละรายจะได้รับการถ่ายภาพกระดูกทั่วตัวเพิ่มเติมด้วยเทคนิค Evolution SPECT/CT รอยโรคทุกตำแหน่งในภาพถ่ายกระดูกทั่วตัวทั้งสองเทคนิคจะได้รับการวินิจฉัยเป็น 5 กลุ่ม คือ รอยโรคที่เป็นการแพร่กระจายของมะเร็งมายังกระดูก, รอยโรคที่น่าจะเป็นการแพร่กระจายของมะเร็งมายังกระดูก, รอยโรคที่ไม่สามารถวินิจฉัยได้, รอยโรคที่น่าจะไม่ใช่มะเร็ง และรอยโรคที่ไม่ใช่มะเร็ง การวินิจฉัยของแต่ละรอยโรคจะถูกนำมาตรวจสอบความถูกต้องกับการตรวจติดตามด้วยภาพวินิจฉัย, รายงานผลทางพยาธิวิทยาหรือการตรวจติดตามอาการจากเวชระเบียนของผู้ป่วยเป็นระยะเวลาอย่างน้อย 6 เดือน*

ผลการศึกษา : *ในภาพถ่ายกระดูกทั่วตัวด้วยเทคนิค planar พบรอยโรคทั้งหมด 442 ตำแหน่ง และเทคนิค Evolution SPECT/CT พบรอยโรคทั้งหมด 477 ตำแหน่ง ภาพถ่ายกระดูกทั่วตัวด้วยเทคนิค planar สามารถวินิจฉัยรอยโรคที่เป็นการแพร่กระจายของมะเร็งมายังกระดูกด้วยความไวร้อยละ 27 (95% CI: 13.8, 44.1) ความจำเพาะร้อยละ 63.2 (95% CI: 58.5, 67.7) และความถูกต้องร้อยละ 60 ส่วนภาพถ่ายทั่วตัวด้วยเทคนิค Evolution SPECT/CT มีความไวร้อยละ 97.3 (95% CI: 85.8, 99.9) ความจำเพาะร้อยละ 100 (95% CI: 96.4, 100) และความถูกต้องร้อยละ 99.8 รอยโรคที่ไม่สามารถวินิจฉัยได้ในภาพถ่ายกระดูกทั่วตัวด้วยเทคนิค planar คือร้อยละ 34.2 (151 จากรอยโรคทั้งหมด 442 ตำแหน่ง โดยในจำนวนนี้เป็นรอยโรคในบริเวณกระดูกแกนกลางของร่างกายถึง 135 ตำแหน่งจากรอยโรคที่ไม่สามารถวินิจฉัยได้ทั้งหมด 151 ตำแหน่ง คิดเป็นร้อยละ 89.4) ส่วนเทคนิค Evolution SPECT/CT สามารถให้การวินิจฉัยได้ทุกรอยโรค*

สรุป: *ในการวินิจฉัยแยกรอยโรคที่ไม่ใช่มะเร็งกับรอยโรคที่เป็นการแพร่กระจายของมะเร็งมายังกระดูก การถ่ายภาพกระดูกทั่วตัวด้วยเทคนิค Evolution SPECT/CT มีความสามารถในการวินิจฉัยและให้ความมั่นใจในการวินิจฉัยสูงกว่าเทคนิค planar ดังนั้นจึงควรพิจารณาใช้การถ่ายภาพกระดูกด้วยเทคนิค Evolution SPECT/CT เข้ามาช่วยในการวินิจฉัยเมื่อพบรอยโรคที่ไม่สามารถวินิจฉัยได้ โดยเฉพาะอย่างยิ่งในบริเวณกระดูกแกนกลางของร่างกาย*