

## Single Photon Emission Computed Tomography (SPECT) for Low Back Pain Induced by Extension With No Root Sign

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### Key Words

bone scintigraphy;

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magnetic resonance Imaging;

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**Background.** Low back pain (LBP) is very common in the general population. Most patients with LBP will receive an X-ray examination on lumbar spine; however, the results are likely to show a negative finding or degenerative joint disease, which are not truly pathological factors. Among various imaging diagnostic tools for active bony lesions of lumbar spine, planar bone scintigraphy has a higher sensitivity, but its ability to locate anatomic lesions is less satisfactory. The purpose of this study was to investigate the role of SPECT for evaluation of LBP.

**Methods.** Fifty-two consecutive patients who had low back pain induced by extension were studied. They had no evidence of malignant tumor, immune disease, spinal infection and neurological disorder by history-taking and physical examination. All patients received planar bone scintigraphy and SPECT exams following an X-ray examination. The results of X-ray finding were grouped into 3 categories: (A) normal; (B) degenerative joint arthritis; (C) spondylolysis. The data of test results and clinical evaluation were then used for analysis.

**Results.** Twenty (38.5%) out of 52 patients examined by planar scan had abnormality, with 29 increased uptake lesions, compared with 28 (53.8%) out of 52 patients with 60 increased uptake lesions by SPECT with planar scan; SPECT disclosed 1-2 more lesions with improved location in 15 patients ( $p < 0.05$ ). Of the 52 patients, 21 (40.4%) presented in group A, 21 (40.4%) in group B, and 10 (19.2%) in group C according to the X-ray examination. In group A, 9 out of 21 (42.9%) patients had an abnormal SPECT result, compared to 5 of 10 (50%) in group B, and 14 out of 21 (66.7%) in group C, respectively ( $p > 0.05$ ). The location of abnormal uptake on L-spine included vertebral body and arch (57.1%), vertebral arch (28.6%), and vertebral body (14.3%). Most of lesions (91.5%) were distributed at the 4<sup>th</sup> and 5<sup>th</sup> lumbar vertebral segments.

**Conclusions.** SPECT was more sensitive and located more lesions than planar bone scintigraphy, especially when the lesions were located at posterior element of vertebrae. Most of the lesions were distributed at the 4<sup>th</sup> and 5<sup>th</sup> lumbar vertebral segments. There was no significant statistical difference of abnormal SPECT related to X-ray finding. The use of SPECT was the first choice among all image modalities when cause of low back pain was assumed to arise from bone and joint disorder at clinical evaluation.

Low back pain (LBP) is a common complaint in the general population. Around 60-80% of people develop the symptom during their lifetime. LBP can be caused by a variety of conditions including muscoligamentous disorder, bone and joint disorder, and neurological disorder.<sup>1</sup> Previous studies have investigated

the use of X-ray, CT, MRI, and bone scan tests in LBP diagnosis. However, these examinations are still unable to determine the pathologic factors in about half of the patients. Among these, bone scan has the highest sensitivity to several disorders of bone and joint at vertebrae of lumbar spine, including active vertebral bony fracture or

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defect, spondylodiskitis, active osteoarthritis of the facet joint, tumor and infection.<sup>1-6</sup> Bone scan can also distinguish the active phase from static phase of the injury, but its specificity and ability to locate anatomic lesions are relatively poor.<sup>3</sup> Several studies have been conducted elsewhere in the world using SPECT as a diagnostic tool for LBP, but is still not available in Taiwan. SPECT can identify the location of injury at vertebral body, intervertebral disc, and vertebral arch of the L-spine. It can compensate for the deficiencies of bone scan and other tools.<sup>1,2,5,6</sup> The objective of this study was to investigate the role of SPECT for evaluation of LBP.

## METHODS

Between July 1, 1999 and December 10, 2000, a total of 52 consecutive patients with chronic LBP were recruited from the outpatient clinic of the Department of Physical Medicine and Rehabilitation at a medical center in central Taiwan. Patients with complaint of low back pain for longer than 3 months and aged between 20 and 60 years of age were enrolled. All studied subjects were examined by the same appointed physiatrist for collection of medical history, physical and neurological data. None of the patients had history of malignant tumor, infection disease, immune disease or acute injury on the lower back. Patients symptoms included persistent backache, knocking pain and local tenderness in the lower back. Back pain was induced by back extension in standing test. Neurological disorders, such as radiation pain and paresthesia to lower leg, sensory or motor deficit, and positive Straight Leg Raising Test (SLRT) were excluded through clinical evaluation. Lumbar spine (L-spine) X-rays, both anterior-posterior (AP) and lateral view, were performed on all patients. Additional L-spine X-rays of both oblique views were taken for patients whose previous X-rays suggested spondylolysis. The results were grouped into 3 categories by a radiologist: (A) normal: negative finding from X-ray of L-spine including alignment, vertebral body, disc space, arch and facet joint; (B) degenerative joint arthritis: marginal spur at vertebral body, narrowing of disc space and hypertrophy change with spur formation at facet joint; (C) spondylolysis: bilateral or unilateral bony defect at pars interarticularis with or without spondylolisthesis. Tc-99m

ethylene diphosphonate (MDP) bone scan was given to all patients following the X-ray examination. Two hours after the intravenous injection of 20-30 mCi Tc-99m MDP, depending on the body weight, whole body planar scanning was performed on all patients using dual-headed  $\gamma$  camera (Helix HR, Elscint Ltd; Haifa, Israel) fitted with a collimator of low energy and high resolution. According to the planar imaging result, all patients received L-spine SPECT examination. The SPECT image was taken using the same camera. Data were acquired in a  $64 \times 64$  matrix with a 1.3 zooming through  $360^\circ$  ( $180^\circ$  for each head) rotation at  $6^\circ$  intervals for 15 seconds per arc interval. The images were presented into coronary, transversal and longitudinal planes, which were independently interpreted by 2 nuclear medicine physicians who had no knowledge of other test results. The level of lesions on L-spine was obtained from planar images, while the location of lesions on the spine, including vertebral body or vertebral arch, was identified through SPECT images. The results of both tests were recorded as normal or abnormal uptake. The locations of lesions detected by SPECT were classified into 3 groups as follows: vertebral body, vertebral arch, vertebral body and arch. Diagnostic results from image modality were analyzed by McNemar test and Chi-square test along with patients medical histories and clinical evaluation.

## RESULTS

Twenty-two men and 30 women were enrolled in the study. The patients mean ( $\pm$  standard deviation) age was 41 ( $\pm$  11) years, ranging from 20 to 60 years; 38 ( $\pm$  9) years in group A, 44 ( $\pm$  10) years in group B, 52 ( $\pm$  12) years in group C. Twenty (38.5%) out of 52 patients had an abnormal planar scan and 28 (53.8%) out of 52 patients had an abnormal SPECT result. Planar scan and SPECT disclosed 29 (7 + 4 + 18, in Groups A; B; C) and 60 (17 + 9 + 34) abnormal uptake lesions, respectively. There were 8 cases (15.3%) with a two-fold difference in the number of detected lesions (60/29) between planar bone scan and SPECT examination (McNemar test;  $p = 0.008$ ). Compared with planar scan, SPECT disclosed 1-2 more lesions with improved location in fifteen patients (Table 1). Of the 52 patients, 21 (40.4%) presented

in group A, 21 (40.4%) in group B, and 10 (19.2%) in group C, according to the X-ray examination. In group A, 5 out of 21 (23.8%) patients had an abnormal planar scan and 9 out of 21 (42.9%) had an abnormal SPECT result, compared to 3 of 10 (30%) and 5 of 10 (50%) in group B, and 12 of 21(57.2%) and 14 out of 21 (66.7%) in group C, respectively (Table 2). There was no significant statistical difference among the groups analyzed by Chi-square test (CA:  $p = 0.215$ ; CB:  $p = 0.447$ ; BA:  $p = 1.000$ ). The locations of abnormal uptake on L-spine were vertebral body and arch (57.1%), vertebral arch

(28.6%), and vertebral body (14.3%)(Table 3). Locating the lesions on vertebral arch revealed that unilateral lesions (7/8, 87.5%) were more common than bilateral lesions (1/8, 12.5%), and more lesions were found on the left side (6/7, 85.7%) than on the right side (1/7, 14.3%). Compared with X-ray finding, 14 out of 17 (82.4%) abnormal uptake of SPECT result were distributed at the 4th and 5th lumbar vertebrae in group A, 9 /9 (100%) in group B and 25/34 (73.5%) in-group C (Table 4).

**Table 1. Analysis of abnormal uptake by planar and SPECT examination**

Scan finding	Patients				Lesions	
	Planar normal	Planar abnor	SPECT normal	SPECT abnor	Planar	SPECT
Planar normal SPECT normal	32	0	24	0	0	0
Planar normal SPECT abnormal	8	0	0	8	0	9
Planar abnormal SPECT normal	0	0	0	0	0	0
Planar abnormal SPECT abnormal	0	20	0	28	29	60
Same number of lesions; no Improvement with SPECT 1-2 more lesions seen on SPECT than on planar and improved location	0	5	0	5	6	6

**DISSCUSION**

Radiography in patients with lower back pain (LBP) may reveal abnormalities, such as scoliosis, narrowing disc space, osteophytes, spondylolysis, or osteoporotic fractures. However, the same imaging finding may be observed in asymptomatic persons, which calls into question the relationship between imaging findings and clinical symptoms. A potential advantage of bone scintigraphy is that it can show physiological activity of osseous lesions, whereas radiography reveals only morphologic changes. Thus, the patient symptoms may be assumed to arise from an area that shows abnormal up-

**Table.3. The location of abnormal uptake by SPECT examination on L-spine**

Location	N	%
Normal	24	46.2
Abnormal uptake	28	53.8
Vertebral body	4	14.3
Vertebral arch	8	28.6
Body + arch	16	57.1

**Table 2. Analysis of abnormal uptake by planar and SPECT examination in different groups**

X-ray results	N	% <sup>1</sup>	Planar Abnormal	%	SPECT Abnormal	% <sup>2</sup>
Group A	21	40.4	5	23.8	9	42.9
Group B	10	19.2	3	30.0	5	50.0
Group C	21	40.4	12	57.2	14	66.7
Total	52	100.0	20	38.5	28	53.8

1. Distribution in percentage of X-ray results.
2. SPECT abnormal ÷ N (in the same X-ray category).
3. Group A = negative finding on X-ray.
4. Group B = spondylolysis with or without spondylolisthesis.
5. Group C = degenerative joint disease.

**Table 4. The correlation of positive SPECT finding to X-ray positive levels**

X-ray positive levels	Spondy 5	Planar 3 P (+) 4	SPECT 5 S (+) 9	DJD 14	Planar 12 P (+) 18	SPECT 14 S (+) 34
L4-5	3	2L5	1L4, 3L5	3	2L4, 1L5	3L4, 3L5
L5-S1	2	1L5	3L5	2	1L5	1L4, 4L5
L3-4	1	1L4	2L4	1	1L3, 1L4	1L3, 2L4
L2-3				1	1L2	1L2, 1L3
L4-5-S1				3	2L5, 1S1	2L4, 4L5, 1S1
L1-S1				4	2L2, 3L3	2L2, 3L3
					2L4, 1L5	3L4, 3L5
Location and (+) number % At L4, L5		Planar: 1L4, 3L5 = 4 SPECT: 3L4, 6L5 = 9 9/9 = 100%			Planar: 3L2, 4L3, 5L4, 5L5, 1S1 = 18 SPECT: 3L2, 5L3, 11L4, 14L5, 1S1 = 34 25/34 = 73.5%	

1. 3 P (+) 4 = 3 planar positive with 4 abnormal uptake.
2. 5 S (+) 9 = 5 SPECT positive with 9 abnormal uptake.
3. 5L4 = 5 abnormal uptake at 4th lumbar vertebral area.
4. Spondy = spondylolysis with or without spondylolisthesis.
5. DJD = degenerative joint disease.

take on bone scan. SPECT is particularly useful in such evaluations since it allows precise location of lesions on the vertebral body, disc space, pedicle, pars interarticularis, facet joint, transverse process and spine process. This anatomic distinction is necessary in order to accurately diagnose the underlying condition detected by bone scan.<sup>1-5</sup> Compared with planar bone scan, tomographic reconstruction provide a more precise display of tracer accumulation, which helps differentiate structures that would otherwise overlap on planar images. Vertebral diseases tend to conform to predictable patterns that can be more readily identified by SPECT than by planar imaging.<sup>5,6</sup> In a prospective study of 100 patients evaluated for LBP, Gates found 23 patients (23%) with an abnormality that was seen only with SPECT.<sup>2</sup> In our study, planar whole-body bone scan and SPECT on lumbar spine were done in sequence 2 hours later after intravenous injection of 20-30 mCi Tc-99m MDP depending on the body weight. Twenty (38.5%) out of 52 patients showed 29 (7 + 4 + 18, in Group A; B; C) images with abnormal uptake by planar scan, and 28 (53.8%) out of 52 patients showed 60 (17 + 9 + 34) images with abnormal uptake by SPECT. The 4th and 5th lumbar vertebral segments are most common injured because the most motion and weight-bearing develops there during flexion and extension exercise. The resultants of repeated injury can produced spinal instability, spondylolysis or spon-

dylolisthesis, and degenerative joint disease of the facet joint at these segments in some patients with low back pain showed positive finding on both X-ray and SPECT.<sup>7</sup> Most lesions (91.5%) were distributed at the 4th and 5th lumbar vertebral segments, which all included positive finding on X-ray examination in our samples (Table 4). The results mean about half of samples related to active bone and joint disorder at lower lumbar area and others may be related to other origins. Why is the SPECT positive rate higher than Gates study? The major cause is probably the different clinical presentation of samples. Our samples tended bone and joint disorder because of back pain provoked by back extension on physical examination, compared to Gates samples, which just include all back pain in general population. Low back pain provoked by back extension is typically associated with degenerative joint disease of lumbar spine or active bony lesion at posterior element of vertebrae.<sup>7</sup> There were 8 cases (15.3%) with a two-fold difference in the number of detected lesions (60/29), with a significant difference ( $p < 0.05$ ) between planar bone scan and SPECT examination. Six cases had a small abnormal uptake located at the left pars interarticularis, one case at right side and the other one at both sides. Four out of 8 cases were in group A, and the other 2 cases were in groups B and group C, respectively. These results can explain why SPECT was more sensitive than planar scan. Repeated back exten-

sion movements with loading easily produce stress fractures at the pars interarticularis. They are frequently seen in athletes and manual workers.<sup>7</sup> Patients in group A, youngest among our 3 groups ( $38 \pm 9$  years), have the most chance to sustain back extension injury because they need to work or exercise more at this age group. SPECT had the highest sensitivity and specificity in this condition among all the imaging modalities tested.<sup>3,8</sup> It is widely accepted that degeneration of the intervertebral disc is a major cause of low back pain.<sup>1,7,9</sup> Both mechanical and nutritional factors could induce lumbar marrow MRI changes in the area of the end plate. Conversion of normal bone marrow to a fatty marrow in the end plate may produce MRI change that is similar to that of the ischemic hip at the onset of disc degeneration. Abnormal uptake may be detected at the marginal area of vertebral body where fatty marrow is converted, but X-ray may produce a negative finding.<sup>9</sup> This phenomenon may explain why 23.8% (5/21) and 42.9% (9/21) of patients in group A still had abnormal uptake by planar scan and SPECT, respectively. Secondary marginal spur formation and facet joint degeneration with active arthritis develops as disc degeneration progresses, with resultant vertebral instability.<sup>7</sup> This result could explain the higher positive rate of SPECT (66.7%; 14/21) and why most lesions were located on both body and arch in group C. Patients with congenital spondylolysis, easily diagnosed by X-ray, usually present with inactive bony lesion without abnormal uptake except when a new injury has occurred. Acquired spondylolysis usually reveals abnormal uptake due to increasing bone turnover at onset of injury, followed by normal uptake after bone union or nonunion. Many patients with spondylolysis gradually develop spondylolisthesis with instability of lumbar spine because of repeated back movement with loading and aging process.<sup>1,6,7</sup> Five out of 10 patients (50%; 5/10) in group B had abnormal uptake, with 2 cases of lesion on arch and 3 cases of lesions on both body and arch by SPECT examination. The positive rate of lesion detection by SPECT among patients in group B was not as high as expected. Eight (28.6%) out of 28 cases only had arch lesions, especially on the left side, which was compatible with area of local tenderness at clinical examination. Local lesions on lamina, pars interarticularis or facet joint likely caused this. In many of our patients with

positive SPECT on arch, it was still difficult to differentiate pars interarticularis from facet joint, and specificity was relatively uncertain. Local steroid and xylocaine injection to the focal areas corresponding to some cases with abnormal uptake on arch part can be used for therapeutic diagnosis and treatment when focal infection or malignant invasion are excluded by clinical manifestation and SPECT reading.<sup>10</sup> Osteomyelitis and discitis commonly present with severe low back pain and may produce positive bone scan weeks before radiographic finding. Vertebral osteomyelitis most commonly involve the mid and lower thoracic spine and discitis the L2 to L4 level. Tracer uptake in osteomyelitis may have a butterfly pattern due to paravertebral involvement and in discitis often has a vertical, ovoid configuration centering on the disc space.<sup>11,12</sup> In our study, outcomes with this method were satisfactory for several cases. Further studies with CT or MRI are needed to optimize their use in therapeutic diagnosis and treatment of LBP.

In conclusion, SPECT was more sensitive than planar scan, especially for stress fracture at portions of the arch, but had uncertainty in specificity. The use of SPECT can identify the location of the lesion on vertebral body, transverse process, arch, and spinal process, which may help differentiate the characteristics of the lesion at bone and joint. Most of lesions were distributed on the 4th and 5th lumbar vertebral segments. There was no significant statistical difference of abnormal SPECT results among all groups of X-ray findings. The use of SPECT was the first choice among all image studies, including CT and MRI, for cases of low back pain assumed to arise from bone and joint disorder at clinical evaluation. Local injection to the focal area corresponding to abnormal uptake can be used for therapeutic diagnosis and treatment of low back pain.

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