Pinhole Collimator Scintigraphy in Differential Diagnosis of Metastasis, Fracture, and Infections of the Spine

Yong Whee Bahk, Ok Hwa Kim, and Soo Kyo Chung

Department of Radiology, Kangnam St. Mary's Hospital and St. Mary's Hospital, Catholic Medical College and Center, Seoul 135 Korea

The informational gains obtained by the use of pinhole collimator scintigraphy (PCS) have been well documented. The present study has been undertaken to prospectively investigate its efficacy in diagnosing several commonly occurring spinal diseases. Patient material consisted of metastatic cancer (39 vertebrae), compression fractures (33 vertebrae), tuberculous spondylitis (17 vertebrae), and pyogenic spondylitis (six vertebrae). PCS findings were characterized in terms of localization, appearance, and homogeneity of abnormal radionuclide accumulation. Thus, metastatic cancer manifested as diffusely or focally homogeneous accumulation within the vertebral body or as a typical short-segmental accumulation along the end-plate, whereas compression fracture manifested as characteristic board-like accumulation along the entire length of end-plates. Tuberculous spondylitis, on the other hand, revealed homogeneous accumulation throughout the vertebral body, and pyogenic spondylitis revealed accumulation at the end-zone of opposing vertebral bodies giving sandwich-like appearance. The disk space at the affected level was not narrowed in the former two diseases but it was narrowed in the latter two. It was concluded that PCS may be useful in differentiating metastatic cancer, compression fracture, tuberculous spondylitis, and pyogenic spondylitis.

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The informational gains obtained from the enlarged display of the pathologic findings in the skeletal system of pinhole-collimator scintigraphy (PCS) have been well documented (*1–3*). However, apparently due to its time-consuming nature and failure to appreciate how much detail can be revealed by PCS, this examination has found a limited place in exploring the spine which is often the site of such significant diseases as metastatic cancer, fracture, and infection. In spite of the fact that accurate diagnosis of these conditions is imperative, differential diagnosis by routine radiography, multi-hole-collimator scintigraphy, and even by computed tomography is not easy (*4–8*).

With these facts in mind, we have applied PCS in the study of several common spinal diseases to prospectively investigate the usefulness of this examination as a single determinant. The experiences obtained from these observations form the basis of the present communication.

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For reprints contact: Yong Whee Bahk, MD, Dept. of Radiology, Catholic Medical Center and College, Seoul, 135 Korea.

MATERIALS AND METHODS

The clinical materials consisted of 39 vertebrae of 16 patients with metastatic cancer of the spine from various primary lesions (age 22–72 yr with mean 54), 33 vertebrae of 20 patients with compression fractures (age 25–74 yr with mean 50.2), 17 vertebrae of six patients with tuberculous spondylitis (age 27–50 yr with mean 41.8), and six vertebrae of three patients with pyogenic spondylitis (age 24–52 yr with mean 39). All patients were seen in our medical centers during the past several years. Diagnosis has been established in each case by x-ray, computed tomography, surgery, and/or histology.

PCS has been performed 2–4 hr after injection of 20–30 mCi of technetium-99m methylene diphosphonate (MDP). A pinhole collimator having a 3-mm aperture was placed over the region of interest which had been disclosed by a prior single-pass-area scanning or single-spot view of the whole skeletal scintigraphy. The gamma camera used was an Ohio-Nuclear Sigma 410 model. PCS images were made at the source-aperture distance being 5 to 10 cm and radioactivity counts were accumulated from 400,000 to 500,000 over a period of 20 to 30 min.

PCS findings were characterized in terms of localization within the vertebra, appearance, distribution pattern and homogeneity of abnormal radionuclide accumulation. In addition, the involvement of disk space was evaluated.

RESULTS

Of 39 vertebrae affected by metastatic cancer, 34 (87.2%) showed diffusely homogeneous accumulation of radioactivity either throughout the entire vertebral body (15 cases) or in a portion (19 cases) whereas the remaining five (12.8%) showed typical short segmental accumulation in the vertebral end-plate (Figs. 1A and B). There were 33 vertebrae affected by compression fracture. Of these, 20 (60.6%) showed characteristic board-like involvement of the entire length and thickness of the upper, 5 (15.2%) the lower, and 8 (24.2%) both the upper and lower end-plate of the vertebrae (Fig. 2A). The demarcation of the board-like accumulation was sharp in 25 (75.8%) and not sharp in the remaining eight (24.2%). It was remarkable that such board-like accumulation demonstrated by PCS could not be recognized in the great majority (75.8%) of the cases on single-spot scintigram as shown in Figure 2B. Disc-space narrowing was not noted in any of the cases with metastatic cancer or compression fracture (*vide infra*).

There were 17 vertebrae involved by tuberculosis and six by pyogenic infection. Of the former, 12 (70.6%) showed rather diffuse and homogeneous accumulation of radioactivity within the vertebral body which was similar in appearance to metastatic cancer. But in every case of tuberculous spondylitis, there was moderate to marked narrowing or complete obliteration of the adjacent disk space (Fig. 3). In five cases (29.4%) the radioactivity accumulation was segmental. There were six vertebrae afflicted with pyogenic infection and, unlike in tuberculosis, the radioactivity accumulation was more or less localized segmentally to the peripheral or subend-plate zone of two opposing vertebral bodies with narrowed disk space giving a sandwich appearance (Fig. 4A). Again it was noted that such a typical feature was not depicted by single-spot scintigram (Fig. 4B).

DISCUSSION

The use of a pinhole collimator has resulted in marked improvement of anatomic and spatial resolution on bone scintigram as to efficiently depict and characterize many specific findings. For example, diminished uptake indicating avascular necrosis in the capital femoral epiphysis in Legg-Perthes' disease and,

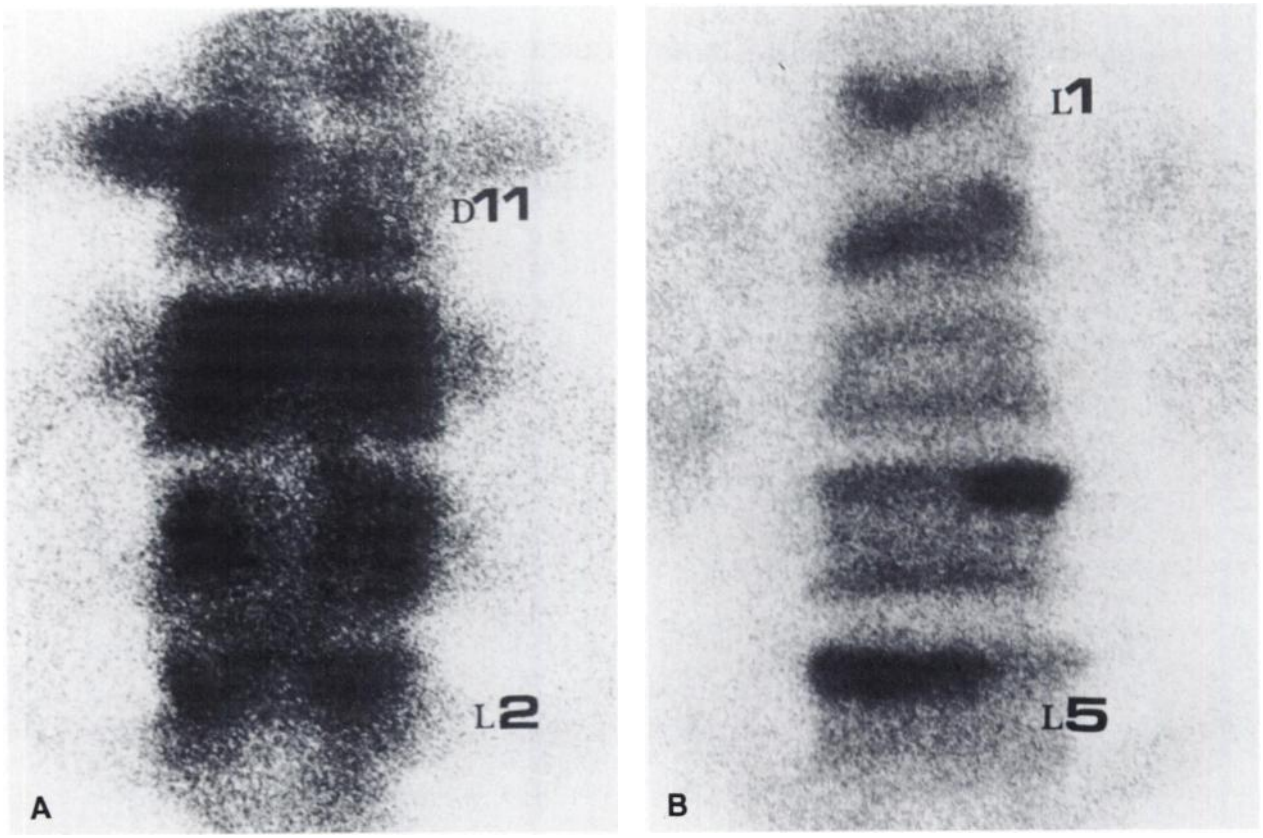

FIGURE 1
A: Multiple metastases to D11-L2 vertebrae from bronchogenic carcinoma demonstrated as diffusely homogeneous accumulation of radioactivity throughout the vertebral bodies by pinhole collimator scintigraphy (PCS). B: PCS of multiple metastases to lumbar spine from bronchogenic carcinoma showing typical short-segmental accumulation of radioactivity along the end-plates of L4 and L5 vertebrae, while the accumulation is diffuse in L1 and L2 vertebrae.

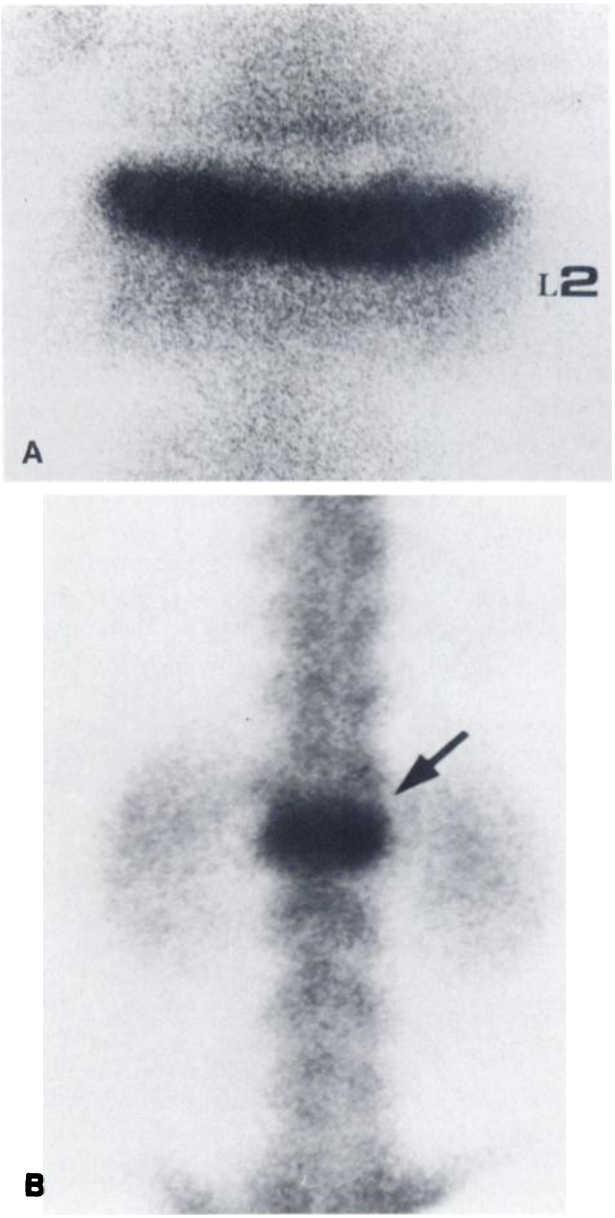

FIGURE 2
A: PCS of a single compression fracture involving the upper end-plate of L2 vertebra showing typical board-like accumulation of radioactivity. B: Single-spot scintigram of the same patient as Figure 2A showing diffuse homogeneous accumulation pattern throughout the entire vertebral body without distinguishing features demonstrated by PCS.

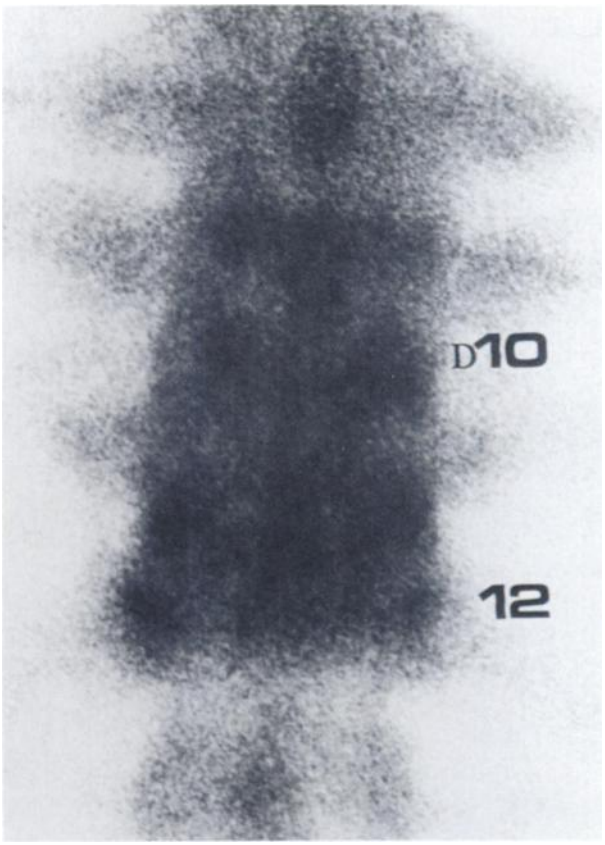

FIGURE 3
Tuberculous spondylitis involving D10-12 demonstrated as diffusely homogeneous accumulation of radioactivity throughout the affected vertebral bodies with total obliteration of disk spaces. This last finding distinguishes tuberculosis from metastatic cancer.

conversely, return of uptake indicating revascularization have been well demonstrated by the use of PCS (*1*). One of the present authors has also shown quantitatively that PCS is by far superior to single-pass-area scanning and single-spot scintigram in delineating anatomic details and pathologic changes in a variety of bone and joint diseases (*2,3*).

Our extended application of PCS in the study of cancer metastasis, fractures, and infections of the spine has revealed that this examination provides many specific findings for differential diagnosis. Thus, in each disease one or more characteristic PCS findings were noted and such observations seem to warrant the statement that the contention held by some (*4,8*) that radionuclide bone imaging is nonspecific appears less valid when the examination is supplemented by PCS.

The vast majority (87.2%) of metastatic cancer sites demonstrated homogeneously increased accumulation of radioactivity either in a diffuse or focal fashion within the vertebral body. This type of accumulation pattern appears to reflect the fact that metastatic cancer lesions present as large single confluent foci and/or small multiple foci within the cancellous portion of the vertebra (*4,6,9*). In the remaining 12.8% the radioactivity accumulation assumed a short segment-like appearance along the end-plate of the vertebra as shown in Figure 1B. Such a finding was not observed in any other conditions investigated.

All 33 vertebrae with compression fracture demonstrated characteristic board-like accumulation along the entire length and thickness of either the upper and/or lower end-plates (Fig. 2A). We consider this finding to be characteristic of compression fracture. According to

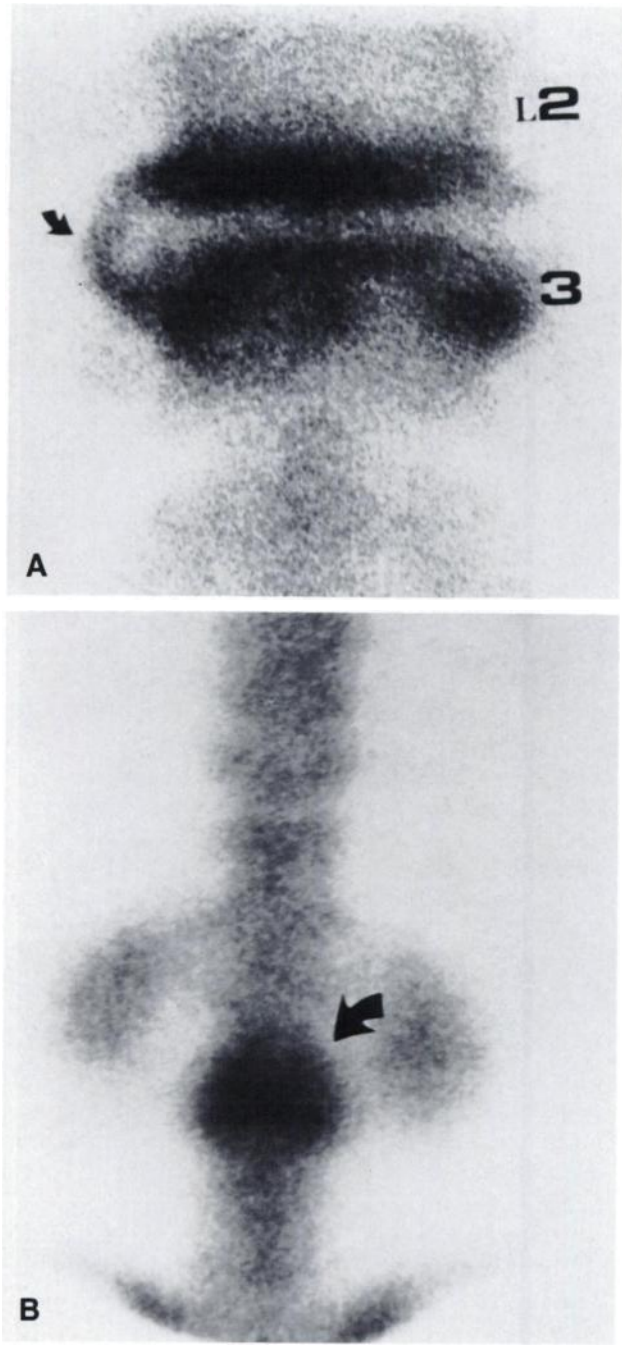

FIGURE 4
A: PCS of chronic pyogenic spondylitis involving L2-3 vertebrae showing characteristic end-zone accumulation of radioactivity in two opposing end-plates with narrowing of the disk space in between giving sandwich-like appearance. An incidental pre-existing spur is well visualized (arrow). B: Single-spot scintigram of the same patient as Figure 4A showing rather diffuse and unrevealing accumulation pattern (arrow).

Denis (*11*) the most frequent type of compression fracture involves the upper end-plate of the vertebra, and there are isolated breaks of the inferior end-plate and sometimes of both end-plates. In a few cases with bursting fracture (not included in the present series) accumulation of the radioactivity was diffuse without end-plate localization, making distinction from metastatic cancer difficult by PCS alone. In both metastatic cancer and compression fracture, vertebral disk space was not narrowed and this finding enabled us to distinguish these two conditions from tuberculosis and pyogenic infection of the spine in which disk-space narrowing was a central and constant feature.

Of 17 vertebrae affected with tuberculosis 70.6% presented rather homogeneous accumulation throughout the vertebral body, much like the finding in metastatic cancer. But in every case of tuberculous spondylitis, there was narrowing of the adjacent disk space (Fig. 3). In contrast, in all six vertebrae affected by pyogenic infection, the radioactivity accumulation was localized to the end-zone of the vertebral bodies opposing each other, producing sandwich-like appearance with an intervening "cold" disk space (Fig. 4A). Pathologically this finding reflects the fact that the offending microorganisms of spinal osteomyelitis most commonly lodge in the end-zone vascular arcades producing prominent reaction at the periphery of vertebral body (*10*). The end-zone involvement by a pyogenic infection is usually followed by the invasion of adjacent disk, resulting in obliteration of the disk space when the process is not properly treated.

In conclusion, PCS may be useful in differentiating metastatic cancer, compression fracture, tuberculous spondylitis, and pyogenic spondylitis.

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