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Skeletal Metastasis in Renal Cell Carcinoma: Photon Deficiency on Bone Scintigraphy

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ABSTRACT. Bone scintigraphy with ^{99m}Tc-labeled phosphorous compound is an excellent technique for the detection of bone metastasis. Bone metastases are usually visualized as multiple hot spots on bone scintigraphy. However, photon deficiency in the metastatic lesion on bone scintigrams is reported in few cases with malignancy. In this study, we have evaluated the photopenic bone metastasis from renal cell carcinoma by the radiographic and computed tomographic examinations.

Photon deficient metastatic lesions were seen on bone scintigraphy in 5 patients with renal cell carcinoma. All of the photon deficient lesions were osteolytic on bone radiography and computed tomography.

The pure photon deficient lesions not associated with surrounding hot margins were seen on the thoracic vertebrae and rib and the ones with surrounding hot margins were seen on the sternum, pelvis and femur. This difference may be due to the differences in the growth rate of the tumor and reactive hyperemia and new bone formation in the metastatic lesions.

Key words : bone metastasis — bone scintigraphy — photon deficiency — renal cell carcinoma

It is well known that bone scintigraphy with ^{99m}Tc-phosphorous compound is an excellent method for the detection of malignant bone metastasis.[1-3] However, since the accumulation of the ^{99m}Tc-phosphorous compound in bone lesions does not indicate directly the presence of tumor cells but shows the accelerated bone formation following its destruction,[4] bone scintigraphy not infrequently presents a negative image when tumor growth is not accompanied by bone formation.[5,6]

In the lesions of bone metastasis from renal cell carcinoma, in which rapid osteolysis with little bone formation take place, none to slight accumulation of the radionuclide in the lesions is not infrequently experienced despite of the existence of a neoplasma.

In this study, we have evaluated photopenic bone metastasis from renal cell carcinoma on bone scintigraphy, and compared with radiographic and computed tomographic findings.

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MATERIALS AND METHODS

Pertinent laboratory data are summarized in Table 1. Patients received 20 mCi of ^{99m}Tc-methylene diphosphonate intravenously, and 3 hours later whole body images and spot images of the suspected lesions were taken. Abnormal findings were compared with those on radiograms and computed tomograms.

TABLE 1. Pertinent laboratory data

Patient	Age/Sex	Alkaline phosphatase (I.U./l)	Calcium (mEq/l)
1	48/M	222	6.0
2	71/M	64	4.8
3	57/M	61	4.5
4	58/M	145	4.1
5	50/M	68	4.3

RESULTS

Table 2 is a summary of the localization of photon deficient areas on bone scintigraphy and their corresponding radiographic and computed tomographic findings.

Photon deficient lesions without surrounding hot margins were seen on the thoracic vertebrae and rib in 2 patients. On the other hand, photon deficient lesions with surrounding hot margins were noted on the sternum, pelvis, fibula and femur in 4 patients.

TABLE 2. Comparison of scintigraphic, radiographic and computed tomographic findings

Patient	Site of photon deficiency	Reaction around photon deficient area	Bone x-p	Computed tomography
1	Thoracic spine	→	lytic (?)	lytic
2	Fibula	↑	lytic	
3	Sternum	→	lytic	lytic
4	Thoracic spine	→	lytic	lytic
	Rib	→	lytic	lytic
	Femur	→	lytic	
5	Pelvis	↑	lytic	

CASE REPORTS

Case 1 (Fig. 1)

A 48-year-old man, under diagnosis of the right renal cell carcinoma with multiple lung metastases, was received immunochemotherapy for one year without improvement. In December 1985, disturbance in walking and back pain appeared. A cold defect was recognized in the eighth thoracic spine on the bone scintigraphy, while no increased accumulation was shown in that region (Fig. 1a). Computed tomography showed the replacement of the bone architecture in large part of the vertebral body by tumor tissue (Fig. 1c).

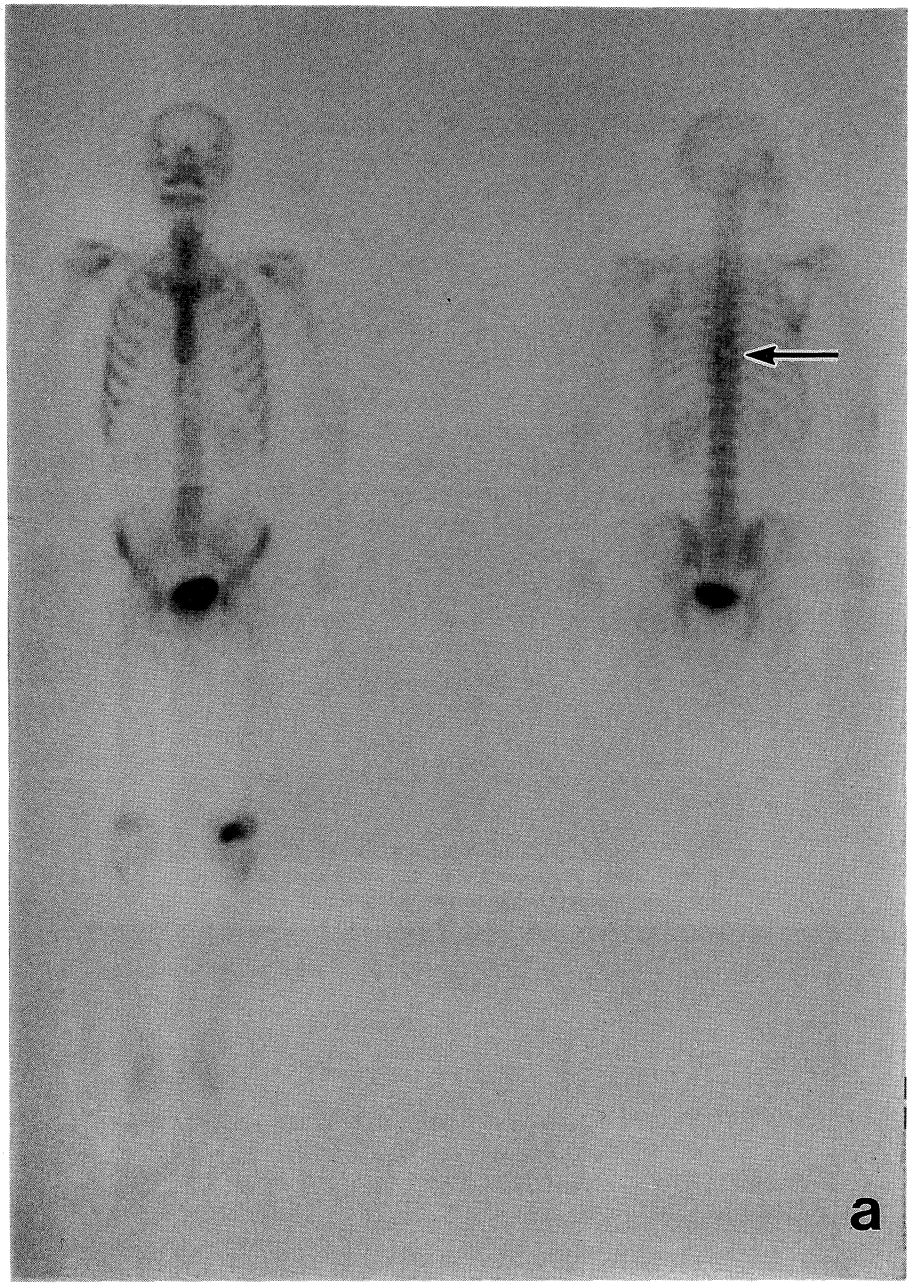

Fig. 1a. Bone scintigraphy showed cold defect, nearly normal pattern, in the eighth thoracic vertebra.

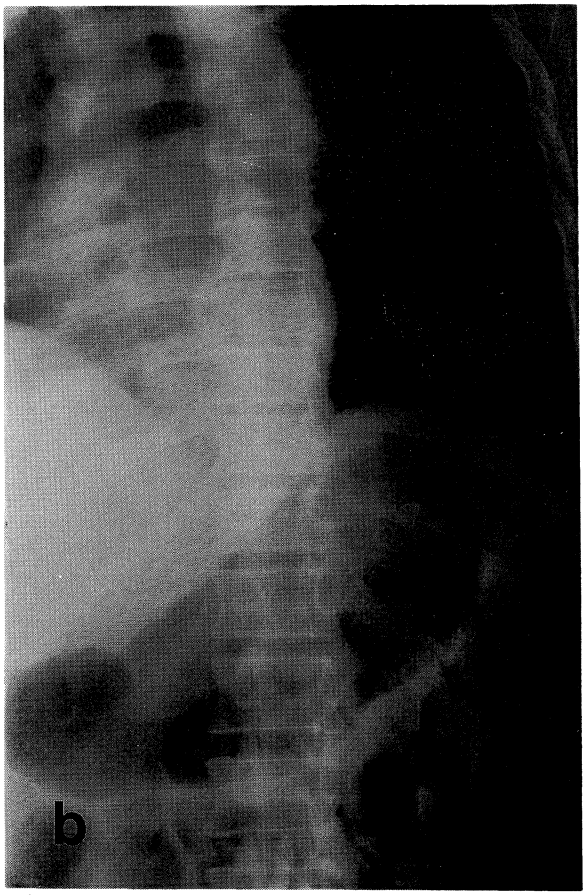

Fig. 1b. Bone radiography of the thoracic vertebrae: Faint osteolytic change can be detected.

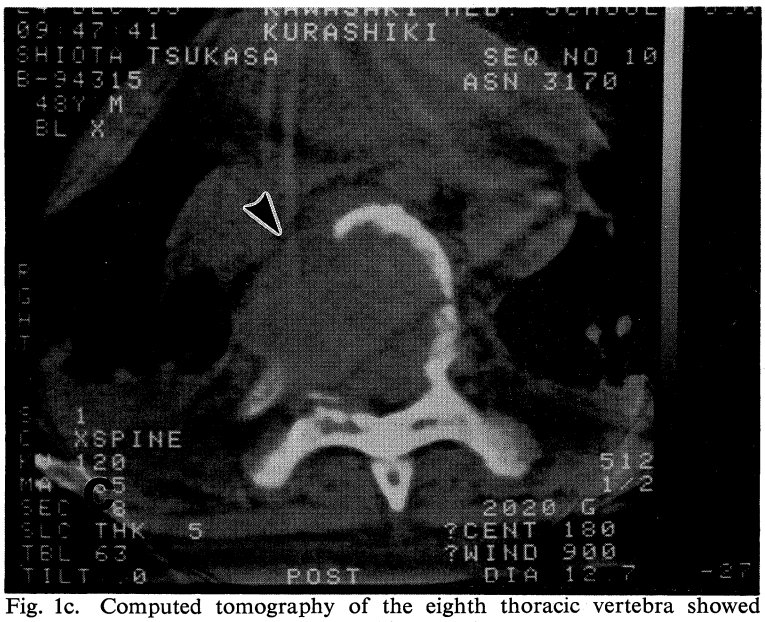

Fig. 1c. Computed tomography of the eighth thoracic vertebra showed the replacement of the bone architecture by tumor.

Case 2 (Fig. 2)

A 71-year-old man noticed lower limb pain in May 1985. In May 1986, the radiography of the right fibula showed osteolytic change (Fig. 2a). Bone scintigraphy showed an abnormal doughnut-shaped accumulation of the radionuclide, with a central cold area and a surrounding hot margin, in the diaphysis of the right fibula (Fig. 2b).

A biopsy was performed, and the diagnosis of a metastatic bone tumor from renal cell carcinoma was made.

Fig. 2a. Bone radiography of the right fibula: Osteolytic change can be detected.

Case 3 (Fig. 3)

A 57-year-old man noticed a tumor over the upper part of the sternum in July 1986, and the tumor gradually enlarged.

Bone scintigraphy showed a photon deficient area with surrounding hot margin in the sternum (Fig. 3a).

In January 1987, a biopsy was performed, and the diagnosis of clear cell carcinoma was made. Computed tomography demonstrated the encroachment of the sternum by tumor (Fig. 3b).

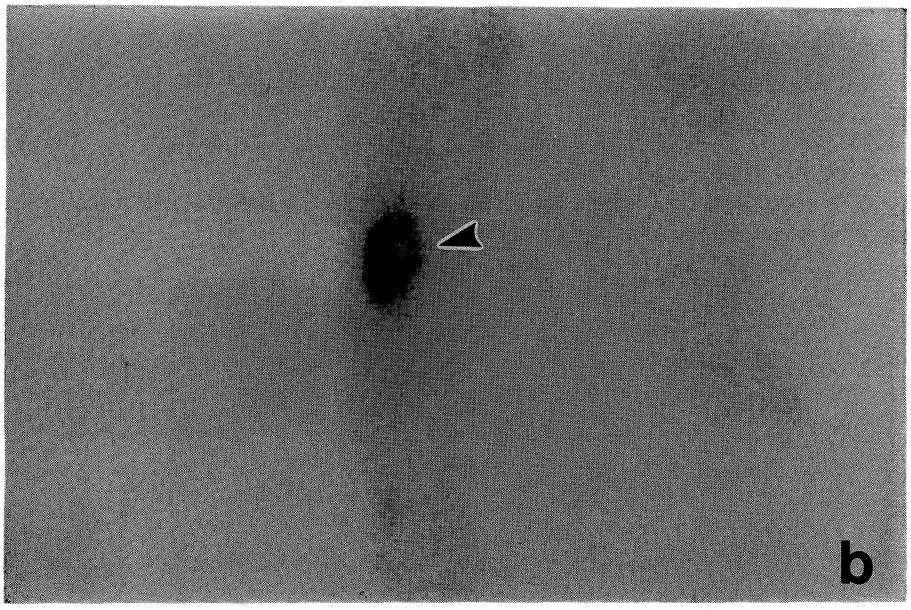

Fig. 2b. Bone scintigraphy showed cold defect, like a doughnut.

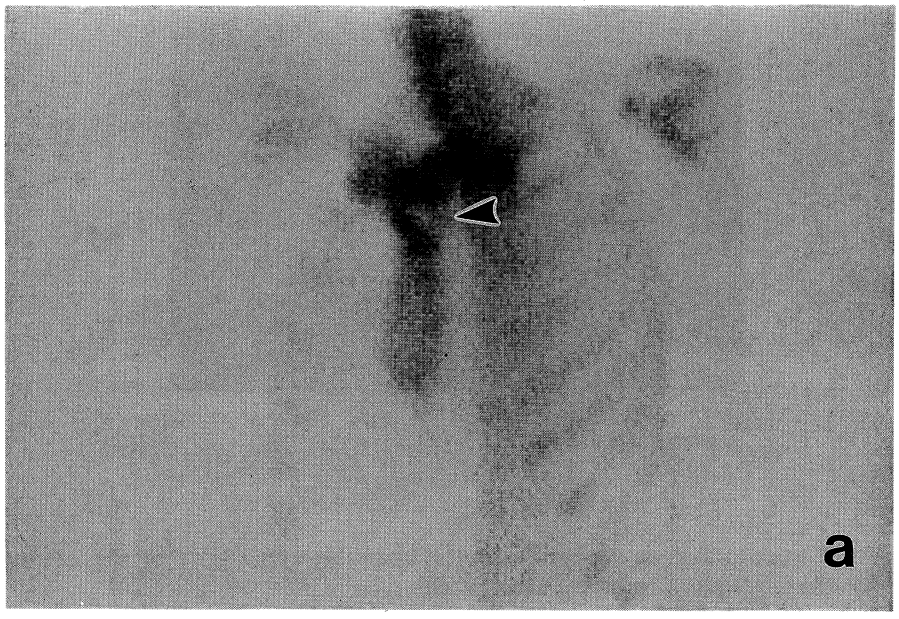

Fig. 3a. Bone scintigraphy showed a photon deficient area with surrounding hot lesion in the sternum.

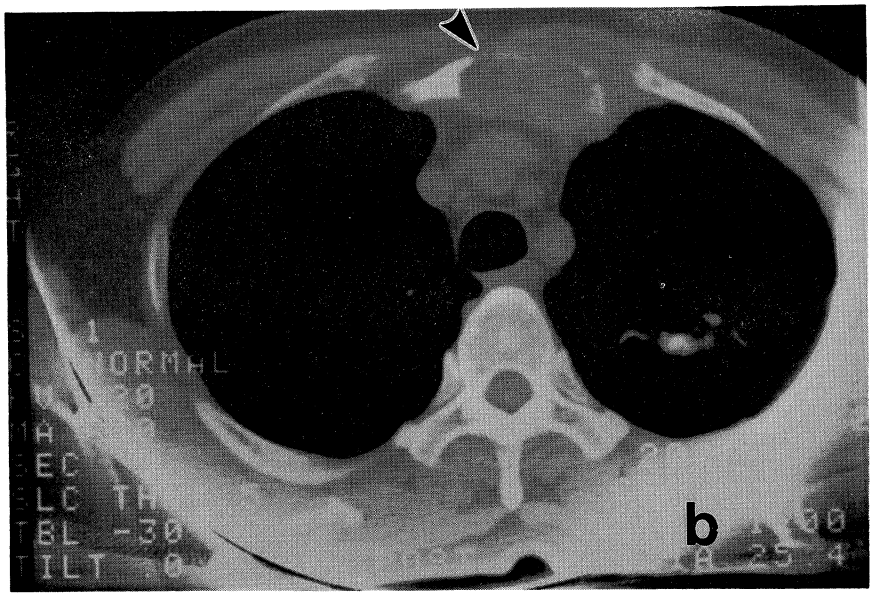

Fig. 3b. Computed tomography demonstrated the encroachment of the sternum by tumor.

Case 4 (Fig. 4)

A 58-year-old man with severe back pain was diagnosed of renal cell carcinoma, and underwent left radical nephrectomy. Bone scintigraphy showed photon deficient areas in the eighth thoracic vertebra, rib and right femur (Fig. 4a).

The radiography and computed tomography showed osteolytic lesions in these areas (Fig. 4b, c, d).

DISCUSSION

A survey of metastatic bone tumors by bone scintigraphy greatly facilitates an early diagnosis, as compared with bone radiography.[1-3] The latter generally requires 30-50% decalcification before the bone destruction becomes apparent on films. However, ^{99m}Tc-phosphorous compounds do not accumulate specifically in malignant bone tumors, but accumulate in the areas of rapid bone renewal in response to the bone destruction directly by the tumor or indirectly through the activation of osteoclast.[7,8] Thus, when bone formation is activated, a high accumulation of the radionuclide generally is associated. However when the reactive bone formation is none or minimal, there usually is the little accumulation displaying photon deficient images, even though a tumor is present.[4] That photon deficient bone lesions are known to be frequently seen in renal cell carcinoma and multiple myeloma. In multiple myeloma, it is widely known that the only bone resorptions is accelerated by activated osteoclasts through chemical mediator(s) such as osteoclast activating factor(s) without activation of osteoblasts.[9] On the other hand, in renal cell carcinoma which bone destruction may be so fast that osteoblastic bone formation could not

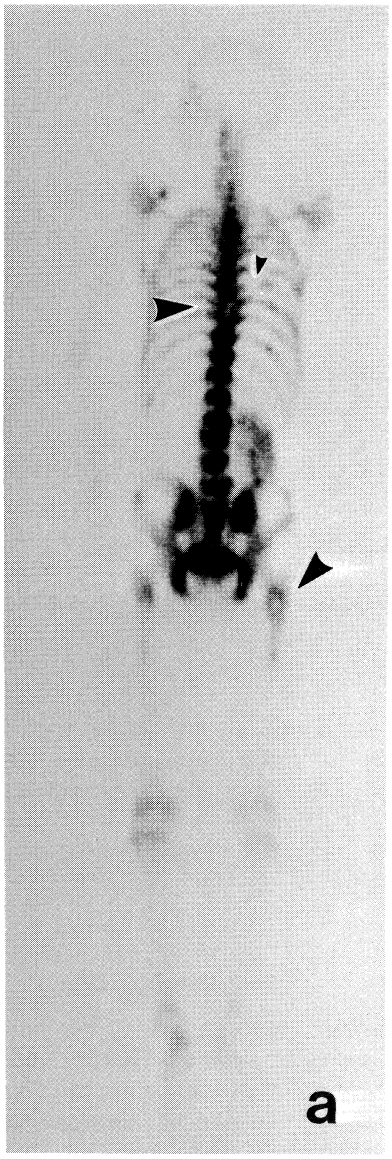

Fig. 4a. Bone scintigraphy showed photon deficient areas in the eighth thoracic vertebra, rib and right femur.

catch up with osteolytic change.

In our patients with renal cell carcinoma, lack of osteoblastic bone formation might contribute to their lack of radionuclide uptake by the bone lesion. In fact, bone radiographies and computed tomographies demonstrated the osteolysis without osteoplastic change in the lesions.

Although not common as in the renal cell carcinoma[10,11] the photonopenic findings in the metastatic bone lesions were also reported in some cases of

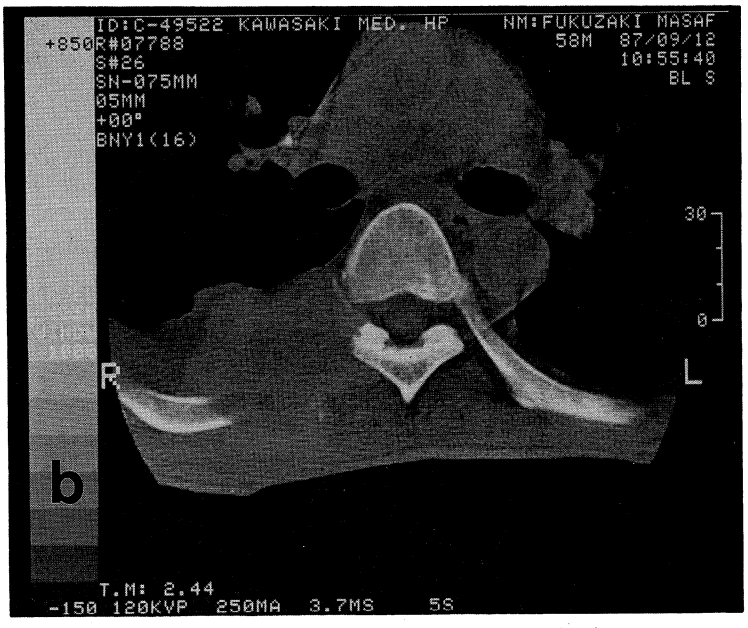

Fig. 4b. Computed tomography showed the soft tissue mass in the right rib.

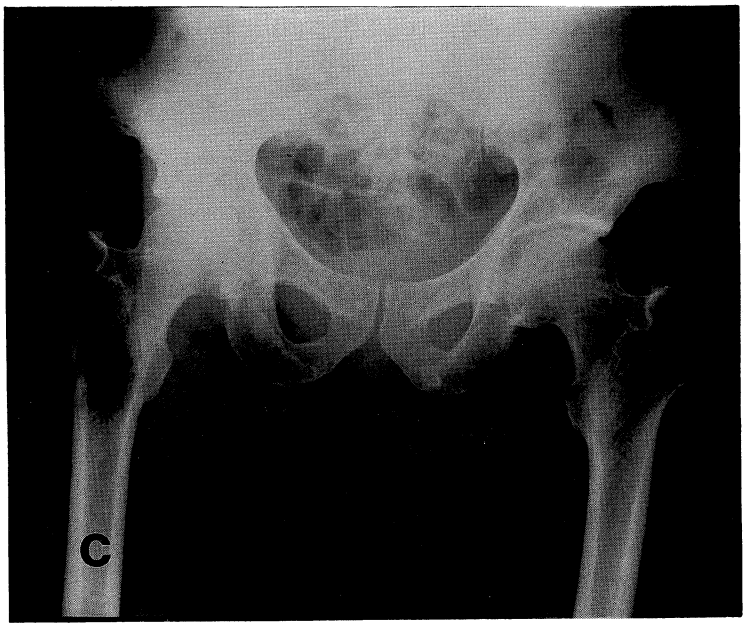

Fig. 4c. Bone radiography showed osteolytic change in the right femur.

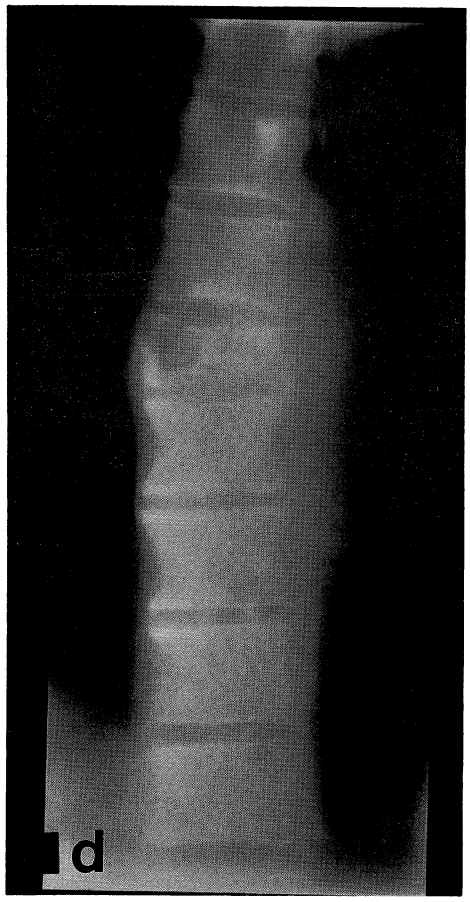

Fig. 4d. Bone radiography of the thoracic vertebra (tomography) showed the marked destruction of the eighth thoracic vertebra.

lung carcinoma and breast carcinoma. In most of the cases of lung carcinoma and breast carcinoma the osteolytic lesions were generally associated with osteoblastic changes.

Sy, W.M. *et al.* stated that a lytic lesion larger than 2 cm in diameter would manifest as a cold area on scintigraphy, only when the vascularity was poor around the lesions.[12] Considering that, however, when the whole bone architecture was totally replaced by tumor tissue, no residual bone would be capable of accumulating sufficient amount of the radionuclide to be visualized.

In this study, photon deficient lesions not associated with surrounding hot area were seen on the thoracic vertebrae and rib. On the other hand, photon deficient lesions with surrounding hot area were noticed on the sternum, pelvis and femur. This differentiation might be due to the differences in growth rate metastatic tumor, blood flow and reactive new bone formation in each lesion.

No matter what the accurate mechanism for the production of variety type of photon deficient lesions on bone survey in renal cell carcinoma, it is necessary to keep in mind that this type of lesion may occur as a manifestation of metastatic disease, as to avoid possible misinterpretation in bone scintigraphy.

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