BONE SCAN PATTERNS OF PATIENTS WITH DIFFUSE METASTATIC CARCINOMA OF THE AXIAL SKELETON

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Bone scan findings (using ^{99m}Tc-stannous pyrophosphate) in five patients with diffuse metastatic carcinoma of the axial skeleton are reviewed. Although there were few visually recognizable asymmetries of tracer localization, the diffuse involvement was diagnosed through abnormally elevated counting rates in the axial skeleton, decreased visualization of the kidneys, and faint or absent visualization of the appendicular skeleton.

Since the introduction of technetium-labeled phosphate compounds, detection of bony abnormalities by bone scanning has improved (*1–5*). Because of the greater sensitivity of bone scans, Pistenma et al (*6*) suggested that these scans should replace the conventional radiographic skeletal survey as a means of detecting early metastatic bone disease. However, Thrupkaew et al (*7*) and Frankel et al (*8*) recently described normal-appearing bone scans in patients with diffuse metastatic disease of the axial skeleton which was demonstrable by x-ray. Recognition of these false-negative results is obviously important. We have evaluated five patients who had diffuse metastases to the axial skeleton which were not obvious on initial examination of their bone scans. Here we discuss the factors that provided clues to the correct interpretation of these studies.

MATERIALS AND METHODS

Five male patients were studied: four with adenocarcinoma of the prostate and the fifth with a transitional cell carcinoma arising in the renal pelvis. All were studied with a 5-in. dual-probe rectilinear scanner (Ohio-Nuclear Model 84, Solon, Ohio) 3 hours after the intravenous administration of 15 mCi of ^{99m}Tc-stannous pyrophosphate (Mallinckrodt, St. Louis, Mo.). Minified images (5:1) were obtained, and a count density of 360 counts/cm^2, with ⅛-in. line spacing, was used to determine scan speed. Counting rates over the sternum and thoracic spine normally fell between 50,000 and 80,000 cpm. The

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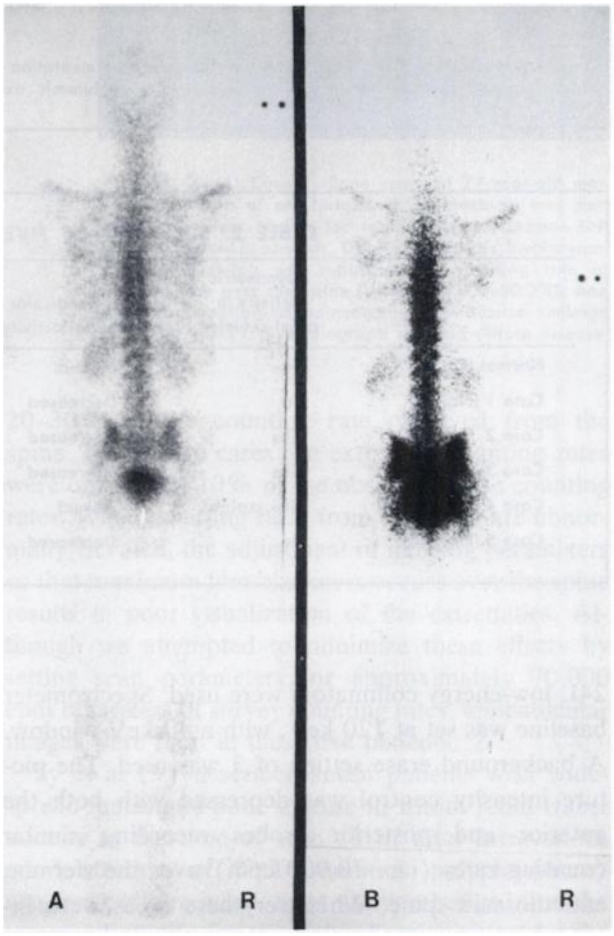


FIG. 1. (A) Normal posterior bone scan of 55-year-old man with carcinoma of prostate. Counting rate is 60,000 cpm over spine, 50,000 cpm over sternum. (B) Posterior scan on same patient employing contrast enhancement of 2. Note false accentuation of axial skeleton and loss of appendicular skeletal image.

TABLE 1. CLINICAL DATA FOR FIVE PATIENTS WITH FALSE-NEGATIVE BONE SCANS

Pat. No. Age/Sex	Initial complaint	Physical examination	Laboratory findings	Diagnosis	Treatment	Metastases
1 77/M	Backache (Lt nephrectomy 5 yrs earlier for ca kidney)	No abnormality	Elevated acid phosphatase, anemia, ESR 125	Adenocarcinoma prostate by biopsy	Radiation	Blastic, rt hip, and lumbar spine
2 68/M	Urinary obstruction (Rt nephrectomy 12 yrs earlier for calculi)	Enlarged rock-hard prostate	Elevated acid phosphatase and LDH, anemia	Adenocarcinoma prostate (poorly differentiated)	TURP, estrogen, orchiectomy	Pelvic and thoracic spine
3 58/M	Bloody ejaculate, backache	Induration in prostate	Elevated acid phosphatase and LDH, anemia, ESR 33	Adenocarcinoma prostate (poorly differentiated)	TURP, orchiectomy	Perineural lymphatic, blastic pelvic
4 52/M	Asymptomatic	Hypertension, tenderness in sacroiliac areas	Elevated acid phosphatase, anemia, ESR 113	Ca lt renal pelvis	Nephrectomy, radiation, chemotherapy	Ribs, pelvis, thoracic, lumbar spine
5 69/M	Low back pain, weight loss (Prostatectomy 7 yrs earlier for ca)	Mass rt prostate, hepatomegaly, decreased breath sounds at lung base, pleural effusion	Elevated acid phosphatase, LDH, SGOT, and uric acid; anemia; ESR 75	Ca prostate	Orchiectomy, estrogens	Perineural, blastic in ribs, spine, pelvis

Abbreviations: ca—cancer; ESR—erythrocyte sedimentation rate (Westergren method); LDH—lactic dehydrogenase; TURP—transurethral resection of prostrate; SGOT—serum glutamic oxaloacetic transaminase.

TABLE 2. SUMMARY OF FIVE FALSE-NEGATIVE BONE SCANS

	Asymmetric activity in axial skeleton	Appendicular skeletal activity	Renal activity	Thoracic-spine counting rate (cpm)	Sternum counting rate (cpm)
Normal (Fig. 1)	No	Normal	Normal	60,000	50,000
Case 1 (Fig. 2)	No	Decreased	Decreased	110,000	120,000
Case 2	Ribs	Decreased	Decreased	100,000	100,000
Case 3	Ribs	Decreased	Absent	160,000	80,000
Case 4	Ribs, spine	Absent	Absent	170,000	150,000
Case 5 (Fig. 3)	No	Decreased	Decreased	150,000	100,000

24L low-energy collimators were used. Spectrometer baseline was set at 120 keV, with a 40-keV window. A background erase setting of 3 was used. The picture intensity control was depressed with both the anterior and posterior probes recording similar counting rates (i.e., 70,000 cpm) over the sternum and thoracic spine. Whenever these areas were involved by disease, the picture intensity control was depressed with the probes positioned wherever equal counting rates of about 70,000 cpm could be obtained.

RESULTS

Clinical data for the five patients studied are presented in Table 1. The bone scan findings are summarized in Table 2. Figure 1A shows a normal posterior bone scan for comparison with the abnormal studies, and Fig. 1B is a scan of the same patient taken with a contrast enhancement setting of 2 (Ohio-Nuclear Model 84). Figures 2 and 3 show the bone scans and radiographs of two representative cases (Nos. 1 and 5). Abnormal findings in these patients were (A) elevated counting rates from the spine and

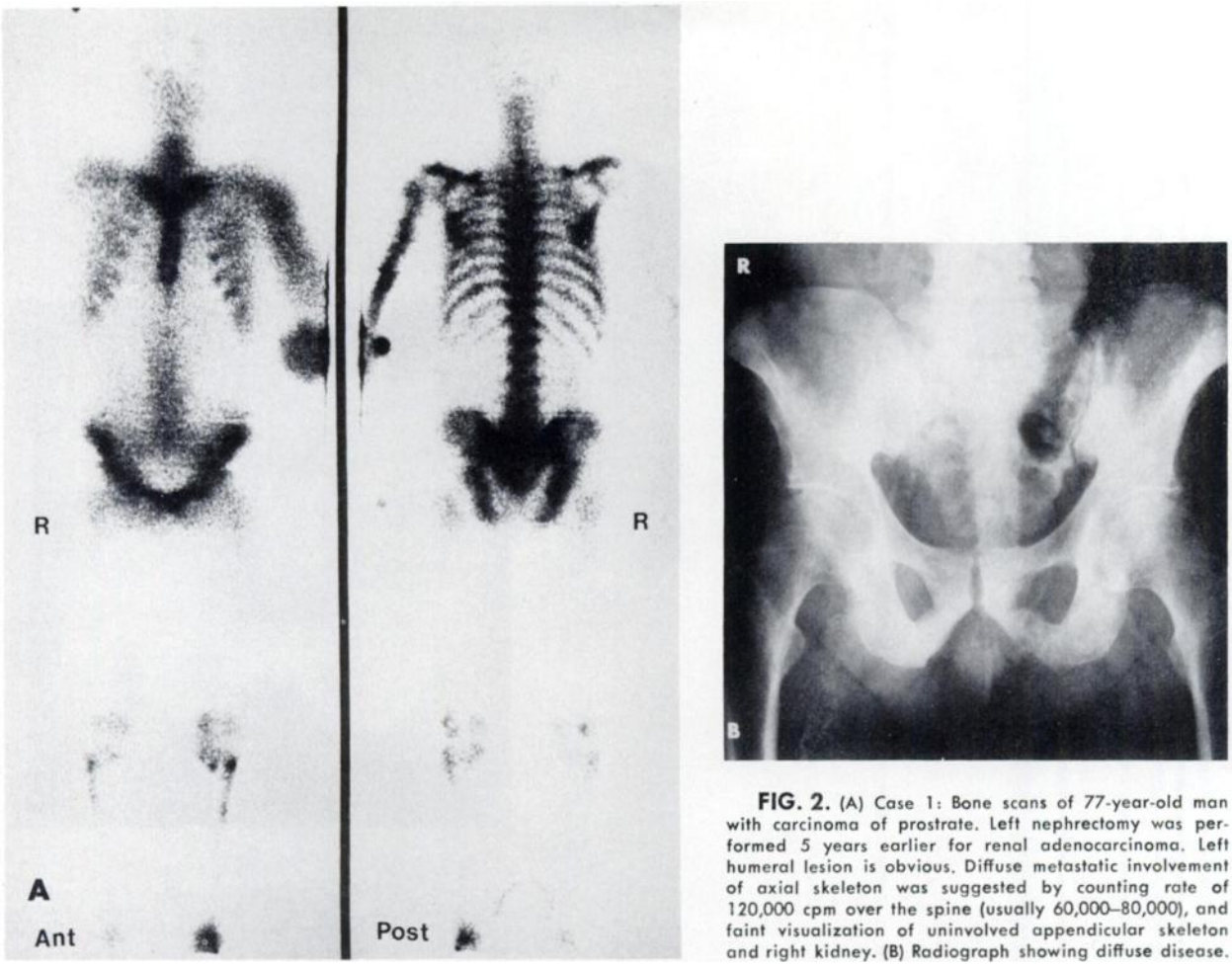


FIG. 2. (A) Case 1: Bone scans of 77-year-old man with carcinoma of prostrate. Left nephrectomy was performed 5 years earlier for renal adenocarcinoma. Left humeral lesion is obvious. Diffuse metastatic involvement of axial skeleton was suggested by counting rate of 120,000 cpm over the spine (usually 60,000–80,000), and faint visualization of uninvolved appendicular skeleton and right kidney. (B) Radiograph showing diffuse disease.

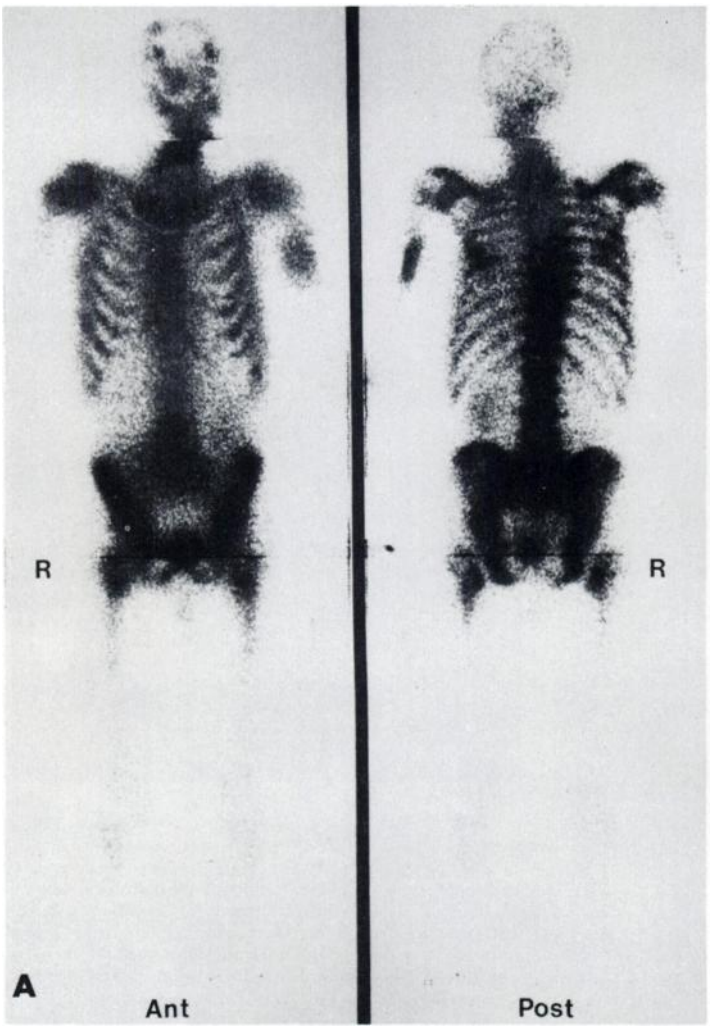
sternum, and (B) faint or absent imaging of the kidneys and extremities. Minor asymmetries in distribution of activity in the ribs were frequently noted.

DISCUSSION

Detection of skeletal disease by bone scanning depends upon the recognition of areas of greater than normal tracer localization. Diffuse symmetric involvement of the axial skeleton may not be recognized if there are few or no areas of increased tracer localization. Frankel et al (*8*) and Thrumpkaew et al (*7*) reported cases of diffuse malignant disease of the axial skeleton in patients whose bone scans showed relatively symmetric distribution of tracer activity in the involved bones. It is particularly important to recognize minor rib asymmetries, such as those seen in Cases 2, 3, and 4.

Using the above equipment, faint or absent appendicular skeletal images will result when increased axial-skeletal counting rates occur with normal counting rates from the forearm bones, humeri, femurs, and lower leg bones. Counting rates in the upper and lower extremities are normally similar, being about 20–30% of the counting rate observed from the spine. In our five cases the extremity counting rates were only about 10% of the observed spine counting rates. When counting rates from the spine are abnormally elevated, the adjustment of imaging parameters so that maximum film blackness occurs over the spine results in poor visualization of the extremities. Although we attempted to minimize these effects by setting scan parameters for approximately 70,000 cpm regardless of survey counting rates, appendicular images were faint in these five patients.

Sy et al (*9*) described seven patients with widespread metastatic bone disease in whom renal tracer activity at the time of scan (3 hr after intravenous administration of ^{99m}Tc-stannous polyphosphate) was markedly reduced. Sy et al hypothesized that the increased avidity for the radiopharmaceutical by the diseased bone resulted in reduced phosphate excretion, thereby producing faint renal images in the bone scans. Kidney activity was faint or absent in all five of our cases. Decreased visualization of the kidneys in bone scans therefore suggests the possibility of widespread bone disease. This may be quite



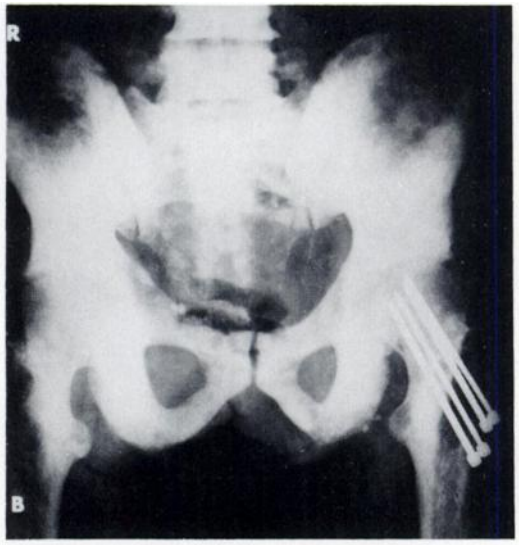


FIG. 3. (A) Bone scans of 69-year-old man with carcinoma of prostrate showing left humeral lesion. Diffuse involvement of axial skeleton was suggested by counting rate of 150,000 cpm over sternum (usually 50,000–70,000 and decreased visualization of appendicular skeleton and kidneys. (B) Radiograph showing diffuse skeletal involvement.

obvious when numerous lesions produce marked asymmetry in tracer localization, as reported by Sy et al (*9*), or it may only provide a clue to the diffuse disease, as in our five patients. Although this was a consistent finding in our cases, the renal images appear normal in the case reported by Frankel et al (*8*).

Either contrast enhancement or background subtraction will result in loss of the appendicular images (Fig. 1B). Neither (unless employed at high levels) will result in the loss of normal renal images. Background subtraction or enhancement of bone should be employed sparingly, if at all, because of the resultant suppression of potentially useful information.

To avoid errors in interpreting bone scans in patients with diffuse disease of the axial skeleton, counting rates over survey areas in the skeleton must be recorded at the time the scans are obtained. Knowing the usual counting rates in patients without bone disease scanned on rectilinear scanners and the normal exposure times for images obtained on stationary imaging devices is essential. Markedly elevated counting rates over the spine and anterior chest wall should suggest diffuse disease of the axial skeleton.

CONCLUSION

In summary, abnormally elevated counting rates in the axial skeleton, decreased kidney visualization, and faint or absent visualization of the appendicular skeleton should suggest the possibility of diffuse axial-skeletal disease even when asymmetries in tracer distribution are minor. These findings should be sought in patients with those malignancies which commonly metastasize to bone (breast, prostate, lung), particularly if bone scanning has replaced routine radiographic skeletal surveys as the primary means of detection of bony abnormalities in such patients.

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