Significance of Photon-Deficient Areas in Radionuclide Bone Scans

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Photon-deficient areas were observed in 64 out of 884 (7.2%) bone scans performed in a general hospital over a period of 1 yr. The intrinsic causes constituted about 80% of the "cold" lesions seen; whereas extrinsic causes were responsible for the remaining 20%. Orthopedic implants were the most common source of artifactual cold lesions. The value of special views during bone scanning and care during interpretation is suggested.

Bone scans are performed to detect a variety of skeletal disorders in many medical centers around the country. The value of such studies has been well established in the diagnosis of bone neoplasms, infections, trauma, and metabolic disorders. Technetium-labeled diphosphonates are primarily used for bone imaging and are known to accumulate by the exchange compartment of the bone, apatite crystalline structure, and by active binding with immature collagen *(1)*. Pathologic processes are most frequently seen as increased uptake of radiotracer in the affected regions, producing "hot" lesions in a background of normal uptake. On the other hand, photon-deficient or cold areas are sometimes seen during bone imaging. The frequency of such lesions on bone scans and their pathogenesis is not well understood. Several causes including prostheses, bone infarct, rapidly growing neoplasms, sickle cell crisis, and radiation therapy have been reported to produce such images *(2)*. We conducted a retrospective study to assess the incidence of photon-deficient cold areas observed on routine bone imaging and their correlation with underlying processes.

Materials and Methods

All bone studies performed during 1978–79 at the Danbury Hospital were screened for the presence of photon-deficient areas. A total of 884 studies were reviewed. There were multiple indications for bone scanning; 504 (57%) studies were performed in search of metastatic disease, 123 (14%) for suspected osteomyelitis, 132 (15%) for arthritis, 53 (6%) for fractures, and 72 (8%) for miscellaneous conditions including metabolic bone disorders and Legg-Calve-Perthes disease. Of the 884 studies, 64 (7.2%) revealed focal diminished uptake (photon-deficient areas); these formed the basis of our study. Of the 64 patients, there were 35 men and 29 women. The mean age of the patients was 68 years (range: 9–87). Whole body imaging was performed 3 to 4 hr after intravenous administration of 15–20 mCi of Tc-99m Osteolite (medronate sodium, NEN). In persons under 18 years of age, dose was calculated at 200 μCi per kilogram of body weight. A dual-probe Cleon whole body imager, model 760 (Union Carbide), was used with a spectrometer window setting of 130–170 keV. In some cases, images were repeated on a Dynacamera 4/15 (Picker Corp.). Medical records of these patients were reviewed for pertinent data regarding clinical problems, history of operations, implantation of prostheses or pacemakers, radiation therapy, ingestion of corticosteroids, renal dysfunction, or sickle cell disease. Available radiographs were reviewed.

Results

In the largest group of patients, the photon-deficient areas were produced by a prosthetic device in hip joints or over breasts (61%), followed by relatively less common causes, such as coins in a pocket or pendants around the

TABLE 1. Causes of Photon-Deficient Areas in Present Study

Cause	Number of Patients	Percent (%)
Intrinsic		
Hip prosthesis	31	48.5
Pacemakers	4	6.2
Dental Work	3	4.7
Avascular bone necrosis	6	9.3
Bone infarcts	3	4.7
Postradiation effect	4	6.2
Extrinsic		
Breast prosthesis	8	12.5
Coins and pendants	5	7.8
Total	64	100.0

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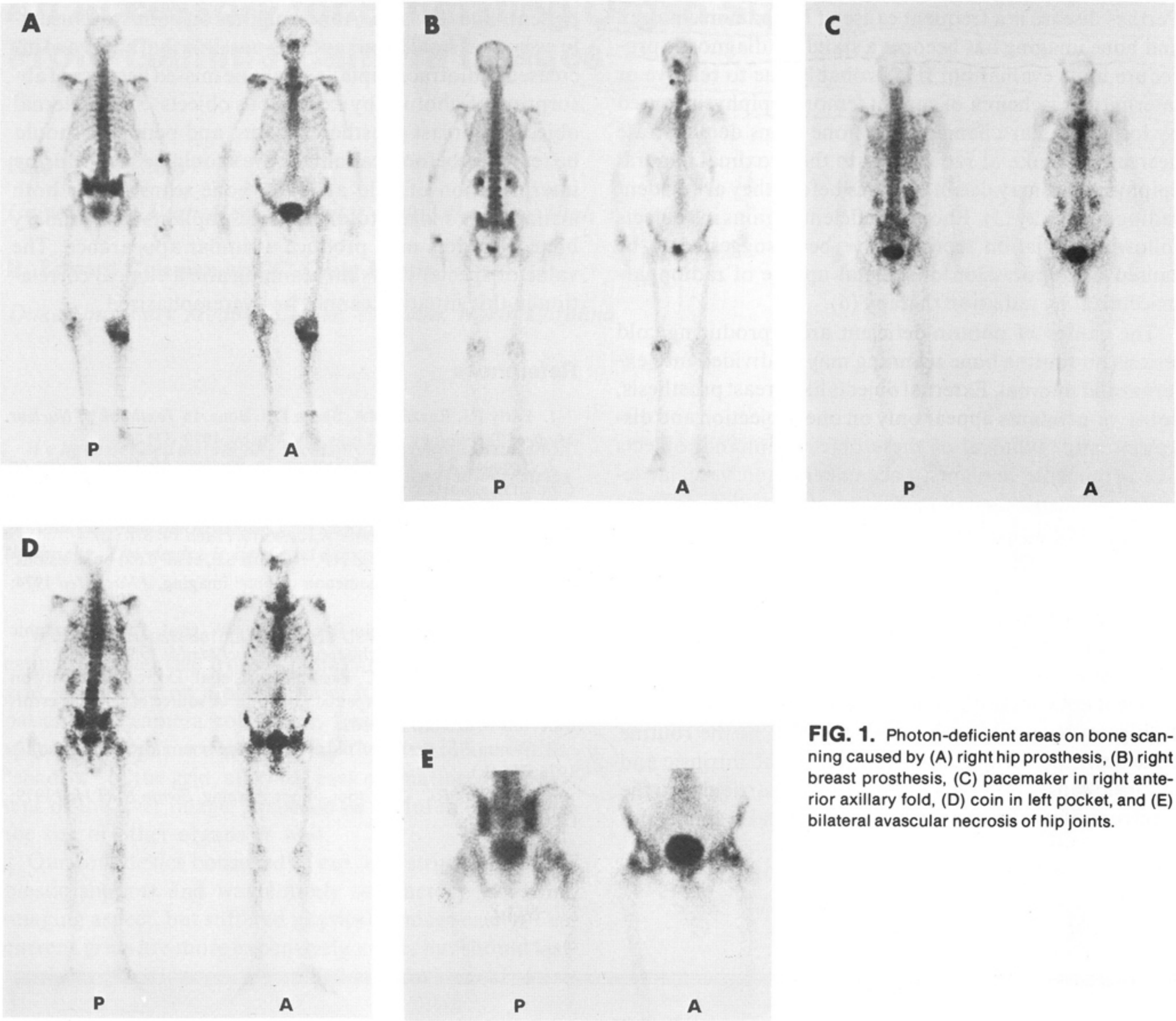

FIG. 1. Photon-deficient areas on bone scanning caused by (A) right hip prosthesis, (B) right breast prosthesis, (C) pacemaker in right anterior axillary fold, (D) coin in left pocket, and (E) bilateral avascular necrosis of hip joints.

neck, pacemaker, postradiation effect, avascular bone necrosis, bone infarct, and dental work in the jaw (Table 1). Typical appearance of photopenic defects produced by hip prosthesis, breast prosthesis, pacemaker, bilateral avascular necrosis of the hip, and coins is presented in Fig. 1. Another 106 patients (12%) demonstrated a photon-deficient region in the epigastric region because of postprandial gastric distention; these were not included in the study.

The four patients with postradiation effect demonstrated a well-defined photopenic region over the spine and all these had received regional radiation therapy for lymphomas and lung neoplasms. The patients demonstrating avascular bone necrosis were mainly in the younger age group and were diagnosed as having Legg-Perthes disease. None of these patients had history of ingestion of long-term corticosteroids, and there was also no evidence of sickle cell disease in any of the patients in this study. Such extrinsic conditions as breast prosthesis and coins in a pocket when observed to cause a photon-deficient area were removed and the scans repeated. The cold artifacts seen earlier were not evident in repeat studies.

Discussion

Photon-deficient regions or cold areas on bone scanning have been reported in a variety of conditions including metallic implants, breast prostheses, bone infarction, radiation therapy, avascular bone necrosis, rapidly growing neoplasms, hemangioma, cysts, disuse atrophy, and neoplasms (*2–8*). With the use of such relatively low energy radiopharmaceuticals as Tc-99m, there is considerable attenuation of photons by extraneous objects like protheses (*3*), coins, and orthopedic implants. Reduction in the vascular transport of radionuclide to the bone structure—as occurs in sickle cell sludging, trauma, infarction, and tumor obstruction of the vascular supply—might result in the bone infarction of the affected region. This has been suggested as a primary mechanism in the production of photon-deficient areas in some of the cases (*4*). Legg-Calve-Perthes disease is a frequent cause of hip pain in children and bone imaging has become a standard diagnostic procedure in its evaluation. It is probably due to relative or intermittent ischemia of capital femoral epiphysis caused by local vascular changes. The bone scans demonstrate decreased uptake of radiotracer in the proximal femoral epiphysis and may detect changes before they are evident radiographically (*5*). Photon-deficient regions in subjects following radiation therapy have been suggested to be caused by suppression of skeletal uptake of radiopharmaceutical by radiation therapy (*6*).

The causes of photon-deficient areas producing cold lesions on routine bone scanning may be divided into external and internal. External objects like breast prosthesis, coins, or pendants appear only on one projection and disappear after removal of these objects. Internal objects like orthopedic implants, pacemakers, and vascular lesions are usually seen in more than one position. In cases of suspected Legg-Perthes disease, special views of the hips with a pinhole collimator should be obtained. In other cases of photopenic areas observed, extra oblique and lateral views with converging collimator are often helpful for better resolution.

This study demonstrates that visualization of photon-deficient cold areas on bone scanning is a relatively common phenomenon observed in about 7% of the routine bone scans performed. Distribution of the intrinsic and extrinsic causes observed in this study is particular to the spectrum of conditions seen in our hospital and may not apply to other hospitals with a different distribution of patients and illnesses. Abnormalities on bone scans usually present as hot lesions and it is possible that an area of increased radiotracer uptake might be missed because of absorption of photons by extraneous objects. Such external objects as breast prostheses, coins, and pendants should be removed before scanning. Care should be taken during interpretation of cold areas on bone scans—since both artifacts secondary to orthopedic implants and primary bone disorders may produce a similar appearance. The value of special views on scanning and a clinical correlation in this situation cannot be overemphasized.

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