Imaging

Rapid Urine Dilution to Improve Pelvic Imaging in Bone Scanning

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A significant reduction in the contribution of bladder radioactivity to total counts seen on the anterior pelvic view of a bone scintiscan can be effected by the administration of 16 to 32 oz of water given immediately after the initial series of bone images (3 hr delayed) with a repeat pelvic spot view immediately thereafter. A mean reduction of bladder radioactivity from 29% of total pelvic counts to 7.5% was facilitated using this modification of our routine bone imaging protocol. This simple, rapid dilution technique improved image quality in each of a total of 11 arbitrarily selected patients evaluated by bone scintigraphy, without increasing total scan time or resulting in any adverse or untoward effects.

The problem of urinary retention on bone scanning in males occurs frequently as a result of the age-dependent increase in the incidence of obstructive uropathy (*1*). Approximately 80% of men 50–60 yrs or older have benign prostatic hyperplasia and 20–30% will develop symptomatic bladder outlet obstruction (*1,2*). Bladder outlet obstruction results in significant post-void residual urine volume and poses difficulties in the evaluation of metastatic disease to the osseous structures of the pelvis due to Compton scatter of bladder radioactivity (*3*).

Prostate carcinoma is the second most common cancer in men, and third most common cause of death from cancer in men over 60 yrs of age (*4*). The close anatomic association between the bladder neck and the prostate accounts for the development of obstruction from both benign and malignant prostatic disease (*5*). The coexistence of bladder outlet obstruction and prostate carcinoma is problematic as prostate carcinoma tends to metastasize early to surrounding bony structures (*6,7*), the pelvis being the most common site of prostate metastasis (*8*). Thus, a quality bone scan is compromised in patients who have voiding difficulties. We introduce a modification of the routine bone scanning protocol to include the ingestion of 16 to 32 oz of water at the time of delayed imaging if significant residual urinary activity is observed. This simple technique improved pelvic image quality.

MATERIALS AND METHODS

Over a 3-mo period, 116 male patients received bone scans for a variety of reasons. The most common request was exclusion or follow-up of bone metastases from lung or prostate carcinoma; however, exclusion of osteomyelitis or evaluation of bone pain were also common requests. A uniform protocol for bone scanning was used. Fifteen to 20 mCi of ^{99m}Tc-HDP* was administered intravenously, and the patients were instructed to drink 4–6, 8 oz glasses of water with delayed images obtained 2–3 hr later. Whole body and spot views were performed using a wide field-of-view scintillation camera equipped with a low-energy, parallel-hole collimator interfaced to a mini-computer for data storage and region of interest (ROI) analysis. The photopeak was set at 140 keV with a 20% energy window. Patients assigned to this camera for delayed imaging (n = 34) were instructed to void upon returning (as routine), and an initial anterior pelvic image was obtained immediately post-void. If excessive residual tracer counts were found in the bladder and the staff physician felt that there was obscuration of the pelvic image, the patient was entered into the modified bone scan protocol. The procedure required that the patient drink an additional 16–32 oz of water while the remainder of the skeletal system was imaged, (total imaging time ~ 60 min). Of the initial 34 patients imaged, 15 had obscuration of the anterior pelvic image; however, 4 of these could not be entered into the study due to excessive debility and inability to ingest the additional fluid. Eleven patients could comply and easily ingested the additional water within the initial 5–10 min of the bone scan. Approximately 60 min post-additional ingestion of water, at the time of completion of the bone scanning procedure, the patient was again asked to void, and the anterior pelvic image was repeated, and compared with the initial pelvic image.

RESULTS

Table 1 summarizes the reduction in bladder counts given

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TABLE 1. Bladder Activity Reduction

		Initial Bladder Scan	After Modified Voiding Procedure
% of bladder counts to total counts in the pelvic image	Average:	29%	7.5%
	Range:	(12–44%)	(2.2–18.1%)
% reduction in bladder counts	Average:	100%	26%
	Range:	—	(7.7–61%)

as percent of total counts in the anterior pelvic image of the bone scan before and after the modified voiding procedure for the 11 patients successfully completing the study. The percent of bladder counts decreased from 29% to 7.5% yielding an average residual count activity of 26% of the original residual activity. Figure 1A demonstrates a representative example of the anterior pelvic view of the bone scan in one of the eleven patients where the initial pelvic image was obscured by excessive bladder radioactivity. The patient had a history of benign prostatic hyperplasia and was evaluated for metastatic prostate carcinoma. After ingestion of 32 oz of water and re-voiding 1 hr later, the bladder counts were reduced to 22% of the original activity, and the pelvic bone structures are better resolved (Fig. 1B). The remainder of the skeleton was free of abnormal tracer uptake suspicious for metastatic bone disease. Figure 2 shows the results of a bone scan of a 62-yr-old male with prostatic carcinoma who was being evaluated for metastatic diesase. After excessive bladder radioactivity was noted on the initial image (Fig. 2A) the modified bone scanning protocol was instituted. The patient initially ingested 16 oz of water. There was improvement in pelvic imaging quality (Fig. 2B) (45 min post-ingestion). After ingestion of an additional 16 oz of water, there was further improvement in the image quality (Fig. 2C). The bladder counts decreased from 43% of the total pelvic counts to 18% of the

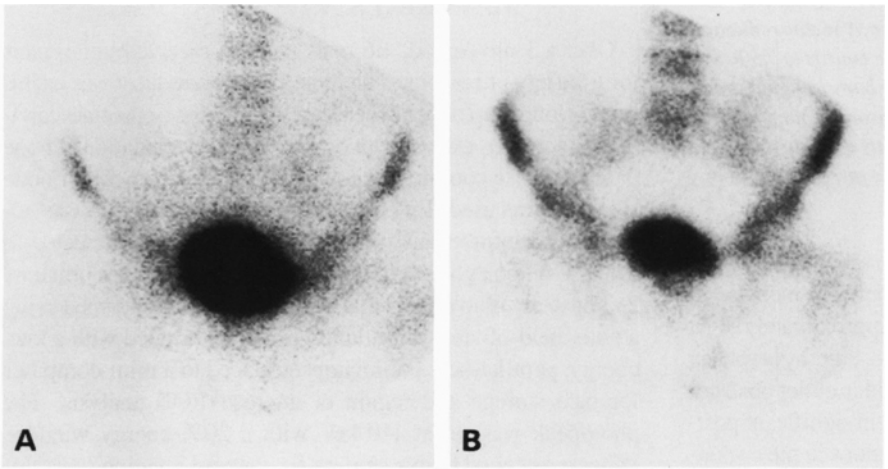

FIG. 1. (A) Anterior pelvis post-void view from patient with benign prostatic hyperplasia showing residual bladder activity resulting from bladder outlet obstruction. (B) Anterior pelvic image after ingestion of 32 oz of water and revoiding 1 hr later.

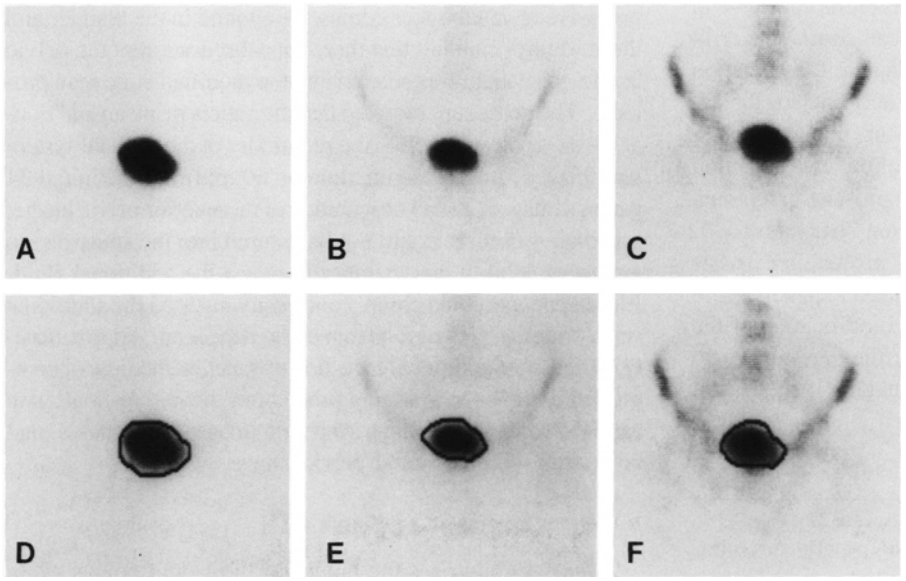

FIG. 2. (A) Anterior pelvic image of a patient with prostatic carcinoma imaged at the time of induction into study. (B) Forty-five-minute delayed pelvic image after ingestion of 16 oz of water and voiding. (C) Ninety-minute delayed pelvic image after the additional ingestion of 16 oz of water and voiding.

total pelvic counts after the initial 16 oz of water ingestion, and to 6.7% after the second 16 oz of water ingestion. This resulted in progressive improvement in the ability to visualize pelvic structures such as the symphysis pubis, rami, and hips. The ROIs drawn around the bladder were approximately the same size in each image evaluated (bottom row, Fig. 2D-F). The total number of counts/unit time in the anterior pelvic image (i.e., the osseous structures excluding the bladder), did not significantly change during imaging period. Figure 3 shows the image results of an in vitro study in which the same volume of fluid and size and shape of containers were imaged, one container (Fig. 3A) having 10 times the activity/unit volume as the other (Fig. 3B). Round containers were chosen to simulate the geometric shape of the bladder. The acquisition time, intensity setting, and position with respect to the face of the gamma camera was the same for both containers. There is an apparent increase in size and loss of resolution in the areas adjacent to the main concentration of tracer of the image in figure 3A compared with 3B. Figure 4 shows the anterior pelvic image of a bone scan in a 64-yr-old male with lung carcinoma who was scheduled for pneumonectomy if metastatic carcinoma could be excluded. In this case, there is better visualization of the bony structures of the pelvis after ingestion of 32 oz of water for two reasons: first, there was dilution and loss of tracer counts from the bladder, but in addition the increased water ingestion caused a diminution in bladder size (due to better emptying during the second void).

DISCUSSION

When confronted with a patient with bladder outlet obstruction, there are several choices available to alleviate Compton scatter due to excessive concentration of activity in the bladder (*3*). The bladder could be catheterized, but this procedure has morbidity (*9,10*). The bladder region can be shielded with lead or special views obtained; however, these methods are not always effective (*11*). The phenomenon and problems associated with relatively high concentrations of radionuclide agents, and the resulting obscuration of surrounding structures as well as the apparent increase in the size of the volume of activity have been previously described in the evaluation of biliary obstruction (*12*).

In our study, the increase in image quality obtained by reduction of excessive radionuclide concentration has been applied in cases of urinary retention due to bladder outlet obstruction. This method is effective because, in uncomplicated cases of bladder outlet obstruction, the bladder usually returns to approximately the same post-void residual volume and a reduction of total counts/unit volume by urinary dilution will improve pelvic imaging (*13,14*). The patients fell into three categories: 1) those who were instructed to increase fluid consumption and

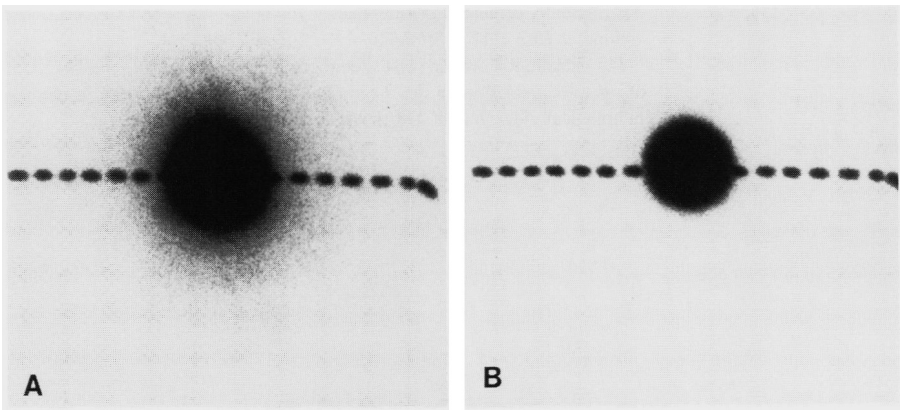

FIG. 3. (A) In vitro study showing apparent increase in image size and loss of resolution due to a higher concentration of radioactivity. The two containers were identical in size and had the same volume of fluid. Container on left had 1 mCi [^{99m}Tc]sodium pertechnetate in 100 cc fluid. (B) Container with 0.1 mCi-[^{99m}Tc]sodium pertechnetate in 100 cc fluid.

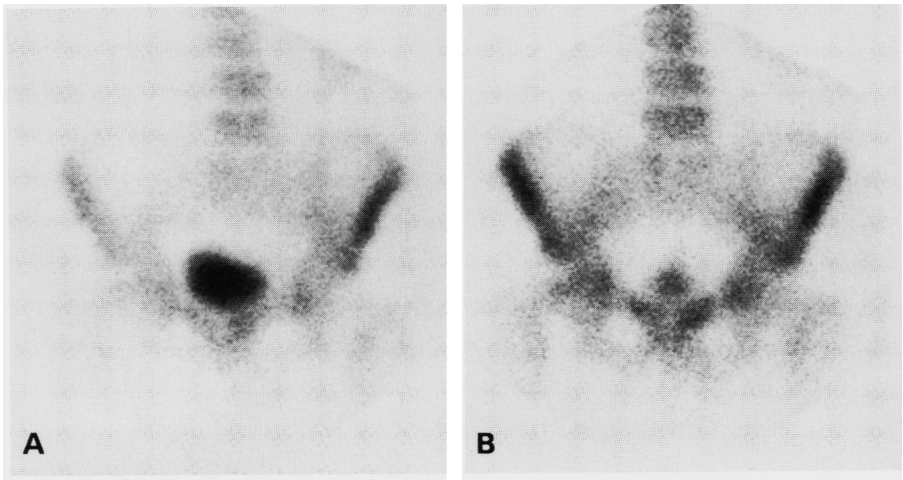

FIG. 4. (A) Initial anterior pelvic image of patient with lung carcinoma. (B) Forty-five-minute delayed pelvic image after ingestion of 32 oz of water and voiding.

had little problem emptying their bladder for the post-void image. In these cases the osseous structures of the pelvis could usually be evaluated without additional maneuvers; 2) those who did not adequately increase their fluid consumption. These patients typically returned with concentrated radioactivity in the bladder, and urine dilution at the time of delayed scanning, in general, greatly improved the quality of the anterior pelvic image; and 3) those who ingested fluids as instructed but had post-void residual activity. These patients also benefitted from the protocol since, after water ingestion and revoiding, the residual volume tended to be the same, but there were less counts per unit volume. Thus, in ambulatory patients this protocol is easily implemented and usually requires only one additional view. In most cases, increasing the ingestion of water even as late as the onset of scanning, can significantly improve the quality of the bone scan due to dilution of bladder radioactivity.

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NOTES

*Mallinckrodt, St. Louis, MO.

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