Detection of Obstructive Uropathy by Bone Scintigraphy

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We prospectively evaluated routine bone scintigraphs to determine the prevalence of radiotracer retention in the renal collecting system, and to test the reliability of this finding as an indicator of obstructive uropathy. Post-diuretic renal washout was also measured, to evaluate the use of this procedure after bone scintigraphy. Stasis occurring only in the supine position was excluded by obtaining upright images. The findings on bone scintigraphy were compared with the results of renal sonography. Patients showing persistent pelviccaliceal concentration in the upright position after bone scintigraphy were found to have evidence of obstructive uropathy by sonography or other studies. Furosemide administration was followed by washout of the bone tracer from all kidneys with proven partial ureteral obstruction. Persistent renal pelviccaliceal concentration, in upright images after bone scintigraphy, appears to be a reliable indicator of obstructive uropathy. However, measurement of post-diuretic renal washout, after bone scintigraphy, does not reliably detect obstructive uropathy, and may be misleading if interpreted in the same way as the standard diuretic renogram.


The kidneys are normally well visualized on routine bone scintigraphs, and a number of authors have described the value of these images in detecting renal abnormalities (1–6). However, the reported value in detection of obstructive uropathy has varied greatly, with sensitivities varying from 60% to 100% and specificities varying from 41% to 100% (7). One of the problems in interpreting these images is the difficulty in differentiating obstructive hydronephrosis from a nonobstructed dilated renal collecting system. It has been suggested that upright images may help in this distinction (3). Injection of a diuretic after completion of bone imaging has also been recommended (5,7–9). Further renal images may then be obtained to measure the effect of diuresis on the concentration of radiotracer in the affected kidney, similar to the procedure used for diuretic renography. We prospectively evaluated these procedures over a one year period in patients who had routine bone scintigraphs which were suggestive of urinary tract obstruction.

METHODS

Routine whole body bone scintigraphs were obtained in the supine position, at 2 to 4 hr after i.v. injection of 20 mCi (740 MBq) of technetium-99m (99mTc)methylene disphosphonate. Analog images were obtained, using a large field-of-view gamma camera with whole-body imaging capability, and the images were also recorded on computer disk. All routine bone scintigraphs over a 1-yr period were inspected for retention of radiotracer in the collecting system of either kidney. If tracer retention was found, the patient was asked to stand, and to urinate if able. Another image was then obtained over the renal area, with the patient in an upright position. Patients with persistent tracer concentration in the renal pelvis and calices after standing, then had diuretic imaging. For diuretic images, patients were imaged in the upright position and data were acquired on computer disk at 30-sec intervals. Images were acquired for 5 min before diuretic injection. The patient then received 40 mg of furosemide i.v., and imaging was continued for 15–20 min. Washout curves were obtained from a region of interest placed over each kidney. Washout of tracer from the kidney was calculated from the computer generated washout curve. Percent washout was calculated as:

Maximum cpm – 15 min. cpm × 100/maximum cpm.

A single exponential function was fitting to the washout curve, and the disappearance half-time of the fitted curve was determined. In most cases, a background curve was obtained from a background region inferior and lateral to the kidney. When

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the background data were available, the washout percent and $T_w$ were also calculated after background subtraction. Those patients who had diuretic renal imaging were then referred for renal sonography, which was performed within 15 days.

Sonograms were obtained using real-time equipment. Static images were recorded in transverse, and in sagittal or coronal planes. Evidence for hydronephrosis was graded on a scale of 0 to 4+, using the following sonographic criteria:

1+ = separation of central echoes by echo-free structure without extension into the parenchyma;
2+ = extension of central echo-free zone, with branching, into the parenchyma;
3+ = bulbus dilatation of the branching echo-free central structure; and
4+ = massive dilatation with thinning of renal parenchyma.

Sonograms were considered diagnostic of obstructive uropathy if the hydronephrosis was graded 3+ or 4+. X-ray computed tomography (CT) scans, excretory urograms, and autopsy data were also utilized when available.

RESULTS

During the one year period, 531 routine whole body bone scintigraphs were obtained. Most of these were performed for suspected metastatic tumor. The subjects were all males, age 50 to 91 yr (mean 69 yr). Forty-seven patients (8.8%) were found to have retention of tracer in the renal pelvis or calices on the delayed images at 2 to 4 hr after injection. Upright images were obtained on 44 of these (three patients could not cooperate for upright images and were excluded). On these 44 upright images, 33 patients demonstrated marked reduction in the tracer retention in the affected kidney. Emptying of the renal collecting system after standing was considered to indicate absence of obstruction, and other renal imaging procedures were not routinely obtained in this group. However, ten of these patients did have another imaging procedure which showed no hydronephrosis. Clinical records of the others in this group were reviewed and none had a diagnosis of obstructive uropathy.

The remaining 11 patients had persistent pelvicicalical concentration in the upright position, which was taken to be suggestive of obstructive uropathy. The results in this group are shown in Table 1. Ten patients had unilateral retention and one was bilateral. An example is shown in Figure 1 and Figure 2. These patients then had further imaging after diuretic injection, and were referred for sonography.

Of the 11 patients who had evidence of obstructive uropathy based on bone scintigraphy, eight had renal sonograms within 15 days. These were all found to have 3+ or 4+ hydronephrosis. Sonogram could not be obtained in the other three patients, but one of these (Patient 8) was shown to have hydronephrosis by CT scan and autopsy. Confirmation was not obtained in the other two patients, although one of these (Patient 7) had a dilated renal pelvis on CT scan, and the other (Patient 6) was found to have hydronephrosis 1 yr later.

Furosemide injection resulted in substantial washout of tracer from the hydronephrotic kidney in all cases. Computer derived washout at 15 min, not corrected for background, ranged from 24% to 65% (mean 46%). Washout half-times, obtained by curve analysis without background subtraction, varied from 7.9 min to 27.3 min in the nine patients with confirmed partial obstruction (mean 13.3 min). An example of a renal washout curve, in a patient with confirmed partial obstruction of the ureter, is shown in Figure 3.

In the group of 10 patients who had unilateral renal tracer retention, four patients had no tracer concentration in the opposite kidney, which was taken to indicate absent renal function on that side. Other studies showed this finding to be due to severe hydronephrosis in three cases and to an atrophic kidney in the remaining case.

DISCUSSION

Vieras and Boyd in 1975 assessed the value of renal imaging on bone scintigrams (1). In 119 bone scintigraphs obtained in patients who also had a renal radiographic study, they found 11 cases with asymmetric renal uptake, all of which had obstructive uropathy. Thirteen other cases had a nonvisualized kidney, and this finding was also associated with renal disease in every case. The sensitivity for renal disease in their hands was 97.4%, and specificity was 91.4%. Biello et al. in 1976 using a rectilinear scanner, reported 80% sensitivity for unilateral hydronephrosis and 50% sensitivity for bilateral hydronephrosis (2). They noted that increased concentration limited to the renal pelvis was usually not significant. Adams et al. in 1980 reported that upright views are required to establish that retained renal activity is due to true obstruction (3). In 1983, Pollen et al. compared bone scintigraphs with excretory urograms in patients with prostatic cancer (4). They reported the sensitivity of the bone scintigraph for obstructive uropathy to be 60%, and considered it unreliable. Balachandran et al. (1985) compared bone scintigraph results with renal sonography in 55 patients who had renal tracer retention on the scintigraph (6). They found the routine bone scintigraph image to have a sensitivity for hydronephrosis of 100%, but specificity of only 77%. Based on their data, a normal renal image on bone scintigraph could reliably exclude hydronephrosis, but renal tracer retention had a predictive value for hydronephrosis of only 41%. They did not utilize images in the upright position, which might have improved the specificity.

To evaluate suspected ureteral obstruction, Bedont et al. (1984) recommended furosemide injection after
completion of bone imaging, with measurement of the washout rate of the radiotracer remaining in the kidney (8). Their recommendation was based on measurement of diuretic renal washout in one patient with ureteral obstruction and one nonobstructed patient. Taylor, Bedont, and Raabe (1985) subsequently made the same recommendation, apparently based on the same obstructed case (9). In neither report was the method of calculation of the washout half-time described. In both reports, they quoted a washout half-time of >20 min as abnormal, based on the results reported by Krueger et al. (10). The results referred to were obtained by Krueger et al. in 13 children, using $[^{99m}Tc]$ diethylenetriaminepentaacetic acid renography. Goldfarb, Ongseng, and Chokshi have also recommended furosemide injection after bone scintigraphy, to distinguish obstructive from nonobstructive calciastsis (7).

The present study was undertaken to determine the prevalence of renal radiotracer retention in our routine bone scintigraphs, to test the reliability of this finding as an indicator of obstructive uropathy, and to see if diuretic administration after bone scintigraphy can be used to separate obstructive from nonobstructive renal stasis.

The prevalence of radiotracer retention in the renal collecting system, in the upright position, in our series of 531 routine bone scintigraphs was 2.1%. This is much lower than the 14–24% prevalence of renal retention in some other series (3,6). This difference is due to the fact that the other series were selected from patients suspected of renal disease. Of 44 patients in our series who had renal retention in the supine position, 33 (75%) drained in the upright position and were considered nonobstructed on this basis. As noted by Adams et al. (3), upright or postambulatory images are required to distinguish postural stasis from obstruction.

Persistent pelviccalveal concentration in the upright position appears to be a reliable indicator of obstructive uropathy in this small group of patients. Evidence for obstructive hydronephrosis was found by sonography,

### TABLE 1

<table>
<thead>
<tr>
<th>Patient</th>
<th>Serum creat.</th>
<th>Sonogram*</th>
<th>Lasix washout No Bkg. Subtr. %</th>
<th>Lasix washout Bkg. Subtracted %</th>
<th>Other kidney</th>
<th>Other data</th>
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<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>3+</td>
<td>65%</td>
<td>7.9</td>
<td>85%</td>
<td>4.7</td>
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<tr>
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<td>53%</td>
<td>9.4</td>
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<td>NA</td>
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<td>NA</td>
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<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>3+</td>
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<td>19.6</td>
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</tr>
<tr>
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<td>1.9</td>
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<td>13.9</td>
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<td>1.2</td>
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<td>20.4</td>
<td>59%</td>
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</tr>
<tr>
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<td>42%</td>
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</tr>
<tr>
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<td>24%</td>
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<td>27%</td>
<td>23.9</td>
</tr>
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<td>44%</td>
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<td>16.6</td>
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</table>

* See text for sonogram classification. 
NA = Not Available.
another imaging procedure, or autopsy in nine of 11 cases. Data were not adequate in the other two cases to confirm or exclude obstruction.

Renal imaging after diuretic injection was not helpful in diagnosing obstructive uropathy, and in fact was misleading. All hydronephrotic patients showed washout of tracer after diuretic injection, and the washout rate and washout percent were quite variable.

The effect of a diuretic injection on radiotracer washout from the kidney, after bone scintigraphy, is quite different from the effect seen on conventional diuretic renography. In a partially obstructed kidney, diuretic injection increases the intrapelvic pressure (11). The obstructed pelvis dilates with this increase in pressure, and this pressure change produces an increase in outflow through the partially obstructed ureter. With con-
ventional diuretic renography, the plasma still contains significant radioactivity at the time of furosemide injection and the urine produced in response to the diuretic is radioactive. In the case of static bone imaging, when the diuretic is administered 3–4 hr after tracer administration, the plasma no longer contains significant radioactivity. Urine produced at this time is not radioactive and dilutes the radioactivity remaining in the pelvic-Caliceal system. The normal range for diuretic renal washout on bone scintigraphs has not been established, and is probably too variable to be useful. Certainly, criteria established for standard diuretic renography with \(^{99m}\text{Tc} \)DTPA cannot be applied to this procedure.

CONCLUSIONS

On upright bone scintigraphs obtained 2–4 hr after tracer injection, in adult males, persistent tracer concentration throughout the renal collecting system or ureter, is highly suggestive of obstructive uropathy. Images made in the supine position only, are not dependable for this purpose. Tracer retention must be demonstrated in the upright position to indicate obstruction.

After bone scintigraphy in patients with partial ureteral obstruction, furosemide injection results in progressive decrease in count rate over the obstructed kidney. There is a wide variation in the rate of this washout. This procedure is not comparable to the standard diuretic renogram using \(^{99m}\text{Tc} \)DTPA, and cannot be interpreted in the same way. Normal washout values have not been determined, but this measurement does not appear to be useful in establishing a diagnosis of obstructive uropathy.

REFERENCES