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Increased bone marrow uptake on Tc-99m DMSA scintigraphy in a patient with renal osteodystrophy

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A 16-year-old male patient was evaluated with Tc-99m Diethylenetriamine-pentaacetic acid (DTPA) and Tc-99m 2-3 Dimercaptosuccinic acid (DMSA) scintigraphy for renal failure secondary to renal calculi. The uptake in the renal cortex was significantly decreased both on DMSA and DTPA studies. Uptake calculation on DMSA scintigraphy in the kidneys disclosed values of less than 5%. The activity in the liver and bone was significantly increased. A bone scan performed with Tc-99m methylene diphosphonate (MDP) revealed increased bone uptake with decreased soft tissue activity. Findings on bone scan were compatible with super scan, most likely due to renal osteodystrophy. This case illustrates the altered biodistribution of Tc-99m DMSA and a shift of the radiopharmaceutical to the bone marrow which is mot likely related to colloid formation due to changes in mineral balance in patients with renal failure.

Key words: Radionuclide imaging, Renal osteodystrophy, Renal scintigraphy

INTRODUCTION

SEVERAL AGENTS and diagnostic tests have been used to identify renal function. DMSA which is approximately 50% protein bound reaches a high concentration in the renal cortex binding to the proximal tubules, resulting in slow urinary excretion.[1] Fifteen percent of the administered activity localizes in the liver, but when the Tc-DMSA complex is formed at higher pH values, progressivley lower protein binding and renal concentration occur along with increased liver and bone activity.[2] This case concerns a patient with renal osteodystrophy demonstrating increased bone marrow uptake on DMSA scan. DTPA renal scan showed decreased perfusion and concentration in both kidneys. Tc-99m MDP bone scintigraphy disclosed patterns compatible with super scan.

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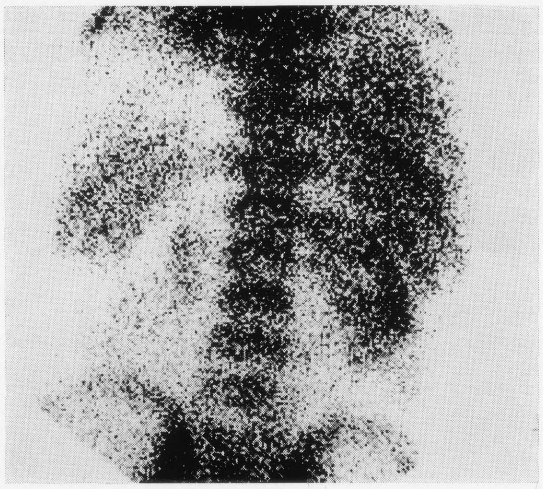
CASE REPORT

A male patient, 16 years of age was admitted to the hospital due to chronic renal failure secondary to renal calculi. The patient was operated on twice for renal stones at the ages of 7 and 15. Four months prior to admission he had an episode of acute streptococcal glomerulonephritis.

On physical examination the patient was pale, and had acidotic breathing. Blood pressure was 110/60 mmHg, temperature 36.5°C and heart rate 108 beats/min. There was generalized bone tenderness and proximal muscle weakness.

Laboratory studies gave the following results: hemoglobin 8 gr/dl, with a white blood cell count of 2,500. Serum BUN was 180% mg (Normal values: 10–20), creatinine 6.6% mg (0.9–2.0), Ca 11% mg (9–11), P 4.9% mg (4–6), K 5 MEq/L (3.5–5), Cl 94 MEq/L (100–106) and Na 146 MEq/L (138–144). Alkaline phosphatase was 481 B.U. (1.5–4.5). Protein levels were within normal limits.

Urine examination showed trace amounts of protein and leukocyturia. Liver function tests were normal. Chest radiographs did not disclose any abnormality. Parathormone fragment C level was 129 U (4.8–30.1). Radiographs of the wrist showed



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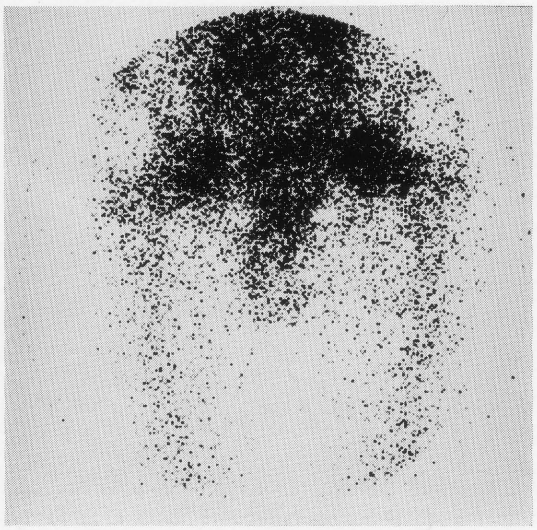

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Fig. 1 a) Tc-99m DMSA scintigraphy obtained at 4 hr. shows diminished renal uptake with increased liver-spleen uptake. b) Images disclose increased deposition of radiopharmaceutical in the bones.

generalized osteopenia, coarsened trabeculae and widening of the metaphyses which were suggestive of renal rickets. Renal ultrasonography showed a small right kidney compatible with chronic pyelonephritis with stones and the left was found to be atrophic.

The DMSA instant kit (Amersham) was used for Tc-99m DMSA scintigraphy and 20 mCi of Tc-99m pertechnetate was added to the vial. The patient received 3 mCi of the radiopharmaceutical and images over the kidneys were obtained at 4 and 24 hours and demonstrated minimal uptake in the kidneys ($<5\%$ in each kidney). Background activity was high and increased activity in the liver and spleen was observed (Fig. 1a). Increased activity was

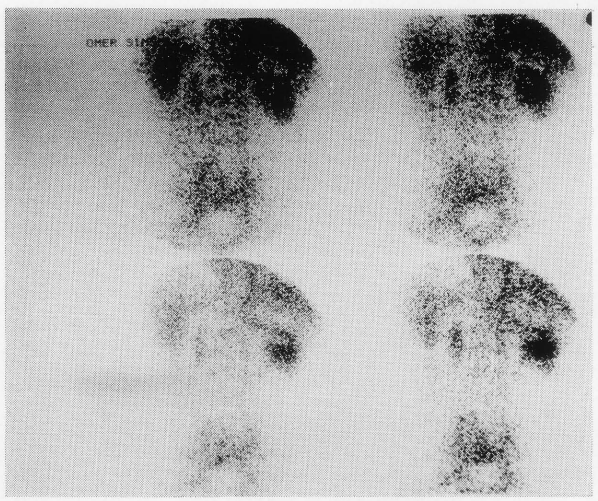
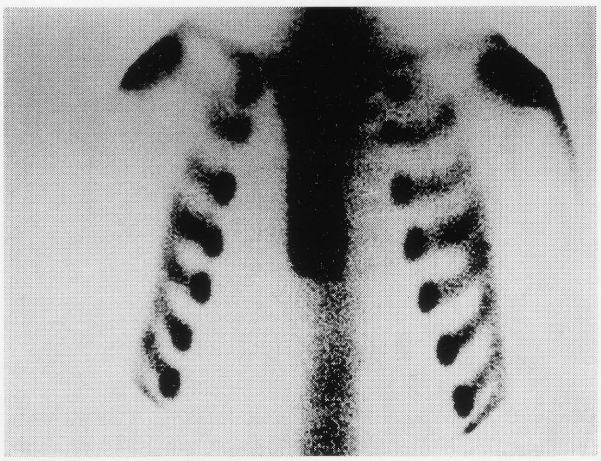


Fig. 2 On Tc-99m DTPA scintigraphy decreased renal perfusion and concentration is observed.



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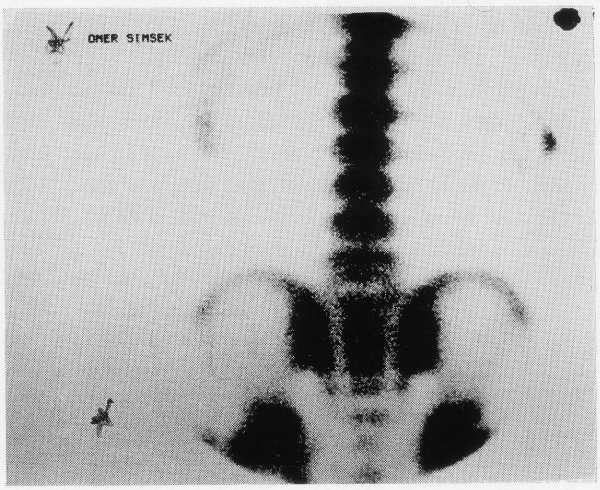

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Fig. 3 (a, b) MDP scan reveals generalized increased bone uptake with minimal soft tissue activity. The acquisition was rapid consistent with super scan.

also noted in the axial and appendicular bones (Fig. 1b). Renal scintigraphy which was performed following the intravenous injection of 7 mCi of DTPA revealed significantly diminished renal perfusion and concentration (Fig. 2). A bone scan following the injection of 10 mCi of Methylene Diphosphonate was performed within three days of the DMSA renal scan and showed increased deposition of the radiopharmaceutical throughout the skeleton. There was no activity in the kidneys and soft tissue uptake was diminished. The acquisition time was fast and with these findings the scan was considered to be a super scan most likely due to renal osteodystrophia (Fig. 3).

DISCUSSION

Tc-99m DMSA is slowly cleared from the blood and concentrates in the renal cortex; 42% of the injected dose remains in the renal cortex at 6 hours. Tc-99m DMSA mimics the biologic distribution of Hg 197 chlormerodrin by reaching a high concentration in the renal cortex with slow urinary excretion.[3] DMSA is an excellent agent for detecting focal abnormalities of the renal cortex. Because of its high kidney uptake, it has been suggested that Tc-99m DMSA may be the best technetium agent for determining the relative functional renal mass. One of the disadvantages of the radiopharmaceutical is the 30 minute shelf life after preparation.[4]

Total DMSA uptake in each kidney can be calculated by determining the counts in each renal Region of Interest and correcting for background activity and renal depth. By using this method, Kawamura et al. found that DMSA uptake averaged 27.8 ± 5.5 percent of the injected dose in the right kidney and 26.1 ± 6.5 percent in the left kidney.[5,6] There was good agreement between the total DMSA uptake in both kidneys and the serum BUN and creatinin, as well as good agreement between the relative DMSA uptake and the relative effective renal plasma flow (ERPF) measured by orthoiodohippurate (OIH) renogram ($r=0.95$).

Decreased uptake in the kidneys on DMSA scintigraphy can be observed in renal failure, acid-base imbalance, cortical necrosis, and acidification of the urine.[7] Increased uptake of the radiopharmaceutical in the liver can be seen in patients with renal insufficiency, but this mechanism is not well understood. Studies conducted in rats with ammonium chloride induced acidosis producing low urinary pH which demonstrated that kidney concentration of DMSA activity was reduced by more than 50 percent and liver activity was increased.[7] The reason for this effect is not known, but the results may be of significance in the quantitative estimation of renal function in patients with acid-base disturbances. Ammonium chloride may exert its effect on distribution by inducing acidosis and acidification of the urine. Another problem that can after the biodistribution of DMSA is the introduction of air into the vial. Moretti et al. conducted a study on rats to demonstrate the altered biodistribution of DMSA and showed decreased renal uptake and increased liver uptake in rats receiving a dose from the DMSA kit which contains air.[8] In practice when multiple doses are to be drawn from the same vial of DMSA, they should be drawn as close together in time as possible and administered immediately to minimize air introduction into the vial.

Although it is known that several causes, as mentioned above, can decrease the renal concentration of the Tc-DMSA complex, increased bone deposition has not been reported. The mechanism for elevated bone uptake in our patient with renal failure remains uncertain but increased bone turnover due to renal osteodystrophy may play a role. The activity in the distribution of bone may represent activity in the bone marrow in the distribution of the reticulo-endothelial system which can be due to colloid formation related to altered mineral balance in renal failure.

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