Annals of Nuclear Medicine Vol. 15, No. 5, 447–449, 2001

Tc-99m MDP, thallium-201 chloride and Tc-99m MAG3 renal uptake in subacute and chronic radiation nephritis compared

Berna DEGİRMENCİ,* Kamer UYSAL,** Recep BEKİS,* Riza CETİNGOZ,***
Gamze Capa KAYA* and Hatice DURAK*

*Departments of *Nuclear Medicine, **Pediatrics and ***Radiation Oncology, Dokuz Eylul University, Medical School, Izmir, Turkey*

The authors present a comparison of the findings for thallium-201 (Tl-201), Tc-99m MAG3 and Tc-99m MDP in subacute and chronic radiation nephritis in a 9-yr-old boy who was treated by radiation therapy for alveolar rhabdomyosarcoma of the left chest wall by a radiation port that partially included the left kidney. Tl-201 imaging three and six months later showed a cortical defect in the left kidney due to radiation nephritis. Tc-99m MDP scan showed increased uptake on both occasions, but more marked in the subacute period than in the chronic period. Tc-99m MAG3 showed decreased concentration and increased cortical retention three months later. Six months after the radiation therapy, a cortical defect corresponding to the cortical area that showed increased parenchymal retention was more prominent in the Tc-99m MAG3 scan.

In the present case, Tc-99m MDP, Tl-201 and Tc-99m MAG3 findings may provide useful information for understanding pathophysiological damage in the kidney after radiation.

Key words: radiation nephritis, Tc-99m MDP, Tc-99m MAG3, Tl-201

INTRODUCTION

INCREASED Tc-99m MDP in kidneys after radiotherapy has been reported,[1–4] but to our knowledge, changes in thallium-201 chloride (Tl-201) and Tc-99m MAG3 uptake in the kidneys after radiotherapy have not been previously published. We are presenting the findings of Tc-99m MDP, Tl-201 and Tc-99m MAG3 uptake in subacute and chronic radiation nephritis in a 9-yr-old boy who was treated by radiation therapy for alveolar rhabdomyosarcoma of the left thoracic wall.

CASE REPORT

A 9-yr-old boy had surgical resection for alveolar rhabdomyosarcoma that involved the 6, 7 and 8th ribs on the left side. The surgery was followed by radiotherapy of the chest wall that involved the left upper quadrant of the abdomen and chemotherapy. The radiation field included the upper part of the left kidney. Three months after the end of the therapy, Tl-201 tumor localization and Tc-99m MDP bone scan studies were requested for evaluation of residual tumor tissue and bony metastasis. A Tc-99m MAG3 study was subsequently requested for evaluation of renal function.

Tl-201 tumor imaging was performed 20 minutes and 2 hours after 74 MBq (2 mCi) of Tl-201 injection. Bone scan was performed after the Tl-201 study with 370 MBq (10 mCi) of Tc-99m MDP. Anterior and posterior whole body and planar images were obtained for both Tl-201 and bone scan. Tl-201 imaging showed decreased uptake on the lateral upper part of the left renal cortex corresponding to the portions of the left kidney that were included in the radiation field (Fig. 1A). The bone scan showed markedly increased Tc-99m MDP uptake in the same region (Fig. 1B). This was thought to be due to radiation nephritis. One week later a Tc-99m MAG3 scan was performed to evaluate the left renal function within a plan of radiation nephritis. It showed a regional decreased concentration and increased cortical retention corresponding

Received December 5, 2000, revision accepted June 13, 2001.

For reprint contact: Berna Degirmenci, M.D., Dokuz Eylul University Medical Faculty, Department of Nuclear Medicine, Inciralti, 35340 Izmir, TURKEY.

E-mail: berna.degirmenci@deu.edu.tr

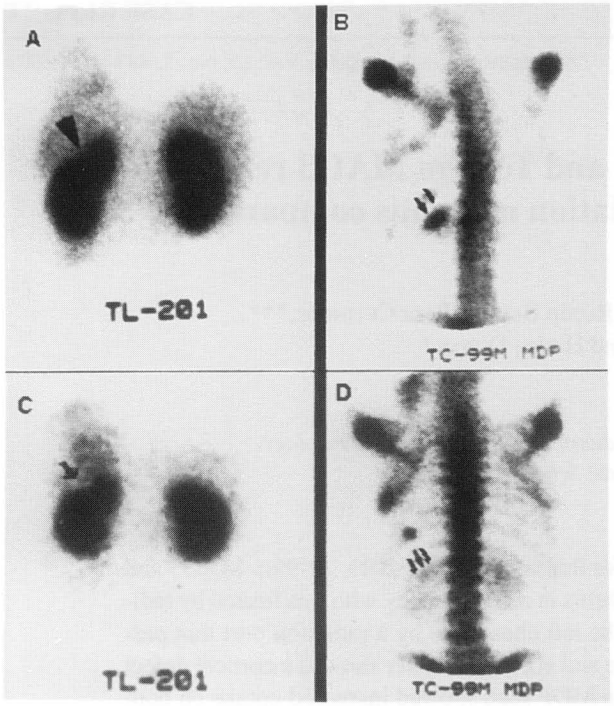

Fig. 1 Three months after radiotherapy, Tl-201 imaging showed decreased uptake on the lateral upper site of renal cortex corresponding to the portions of the left kidney that was included within radiation field (arrowhead) (A). Marked increased Tc-99m MDP uptake was found on the same area (arrows) (B). Six months after radiotherapy, Tl-201 imaging shows decreased uptake on the same area as similar to previous scan (arrow) (C), although slightly increased Tc-99m MDP uptake remained on the lateral upper left kidney (arrows) (D).

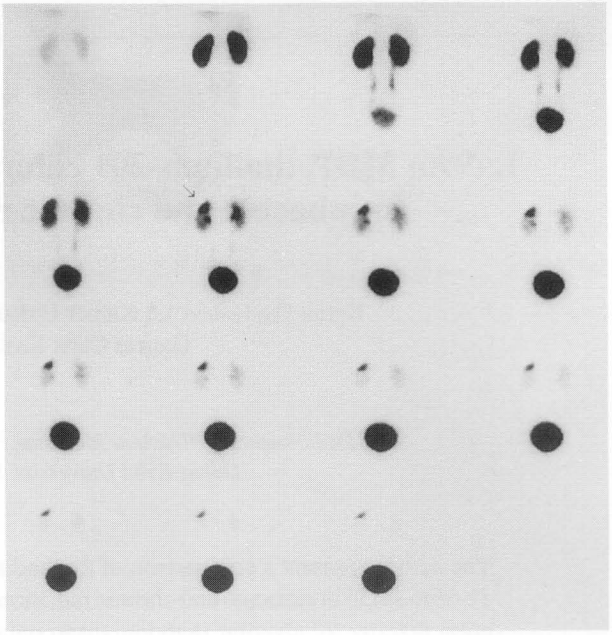

Fig. 2 Tc-99m MAG3 study that was obtained three months after radiotherapy. There is increased cortical retention on the area within the radiation field at dynamic renogram (arrow).

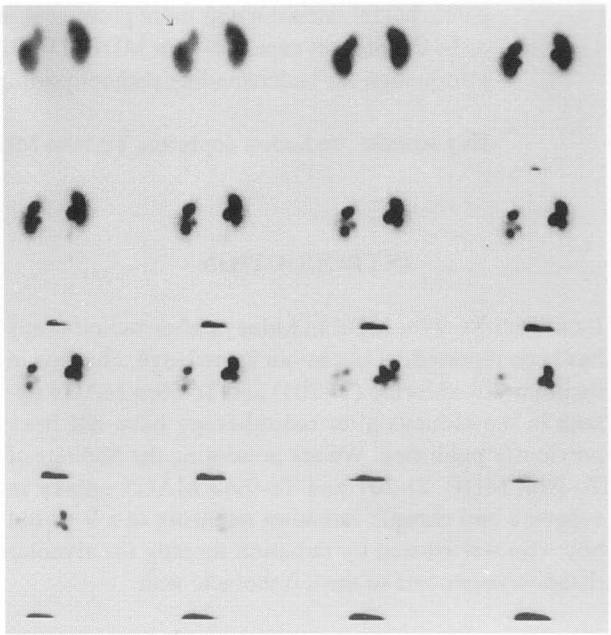

Fig. 3 Six months after radiotherapy, there is a more prominent cortical defect corresponding to the area of the left kidney affected from radiation field due to cortical scar at the concentration phase of Tc-99m MAG3 scintigraphy (arrow). The slight activity retention is seen in the adjacent calyces to cortical scar.

to the area of the kidney affected by the radiation field (Fig. 2). Renal ultrasonography at this time was normal.

Six months after the radiotherapy, all these three scans, Tl-201 chloride, Tc-99m MDP and Tc-99m MAG3 were repeated. Tl-201 imaging showed decreased uptake in the same area similar to the scan three months post radiation therapy (Fig. 1C). The Tc-99m MDP renal uptake remained to a lesser extend on the lateral upper left kidney (Fig. 1D). The Tc-99m MAG3 study showed a prominent cortical defect in the same area in the upper pole of the left kidney in the early images suggesting a renal cortical scar due to radiation nephritis (Fig. 3). A Tc-99m DMSA scan was performed as a standard method to investigate the cortical defect that was seen in Tc-99m MAG3 and Tl-201 studies. The Tc-99m DMSA scan also demonstrated a prominent cortical defect in the same area (not shown).

DISCUSSION

Increased Tc-99m MDP uptake in kidneys soon after radiotherapy has been reported.[1,4] This may be due to damage to renal tubular cells after radiotherapy. The abnormal intracellular flux of ionic calcium induced by ischemia or other damage to cell membrane integrity has been clearly shown to be a preliminary factor in the increased uptake of Tc-99m phosphates by injured cells. Tc-99m pyrophosphate localizes in intracellular calcium

as amorphous calcium phosphate and crystalline hydroxyapatite.[5,6] The same mechanism may be responsible for increased Tc-99m MDP uptake in the early post radiotherapy period as in this case and which could be transient as has been previously reported.[2] Since MDP is a renal clearance agent such as MAG3, another possible mechanism is increased cortical retention as seen in the images of MAG3 in the subacute period of radiation nephritis.

Blood flow, cellular viability, vascular immaturity and increased cellular maturity are factors that influence the uptake of Tl-201 by the cells.[5] The damage of the renal cells after radiotherapy may cause permanent decreased Tl-201 uptake in both subacute and acute chronic radiation nephritis which was seen in this case in both early and delayed periods post radiotherapy when scanned at three months (subacute stage) and six months (chronic stage).

Cortical retention of Tc-99m MAG3 has been reported in segmental acute tubular necrosis after renal transplantation.[8] Radiation therapy produces tubular damage. In the present case, the decreased concentration and cortical retention after radiation therapy may be due to extravascular diffusion of MAG3 accompanied by slower clearance compared to the fast drainage from the adjacent healthy renal parenchyma, in addition to acute tubular necrosis in the irradiated region. In delayed radiation nephritis, when scarring became evident the early images of the dynamic renogram showed a more prominent cortical defect.

This case report of the comparison of the three radiopharmaceuticals, Tl-201 chloride, Tc-99m MDP and Tc-99m MAG3 suggests that Tl-201 and Tc-99m MAG3 images showed renal cortical changes due to radiation nephritis in both subacute and chronic radiation phases. The finding of the Tl-201 scan presented here is not specific for radiation nephritis and can be evaluated as an incidental finding. Nevertheless, Tc-99m MAG3 scan can be used for evaluation of renal function and cortical changes after radiotherapy taking into account that Tc-99m DMSA is the best choice for decreased regional functional volume evaluation. Tc-99m MDP was able to delineate the area of radiation nephritis but it was difficult to recognize once the damaged area had progressed to scar tissue.

REFERENCES

1. Fogelman I. Soft tissue uptake of bone agents. In: *Bone Scanning in Clinical Practice*. Gray HW (ed), Over Wallop, Hampshire; Bas Printers Limited, 1987: 211–219.
2. Titelbaum DS, Fowble BF, Powe JE, et al. Renal uptake of technetium-99m methylene diphosphonate following therapeutic radiation for vertebral metastases. *J Nucl Med* 1989; 30 (6): 1113–1116.
3. Wistow BW, McAfee JG, Sagerman RH, Thomas FD, Grossman ZD. Renal uptake of Tc-99m methylene diphosphonate after radiation therapy. *J Nucl Med* 1979; 20: 32–34.
4. Lutrin CL, Goris ML. Pyrophosphate retention by previously irradiated renal tissue. *Radiology* 1979; 133: 207–209.
5. Wahner HW, Dewanjee MK. Drug induced modulation of Tc-99m pyrophosphate tissue distribution. What is involved? *J Nucl Med* 1981; 22: 555–559.
6. Dewanjee MK, Kahn PC. Mechanisms of localization of Tc99m pyrophosphate and tetracycline in infarcted myocardium. *J Nucl Med* 1976; 17: 639–646.
7. DeThrall JH, Ziessman HA. Tumors. In: *Nuclear Medicine the Requisites*. St. Louis, Missouri; Mosby-Year Book, Inc., 1995: 180–181.
8. Ugur O, Caner B, Bakkaloglu M, et al. Segmental ARN in a kidney with a single artery transplanted from living related donor. *Nuklearmedizin* 1996; 35 (5): 190–192.