Radioiodine Therapy in Patient with Differentiated Thyroid Cancer and Chronic Kidney Disease on Maintenance Hemodialysis: First Case of Bangladesh

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ABSTRACT

The conventional course of differentiated thyroid cancer (DTC) treatment requires surgical resection followed by radioactive iodine (^{131}I) therapy (RAIT). Patients are advised to drink plenty of water, as ^{131}I gets eliminated through the kidneys and the burden of extra radiation is reduced. Treating a case of DTC with chronic kidney disease (CKD) by RAIT is challenging. As a result, when planning hemodialysis in a DTC patient with CKD, the dose of ^{131}I, the timing of the dialysis, and radiation safety must all be carefully considered. Because vI is dialyzable, a standard Geiger counter can observe and detect it. A post-thyroidectomized case of DTC with CKD was successfully treated with ^{131}I while continuing scheduled peritoneal hemodialysis (HD) simultaneously during hospital isolation, as reported here. This case report was aimed at sharing the HD management procedures, challenges to any adverse effects, and exposure doses of ^{131}I-treated DTC patients in their immediate post-ablative days. Geiger counter measurements in the patient after HD following ^{131}I administration revealed levels of less than 4.20 Sv/h on the fifth day, allowing safe hospital discharge in this case.

Keywords: Differentiated thyroid carcinoma, chronic kidney disease, Hemodialysis, ^{131}I exposure dose rate.

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INTRODUCTION

Differentiated thyroid cancer (DTC) is the most prevalent endocrine malignancy, and the most frequent treatment is surgical resection followed by radioactive iodine (^{131}I) administration for ablation or therapy (1). The American Thyroid Association guidelines recommend use of ^{131}I in patients with intermediate- and high-risk DTC with the intent of ablative treatment, adjuvant treatment, and treatment of metastatic disease (2). After being delivered to a patient, ^{131}I is absorbed by the thyroid tissue, and in a normal individual, the kidneys are the thyroid's main competitor for clearing iodide from the blood stream. The kidneys clear the majority of the residual circulating ^{131}I. Patients with chronic kidney disease (CKD) have significantly lower levels of circulating ^{131}I clearance, which causes the effective half-life to be prolonged. CKD causes prolonged excretion of ^{131}I, resulting in comparatively higher side effects such as sialadenitis, xerostomia, and bone marrow depression (3). The effective half-life of ^{131}I was 4.5 times longer in patients on hemodialysis than in patients with normal renal function. Dialysis, which can be either hemodialysis (HD) or peritoneal dialysis, is the only way for CKD patients to clear ^{131}I from their bodies (4). However, ^{131}I is readily hemodialyzed, and excessive exposure can be avoided through patient monitoring with a standard Geiger counter. The patient's blood is in direct and indirect contact with the hemodialysis supplies and the dialysis machine during the operation. It also raises concerns about the safety of the HD equipment when used on other patients and poses potential radiation exposure risks to the HD employees. The HD team and the radiation safety department of a hospital must work closely together to prepare and communicate how to safely administer ^{131}I to these patients. However, the use of dialysis in a patient who has received ^{131}I raises a number of problems, including the dose of ^{131}I, the timing of the dialysis, and radiation safety measures. A case of DTC patient with CKD who was treated successfully with ^{131}I while continuing to have chronic HD.

Radiation Safety Issue

After radioiodine administration, hemodialysis can be done safely but needs to be shielded properly. Other authors described additional safety precautions in addition to the usual ones taken after radioiodine therapy, such as giving lead aprons to everyone attending the patient, keeping a 2 m distance between technician and patient, or having the dialysis technician sit outside the lead-shielded room with the door left open (5, 6). Mello et al. placed a lead shield between the patient and the dialysis technician, and each member of the technical staff was rotated after 2 hours with the patient (7). None of the authors mentioned any substantial contact with staff members or contamination of the room or dialysis equipment. As a result, further safety measures should be taken, such as maintaining a safe distance and shield between the patient and the technician, outfitting the medical staff with protective gear, using absorbent sheets to cover the room, and flushing the dialysate down the toilet. To lessen the radiation exposure, more than one technician and nurse may be employed. Following the delivery of radioiodine, the patient can begin regular dialysis after three of these sessions.

Dialysis

The kidneys are responsible for excreting inorganic iodine, and CKD patients have higher levels of stable iodine in their bodies, which further delays the excretion of ^{131}I. Hemodialysis is 4-5 times more effective at clearing ^{131}I than renal elimination (8). The meticulous planning of the dialysis sessions should guarantee that there is enough ^{131}I present to have a therapeutic effect. Patients should have hemodialysis right before receiving ^{131}I in order to avoid any unexpected requirement for immediate hemodialysis in between the scheduled intervals and to receive the optimum therapeutic benefit. The ideal time for the first dialysis after radioiodine therapy is when ^{131}I uptake in remnant thyroid tissue or cancerous cells peaks, which varies between case reports by different authors. A 48-hour interval between RAIT and the next HD appears appropriate; as shorter interval than 48 hours may result in undertreatment.

CASE REPORT

In January 2022, a 68-year-old male patient visited the National Institute of Nuclear Medicine & Allied Sciences (NINMAS), 20 days after a total thyroidectomy for the treatment of papillary thyroid carcinoma (PTC). The patient had long-standing hypertension with CKD secondary to chronic tubulointerstitial nephritis. He had been on alternate-day hemodialysis for three years and noticed swelling in his neck three months ago. Neck ultrasonography revealed a hypoechoic nodule measuring about 23 mm with microcalcifications in the left lobe of the thyroid gland. A few subcentimetric lymph nodes were also found on the left side. A FNAC of the thyroid nodule confirmed the diagnosis of PTC. He had a total thyroidectomy with central neck dissection within a month. Multifocal papillary carcinoma of the thyroid (maximum tumor dimension, 25mm) without extrathyroidal extension was reported in histopathology. According to the American Thyroid Association, his staging was (T2 N0 Mx), putting him in the intermediate risk category (2).

Post-operative investigations revealed TSH=150 mIU/ml, a stimulated thyroglobulin (Tg) level= 23 ng/ml, anti-TgAb level =1.3 IU/ml, and a creatinine level of 9.0 mg/dl. RAI uptake of thyroid at 24 hours = 7% and 99mTc thyroid scan showed multiple focal areas of radiotracer concentrations in the thyroid bed. Standard dose of ^{131}I for a patient with normal renal function of intermediate-risk category is 100 mCi for ablation of the thyroid remnant and as adjuvant treatment. After thorough literature review and vivid discussion with the tumor board, the dose of ^{131}I was reduced to 30% (30 mCi) to maximize the effect and reduce the radiation exposure to normal tissues. One day before therapy, the patient underwent dialysis in the morning and then received 30 mCi (1110 MBq) of ^{131}I. Though a compromised dose of ^{131}I was administered to the patient, there was no flexibility about the radiation safety issues while an isolated hospital stay was needed for 5 days. Constant supervision of a nuclear medicine physician, a physicist, a technologist, and a nephrologist was ensured. Patient was allowed to take one liter of fluid every day. Next HD was scheduled after 48 and 96 hours of RAI ablation. Radiation protection regulations required by the hospital staff, attendant of the patient, doctors and nurses were strictly maintained. The whole-body radioactivity was measured at various time intervals and after each session of dialysis at the level of the stomach with the patient standing, using an ionization chamber-based gun monitor (Ram Ion; Rotem Industries) at a distance of 1 meter under the supervision of a radiation safety officer.

The patient underwent dialysis at the end of the day in a single room dialysis unit with shielding arrangements. Under normal conditions, more than four patients at a time undergo dialysis in the same room (Figure 1).

Figure 1: The dialysis machine was especially prepared using a portable water supply with the drain line connected to the sewer system. The dialysis machine and portable reverse osmosis unit were kept in rinse mode to eliminate any ^{131}I contamination. Radiation exposure was below the threshold level detected by dosimetry devices carried by the concerned technicians and physicians.

Care was taken to avoid any blood or fluid spills or contamination. The floor near the patient's bed was covered with absorbent sheets. During the 48-hour hemodialysis procedure, the technician wore all the necessary protective clothing (shoe covers, gloves, a face mask, and a lead apron). All personnel attending the patient, including the dialysis technician, were given a pocket dosimeter (Rad-60S; Rados; Mirion Technology) for real-time monitoring of the exposure rate.

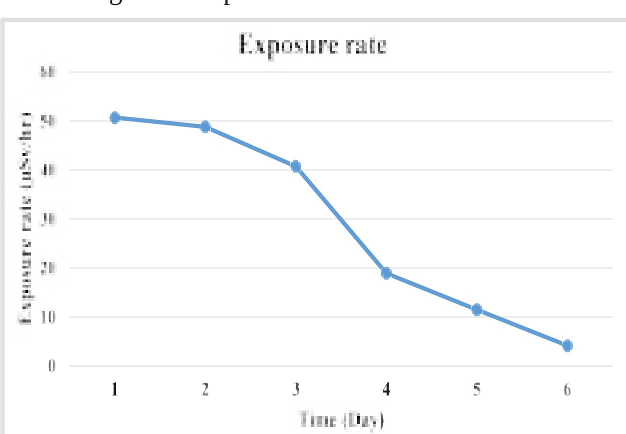

Figure 2: Gradual fall in ^{131}I radioactivity emission following an ablative dose of 30mCi, measured from 1-meter distance from the hemodialysis-dependent patient of papillary thyroid carcinoma.

The dialyzer, blood lines, absorbent sheets, and linen used during the procedure were collected in polyethylene sheets and allowed to decay in the radioactive waste storage room of the isolated ^{131}I therapy ward. The dialysate drain line was connected to the sewer system.

After the dialysis, the hemodialysis machine was put on rinsing mode to eliminate any ^{131}I contamination, though no contamination was observed in the hemodialysis machine when checked with a Geiger–Müller counter (Australia & Austral Rad Mini-8 in 1). A reduction in whole-body radioactivity of 60% was achieved after the first dialysis session (Figure 2).

These findings are consistent with the literature reported by many authors and showed clearance in the range of 50%–80% (9, 10). Radiation exposure rate by survey meter at one meter apart from the patient was measured at 10 minutes and two hours after therapy. The exposure rates were 50.72 µSv/ hr and 48.82 µSv/hr respectively. The patient underwent HD again 48 hours after receiving the ^{131}I dose, and before dialysis, the exposure rate was 40.71µSv/hr; after dialysis, it went down to 18.93 µSv/hr. On the 5th day before dialysis, radiation was 11.52 µSv/hr; after dialysis, it was 4.20 µSv/hr. The total dose received by the patient's attendant and dialysis technician was 37 and 16 µSv, respectively, which appears to be far below the permissible limits. A post therapy whole-body iodine scan (RxWBS) was done on the fifth post-therapy day, which showed radiotracer uptake in the thyroid bed area only (Figure 3).

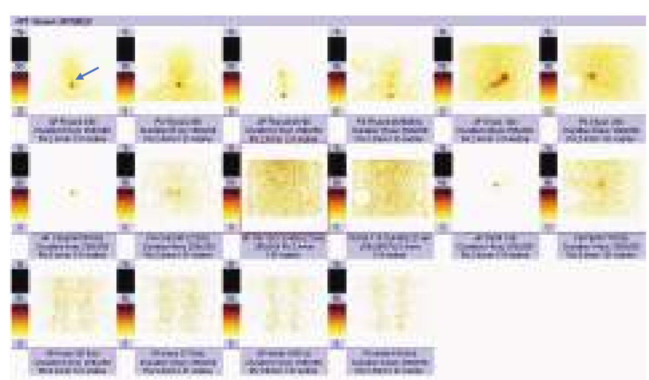

Figure 3: Whole body post-ablation scan done on five days following the administration of 30mCi of ^{131}I. Image shows uptake in the thyroid bed (arrow), as well as physiologic activity in the salivary glands and nasopharyngeal area. The areas of kidneys are unremarkable.

The patient was discharged on the fifth day after radioiodine administration, with an exposure rate of about 4.20 µSv/h measured at the stomach level at a distance of 1 meter, and remained asymptomatic on follow-up. After 6 weeks of RAI therapy, his blood counts showed no change from the baseline (white blood cell counts: 5,200 vs. 5,340 cells/mm3), and his hemoglobin level (10.1 vs. 11 g/dL) was improved. The patient continued the suppressive doses of levothyroxine with a target TSH level of 0.1–0.5 IU/mL. The Tg level was 2 ng/mL at the 4-month follow-up, with a TSH level of.01 mIU/mL.

CONCLUSION

Hemodialysis sessions for patients treated with 131I are safely and effectively achievable in a shielded area under the combined supervision of the nuclear medicine physician, physicist, technologist, and nephrologist. Clearly, good facilities and infrastructure are mandatory to ensure the quality of the water and of the effluent removal system in the decay tanks. In addition, good communication with the hemodialysis department and the dialysis nursing staff is needed to coordinate the use of mobile dialysis devices.

The emotional and physical health of the patient as well as their financial condition should be considered. Each case deserves a multidisciplinary approach with special considerations regarding dosimetry and timing of HD to maintain the effectiveness of 131I as a therapeutic procedure in patients with renal disease. The reported case showed that clinical monitoring along with a standard Geiger counter during the HD procedure provided an effective, noninvasive method of limiting excessive or residual radiation exposure to the patient and staff with no specific modifications to the actual dialysis procedure, apart from the appropriate disposal of non-reuse supplies that retain a low degree of radioactivity. The exposure dose rate was less than half after each dialysis, which was far less than the recommended exposure dose (25 µSv/hr) to be discharged from isolation.

REFERENCES

1. DeGroot LJ, Kaplan EL, McCormick M, et al. Natural history, treatment, and course of papillary thyroid carcinoma. J Clin Endocrinol Metab. 1990; 71:414–424.
2. Haugen BR, Alexander EK, Bible KC, et al. 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: the American Thyroid Association Guidelines task force on thyroid nodules and differentiated thyroid cancer. Thyroid. 2016; 26:1–133.
3. Yeyin N, Cavdar I, Uslu L, et al. Effects of hemodialysis on iodine-131 biokinetics in thyroid carcinoma patients with end-stage chronic renal failure. Nucl Med Commun.2016; 37:283–287.
4. Vermandel M, Debruyne P, Beron A, et al. Management of patients with renal failureundergoing dialysis during 131I therapy for thyroid cancer. J Nucl Med. 2020;61:1161–1170
5. Luster M, Clarke SE, Dietlein M, et al. Guidelines for radioiodine therapy of differentiated thyroid cancer. Eur J Nucl Med Mol Imaging. 2008; 35:1941–1959.
6. Holst JP, Burman KD, Atkins F, et al. Radioiodine therapy for thyroid cancer and hyperthyroidism in patients with end-stage renal disease on hemodialysis. Thyroid. 2005;15:1321–1331.
7. Jim enez RG, Moreno AS, Gonzalez EN, et al. Iodine-131 treatment of thyroid papillarycarcinoma in patients undergoing dialysis for chronic renal failure: a dosimetric method. Thyroid. 2001; 11:1031–1034.
8. Rodby RA, Sinsakul M, Ali A. Radioactive 131I Use in End-Stage Renal Disease: Nightmare or Nuisance?. InSeminars in dialysis 2004 Jan (Vol. 17, No. 1, pp. 53-56). Oxford, UK: Blackwell Science Inc.
9. Mello AM, Isaacs R, Petersen J, et al. Management of thyroid papillary carcinomawith radioiodine in a patient with end stage renal disease on hemodialysis. ClinNucl Med. 1994;19:776–781.
10. Culpepper RM, Hirsch JI, Fratkin MJ. Clearance of 131I by hemodialysis. ClinNephrol. 1992;38:110–114.