^{131}I treatment in patients undergoing renal dialysis: Our experience

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Abstract. Radiation Protection issues concerning patients, public and staff must be considered carefully in hemodialysis for chronic renal failure patients scheduled for ^{131}I high dose therapy. In order to assess the risks related to this medical procedure, hemodialysis clearance of ^{131}I and contamination measurements were carried out. We have studied 12 hemodialysis procedures corresponding to 2 cases of hyperthyroidism disease (555 MBq of ^{131}I administered) and 3 patients with carcinoma of the thyroid (5550 MBq of ^{131}I administered). The arterio-venous difference of ^{131}I across the artificial kidney and dose rate reduction at one meter of patient were measured. Contamination levels of the dialyzer machine, filters and tubes were measured after dialysis with a contamination monitor. Direct read-out dosimeters were used to assess the radiation doses to nursery staff involved. The result obtained for mean ^{131}I clearance in blood was 75±11%. The mean dose rate reduction at one meter of the patient was 58±18%. We also checked that contamination levels for the dialyzer machine, filters, tubes and accessories were lower than 10Bq/cm^2. For the nursery staff the radiation dose was found to be lower than 0.1 mSv.

KEYWORDS: ^{131}I ***treatment; renal dialysis; radiological protection; clearance.***

1. Introduction

The current accepted treatment for carcinoma of the thyroid or ablation of thyroid remnants is ^{131}I oral administration. Normally this isotope is excreted by the renal system. In case of renal insufficiency, the ^{131}I removal is carried out mainly by hemodialysis (HD). This unusual situation represents just 0.1% of the overall patients treated because of hyperthyroidism and 0.6% of the overall patients treated because of thyroid carcinoma. The aim of this work is to present our experience with renal dialysis in patients undergoing ^{131}I treatments. Protocols aimed to minimize exposition and contamination risks for staff as well as radioactive waste management are presented. It was determined the HD effect on ^{131}I clearance. We also measured surface contamination levels of the dialyzer machine, filters and tubes after HD.

2. Methods and materials

Since May 1995 until December 2007 we have studied 12 processes of HD in 5 patients with chronic renal failure which needed therapy with ^{131}I. Two patients with hyperthyroidism were treated with 555 MBq of ^{131}I and three patients with carcinoma of the thyroid were treated with 5550 MBq of ^{131}I. The first HD for each patient was carried out at 24 hours later administration of ^{131}I, since the maximum uptake of iodine in the thyroid gland is achieved at 24 hours of ingestion [1].

Hemodialysis is conducted in a specially conditioned room with structural shielding to guarantee the radiation safety of the personnel. A waste storage system is also available to collect the dialyzing liquids, and the means for personal radiation protection are provided (aprons, gloves, etc.). Patients treated of thyroid carcinoma were kept in the room until dose rate at 1 meter was below 20 μSv/h. On the other hand hyperthyroidism patients left the room after dialysis.

Nursery personnel were monitored with a direct readout monitor Revealer^{TM} (Inovision Radiation Measurements) individually assigned. In order to minimize the radiation exposure, a 0.5 mm Pb apron was used during the patient preparation before the hemodialysis start. A closed circuit TV system was used to view the patient, so that the patient could be observed through the video monitors immediately outside the treatment room. When the nursery personnel needed to go in the treatment room for dialyzer machine or patient check, they were kept behind a lead shields.

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2.1 Hemodialysis equipment

For all the HD studied it has been used a standard dialyzer system, normally used in the Nephrology Service with patients who suffer from chronic renal failure. At the end of the HD saline was pass through the whole of filter and tubes in order to restore circulating blood that had not returned to the patient. This action allowed for a wash of these elements prior to measure them with a Contamat FHT 111M (FAG) radiation contamination monitor. This measurement was conducted after disconnecting and separating the dialyser tubes and filter.

A sample of 1 ml of liquid spilled by the dialyzer machine during washing and disinfection procedure was taken to verify the absence of internal contamination in the dialyzer machine. Activity was measured with a NaI (Tl) scintillation crystal and multi-channel analyzer Genie 2000 (Canberra). The possible contamination on the dialyser surface was verified with a contamination monitor. After completing HD and verifying absence of contamination the use of the dialyser machine with other patients was authorized.

2.2 Clearance of ^{131}I

2.2.1. Blood activity measured

A blood sample of the patient was taken before starting the HD to take a measure of the initial activity. Blood samples were also taken entering (arterial) and leaving (venous) the dialyzer machine and dialysate samples at 30, 60, 120, 180 and 240 minutes after HD started. All samples, both blood and liquid dialyzer, were collected in a volume of 1 ml each. Following the formalism described by Culpepper [2], we define a clearance factor $\boldsymbol{K}$ as:

$$K = \frac{Q_{Bi}\left(A_{Bi} - A_{Bo}\right)}{A_{Bi}} \qquad (1)$$

$$K = \frac{Q_D A_{Do}}{A_{Bi}} \qquad (2)$$

where $\boldsymbol{Q_{Bi}}$ is the blood flow rate fixed in the dialyzer; $\boldsymbol{A_{Bi}}$ y $\boldsymbol{A_{Bo}}$ are the activities of ^{131}I entering and leaving the dialyzer, respectively; $\boldsymbol{Q_D}$ is the dialysate flow rate and $\boldsymbol{A_{Do}}$ is the activity of ^{131}I in the expended dialysate.

Quantitative removal of ^{131}I was estimated by multiplying the arterial blood concentration by the simultaneous clearance for each time point and analytically integrating the area under this time-clearance curve.

2.2.2 Dose rate reduction

^{131}I clearance in blood patient should be reflected in dose rate reduction at different measurement points. If the administered activity to the patient has saturated the thyroid gland, then dose rate measurement at neck should not be significantly affected by the HD, because the greater contribution to this measurement is given by the activity in the thyroid. Furthermore, dose rate at 1 meter of the patient will be greatly influenced by the amount of activity that the HD eliminates. For this reason we choose to use the dose rate variation at 1 meter of the patient to estimate the ^{131}I clearance.

The patient was seated in a chair during the dose rate measurement, in the same position before and after HD. A proportional counter FH 40G (Thermo Eberline ESM) was used for the measurement. Previously, the HD wastes were withdrawn from the room.

2.3 Waste generated

As a treatment involving unsealed radioactive sources, the radioactive wastes generated during metabolic treatment with ^{131}I must be segregated and disposed into different forms. In our case two forms were considered, solid and liquid.

2.3.1 Solid waste generated

Any material in contact with the patient, from his preparation until he leaves, must be considered a radioactive waste, and monitored in order to decide its management. In solid form we find gauzes, syringes, nursery gloves and patient's bed linen. The Radiation Protection Department is in charge of monitoring this material and deciding, if necessary, how long it should be stored before it could be considered a conventional waste.

2.3.2 Liquid waste generated

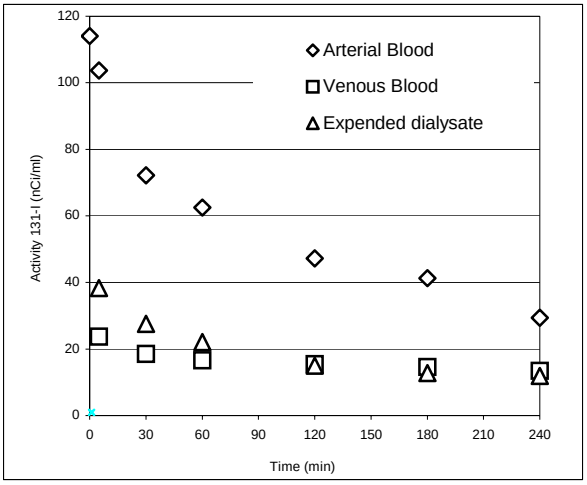
Dialyzing liquid is the only liquid waste generated during HD. Dialyzing liquid flow was adjusted in the range of 500 – 750 ml/min depending on the patient. For radiation protection purposes this is an important parameter because, together with the HD length, give us the volume of liquid to be generated and let us predict the storage necessities. The HD length was set to 4 hours. This generated a volume of wastes in a range of 120 - 180 liters. This liquid was poured directly to the automatic liquid withdrawal system installed in the room.

3. Results

3.1 ^{131}I clearances

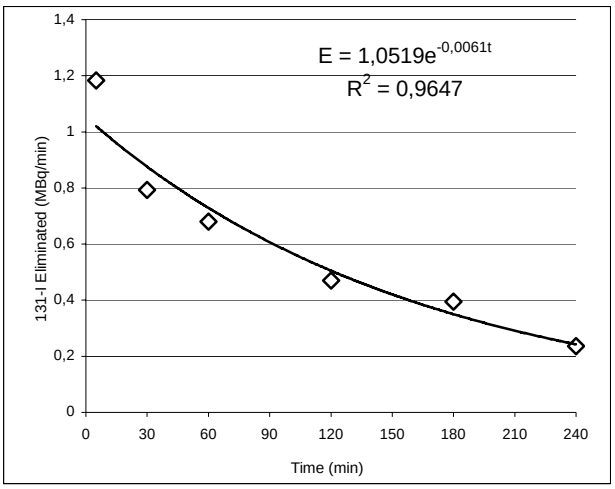
Fig. 1 shows the ^{131}I activity concentration in arterio-venous blood and dialyzer liquid as a function of time, for a hyperthyroidism patient treated with 555 MBq of ^{131}I 24 hours before HD. Blood flow was set to 400 ml/min and the dialyzer liquid was set to 750 ml/min. The mean activity for every blood (arterial and venous) sample is shown. It can be seen an exponential decay for the activity in arterial blood, while for venous blood and dialyzer liquid the activity remains fairly constant in time showing the effectiveness of the dialyzing machine filtering.

Figure 1: Variation in arterial and venous blood and dialysate activity with time.



From these data and multiplying arterial blood activity by the clearance factor (calculated from the corresponding sample) we found the clearance curve, Fig. 2. An exponential curve was fitted to the experimental data so that an analytical integration could be carried out to obtain the total amount of ^{131}I cleared from the patient.

Figure 2: Removal of ^{131}I during HD. Area under this curve represents the quantity of ^{131}I removed over the HD.



$$E(MBq) = \int_0^{240} E(t) \cdot dt \qquad (3)$$

Applying this formula to the fitted equation shown in Fig. 2, we found a clearance of 133 MBq (76%).

We also estimate the clearance of ^{131}I through the measurement of the dose rate at 1 meter of the patient before and after the HD, resulting 13 µSv/h and 4.8 µSv/h respectively. Clearance of 63% was calculated. The mean value of clearance obtained for the 12 HD was 75±11% from blood samples and 58±18% from dose rate at 1 meter of the patient.

3.2 Waste generated

Contamination values for the HD material were negligible for all the cases studied. For this reason the generated wastes were treated as conventional or biological wastes. Contamination levels in tubes and filters reached 10 Bq/cm^2 only for the carcinoma treatment cases, corresponding to the highest activities used (5550 MBq). Such components were stored until their contamination levels fell to radiation background (0.3Bq/cm^2).

Contamination values in the dialyzer liquid are high. The reason is that dialyzer liquid contains about 75% of the initial ^{131}I activity in blood circulation. Therefore it is necessary to collect and store dialyzer liquid until contamination levels permit its evacuation.

The water used for washing and disinfection of the dialyzer machine has negligible values of contamination. Furthermore, measurement showed no contamination on dialyzer machine surface. This result agrees with Morrish et al. [3].

3.3 Staff dosimetry

In all the cases studied radiation dose to nursery personnel was under 0.1 mSv. As most of the radiation exposure occurs during the preparation of the patient (at the HD process beginning and ending), it is necessary the use of lead aprons to reduce the dose. On the other hand, for the rest of their time, nursery personnel must try to remain at least 2 m from the patient.

4. Conclusion

Hemodialysis for chronic renal failure patients undergoing treatment with ^{131}I is an efficient and safe practice removing ^{131}I from the circulating blood. Some authors reach the same conclusion in their studies [2-3]. Since actual dialyzer machine contamination is insignificant, after the ordinary washing and disinfection procedure, the dialyzer machine is ready for use with other patients. Our experience, in spite of the limited cases studied, is that the procedures followed guarantee the radiological safety for the patients as well as for the staff involved.

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