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Evaluation of Reduction in Radiation Dose Rates from Patients Receiving Iodine-131 Therapy for Thyrotoxicosis and Thyroid Cancer

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ABSTRACT

The measurement of radiation dose rates is important in the release of patients treated with radioactive iodine. Radioactive patients present radiation hazards to others after radiopharmaceutical administrations and evaluation of the radiation dose rate close to patients is important. The annual public dose limit is 1 mSv, though the family members are allowed to receive higher doses but as per IAEA guidelines should not exceed 5mSv over 5 years. In the present research radiation dose rates were measured from radioactive patients without the influence of scattered radiation and correction factors. Total 200 patients suffering thyrotoxicosis and (Carcinoma) thyroid disease treated with radioactive iodine I-131 at PIUNM cancer hospital were evaluated. The measurements were performed at a distance of 0.5m, 1.0 m, 1.5m and 2.0m in front of the thyroid tissue. The results obtained were evaluated more accurately exposure rates and consequently absorbed doses near radioactive patients and allow for more effective radiological protection procedures for patient release criteria. The radiation exposure varied from patient to patient at same radioactivity administered due to patient's gland size, age and statues of renal function that contributes in biological half-life of I-131. For all results obtained from patients treated with 5 mCi, 10 mCi, 15 mCi, 20 mCi, 25 mCi, 28 mCi, 29 mCi, 30 mCi, 100 mCi, 150 mCi, 200 mCi and 250 mCi were recorded and statistically analysed. It was concluded that patients treated with 15mCi to 30mCi should not be hospitalized and would be discharged with instructions. The patients treated with 30 mCi to 150 mCi quantities of radioactive I-131 should be hospitalized for a duration of (24 to 40) hrs after administration of radioactive I-131. The patients treated with 150 mCi to 250 mCi of radioactive I-131 should be hospitalized from (60 to 72) hrs after administration of radioactive I-131.

Keywords:
Radiation exposure (RE), Carcinoma (Ca), Thyroid disease (TD), Ionizing radiation (IR).

1. Introduction

Progresses in radiologic techniques to identify human diseases have taken a substantial influence in medical field. About 2.4 million medical diagnostic radiation personnel are involved in using

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ionizing radiation for nuclear imaging procedures in more than 11,000 hospitals worldwide. These ionizing radiations are also environmentally hazardous, and can cause genetic mutations, hematopoietic system dysfunction, oxidative stress and immune dysfunction . The radioisotopes have prime importance in the field of medical like (I-131) in the field of medical, radioisotopes as artificial source synthesized to meet some debilitating problems. The radioisotope, which was used first time in medical treatment is radium and after its use the new branch of science begins calling nuclear medicine. When we combine clinical applications with many basic branches of science like inorganic chemistry, physics, physiology and biochemistry, which makes nuclear medicine such field of challenges. The radiation energy, type and range are prime consideration in tissues. For the purpose of diagnostic, he was used radioactive tracers in medicine principally. As radiation sources, he was used different radio isotopes, as not tracers. These radio isotopes used either internally or externally. For the treatment of patient with thyroid carcinoma and thyrotoxicosis and the study of thyroid physiology most useful substances are radioactive substance. There are four different kinds of malignant tumors of the thyroid glands: anaplastic, medullary, follicular and papillary. Follicular and papillary tumors are very common. A potential risk of radiation for the individuals, members of family, the environment and health workers which are very close to that patients who are treated with therapeutic dose of Iodine-131. So the use of I-131 must be according to the precautions, strict measures of safety and specific instruction to avoid exposure of unnecessary radiation. The safeties and recommendations are necessary for radiation protection understanding. The limits of radiation dose to others those who come close contact with these subjects.

Although we have discussed about the releasing of patients from the hospitals after just administration radiopharmaceutical and it influence on quality of life of patients. Time, shielding and distance are very simple technique to minimize the exposure of radiations. The possible greater distance from the patient by maintain with the effective care. With the distance increasing drastically drops off radiation exposure. By use of portable shields, it may possible to reduce further external hazard, with the time increase effectively decreases the amount of radiation exposure and to close contact with the other to avoid amount of time is necessary. The radio nuclei use growing interest and widespread. The patients of Thyrotoxicosis and Thyroid which are treated with Iodine-131 serve as a radiation for diagnosing and therapy purposes source. Technologist and public avoid close contact from the patients burning question for radiation safety; in it the exposure of radiation is evaluated has prime importance. After the given of different radionuclide dose, we are evaluate to the committee exposure of radiation at different distances from the patients of 0.5m,1.0m,1.5m,2.0m after 1 hour to design a new technique in order to save interacting with technologist and general public from the patients of Ca thyroid and benign thyroid disease patients.

1. Materials and Methods

Aim of this research work was to measure the radiation exposure from the patients treated with varying amount of radioactive I-131(5 mCi, 10 mCi, 15 mCi, 20 mCi, 25 mCi, 28 mCi, 29 mCi, 30 mCi, 100 mCi, 150 mCi, 200 mCi and 250 mCi). The patient exposures were measured after one hour of activity administration at different distances (0.5 m, 1.0 m, 1.5 m, 2.0 m) to evaluate radiation dose rate reduction with respect to time and distance. This project was conducted at Punjab Institute of Nuclear Medicine (PINUM).

- By using survey meter background counts of radiation were calculated.
- Radiation exposure was measured on above measurement basis taken. When radioactive iodine was orally administered as I-131 solution rapidly into absorbed systemic circulation and after 1 hour all administered activity almost distributed throughout bodies of patients.

• For exposure rates measurement calibrated Geiger-Miller counter was used. The calibration was carried out at SSDL lab PINSTECH, Islamabad with a calibration factor of Accumulated dose measuring instruments as dosimeters commonly referred, worn by individual to calculate accumulated person dose. Normally two types of instruments as dosimeters were used: pocket dosimeters devices direct read-out and film badges & TLDs indirect. Here, for measure personal dose film badges to monitor are used.

Best way is direct measurement to determine doses rates and in present study survey meter of radiation is used to patient's exposure of radiation measure.

IAEA guidelines recommends that radiation exposure from patients should not exceeds 5 mR at a distance of 1 meter from the patient. Out of 200 total patients 185 cases were those of hyperthyroidism and 15 cases differentiated thyroid cancer. 150 patients were females and 50 were males, with ages ranges from 19 to 75 years.

I-131 radioactive administered all the patients ranged between 15 mCi to 250 mCi. A 30 mCi (1.11 GBq) activity or hyperthyroidism was administered. Patients with cancer of thyroid activity administered was equal or greater than 3.8 GBq (150 mCi), increasing amount therapeutic requirements accordingly.

From radioactive patient exposure rates were measured from 0.5m to 2.0 m (at 0.5 m intervals) patients in front at 1 meter over floor. When radioiodine orally administered as I-131, solution quickly absorbed into systemic circulation and after 1 hour all activity almost administered. All measurements were performed at about 1 hour after administration I-131 for calculation of radiation exposure.

Sex and age of patients were recorded. Patients information Performa were designed to get information about the socioeconomic status and different parameters like way of transportation, presence of children under 12 and pregnant female at home, separate room etc. Generally, patients are discharged on assumption that he/she carries (I-131) less than 30 mCi in his/her body. Exposure rates from these radioactive patients will be measured from 0.5, 1.0, 1.5 and 2.0 m (at intervals of 0.5 m) in front of the patients at 1.0 m over the floor. When radioiodine is administered orally in solution it is rapidly absorbed into the systemic circulation, and after 1.0 h almost all activity administered is distributed throughout the patients' bodies. All measurements were performed at about 1.0 h, 24 h, 48 h and 168 h administration. A Geiger-Muller Model Victorian was used for the measurement of exposure rates. The detector was calibrated by the PINSTECH, Pakistan Institute of Nuclear Science and Technology, Islamabad. Results of study may serve as a database for radiation safety related decision-making. Statistical analysis 2 factorial tests Factor to establish performed in order result after data compiling.

2. Results

A total 200 patients were examined after therapeutic procedures with radioiodine I-131 (hyperthyroidism cases were 185 and differentiated cancer of thyroid cases were 15); 44 patients were males and 156 patients were females, ranging with age from 16 to 70 years.

All the patients administered radioactive I-131 ranges from 5 mCi to 250 mCi. A 30 mCi activity or less administered to the patients among hyperthyroidism and for the patients with thyroid cancer, the activity was administered equal or greater than 100 mCi, the amount increasing according to the requirements of therapeutic procedure such as gland size e.t.c.

From the patients of radioactive Iodine treated, radiation exposure rates were measured from the distance 0.5 meter to 2 meter (at 0.5 m intervals) with distance and with time about 1.0 hour after administration of I-131.

Table 1
Analysis of variance table for Response (mR/hr)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Dose	11	10254.532	932.2302	275.86**
Distance	3	1864.708	621.5693	183.93**
Dose x Distance	33	1713.472	51.9234	15.36**
Error	716	2419.587	3.3793	
Total	763	16270.139		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01)

Table 2
Analysis of variance table for Response (uSv/hr)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-value
Dose	11	1739476.7	158134.20	283.19**
Distance	3	183638.7	61212.90	109.58**
Dose x Distance	33	176032.8	5334.33	9.55**
Error	716	399946.1	558.58	
Total	763	2503874.8		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01)

Table 3
Dose x distance interaction mean±SE

Dose	Distance				Mean
	0.5 m	1.0 m	1.5 m	2.0 m	
5 mci	2.96±0.22ghi	2.45±0.06hi	1.64±0.09i	1.20±0.12i	2.06±0.21F
10 mci	3.70±0.20ghi	2.77±0.16hi	2.15±0.14i	1.53±0.15i	2.54±0.15F
15 mci	4.40±0.24ghi	3.54±0.28ghi	2.77±0.26hi	2.05±0.20i	3.19±0.20EF
20 mci	5.24±0.20gh	4.18±0.21ghi	3.19±0.17ghi	2.23±0.12i	3.71±0.17E
25 mci	5.22±0.07gh	4.10±0.10ghi	3.15±0.09ghi	2.11±0.09i	3.65±0.10E
28 mci	6.09±0.19gh	4.54±0.04ghi	3.75±0.05ghi	2.52±0.19hi	4.22±0.49E
29 mci	5.73±0.11gh	4.27±0.06ghi	3.20±0.07ghi	2.29±0.06i	3.87±0.08E
30 mci	7.20±0.00fg	4.96±0.00ghi	3.20±0.00ghi	2.78±0.00ghi	4.54±1.01E
100 mci	6.60±0.00fgh	11.30±0.00def	7.10±0.00fg	4.90±0.00ghi	7.48±1.36D
150 mci	20.82±1.32b	14.75±3.35cd	9.73±3.60ef	10.24±5.12ef	13.88±2.17C
200 mci	29.71±2.99a	15.70±1.27c	11.47±0.71de	10.21±0.77ef	16.29±1.64B
250 mci	29.11±5.43a	21.88±4.55b	15.91±3.22c	12.28±2.44de	20.24±2.45A
Mean	7.02±0.48A	5.11±0.30B	3.81±0.21C	2.83±0.19D	

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Table 4
Dose x distance interaction mean±SE

Dose	Distance				Mean
	0.5 m	1.0 m	1.5 m	2.0 m	
5 mci	20.77±0.88jk	17.83±1.18jk	13.46±0.59jk	11.27±0.75k	15.83±1.18F
10 mci	36.01±2.66ijk	29.90±2.50ijk	23.10±1.77jk	17.37±1.60jk	26.59±1.50F
15 mci	43.89±3.07ijk	31.52±5.01ijk	28.56±2.43ijk	19.45±1.64jk	30.86±2.21EF
20 mci	48.97±1.87g-k	37.63±1.95ijk	30.09±1.62ijk	21.40±1.36jk	34.52±1.56EF
25 mci	49.26±1.73g-k	39.74±1.30ijk	29.92±1.22ijk	22.01±1.07jk	35.23±1.03EF
28 mci	62.90±6.50g-j	52.05±3.55g-k	45.00±1.80ijk	31.65±3.85ijk	47.90±4.58E
29 mci	61.97±1.18g-j	46.66±0.90ijk	35.91±0.87ijk	27.73±0.83jk	43.07±0.82E
30 mci	56.40±0.00g-k	47.30±0.00hijk	35.40±0.00ijk	27.90±0.00ijk	41.75±6.31EF
100 mci	193.00±0.00cd	113.00±0.00fg	65.90±0.00g-j	48.80±0.00g-k	105.18±32.27D
150 mci	244.86±11.9c	170.11±21.1de	94.40±25.9gh	83.36±29.0ghi	148.18±26.07C
200 mci	290.67±16.2b	183.55±19.2d	140.76±15.2ef	101.77±12.0g	175.06±15.36B
250 mci	366.33±55.7a	308.34±65.5b	234.62±54.85c	194.92±57.3cd	280.35±30.87A
Total	74.52±5.43A	55.91±4.13B	42.61±3.15C	32.57±2.71D	

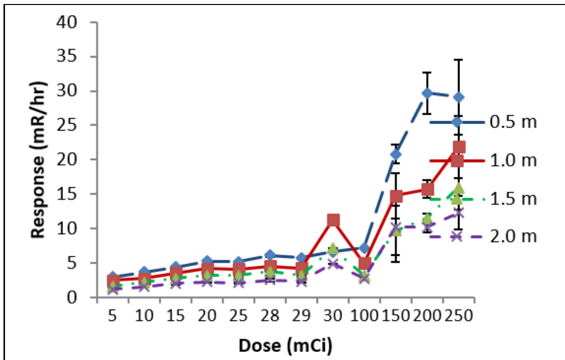

Fig. 1. Relationship b/w Dose (mCi) and Exposure rate (mR/hr)

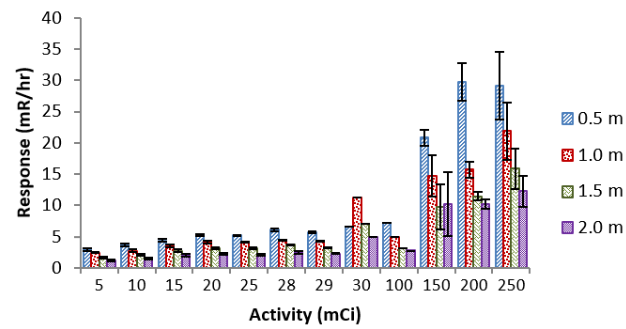

Fig. 2. Relationship b/w Activity (mCi) and Exposure rate (mR/hr)

Figure 1 shows the relationship between radiation dose (mci) delivered to the patients and radiation exposure rate (mR/hr) from patient's thyroid gland and patient's body. As mean radioactivity of I-131 delivered to patients increased, radiation exposure also increased. This means radiation exposure rate is directly proportional to radioactivity administered. As distance varies from 0.5 m, 1.0 m, 1.5 m, 2.0 m radiation exposure decreases following inverse square law and ALARA philosophy.

Figure 2 shows the relationship between radioactivity of I-131 in mCi delivered to the patient and radiation exposure rate (mR/hr) measured from patient's thyroid gland and patient's body. As mean radioactivity of I-131 delivered to patients of hyperthyroid and Ca thyroid increases, radiation exposure from patient's thyroid gland also increased. This means radiation exposure rate is directly proportional to radioactivity. As distance varies from 0.5 m, 1.0 m, 1.5 m, 2.0 m radiation exposure decreases following inverse square law and ALARA philosophy.

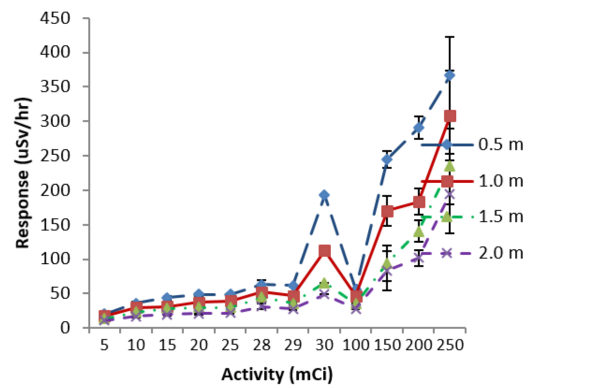

Fig. 3. Relationship b/w Activity (mCi) and Exposure rate (µSv/hr)

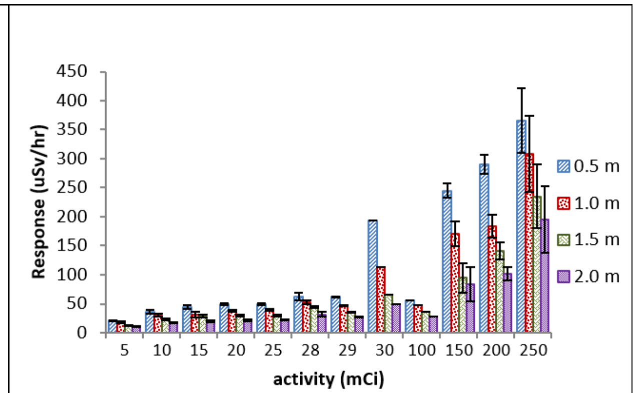

Fig. 4. Relationship b/w Activity (mCi) and Exposure rate (µS/hr)

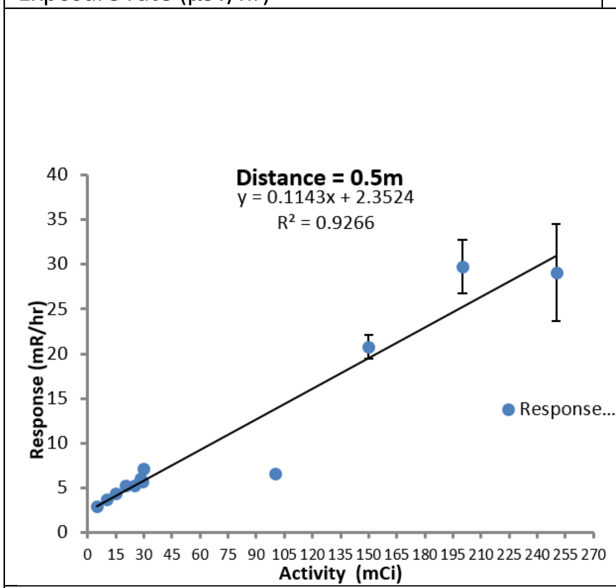

Fig. 5. Relationship b/w Activity (mCi) and Exposure rate (mR/hr) at 0.5 meter distance

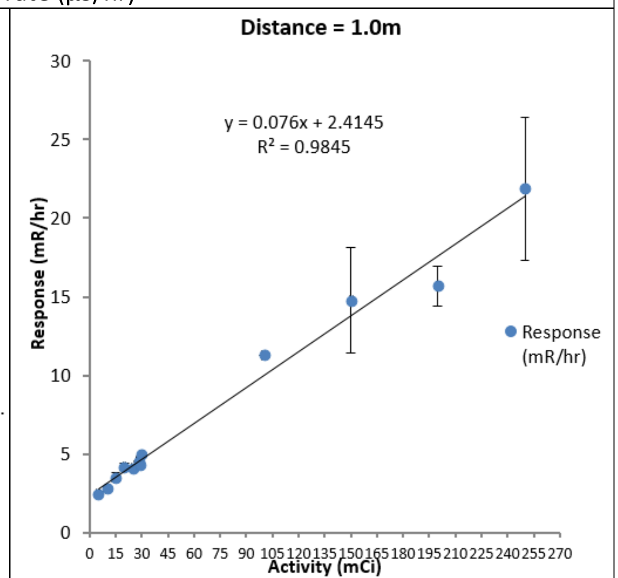

Fig. 6. Relationship b/w Activity (mCi) and Exposure rate (mR/hr)at 1.0 meter distance

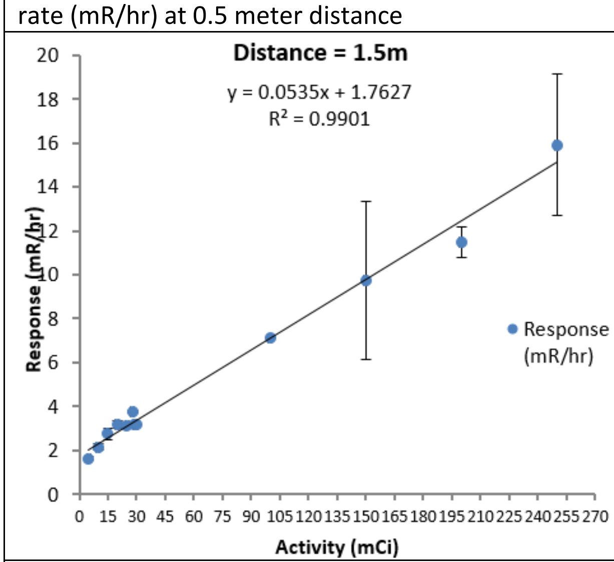

Fig. 7. Relationship b/w Activity (mCi) and Exposure rate (mR/hr) at 1.5 meter distance

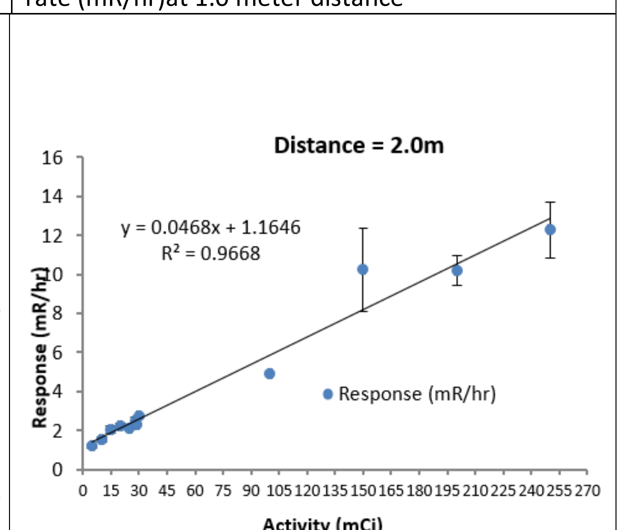

Fig. 8. Relationship b/w Activity (mCi) and Exposure rate (mR/hr) at 2 meter distance

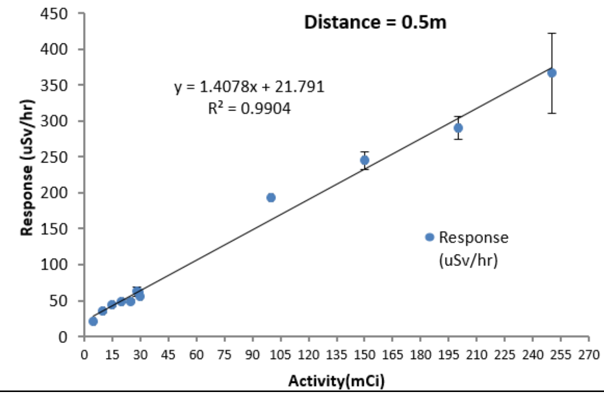

Fig. 9. Relationship b/w Activity (mCi) and Exposure rate (µS/hr) at 0.5 meter distance

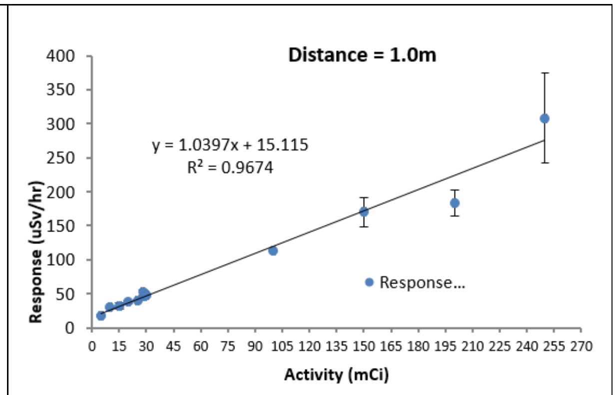

Fig. 10. Relationship b/w Activity (mCi) and Response rate (µS/hr) at 1.0 meter distance

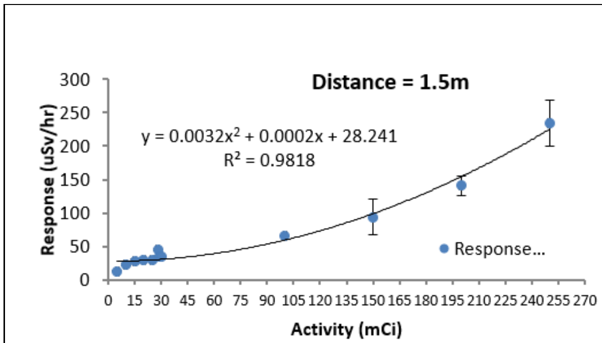

Fig. 11. Relationship b/w Activity (mCi) and Exposure rate (µS/hr) at 1.5 meter distance

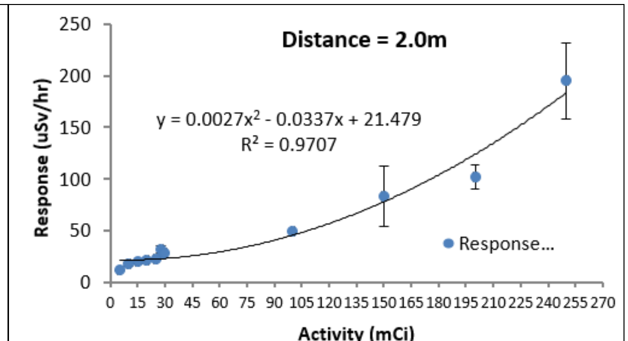

Fig. 12. Relationship b/w Activity (mci) and Exposure rate (µS/hr) at 2.0 meter distance

3. Discussions

All the values of tables: exposure of radiation decrement at the different interval of distance 0.5 m, 1.0 m, 1.5 m, 2.0 m with time 1 hour were recorded. Exposure of radiation deceases on the increasing distance as per inverse square law inverse and ALARA philosophy from patients.

Tables 1 to 4 are describing the results obtained at various values of activity administered during minor therapy as prescribed by the nuclear physicians. The activity delivered to the patient depends upon the size of the thyroid gland tissue. The activities used were ranged in (5, 10, 15, 20, 25, 28, 29, 30 mCi).

Table 4 shows mean of exposure of values with different distance. The mean value of treated patients at the distance of 2.0 meter was 2.83±0.19 mR/hr, at the distance of 1.5 meter mean was 3.81±0.21 mR/hr, at the distance of 1.0 meter mean was 5.11±0.30 mR/hr and at the distance of 0.5 meter mean was 7.02±0.48 mR/hr. Results were showed with increasing the distance significance difference.

The exposure of radiation showed significant difference after the time of 1 hour and other alternative distance intervals 0.5 meter, 1.0 meter, 1.5 meter, 2.0 meter were non-significant results (table 3). Exposures of radiation from radioactive patients decreasing on the increasing distance from the patient and the same follow trend of deceasing in all the measurements. With increasing activity, it is significance difference. From table 4, it concludes that the between activity and exposure of radiation has great interaction and it showed for the some measurements highly significance difference.

Analyzing from the Fig. 1 and Fig. 2, we observed the rising trend which indicated that activity and exposure of radiation had directly proportional relation. By increasing activity the radiation exposure is also increasing. The radiation exposure is increasing but from one value to the other the exposure differs in the range of 1-2%. From Figs. 5 to 8, we obtained the same results as the graphs have the same rising trends and the percentage increasing in exposure goes from (1%-5%). Regression analysis showed that the effect of activity was highly significant as with increasing unit in activity, exposure is increased in very significant trend. Since R is very high we can say that activity is highly correlated with exposure.

From above results, it was concluded that with increasing time, exposure of radiation decreased and with the increasing the quantity of activity, exposure of radiation from the body of the patient increased but with increasing distance from the patient exposure of radiation must be decreased.
Tables 9-12 are describing the results obtained at various values of administered during major therapy as prescribed by the nuclear physicians. The activity delivered to the patient in this case is very high because this is serious type of malignancy of thyroid gland. The high dose level causes a high value of radiation exposure to the staff and for the general public. The patients receiving the major therapy are admitted to the hospital for at least three days. During first three days the radiation exposure is reduced to acceptable level. The activities used in mille Curie (100, 150, 200, 250).

Table 4 exposure of radiation means values with different length were recorded. For mean value of treated patients at the distance of 2 meter mean was 32.57±2.71D µSv/hr, at the distance of 1.5 meter mean was 42.61±3.15C µSv/hr, at the distance of 1 meter mean was 55.91±4.13B µSv/hr and at the distance of 0.5 meter mean was 74.52±5.43A µSv/hr. Results were showed with increasing the length significance difference.

Analyzing the Fig. 3 and Fig. 4, we observed the rising trend which indicated that dose (activity) and exposure have directly proportional relation. By increasing activity the exposure is also increased. The radiation exposure is increasing but from one value to the other the exposure differs in the range of 1-2%. From Fig. 9 to Fig. 12, we obtain the same results as the graphs have the same rising trends and the percentage increasing in exposure was from (1%-5%). The implementation of Regression analysis shows that the effect of dose is highly significant as with increasing unit in dose, exposure is increased in very significant trend. Since R is very high we can say that dose is explaining the phenomenon of exposure very efficiently and results of regression analysis with minor difference.
From above results, it concludes that exposure of radiation decreasing when we increasing distance and by increasing time followed the biological and physical substance of radioactive half-life.

It was concluded that from the interaction of radiation exposure with respect to distance and time showed significant difference for same measurements. For all other results obtain from patients treated with 5 mCi, 10 mCi, 15 mCi, 20 mCi, 25 mCi, 28 mCi, 29 mCi, 30 mCi, 100 mCi, 150 mCi, 200 mCi and 250 mCi follow the same trend of decreasing radiation exposure with respect to time after 1 hour and distances (0.5 meter, 1.0 meter, 1.5 meter, 2.0 meter). Radiation exposure decreasing on increasing time interval but the trend of decreasing radiation exposure at various intervals of distances were not same. This variation involved certain parameters which includes patient's clinical factors, patients living style, biological half-life, statistical error, instruments error, patients renal function efficiency and random nature of radioactivity.

Provision of best possible faculties to patients differentiated carcinoma thyroid in isolation room and discharge limit of should be less than 5mR/hr at 1 meter distance.

4. Conclusion

It was concluded that patients treated with 15mCi to 30mCi should not be hospitalized. They would be discharged with instructions. The patients treated with 30 mCi to 150 mCi of radioactive I-131 should be hospitalized for 24 hours to 48 hrs after administration of radioactive I-131. The patients treated with 150 mCi to 250 mCi of radioactive I-131 should be hospitalized for 60 hours to 72 hrs after administration of radioactive I-131.

The data suggested that hyperthyroid patients can be treated with radioactive Iodine I-131 on an out-patient basis, if given appropriate radiation protection advice. However, special instructions should be given for children at home (family members of patient) under age of 15 years. Close contact to pregnant females should be avoided even after discharge. Admission to hospital is not warranted on radiation protection grounds.

The dose limit–based criterion correlates directly with the basic principles of radiation protection. This criterion is associated with several advantages when compared with previous guidelines that establish patient release when the administered activity is <30 mCi or when the radiation dose rate is less than 5 mR/hr at 1 m.

Even for most safety concern, in most of the studied cases 1 d of hospitalization was sufficient. Releasing patients after 1 d of isolation with written instructions about how to keep doses to other individuals "as low as reasonably achievable" has several advantages: lower health care costs, lower doses to nursing staff, and psychological benefits for patients and families. Written instructions is important, because the first hours after administration of the radiopharmaceuticals are crucial. They would be at high risk for biological effects of ionising radiations.

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