ORIGINAL ARTICLE

Estimation of net percent error in radioiodine-131 activity during administration to patients

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ABSTRACT

Background: Radiation workers have reported that some errors during the measurement of radioiodine-131 (RAI-131) activities have been observed, which may result in poor quality images, greater radioactive waste, and financial burden in the hospital. The purpose of this retrospective study was to estimate the net percent errors in RAI-131 activities during administration to thyroid patients and give some fruitful suggestions to reduce such errors.

Methods: We included 180 random patients, i.e., thirty for each advised activity of 3 mCi, 15 mCi, 20 mCi, 25 mCi, 30 mCi, and 150 mCi in this study from January 2019 to June 2022. All the recommended activities were measured with a CRC-25R dose calibrator. The percent difference between measured and prescribed activities and the percent difference between measured and residual activities were estimated. Finally, net percent errors in administered activities were measured for all patients.

Results: The net percent error in recommended activities of 3 mCi, 15 mCi, 20 mCi, 25 mCi, 30 mCi, and 150 mCi and administered activities were [6.73 (-32.7, 20.95) ± 11.15] %, [3.91 (-3.85, 8.77) ± 2.94] %, [3.63 (-2.39, 7.79) ± 2.51] %, [3.55 (-0.65, 10.67) ±2.6] %, [2.93 (-1.98, 6.78) ± 1.89] %, and [0.88 (-1.04, 2.68) ±0.87] %, respectively.

Conclusion: This study concludes that patients receive approximately 6.73%, 3.91%, 3.63%, 3.55%, 2.93%, and 0.88% less activities than the aforementioned activities, respectively. The net percent error in RAI-131 activities is not alarming but needs to be adjusted to ensure high-quality images and optimum dose delivery.

Keywords: Radioiodine-131, residual activity, thyroid disorder, thyroid carcinoma.

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Introduction

Radioiodine-131 (RAI-131) is a neutron-rich radionuclide and it is used for the management of thyroid disorders, i.e., hyrotoxicosis, toxic nodular disease and thyroid cancer [1–4], and thyroid diagnostic procedures [5]. It is clinically very efficient, secure, and cost-effective in contrast with other therapeutic options [5]. RAI-131 has a physical half-life of 8.02 days [1,6,7]. It decays to the stable isotope Xe-131 after emission of beta particles and gamma radiations [1,2]. The principal gamma rays have an energy of 364 keV and the principal beta particles have a maximum energy of 0.61 MeV with a mean energy of 0.192 MeV [6]. Therefore, the gamma-rays having energy 364 keV (81.7%) are useful for scintigraphy imaging, but for therapeutic purpose the beta particles are important due to their local deposition in the soft tissues with an average range of 4 mm in the soft tissues [1,7,8]. The accurate measurement of RAI-131 is very important [9], as it affects the treatment and quality of scan. Therefore, uncertainty due to any reason in RAI-131 activities during administration to thyroid patients should be estimated and minimized. Analogous studies have been performed by many authors regarding residual activities of Tc-99m/Tc-99m labeled radiopharmaceuticals and other radionuclides in syringes/vials [10-15]. However, in the present study, uncertainty in RAI-131 measured activities, residual activities, and net uncertainties are estimated after oral administration to the patients and such study has not been performed yet to best of my knowledge. Although radiation workers have reported that some RAI-131 activities remain in the syringes [10]. It is worthy to mention that some uncertainties during measurement of RAI-131 activities have also been observed. These originate errors in

RAI-131 activities during administration to the patients, which may result in degradation of the quality of images, greater radioactive waste and high financial burden. The purpose of this study is to estimate the net percent errors in RAI-131 activities during administration to thyroid patients and give some fruitful suggestions to reduce such errors.

Methods and Materials

This retrospective study was performed from January 2019 to June 2022 for a total number of 180 random patients, divided into six groups (from A-F) on the basis of administered activities. The administered activities were 3 mCi, 15 mCi, 20 mCi, 25 mCi, 30 mCi, and 150 mCi and named as group-A, group-B, group-C, group-D, group-E, and group-F, respectively. All activities were measured with Capintech inc., CRC-25R dose calibrator. The percent errors (E_1) in measured activities were estimated for all thyroid patients by Equation (1) [16]. The percent residual activities (E_2) in empty syringes after administration of RAI-131 to the patients were also measured with the same dose calibrator by using Equation (2). Finally, the net percent error (E_{Net}) in prescribed activity of RAI-131 to the patients was measured using Equation (3).

$$E_1 = \frac{\text{AV-MV}}{\text{A.V}} \times 100\% \quad (1)$$

In the above Equation (1), AV is the actual value of RAI-131 activity (prescribed activity) and MV is the measured value of RAI-131 activity (measured by a technician using Capintech CRC-25R dose calibrator).

$$E_2 = \frac{\text{Empty syringe reading}}{\text{Full syringe reading}} \times 100\% \quad (2)$$

In Equation (2), E_2 is the percent residual activities in empty syringes after administration of RAI-131 to the patients.

$$E_{Net} = E_1 + E_2 \quad (3)$$

In Equation (3), E_{Net} is the net percent errors in RAI-131 activities administered to all thyroid patients. Mean measured activities, mean percent errors in measured values, mean remaining activities in syringes, percent remaining activities, and mean net percent errors in RAI-131 activities for all patients were calculated and statistically analyzed by using Microsoft Excel 2010.

Results and Discussion

The percent errors in measured values (E_1), percent residual activities (E_2), and net percent errors (E_{Net}) in RAI-131 for all patients are shown in the following Table 1.

From the above table, it is clear that the mean measured activities were 3.05 (2.67, 4.12) mCi, 15.1 (14.1, 16) mCi, 20.08 (19, 21) mCi, 25.19 (24, 26.1) mCi, 29.9 (28.9, 31) mCi, and 150.08 (148, 152) mCi for prescribed activities of 3 mCi, 15 mCi, 20 mCi, 25 mCi, 30 mCi, and 150 mCi, respectively. The mean percent errors with ranges in the measurements along with standard deviations were [-1.63 (-37.33, 11) ± 9.58] %, [-0.69 (-6.69, 6) ± 2.73] %, [-0.41 (-5, 5) ± 2.46] %, [-0.76 (-4.4, 4) ± 2.11] %, [0.33 (-3.33, 3.67) ± 1.83 ± 0.77] %, and [-0.054 (-1.33, 1.33)] %, respectively. The corresponding mean values of percent residual activities with ranges along with SDs in the empty syringe after the administration to the patients were [8.36 (1.52, 14.29) ± 3.22] %, [4.6 (1.6, 8.5) ± 2.22] %, [4.05 (1.21, 7.29) ± 1.50] %, [4.31 (1.39, 7.17) ± 1.69] %, [2.6 (0.77, 4.67) ± 1.08] %, and [0.93 (0.16, 2.12) ± 0.52] %. The corresponding net percent errors with ranges and SDs in recommended activities were [6.73 (-32.7, 20.95) ± 11.15] %, [3.91 (-3.85, 8.77) ± 2.94] %, [3.63 (-2.39, 7.79) ± 2.51] %, [3.55 (-0.65, 10.67) ± 2.6] %, [2.93 (-1.98, 6.78) ± 1.89] %, and [0.88 (-1.04, 2.68) ± 0.87] %, respectively, as shown in the Figure 1.

All the results revealed that the net percent errors in RAI-131 activities are not alarming in our setup as according to European pharmaceutical guidelines the acceptable limit for radioactivity measurement is ±10%

Table 1. *Recommended actual activities, mean measured activities, mean percent errors in measured values, mean remaining activities in syringes, percent remaining activities, and mean net percent errors in RAI-131 activities for all patients.*

Group #	Actual activity (mCi)	Mean measured activity (mCi)	Mean %error in measurement (E_1)	Mean remaining activity in syringe (mCi)	Percent remaining activity (E_2)	Mean net % error (E_{Net})
Group-A	03	3.05 (2.67, 4.12)	-1.63 (-37.33, 11)	0.25 (0.05, 0.4)	8.36 (1.52,14.29)	6.73 (-32.7, 20.95)
Group-B	15	15.1 (14.1, 16)	-0.69 (-6.69, 6)	0.7 (0.24, 1.3)	4.60 (1.6, 8.5)	3.91 (-3.85, 8.77)
Group-C	20	20.08 (19, 21)	-0.42 (-5, 5)	0.81 (0.236, 1.45)	4.05 (1.21, 7.29)	3.63 (-2.39, 7.79)
Group-C	25	25.19 (24, 26.1)	-0.76 (-4.4, 4)	1.09 (0.34, 1.8)	4.31 (1.39, 7.17)	3.55 (-0.65, 10.67)
Group-E	30	29.9 (28.9, 31)	0.33 (-3.33, 3.67)	0.78 (0.23, 1.4)	2.60 (0.77, 4.67)	2.93 (-1.98, 6.78)
Group-F	150	150.08 (148, 152)	-0.05 (-1.33,1.33)	1.4 (0.245, 3.2)	0.93 (0.16, 2.12)	0.88 (-1.04, 2.68)

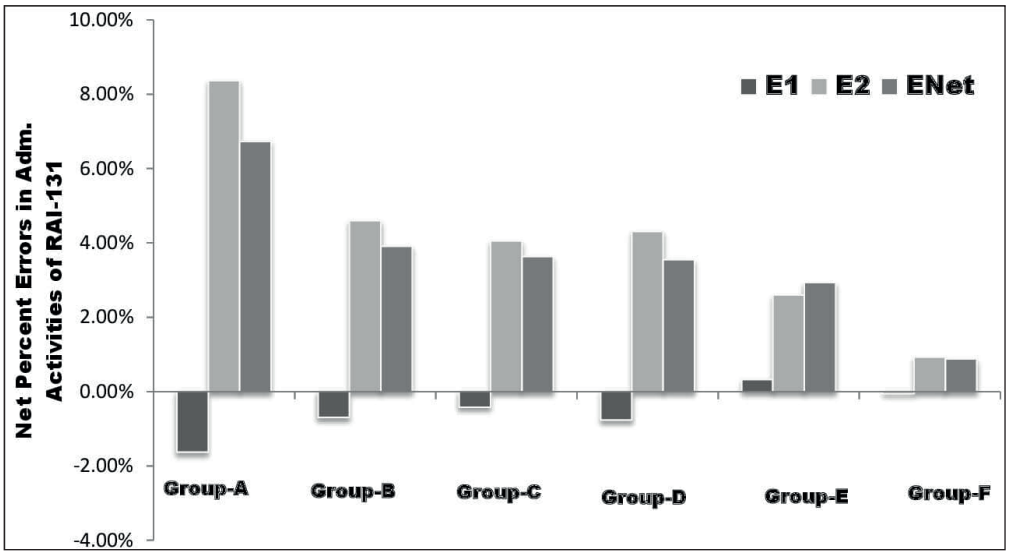

Figure 1. *Graph for net percent errors in administered activities of RAI-131 for all groups of patients.*

for diagnostic procedures [17] and ±5% for therapeutic procedures as per AAPM report no. 181 [18,19]. However, some capacity for improvement is present in every clinical hospital for dose optimization [20]. Therefore, this type of study is important for improving radiation safety programs. It is very clear from Table 1 and Figure 1, that the net percent error in administered activities of RAI-131 decreases as the values of prescribed activities increase and vice versa. This percent decrease depends upon the volume of the activities, types of syringes, and human error or lack of experience of technicians in taking measurements. In this study, same type of syringes were used for measurements of RAI-131 activities. It is also worth mentioning that a smaller fraction of residual activities in the syringes were obtained for greater activities and vice versa. The reason is that almost same amount of activity remains in syringes' needles for all RAI-131 activities. The percent errors in the measurements are due to human error, negligence, and inexperience of the technicians, which need to be minimized by proper training [20] and vigilant supervision. The net percent errors in administered activities should be minimized by proper exercise, training, steady supervision, and carefulness of technician to ensure optimum dose delivery to patients, best quality of images, less radioactive wastes, and less financial burden.

Conclusion

This study concludes that patients receive on average 6.73%, 3.91%, 3.63 %, 3.55 %, 2.93 %, and 0.88 % less than the prescribed activities of 3 mCi, 15 mCi, 20 mCi, 25 mCi, 30 mCi, and 150 mCi, respectively. This percent decrease in RAI-131 activity is not alarming in our setup but still needs to be adjusted for the sake of improvement to ensure the best quality images and optimum dose delivery in RAI-131 therapy through proper training and vigilance supervision. This study also favors that a soft gel capsule of RAI-131 should be provided instead of its liquid form because some risk factors such as vaporization, greater wastes, and spillage are associated with the liquid form of RAI-131.

List of Abbreviations

AV	Actual value
E	Error
MV	Measured value
RAI-131	Radioiodine-131

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate

Not applicable.

Ethical approval

Not applicable.

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