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Gamma camera based method for ^{131}I capsule counting: an alternate method to Uptake probe method.

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The main objective of this study was to check the validity of using gamma camera as an alternate method to thyroid uptake probe, for counting 25uCi (0.925 MBq) and 50uCi (1.85 MBq) ^{131}I capsules before administration to thyroid patients. Methods: - 10 sets each of 25uCi (0.925 MBq) and 50uCi (1.85 MBq) ^{131}I capsules received from Board Of Radiation and Isotope Technology, Department Of Atomic Energy, India (BRIT, DAE) have been counted individually using thyroid uptake probe for 10 seconds following institutional protocol and also by keeping individual capsule of a set with 8cm gap between each of them .These capsules were also scanned by Scintillation gamma camera for 100 seconds. Capsules having counts within the range of mean ±2 Standard Deviation (SD) were accepted for patient administration. After analysing both the data, correlation coefficient between these two methods has been evaluated. Results: Scanned images were analysed by drawing Identical ROI around each set of 25uCi (0.925 MBq) and 50uCi (1.85 MBq) ^{131}I capsules. Capsules with counts within 2 Standard Deviation from mean were accepted for patient administration. Good correlation coefficient (r >0.95) was observed between these two counts set. Conclusion: Gamma camera based ^{131}I -capsule counting method is an easy and time saving method compared to probe based capsule counting method as we can scan a set of capsules in a single acquisition.

It can provide uniformity information for a batch of ^{131}I -capsules and avoid the time consuming method of individual capsule counting with the thyroid uptake probe.

Key Words: Gamma camera based capsule counting, Thyroid uptake probe, ^{131}I capsule

Use of ^{131}I in nuclear medicine is well known for diagnosis and treatment of thyroid related disorders. The measurement of thyroid uptake of radioiodine was one of the earliest clinically useful procedures in diagnostic nuclear medicine. In spite of its success, several sources of inaccuracy and inconsistency have been recognized over the years (1). Construction of the thyroid neck phantom to simulate the absorption and scatter characteristics of a human neck was one of the first steps towards adequate standardization of the thyroid uptake test. Differences in neck-phantom characteristics and High Voltage (HV) fluctuation obviously may introduce significant errors into any thyroid uptake measurement, but even today the test is carried out in most laboratories with very little attention to these factors (2).

Although $^{99m}TcO4^{-}$ can also be used for thyroid imaging, it is not organified by thyroid gland. High background activity and less neck uptake make ^{131}I as a better agent mainly for pre ^{131}I therapy evaluation (3). Although ^{123}I is a better diagnostic scan agent, ^{131}I continues to be used in several developing countries, where ^{131}I is not easily available .It is a normal practice to give doses in the range of few uCi of ^{131}I for assessment of benign thyroid disorders, assessment of remnant thyroid tissue to decide therapy dose for ablation of remnant thyroid tissue and few mCi of ^{131}I for evaluation of metastasis by performing whole body scan (4). Quantitative evaluation of ^{131}I thyroid uptake is very important to distinguish different functional status of the thyroid as qualitative information which is obtained by gamma camera alone may not be adequate in many clinical conditions (4). It is a normal practice in our centre to administer 25 uCi (0.925 MBq) ^{131}I doses for thyroid patients referred for evaluation of hyperthyroidism, hypothyroidism, Multi-nodular Goitre etc. Comparatively higher dose i.e. 100 uCi (3.7MBq) of ^{131}I is administered for thyroid cancer patients referred for evaluating post thyroidectomy remnant thyroid tissue status and 3-5 mCi (111-185 MBq) doses of ^{131}I for post ^{131}I treatment to patients coming for follow-up whole body scan and neck uptake. Neck uptake of ^{131}I is computed using thyroid uptake probe having NaI (Tl) crystal fitted with a flat field collimator and associated electronics (1). Alternate method of gamma camera based uptake calculation is also a good option (5). 20 capsules each of 25 uCi (0.925 MBq) ^{131}I and 40 capsules each of 50 uCi (1.85 MBq) ^{131}I are procured from BRIT, DAE India weekly. In our institute, it is normal practice to count all 25 uCi (0.925 MBq) ^{131}I and 50 uCi (1.85 MBq) ^{131}I capsules individually using thyroid uptake probe and 3-5 mCi (111-185 MBq) ^{131}I doses using dose calibrator before administration to the patients. Using thyroid uptake probe, counting individual capsule is a time consuming job. The aim of this study was to image sets of capsule for easy and quick counting.

MATERIALS AND METHODS

Thyroid uptake Probe based capsule counting method: -

Thyroid uptake probe (Nuclear Chicago) fitted with a flat field collimator; associated electronics and single channel analyser was used for individual capsule counting and for thyroid uptake determination in referred patients. Energy calibration of Thyroid uptake probe was performed using ^{131}I source daily before routine use and monthly testing of absolute sensitivity of the probe using ^{137}Cs.(6). Baseline energy was kept at 310 keV with 100 keV window. Each capsule containing ^{131}I is kept in serially numbered test tubes. Each capsule was counted for 10 seconds after keeping each capsule individually in Lucite phantom (Thyroid phantom) (5) at a working distance of 30 cm (iso-response region) from the face of the detector of thyroid uptake probe. Background counts were obtained for 10 seconds. Background counts were subtracted from capsule count and mean and Standard Deviation was calculated for 25 uCi (0.925 MBq) ^{131}I capsules and 50 uCi (1.85 MBq) ^{131}I capsule sets separately. Capsules with counts within a range of mean± 2 Standard Deviation from mean have been considered as identical and used for administration to patient. One of these capsules randomly was used as a standard source for the entire week, which is used for patient's neck uptake calculation (Fig 1).

Before radioactive iodine administration to the patient, it is confirmed that patient is following iodine restriction and not taking any interfering drugs. In female patients, lactation and pregnancy were contraindications. After the dose administration of 25 uCi (0.925 MBq) or 2x50uCi (1.85 MBq) =100 uCi (3.7MBq) of ^{131}I) to the patient's, neck counts were taken at 2 hrs and at 24hrs respectively (5). Patient was positioned supine with neck extended and probe was placed at a distance of 30 centimetre (iso-response region).Two sets of neck counts were obtained for 100 seconds each. Neck background counts were obtained by placing neck lead shield over the patient's neck. Ratio of Background corrected neck count to standard capsule count was calculated to get the percentage (%) neck uptake (7) which may be represented as % uptake = [(neck count - patient background count)/ (standard phantom count -phantom background count)] ×100

Gamma Camera based method for capsule counting: -

SIEMEN"S (Symbia) gamma camera with 5/8" thick NaI (Tl) crystal, mounted with High Energy collimator was used for imaging. These ^{131}I capsules which were counted using thyroid uptake probe were again scanned by arranging them on thermocol support having grooves to place tubes with capsule and were kept directly on gamma camera head .Data was acquired for the set of capsule using 256x256 matrix. The data was acquired for different acquisition time 100,200 and 300 seconds respectively. The optimum distance required between two nearby capsules was measured by calculating percentage scatter contribution at different distance from the centered 25 uCi (0.925 MBq) capsule placed in thermocol support. Percentage scatter contribution was calculated by drawing region of interest around the centered 25 uCi (0.925 MBq) scanned capsule at 2cm, 4cm, and 6cm and 8cm distances to obtain scatter counts and calculating its ratio with capsule counts after background subtraction (Table 1). The same procedure was repeated for 50 uCi (1.85 MBq) capsules also (Table 2). It has been observed that 8 cm distance from the centered capsule, the percentage scatter counts in it is less than1% and this distance has been selected as optimum distance required between individual capsules to be placed in test tubes along both the axes (Figure 2)

The same has been further confirmed by adding capsule one by one around the central capsule 8cm along x and y axis direction (Figure 3) .Region of interest was drawn around the central capsule to get counts addition after adding capsule one by one, 8 cm away in all 4 directions as shown in Table 2. It has been observed that the presence of capsules 8 cm away from the central capsule does not make significant scatter contribution (<1%) to the centre capsule and vice versa. Accordingly grooves were made in thermocol sheet. Institutional approval to conduct this experiment was taken and no patients or animals were involved in these experiments.

Sealed gelatine capsules of 25 uCi (0.925 MBq) ^{131}I (15 Number) and 50 uCi (1.85 MBq) ^{131}I (20 Number) were arranged on thermocol sheets support with 8 cm gap between individual capsules. For both sets of capsules Images were acquired using gamma camera equipped with high energy collimator. Data was acquired for 100 seconds, 200 seconds and 300 seconds .Image acquisition matrix used was 256 X 256, zoom 1 and energy window peaked at 364 keV with 15% window, (Figure 4 & 5). Identical circular region of interest was drawn around each capsule from the single scanned image. Counts from each region of interest were noted and mean counts and Standard Deviation (SD) were obtained. The acceptance criterion used here was that those capsules having counts falling within two standard deviations from mean were considered as within acceptable limit and were used for dose administration to patient and also as a standard for uptake calculation (Table 3 & Figure 4). For comparative purpose of counting statistics, gamma camera images were acquired for 100 seconds, 200 seconds and 300 seconds respectively. From the result, it was also observed that 100 seconds counts obtained for 25 uCi (0.925 MBq) ^{131}I and 50 uCi (1.85 MBq) ^{131}I by gamma camera based method is well comparable with 10 seconds thyroid uptake probe based counting of individual capsules. Increasing the scan time to 200 seconds and 300 seconds by gamma camera based method did not improve the result which made 100 seconds scan time optimum for data acquisition. Same procedure was repeated for 50 uCi (1.85 MBq) ^{131}I Capsule as shown in Table (4).

All 20 capsules of 50 uCi (1.85 MBq) ^{131}I were accepted as per criteria of 2 Standard Deviation range from mean by both these methods.

RESULTS

Data obtained from 10 sets of 25 uCi (0.925 MBq) ^{131}I and 10 sets of 50 uCi (1.85 MBq) ^{131}I capsules counting of probe based method were correlated with Gamma camera based method. Good correlation (correlation coefficient > 0.95) was observed in all the set of data by both these methods. Counts obtained at 100 seconds scanned image using Gamma camera method was found to be well correlated to 10 seconds counts of thyroid uptake probe uptake, which may vary for different instruments.

DISCUSSION

Capsule counted by both probe based and Gamma camera based methods shows that all 15 capsules of ^{131}I 25 uCi (0.925 MBq) in 10 sets are comparable. Similarly all 10 sets of 20 capsules of 50 uCi (1.85 MBq) ^{131}I capsules shown good correlation when counted by both gamma cameras based and probe based method. Since capsules are counted individually in probe based method, each capsule should be kept under identical condition. This issue is automatically addressed in gamma camera based method since large numbers of capsules are scanned in single acquisition. Patient throughput can be increased by using gamma camera based counting as less time(100 seconds per set of capsules) is spent in counting, rather than counting capsule individually using thyroid probe(10 seconds per capsule). Since camera based thyroid uptake is an alternative option to thyroid uptake probe method, capsule counting by gamma camera will be a better option when standards capsules are counted using gamma camera.

CONCLUSION

Gamma Camera based ^{131}I capsule counting method is an easy and time saving method compared to Thyroid uptake probe based capsule counting. It can provide uniform information for a batch of ^{131}I capsules and avoid the time consuming method of counting individual capsule with the thyroid uptake probe.

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Figure 1. Thyroid uptake probe (^{131}I capsule in Lucite phantom)

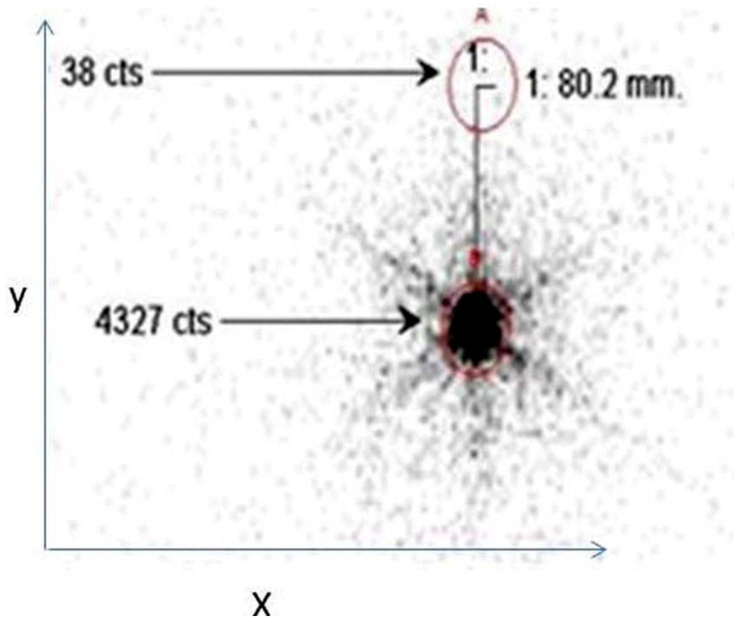

Figure 2. Scatter counts at 8 cm away from 25 uCi (0.925 MBq) ^{131}I Capsule

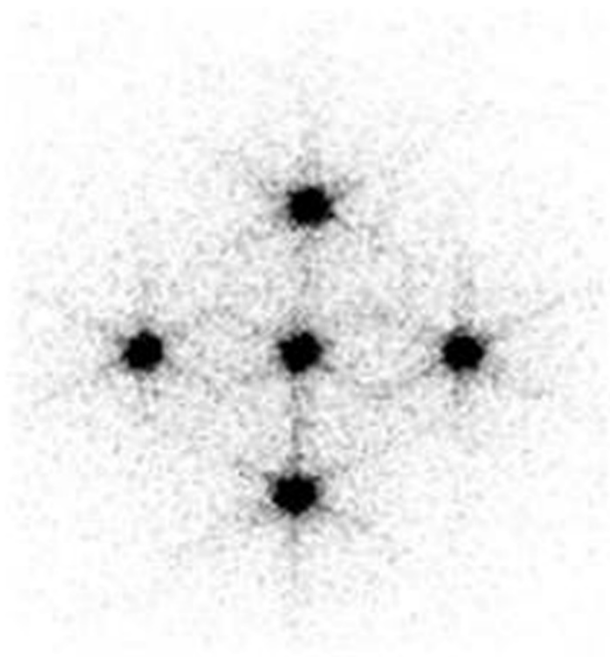

Figure 3. Capsules arranged around center capsule.

Figure 4. Capsule arrangement in gamma Camera Based ^{131}I capsule counting.

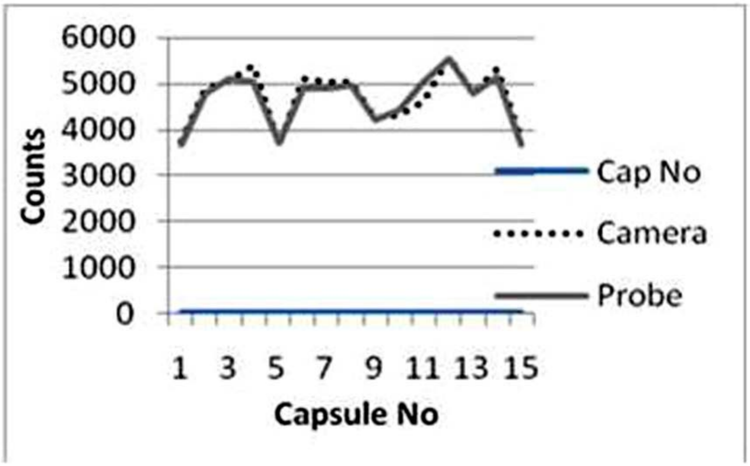

Figure 5. Counts Vs Capsule Number, by gamma camera and probe based methods

Region of Interest	25uCi(0.925 MBq) (Y direction) Counts(% scatter)	(25uCi(0.925MBq) (Y direction) Counts(% scatter)	50uCi(1.85 MBq) (Y direction) Counts(% scatter)	50uCi(1.85 MBq) (Y direction) Counts(% scatter)
Center	4327(100%)	4327(100%)	6666(100%)	6666(100%)
2cm	60(1.38%)	116(2.6%)	595(8.9%)	588(7.1%)
4cm	46(1%)	53(1.22%)	294(4.4%)	129(1.9%)
6cm	40(1%)	42(1%)	113(1.6%)	64(0.9%)
8cm	38(1%)	19(0.4%)	32(0.4%)	10(0.1%)

Table 1.Scatter counts and percentage (%) scatter contribution from centered 25uCi (0.925 MBq) capsule at different distances.

	25uCi (0.925 MBq) Capsule		50uCi(1.85MBq) Capsule	
Capsule No #	**Counts/100 seconds**	Count Ratio @	**Counts/100 seconds**	Count ratio @
Center	3139		6385	
1	3111	0.9	6344	0.65
2	3125	0.86	6399	0.86
3	3147	0.70	6446	0.73
4	3132	0.48	6423	0.36

Number of capsule added around the central capsule
@ Central to neighbour capsules counts ratio.

Table 2.Percentage (%) scatter count around the central capsule with different capsule around

	Camera Based(Counts)			Probe Based (Counts)
Capsule No	**100 seconds**	**200 seconds**	**300 seconds**	**10 seconds**
1	4639	9297	13775	5377
2	4215	8271	12375	4665
3	4296	8627	12750	4832
4	4302	8729	13334	4826
5	4911	9895	14669	5258
6	4849	9519	14156	5419
7	4391	8557	12935	5010
8	4850	9741	14543	5353
9	4645	9447	14458	5443
10	3913	7764	11641	4493
11	3794	7644	11313	4215
12	5149	10216	14945	5555
13	4481	9215	13566	4982
14	4125	8209	12468	4655
15	5281	10338	15836	5655
Mean	4523	9031	13518	5049
S D #	434	851	1279	428

#Standard deviation

Table 3:- 25 uCi (0.925 MBq) ^{131}I Capsules counted by gamma camera based method for different time of acquisition and thyroid probe based method.

	Camera Based (Counts)			Probe Based (Counts)
Capsule No	100 Seconds	200 Seconds	300 Seconds	10 Seconds
1	9096	18090	26761	9790
2	8695	17704	26344	9462
3	8567	17341	27009	9562
4	8729	17141	26200	9277
5	8150	16392	24814	9109
6	9377	18658	28271	9946
7	9232	18450	28375	9904
8	8282	16528	25320	9057
9	8141	16566	25100	9068
10	8046	16328	24164	8999
11	8588	17317	26201	9288
12	9160	19213	27620	9934
13	8230	16249	23709	8975
14	9724	19096	28742	10292
15	8580	17431	25836	9273
16	9291	18160	27271	9579
17	8629	17346	26598	9395
18	8590	17359	25901	9329
19	7949	15789	23666	8978
20	9238	17781	26848	9847
Mean	8694.63	17413.11	26209.95	9453.11
SD #	511.24	979.93	1505.46	408.17

Standard Deviation

Table 4:- 50 uCi (1.85MBq) ^{131}I Capsules counted by gamma camera based method for different time of acquisition