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ORIGINAL PAPER

An Experimental Comparison of Two Different Technetium Source Activities Which Can Imitate Thyroid Scintigraphy in Case of Thyroid Toxic Nodule

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ABSTRACT
Purpose: In cases of thyroid toxic autonomous nodule, anterior projection of Tc-99m pertechnetate image shows a hot nodule that occupies most, or the entire thyroid lobe with near-total or total suppression of the contra lateral lobe. In this case is very difficult to distinguish toxic nodule from lobe agenesis. Our interest was to estimate and determinate the rate of radioactivity when the source with high activity can make total suppression of the second source with low activity in same conditions with thyroid scintigraphy procedures. **Material and methodology:** Thyroid scintigraphy was performed with Technetium 99 meta stable pertechnetate. A parallel high resolution low energy collimator was used as an energy setting of 140 KeV photo peak for T-99m. Images are acquired at 200 Kilo Counts in the anterior projection with the collimator positioned as close as the patient's extended neck (approximately in distance of 18 cm). The scintigraphy of thyroid gland was performed 15 minutes after intravenous administration of 1.5 mCi Tc-99m pertechnetate. Technetium 99 meta stable radioactive sources with different activity were used for two scintigraphies studies, performed in same thyroid scintigraphy acquisition procedures. In the first study, were compared the standard source with high activity A=11.2 mCi with sources with variable activities B=1.33 mCi; 1.03 mCi; 0.7 mCi; 0.36 mCi; and 0.16mCi) in distance of 1.5cm from each other sources, which is approximately same with distance between two thyroid lobes. In the second study were compared the sources with low activity in proportion 70:1(source A = 1.5 mCi and source B=0.021mCi). As clinical studies we preferred two different patents with different thyroid disorders. There were one patient with thyroid toxic nodule in the right lobe, therefore the second patient was with left thyroid nodule agenesis. **Results:** During our examination, we accurately determined that two radioactive sources in proportion 70:1 will be displayed as only one source with complete suppression of other source with low radioactivity. Also we found that covering of toxic nodules with lead cover (plaque), can allow visualization of activity in suppressed lobe. **Conclusion:** Our study concluded that total lobe suppression, in cases of patients with thyroid toxic nodule, will happened for sure, if toxic nodule had accumulated seventy times more radioactivity than normal lobe. Also we concluded that covering of the toxic nodule with lead plaque, may permit the presentation of radioactivity in suppressed nodule.
Key words: toxic nodule, lob agenesis, radioactivity, lead covering..

1. INTRODUCTION

According to the many reported data, spatial resolution of gamma camera was defined as ability of detector to determine two separate point sources of gamma photons, located at minimum of 18 mm apart at 5 cm away from the camera face. The ability of the detector to accurately determine energy of incoming radiation is known as Energy resolution (6, 7, 8, 9, 10, and 11). Full width of half maximum, which should typically be less than 10%, is one indicator who directly determines the spatial resolution. The lower the number of FWHM means the better the energy resolution and high the number of FWHM, means lower energy resolution (10). Based in the presented data and present knowledge, where was showed that, the non proportionality of the light yield of scintillators appears to be the fundamental limitation of energy resolution, Moszyriski M, Nassalski A and coauthors in their several observations a common conclusion was the fact that the highest energy resolution and particularly the intrinsic resolution measured with scintillators , characterized by two components of the light pulse decay was obtainable when the spectrometry equipment integrates the whole light of both components (4).

Thyroid nodules are common clinical findings, with an estimated prevalence on the basis of palpation that ranges from 3% to 7% (12, 13). Vander Jb and Gharib H in two reported studies suggested that 300 000 thyroid nodules were detected every year in USA (14, 15).

Activity	Source Activity in mCi		Distance in cm	Registered activity	Time
Sources	A(mCi)	B(mCi)	18	Kcount	Sec.
Activity	1.33	11.2	18		
Both opened	very small activity	high activity	18	180	5
B covered	small activity	Covered	18	198	60

Table 1. *The scintigraphy of two radioactive sources in ratio 8.4:1*

Activity	Source		Distance (cm)	Registered activ.	Time
Sources	A(mCi)	B(mCi)	18	K Count	Sec.
Activity	0.7	11.2	18		
Both opened	very small activity	high activity	18	148	5
B covered	small activity	Covered	18	198	110

Table 3. *The scintigraphy of two radioactive sources in proportion 16:1*

Activity	Source		Distance (cm)	Registered act.	Time
Sources	A(mCi)	B(mCi)	18	Kcount	sec
Activity	1.03	11.2	18		
Both opened	very small activity	high activity	18	162	5
B covered	small activity	Covered	18	198	75

Table 2. *The scintigraphy of two radioactive sources in proportion 10.87:1*

Activity	Source		Distance (cm)	Registered acti.	Time
Sources	A(mCi)	B(mCi)	18	K Count	Sec.
Activity	0.36	11.2	18		
Both opened	very small activity	high activity	18	148	6
B covered	small activity	Covered	18	194	210

Table 4. *The scintigraphy of two radioactive sources in proportion 31.11:1*

Based in the affinity of radionuclide uptake, nodules may be classified as hyper functioning, hypo functioning or indeterminate. Hyper functioning nodules almost never represent clinically significant malignant lesion, whereas hypo functional or indeterminate nodules have a reported malignancy risk of 3-15%. However differentiation of thyroid hyper functional nodules is important to exclude lobe agenesis. In this case usually were indicated TSH stimulated test, where positive response TSH test always exclude agenesis of contra lateral lobe. The early recognition of autonomous nodules, before they induce the suppression of TSH, enables early treatment to avoid thyroid growth and progression towards manifests hyperthyroidism (15).

2. MATERIAL AND METHODOLOGY

As clinical study, we preferred two different cases of thyroid disorders. There were one patient with thyroid toxic nodule on the right lobe and another patient with left thyroid nodule agenesis.

In our study were included, a 34 year old female patient with thyroid hyper functional autonomous adenoma and a 26 year old female patient with left thyroid lobe agenesis. The different sources of technetium activities were used as experimental material in our study. Technetium 99 meta stabile radioactive sources with different activity were used for two scintigraphy studies performed in same thyroid scintigraphy acquisition procedures. In the first study we have compared a standard source with a high activity (A=11.2 mCi) with sources with variable activities (B=1.33 mCi; 1.03 mCi; 0.7 mCi; 0.36 mCi; and 0.16mCi), always in one distance of 1.5 cm between each others, which was approximately the same like distance between the lobbies of the thyroid gland. In the second study we have compared two sources with low activity in proportion 70:1(source A = 1.5 mCi and source B=0.021mCi). The measurements of radioactivity were done in dose calibrator whereas scintigraphy was performed with Siemens dual head gamma camera (2008).

Thyroid scintigraphy of thyroid gland was performed with Technetium 99 meta stable pertechnetate. A parallel high resolution low energy collimator was used as an energy setting of 140 KeV photo peak for T-99m. Images are acquired at 200 Kilo Counts in the anterior projection with the collimator positioned as close as the patient's extended neck (approximately in distance of 18 cm). The scintigraphy of thyroid gland was performed 15 minutes after intravenous administration of 1.5 mCi Tc-99m pertechnetate. The hyper functional node was covered with seating consisting of lead with wall thicken 4-5 mm, whereas radioactive sources of technetium have placed in lead boxes with wall thickness of 4-5 mm and covered with a lid of lead with thickness like the walls of boxes.

3. RESULTS

The results of the first scintigraphy made for two different activities are presented in table 1. When beneath detector were placed two sources with different activities in proportion to 8.4:1, the required time for completion of the study was 5 seconds, meantime in display were shown as two separated activities. In repeated study when the source B with high activity was covered by cover of lead, the required time for completion of the study was 60 seconds, whereas in display was shown only source A with low activity (Table 1, Figure 1).

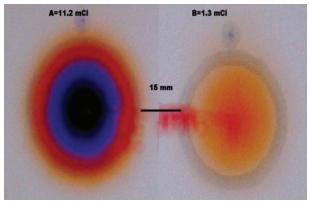

Figure 1. *Scintigraphy in rate 8.4:1*

In the second study, we have compared two radioactive sources in proportion 10.87:1. The required time for the study in conditions when we have

Activity MBq	Source		Distance cm	Regis-tered act	Time Sec.
sources	A(mCi)	B(mCi)	18	K count	Sec.
Activity	0.16	11.2	18		
Both opened	non visual	high activity	18	185	7
Bcovered	small activity	Covered	18	139	275

Table 5. *The scintigraphy of two radioactive sources in rate 70:1*

Activity	Source		Distance in cm	Registered acti.	Time
sources	A(mCi)	B(mCi)	18	K count	Sec.
Activity	0.021	1.5	18		
Both opened	non visual activity	high activity	18	197	37
B covered	small activity	Covered	18	34	300

Table 6. *No. of Kilo Counts registered in our study sources*

compared two sources in proportion 10.8:1 was 5 seconds, whereas during this time were recorded 162 Kilo Counts. In screen two sources are displayed as two separate activities, understood that the source of highest activity is presented as the dominant source in comparison with the lowest activity. In conditions when source of highest activity was covered with cover of lead, the required time of study was 60 seconds, whereas in screen is presented only opened activity and during the time of 60 seconds are recorded 198 Kilo Counts (Table 2).

The two next studies presented in table 3 and 4 showed the data obtained when two radioactivity sources were compared in proportion 16:1 and 31:1. The required time for the study, in conditions when the two radioactive sources were opened, was 5 seconds, whereas in cases when the sources with highest activity were covered the needed time was 110 seconds at first case, respectively 210 seconds at second case. In both studies the two sources were presented as separated sources on the screen (Table 3 and table 4)

In the fifth study, when radioactive sources were in proportion 70:1, despite the facts that two radioactive sources were uncovered, on the display was presented only source with the highest activity, while the source with lowest activity was entirely suppressed (table 5, Figure 2).

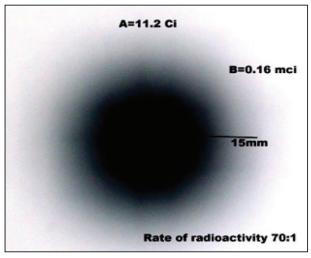

Figure 2. *Scintigraphy in rate 70:1-Suppression of source B*

To simulate the thyroid gland, in next study presented in table 6, were compared the two radioactive sources with lower activity but in same proportion 70:1. Usually for scintigraphy of thyroid gland in adults, in our institution we used ^{99m}Tc pertechnetate in activity of 1.5 mCi, the same activity which we have used for our study. Even in this case, the source of highest activity has completely suppressed the source with lesser activity. After we cover the source with the highest activity with covering of lead, on the display was appeared the source with the smallest activity. In this case the required time of study was 5 minutes, usually the time needed for scintigraphy of thyroid gland. (Table 6)

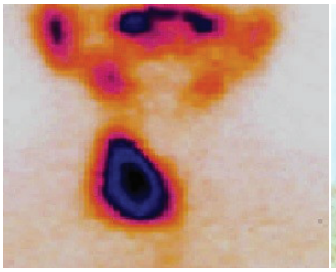

Figure 3. *Toxic hot right nodule*

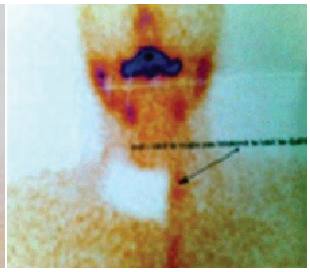

Figure 4. *Coverage hot nodule*

The scintigraphy of thyroid gland at first case showed a huge solitary toxic nodule in the right thyroid lobe at the lady patient 34 year old, while uptake in the normal left lobe was suppressed. In differential diagnosis were considered toxic adenoma or absence of the left lobule. As replacement test for the TSH test we have cover the right thyroid lobe with cover of lead and then on the display was registered accumulation on the left thyroid suppressed lobe (figure 3, 4)

4. DISCUSSION

Based on the recent data there are lot of factors who affect the energy resolution. Moszyriski M., Nassalski, A. and their coauthors in their study concluded that the non proportionality of the light yield of scintillators, appear to be the fundamental limitation of energy resolution (4, 6).

A common conclusion of 10 years observations is the fact that the highest energy resolution and particularly the intrinsic resolution measured with scinitllator, characterized by two components of the light pulse decay, and is obtainable when the spectrometry equipment integrates the whole light of both components (4, 5). Although were reported lot of the studies about energy resolution of gamma camera, we didn't found any information about suppression effect when were compared two different amounts of radioactivity under scintillator of gamma camera.

During our measurements and investigations we found that effect of suppression will happened when ratio of two sources of radioactivity is 70:1. In case of thyroid gland, when thyroid nodule is toxic and hyper functional, the nodule will uptake more radioactivity. In some cases the toxic nodule can make complete suppression of contra lateral lobe of thyroid gland. In this case, for physician is necessary to make differential diagnosis between toxic nodule and agenesis of thyroid lobule. Usually as confirmation test for toxic nodule we use stimulation test with thyroid stimulation hormone. After intra muscular administration of TSH in cases of toxic nodule as well as toxic nodule will be presented contra lateral sup-

pressed lobe while in case of lobe agenesis, even after stimulation with TSH, the missing lobe will not presented. Based on these data and information, we have attempted to demonstrate experimentally if it's possible to confirm exactly in which ratio the source with highest activity will suppress completely the source with lowest activity. According our results, the suppression of sources with lowest activity has happened when ratio of activity between two sources was 70:1. When the source with highest activity was covered with cover of lead, then the accumulation of radioactivity (in our case ^{99m}Technetium pertechnetate) in small amounts was presented in suppressed lobe.

5. CONCLUSION

During our experimental study we have exactly confirmed that crystal made from NaJ (Tl+) placed on detector of our gamma camera, is not able to detect two sources of radioactivity as separate activities, in the case when the ratio of radioactivity between two sources was 70:1. When two radioactive sources in distance 15 mm between them are in ratio 70:1, then radioactive source with the lowest activity will be completely suppressed and will be presented only radioactive source with the highest activity as one single source. If the source with highest activity will be covered with cover of lead plaque then will be presented the source with the lowest activity. This technique of coverage is possible to enable the presentation of suppressed lobe in case of thyroid toxic nodule.

CONFLICT OF INTEREST: NONE DECLARED

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