Original Article

The Role Of Tc99m Mibi Spect/Ct In Detection And Localization Of Ectopic Parathyroid Adenoma

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Abstract

Introduction: The main regulator of calcium homeostasis in human's body is parathyroid hormone. Hypercalcemia is a symptom of primary hyperparathyroidism (PHPT) and is caused by an inappropriate overproduction of parathyroid hormone by one or more parathyroid glands. **Aim:** Accurate pre-operative localization of ectopic parathyroid adenoma via TC99m MIBI and comparison to dual phase planar images. **Patients and methods:** This prospective study was performed at NEMROCK center, Cairo University. It wa:s done on one hundred and five patients. The common eligibility criteria were a preoperative diagnosis of primary parathyroid hyper-functioning diseases in patients with elevated parathormone (PTH). **Results:** Planar images detected parathyroid lesions (adenoma/hyperplasia) in 38/105 (36.2%) in the early images, and 56 (53.3%) in the late images 23/105 patients showed ectopic parathyroid adenomas.16/23 (69.9%) were originating from inferior the inferior glands where 7/16 (43.8%) were inferior to the lower thyroid border, 6/16 (37.5%) were retro-clavicular and 3/16(18.7%) were at the anterior mediastinum. 7/23 (30.4%) were originating from the superior glands where 5/7(71.4%) were in the trachea-esophageal groove and 2/7(28.6%) were in the posterior mediastinum. Dual phase planar images detected ectopic adenomas in 5 (4.8%) and 6 (5.7%) patients in early and late image respectively. On the other hand, SPECT/CT could detect 23 (21.9%) and 18 (17.1%) respectively. It should be noted that 5 cases could not be diagnosed in early SPECT/CT images but diagnosed in the late images. **Conclusion:** TC99m MIBI SPECT/CT has a significant role in preoperative localization of ectopic parathyroid adenoma.

Keywords: The role of TC99m MIBI SPECT/CT, detection, localization, ectopic parathyroid adenoma.

INTRODUCTION:

The main regulator of calcium homeostasis in human's body is parathyroid hormone. Hypercalcemia is a symptom of primary hyperparathyroidism (PHPT), and is caused by an inappropriate overproduction of parathyroid hormone by one or more parathyroid glands (1). The home to the parathyroid glands is the four poles of the thyroid gland. Upper mediastinal tumours are easily detected, even though they are not in the predicted position. Meanwhile parathyroid glands can be located in a variety of places and can be difficult to find. To detect irregular parathyroid tissue, parathyroid imaging has become a common preoperative technique (2). Thyroid imaging is not a diagnostic technique and can only be used if surgery is being considered. The presence of parathyroid adenomas or hyperplastic parathyroid glands is not always certain. Since experienced parathyroid surgeons will find dysfunctional parathyroid glands regardless of imaging, PTx should not be avoided in diagnosed patients due to a lack of positive imaging. Imaging's importance stems from its ability to accurately identify irregular parathyroid tissue and thus aid in the preparation of successful parathyroid surgery.

Aim of Study

Accurate pre-operative localization of ectopic parathyroid adenoma via TC99m MIBI and comparison to dual phase planar images.

MATERIAL AND METHODS

This prospective study was performed at NEMROCK center, Cairo University. It was done on one hundred and five patients. The common eligibility criteria were a preoperative diagnosis of primary parathyroid hyper-functioning diseases in patients with elevated parathormone (PTH).

Inclusion criteria Patient at any age and sex proved to have primary hyperparathyroidism.

Exclusion criteria Patients with secondary or tertiary hyperparathyroidism as well as pregnancy.One hundred and five patients underwent an extensive preoperative evaluation, including nuclear imaging (functional imaging) and SPECT/CT imaging (anatomical imaging) before surgery. This included medical history and complete physical examination, PTH level, calcium level, phosphorus level, neck Ultrasonography, isotope thyroid scan followed by surgical excision with histopathology.

Technique of scan All patients were injected preoperatively intravenously with 925–1,110 MBq of 99mTcsestamibi followed by administration of pertechnetate is generally 370-640 MBq (10-20 mCi) IV.

Planar Imaging Protocol Acquisition. At 15 min and 2 h after injection, 10- min anterior, 35 right anterior oblique, and 35 left anterior oblique planar images were acquired in a 128 · 128 matrix, with a 20% window centered around the 140-keV photopeak using a lowenergy, high-resolution parallel collimator.

SPECT/CT protocol SPECT and CT images of the same area were acquired over a 360° arc, using 64 frames at 25 s per frame. The images were obtained into a 128 x 128 matrix and reconstructed using iterative protocol "4 iterations, 4 subsets, and Gaussian filter 8". The CT part was acquired at a slice step of 1 mm, a current of 70-80 mA, and a voltage of 130 kV. The total SPECT/CT acquisition took approximately 30 min. After finishing SPECT/CT both at early and delayed acquisition, static anterior neck and chest images were obtained using a 256 x 256 matrix, for 10 minutes each. Additionally, after finishing the delayed SPECT/CT and static images, and after confirming adequate washout of the 99mTc-MIBI from the thyroid, using the same position, another static image will be obtained after injection of 99mTc-pertechnetate.

Image Interpretation Visual inspection of 99mTc-sestamibi/99mTc-pertechnetate, as well as computer subtraction or rapid alternating display of images, are recommended (cine). The absorption of 99mTc-sestamibi in abnormal parathyroid tissue appears to be higher than average. In cases where visual results are ambiguous, computer subtraction may help.

Visual scoring (0-3):

0 …. No uptake
1 …. Uptake less than thyroidal uptake
2 …. Uptake equal to thyroidal uptake
3 …. Uptake more than thyroidal uptake

RESULTS:

The study included 105 patients proved chemically as primary hyperparathyroidism. They were eighty-six females (82%) and 19 males (18%) with ratio 4.5:2.

Table (1): Distribution of the studied patients according to sex

	Female	Male
Number	86/105	19/105
Percentage	82%	18%

Ratio	4.5:2

The range of their age was 17-88 years old with a mean 49.4 ± 15.58 years old**.**

Table (2): Median, Mean values and standard deviation of the age of the studied patients

95% CI		
Mean + SD	**49.4 ±15.58**	**43.9 – 54.9**
Median	49	46 – 57
Range	17-88	
25% percentile 75% percentile	38.5 61.5	

90/105 (76.2%) adenomas had been diagnosed as single adenomas. Forty-five (50%) were detected in the right side, 30/45 (66.7%) were inferior and 15/45(33.3%) superior. Forty-five were detected on the left side, 25/45 (55.6%) were inferior and
20/45 (44.4%) superior. Double adenomas were 10/105 in number, 7/10 were detected on both sides, 3/10 on one side (2 on the right and one on the left). Five cases (4.8%) showed more than double adenomas.

Table (3): Distribution of the studied patients according to the number of adenomas detected.

	Single Adenoma				**Double Adenomas**		**>2 adenomas**
	Right		**Left**		**Unilateral**	**Bilateral**	
	Superior	**Inferior**	**Superior**	**Inferior**			
No(%)	15 (33.3%)	30 (66.7%)	20 (44.4%)	25 (55.6%)	3 (30%)	7 (70%)	5 (4.8%)

Planar images detected parathyroid lesions (adenoma/hyperplasia) in 38/105 (36.2%) in the early images, and 56 (53.3%) in the late images
23/105 patients showed ectopic parathyroid adenomas
16/23(69.9%) were originating from inferior the inferior glands where 7/16 (43.8%) were inferior to the lower thyroid border, 6/16(37.5%) were retro-clavicular and 3/16(18.7%) were at the anterior mediastinum.
7/23 (30.4%) were originating from the superior glands where 5/7(71.4%) were in the trachea-esophageal groove and 2/7(28.6%) were in the posterior mediastinum.
Dual phase planar images detected ectopic adenomas in 5 (4.8%) and 6 (5.7%) patients in early and late image respectively. On the other hand, SPECT/CT could detect 23 (21.9%) and 18 (17.1%) respectively.
It should be noted that 5 cases could not be diagnosed in early SPECT/CT images but diagnosed in the late images.

Table (4): Distribution of the studied patients according to detection of adenoma/hyperplasia lesions by 99mTc-MIBI Dual imaging protocol.

	Number of positive patients		**Location**			
			Normal		**Ectopic**	
	No.	**% of 105**	**No.**	**% of 105**	**No.**	**% of 105**
Planar						
Early	38	36.2	33	31.4	5	4.8
Late	56	53.3	50	47.6	6	5.7

SPECT/CT						
Early	100	95.2	77	73.3	23	21.9
Late	82	78.1	64	60.9	18	17.1

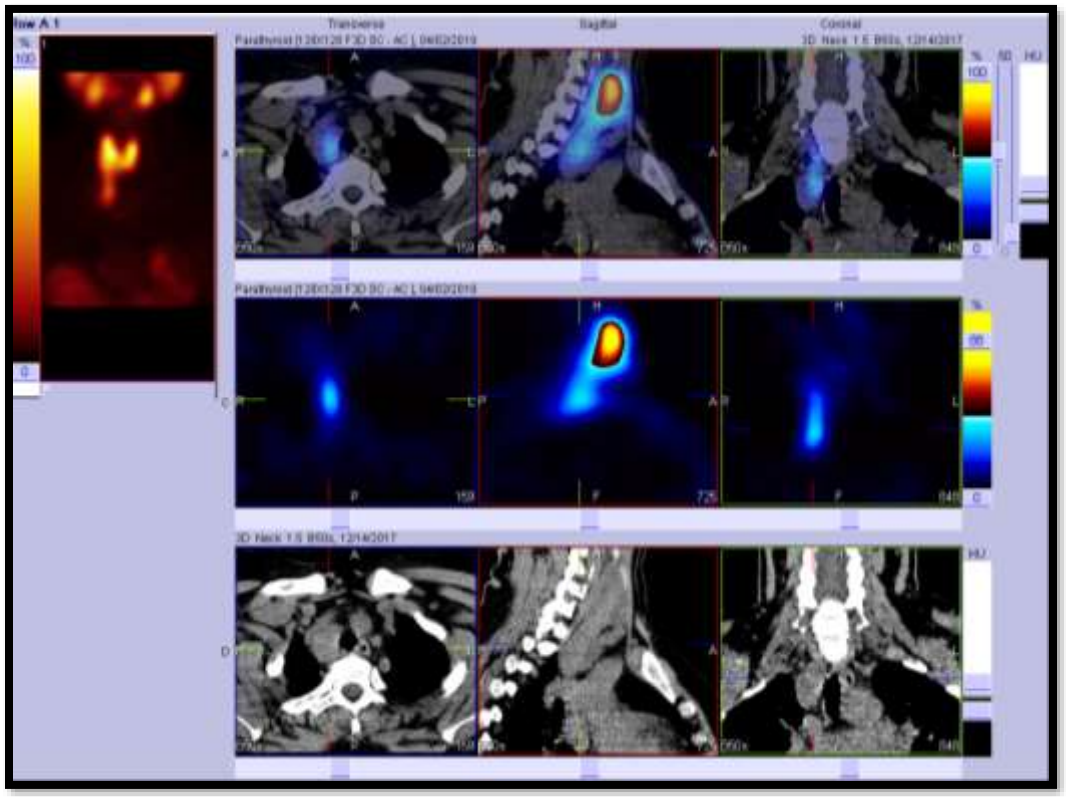
Case Presentation

Case 1:(Fig1) 49 years old female with elevated calcium 3.9 mmol/l and parathormone 128 pmol/l
99mTc-MIBI SPECT/CT revealed

Multinodular goiter with mainly enlarged right thyroid lobe.

Retention of activity in ectopic tissue below the lower pole of right thyroid lobe. This lesion is big, paratracheal, paraesophageal and prevertebral. It lies in the posterior mediastinum retro-aortic.

Pathology report



Right parathyroid adenoma in the ectopic tissue

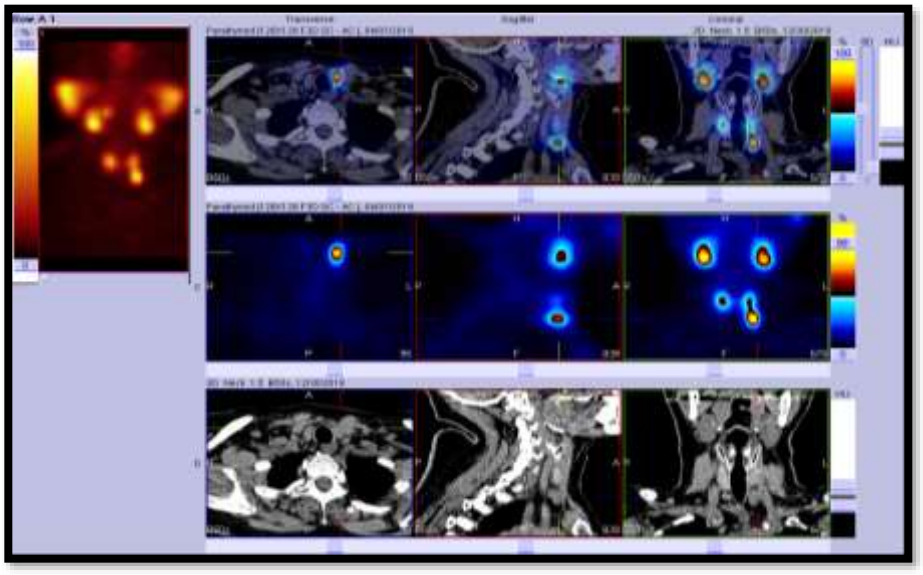
(Figure 1) Axial, sagital and coronal SPECT/CT, SPECT and CT cuts showing right ectopic parathyroid adenoma

Case 2: (Fig 2) Female patient, 69 years old complaining of bony pains , thirst, proved to have primary hyperparathyroidism where her parathormone hormone proved to be elevated 388 pmol/l and serum calcium was 3.75 mmol/l, alkaline phosphatase was 668 U/l.

99mTc-MIBI images: area of retained activity below the lower pole of left thyroid lobe. This area is pre and paratracheal. Its lower border is seen in the thoracic inlet and corresponding to T1. Its anterior border is just behind

and lateral to the sternal manubrium (i.e. lies in the anterior mediastinum). Its lateral border medial to left sternomastoid muscle.

Conclusion: ectopic left inferior parathyroid adenoma..

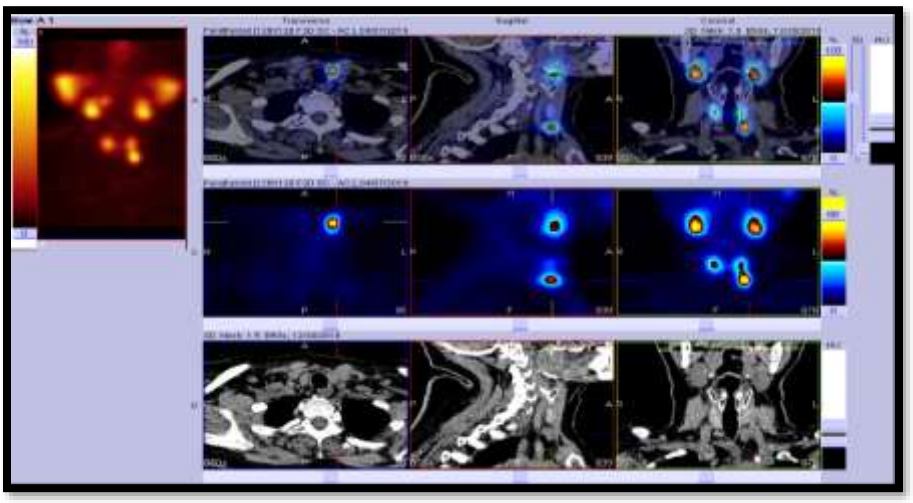


(Figure 2) Axial, sagital and coronal SPECT/CT, SPECT and CT cuts showing ectopic left inferior parathyroid adenoma (mediastinal)

Case 3: (Fig 3) Female patient, 60 years old complaining of bony pains , heart burn, proved to have primary hyperparathyroidism where her parathormone hormone proved to be elevated 134 pmol/l and serum calcium was 3.98 mmol/l, alkaline phosphatase was 568 U/l.

99mTc-MIBI images: area of retained activity behind and below the lower pole of left thyroid lobe. This area is retrotracheal, parapharyngeal, and prevertebral. The medial border of this area lies in the tracheoesophageal groove (where the left recurrent laryngeal nerve is very close). The posterior border rest on the body of C7 vertebra. The lower border is just above the thoracic inlet.

Conclusion: ectopic left superior parathyroid adenoma**.**



(Figure 3) Axial, sagital and coronal SPECT/CT, SPECT and CT cuts showing left superior ectopic parathyroid adenoma

DISCUSSION

The classic curative management of primary hyperparathyroidism removes the detected adenoma by an open, four-gland exploration (Touska et al., 2019). [168]However, recently selective minimally invasive parathyroidectomy replaced the classic surgery to reduce the morbidity and recovery time (Chen et al., 1999, Alder et al., 2008) (3,4). This requires accurate localization of the causative gland/s preoperatively using SPECT/CT and ultrasonography.The embryological origin of the parathyroid glands challenges the imaging-based localization. The modalities in combination increase the sensitivity of localization (Touska et al., 2019) (5). Parathyroid scintigraphy is one of the most sensitive methods for the preoperative localisation of the hyperfunction parathyroid gland. Parathyroid imaging is not a diagnostic procedure and is not advised unless surgical intervention is planned Khan et al., (2016) (6). Parathyroid scintigraphy and neck ultrasonography are routine preoperative localization procedures. However, when thyroid disease coexists and the lesion has low weight, their diagnostic accuracy is possibly diminished Kunstman et al., (2013) (7). Single-photon emission computed tomography (SPECT) helps localize parathyroid lesions, discriminate thyroid from parathyroid lesions, and detect and localize ectopic parathyroid lesions. SPECT/CT improves planar scintigraphy detection rate. In addition, It adds anatomical details useful in preoperative planning (minimally-invasive parathyroidectomy) Kunstman et al., (2013) (7). The current study aimed to accurately localize ectopic parathyroid adenoma preoperatively via TC99m MIBI and comparison to dual phase planar images. A prospective study had been done on 105 patients from 2019 to 2021, these patients biochemically proved to have primary hyperparathyroidism and referred to the nuclear medicine unit at NEMROCK. All patients had been subjected to clinical assessment (Age and sex), laboratory assessment (for parathormone hormone, serum calcium, and phosphate levels), nuclear imaging in the form of 99mTc-pertechnetate thyroid planar images, 99mTc-Sestamibi planar, and SPECT/CT images. All images had been done within 10 min. after injection (early) and 2 hours post-injection (delayed). Then all patients had been treated by surgical removal followed by histopathological assessment of the surgically removed specimens for parathyroid and thyroid histopathology.

Moron et al. (2019) reported a 20% incidence for ectopic parathyroid adenomas. The current study agrees with that incidence where SPECT/CT could detect 21.9% ectopic adenomas. In addition, the present study could detect 69.6% as inferior origin versus 30.4% from superior glands, similar to Moron et al. reports.[164] Another interesting point that Duke et al. (2016) and Moron et al. (2019) reported that the tracheoesophageal groove is an ectopic site for the superior gland. That is why the present study considered those adenomas laying in the tracheoesophageal groove as an ectopic adenoma(8,9) .

Limitation

We admit few of limitations in this study. First, Small number of patients,second,hyperparathyroidism in pregnant patients and third patients with secondary and tertiary hyperparathyroidism.

CONCLUSION

TC99m MIBI SPECT/CT has significant role in preoperative localization of ectopic parathyroid adenoma

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