

Comparison of Tc-99m pertechnetate images with dual-phase Tc 99m MIBI and SPECT images in primary hyperparathyroidism

Sait Sager, Hojjat Shafipour, Sertac Asa, Sabire Yılmaz, Serkan Teksöz¹, Çetin Önsel

Department of Nuclear Medicine, ¹Department of Endocrine Surgery, Istanbul University, Cerrahpasa Medical Faculty, Istanbul, Turkey

ABSTRACT

Background: The purpose of this study was to evaluate the value of Tc-99m pertechnetate planar, dual-phase MIBI and MIBI-SPECT images in the determination and localization of parathyroid lesions. **Materials and Methods:** In this study, 38 patients who underwent operation for primary hyperparathyroidism were included. Tc-99m pertechnetate planar-pinhole imaging of the neck and then MIBI planar and SPECT images in supine position was performed. Late SPECT images were acquired 120 minutes after the injection. Early and late MIBI images were quantitatively evaluated. **Results:** Of the 38 patients, 30 of them had adenoma, 2 patients had hyperplasia and 6 of them were normal on planar images. Thirty-four of 38 patients were positive on SPECT images. SPECT images of the patients with positive results were matched with pathology results. **Conclusion:** As a result, Tc-99m pertechnetate planar-pinhole, Tc-99m MIBI planar and SPECT images are useful for localization of parathyroid lesions especially in multinodular thyroid gland. However, US or CT images are necessary for more accurate localization and Tc-99m pertechnetate images are useful for interpreting and comparing with the early and late MIBI images.

Key words: MIBI, primary hyperparathyroidism, scintigraphy, Single-photon emission computed tomography, TC-99m pertechnetate

INTRODUCTION

Primary hyperparathyroidism (PHP) is an endocrine system disease, mostly seen in older population.^[1] The cause of PHP is solitary parathyroid adenoma (PA) in 80-85% of the cases. Number of imaging techniques have been used for preoperative localization of parathyroid adenoma including Technetium-99m labelled methoxyisobutyl isonitrile (Tc-99m-MIBI), ultrasound (US), magnetic resonance imaging (MRI) and computed tomography (CT). However these imaging methods have low sensitivity in PA localization. Although some authors use US alone as the primary modality to diagnose parathyroid adenoma and

hyperplasia, it is dependent on the physician's experience and has a suboptimal detection rate in multinodular goiter, also in the mediastinum, tracheoesophageal groove and retroesophageal regions.^[2-4] Tc-99m-MIBI is a widely used and accurate scintigraphy technique for the preoperative localization of PA in PHP. Sensitivity of PA diagnosis is improved with early and late planar imaging. Single-photon emission computed tomography (SPECT) imaging provides information about localizing parathyroid lesions, differentiating thyroid from parathyroid lesions, detecting and localizing ectopic parathyroid tissues.^[5,6]

The aim of this study was to compare the value of Tc-99m pertechnetate, dual-phase MIBI and MIBI-SPECT images in the determination and localization of parathyroid lesions and was to compare both planar and SPECT images with lesion based.

MATERIALS AND METHODS

Ninety-three patients who referred to parathyroid scintigraphy

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Corresponding Author: Dr. Sait Sager, Department of Nuclear Medicine, Istanbul University, Cerrahpasa Medical Faculty, Cerrahpasa, Fatih, Istanbul, Turkey. E-mail: saitsager@yahoo.com

with the preliminary diagnosis of hyperparathyroidism were included in this study. After positive parathyroid lesion imaging and clinical findings, 38 of these patients were operated. The mean PTH level was 258 ± 161.5 pg/mL, calcium level was 11.26 ± 0.85 mg/dL and phosphorus level was 2.56 ± 0.71 mEq/L. For all patients, BUN and creatinine values were in normal limits.

Two patients had history of surgery due to parathyroid adenoma and imaging was performed for recurrent hyperparathyroidism. All patients had thyroid-parathyroid ultrasonography (US).

Imaging

Single head gamma camera was used for planar imaging and dual head gamma camera (Mediso Nucline Spirit, Hungary) was used for SPECT imaging. Twenty minutes after the intravenous injection of 185 MBq Tc-99m pertechnetate, planar imaging and directly after, SPECT imaging of the neck with dual head gamma camera was performed for all patients. Then 20 min after the injection of 740-925 MBq Tc-99m MIBI, 10 minutes of thyroid static images and anterior mediastinum were performed. After planar imaging, MIBI SPECT images were performed with the same parameters as early and late imaging. Late mediastinal images were acquired for 5 min. Late SPECT images were obtained 120 min after the injection of the radiotracer.

Image interpretation

Tc-99m pertechnetate and MIBI, early and late MIBI SPECT images of all patients were interpreted by two independent physicians who were blinded to clinical and other data. Tc-99m pertechnetate images and Tc-99m MIBI images were evaluated together. The relatively increased activity in MIBI images but not be seen in pertechnetate images were considered as pathological parathyroid tissue. Tc-99m pertechnetate planar and SPECT images were used to determine the boundaries of thyroid gland and discriminate the parathyroid gland from thyroid tissue.

Quantitative assessment

For quantitative assessment, region of interest (ROI) was drawn on each Tc-99m MIBI early and late SPECT images according to color scale where the highest level of activity and on the background in every patient. The average number of the count taken from late SPECT images were divided to the average number of the count from early SPECT images.

RESULTS

Table 1 shows the clinical characteristics of all patients. Out of 38 patients, 30 of them were diagnosed to have PA, 2 patients had PH on planar images, whereas 6 patients were evaluated

Table 1: Characteristics and results of 38 patients

Age	Sex	PTH pg/mL	Thyroid USG	Planar	SPECT	Pathology
38	F	793.7	N	PA	PA	PA
61	M	168	N	N	N	PA
64	F	191	RT/NG	PH	PH	PH
64	F	110	N	PA	PA	PA
37	F	125	NG	N	N	PA
38	M	96.6	N	N	PA	PA
68	M	453	RT/MNG	PA	PA	PA
60	F	208	N	PA	PA	PA
64	F	269	MNG	N	N	PA
44	F	228	NG	PA	PA	PA
56	F	160	RT/MNG	PA	PA	PA
40	F	161	NG	PA	PA	PA
47	F	129	N	PH	PH	PH
60	M	124	MNG	PA	PA	PA
22	F	221	N	PA	PA	PA
81	F	299	N	PA	PA	PA
52	M	233	MNG	PA	PA	PA
42	F	257	N	N	N	PA
55	F	330	NG	PA	PA	PA
16	M	198	RT/MNG	PA	PA	PA
56	F	203	N	PA	PA	PA
39	F	361	NG	PA	PA	PA
45	F	165	MNG	PA	PA	PA
49	M	214	NG	N	PA	PA
67	F	228	MNG	PA	PA	PA
71	F	136	N	PA	PA	PA
85	F	254	N	PA	PA	PA
76	M	128	N	PA	PA	PA
49	M	233	MNG	PA	PA	PA
54	F	226	NG	PA	PA	PA
65	F	125	MNG	PA	PA	PA
58	F	127	NG	PA	PA	PA
49	F	158	N	PA	PA	PA
52	M	147	N	PA	PA	PA
51	M	368	N	PA	PA	PA
61	F	412	NG	PA	PA	PA
66	F	321	MNG	PA	PA	PA
67	M	128	NG	PA	PA	PA

F: Female, M: Male, PTH: Parathyroid hormone, USG: Ultrasound, SPECT: Single-photon emission computed tomography, MNG: Multinodular Goiter, RT/NG: Remnant Tissue/Nodular Goiter, PA: Parathyroid adenoma, PH: Parathyroid hyperplasia

as normal with planar images Figure 1. According to Tc-99m MIBI SPECT images, 34 of 38 patients were diagnosed to have PA. According to both SPECT and planar images, 4 of these 38 patients were observed to have harmonious activities under both thyroid lobes related with PH. Histopathologic evaluation of the lesions which were surgically removed from the same areas confirmed diagnosis of PH.

Six patients were diagnosed as normal via Tc-99m MIBI and pertechnetate planar images and four of these patients reported to have positive status for parathyroid adenoma in early MIBI SPECT. Thyroid USG revealed MNG in four of these six patient and the other two patients were diagnosed to have solitary NG. Out of these thirty-eight patients, 16 were diagnosed with MNG and 12 of them with solitary NG. According to planar MIBI images, out of these 38 patients, 30 had positive in terms of PA, 2 had

PH, whereas 6 had negative. Early MIBI SPECT images of these 34 patients were positive in terms of PA.

Early MIBI SPECT imaging findings matched with pathology results in 34 patients as PA. In one patient,

even though scintigraphy showed to have PA at lower right lobe, PA was found to be on the middle right lobe in the surgical operation. According to pathology results, 34 of the 38 patients were diagnosed to have PA and 4 patients were diagnosed to have PH.

For the other PA cases, early SPECT and planar images correctly determined the lesions. In one patient, Tc-99m pertechnetate scintigraphy showed two thyroid nodules, one of them was large and hyperactive whereas the other one was small and normoactive. Tc-99m MIBI images confirmed the same results. Thyroidectomy was applied to the patient and the pathology result showed multicentric thyroid papillary carcinoma. According to these results, the sensitivity of Tc-99m MIBI planar and pinhole imaging is 88.2%, Tc-99m MIBI SPECT sensitivity is 100% in detecting parathyroid adenoma Figure 2.

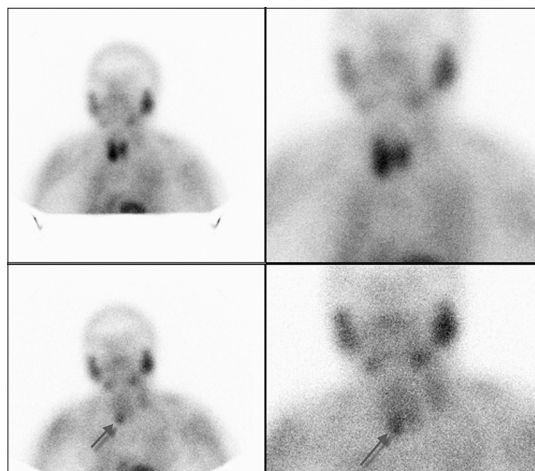


Figure 1: Tc-99m PO4, Tc-99m MIBI early and late planar images of 38-year-old female patient

DISCUSSION

Dual-phase Tc-99m MIBI parathyroid scintigraphy is a valuable method based on the differential washout rate

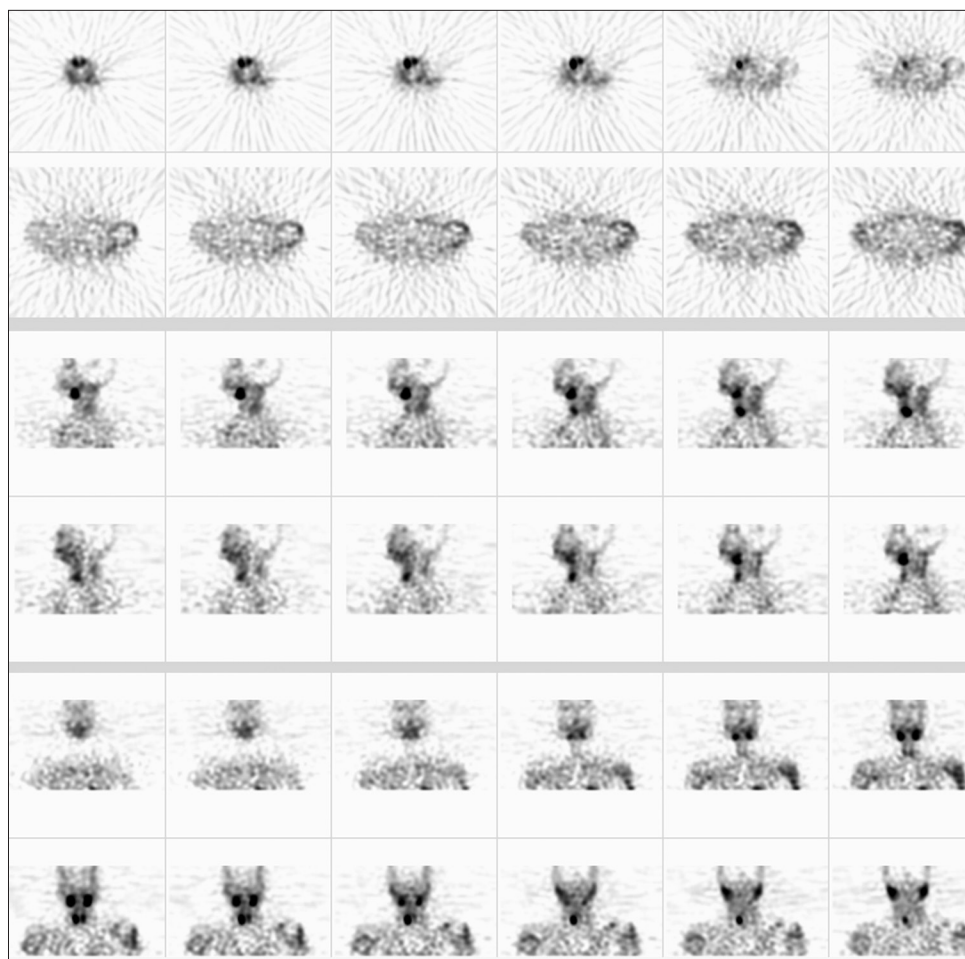


Figure 2: Tc-99m MIBI SPECT images of another patient showed increased uptake in the right inferior adjacent area of the thyroid gland

between the thyroid tissue and PA. PAs have very high metabolic rate despite of their small size and they show intense Tc-99m MIBI uptake. Oxyphilic cells which are enriched by mitochondria and the increased vascularity are the main causes of this uptake.^[7]

Bilateral exploration of the parathyroid glands with excision of the abnormally enlarged glands and biopsy of at least one normal size gland has been the traditional standard approach for the surgical management of PHP.^[8] Experienced endocrine surgeons successfully cure the PHP by bilateral neck dissection in 95% of patients without needing any preoperative imaging. However, the morbidity and unsuccessful surgery rate increase with the less experienced surgeons.

Benard F *et al.* hypothesized that mitochondria-rich oxyphil cells constitute a logical target for the prolonged retention of Tc-MIBI usually observed in abnormal parathyroids because tissues with a low mitochondrial content would not be expected to significantly accumulate the tracer. In such cases, rapid washout of Tc-99m MIBI from abnormal tissue with low number of mitochondria can result a false negative study on late images. Pathologic parathyroid tissue activity can be observed at early MIBI images probably because of increased flow or cellularity in the tumor.^[9] SPECT images are useful for localization of preoperative parathyroid adenomas, which have negative planar imaging and especially for the cases localized in mediastinum and may increase the sensitivity. As already stated in our study, early SPECT have extra contribution to the patients that have been diagnosed with parathyroid adenoma via planar imaging.^[10]

To improve the lesion detectability, some studies using a pinhole collimator for imaging reported better localization of adenomas than images acquired by a parallel-hole collimator or delayed SPECT.^[11] It is also reported that a combination of early and delayed pinhole imaging and SPECT maximize parathyroid lesion detection.^[12] Pinhole SPECT was shown to be a complementary to planar scintigraphy, especially in secondary hyperparathyroidism.^[13,14] Using US combination with scintigraphy is common method for lesion localization and to exclude thyroid nodules in the thyroid glands. Using a hybrid SPECT/CT scan can further enhance localization by providing better resolution of surrounding structures and this system allows for the combined anatomic information from CT and the physiologic three-dimensional information from SPECT. However SPECT/CT is high cost modality and many departments can-not afford this system. Also CT scan gives more radiation to the patients.

The sensitivity of Tc-99m MIBI for localization of

preoperative parathyroid adenoma was found different in various studies. Civelek *et al.* found that the sensitivity of Tc-99m MIBI late SPECT imaging in abnormal parathyroid tissue detection in the patients who had not underwent surgery as 87%, in the patients who had been operated is 92%; and in patients with hyperplastic glands is 45%.^[15] Perez-Monte *et al.* compared the early and late Tc-99m MIBI SPECT images of 37 patients who had parathyroid adenoma and had been operated. Pathologic reports confirmed parathyroid adenoma in 34 patients (92%) and PA in 3 patients (8%). 91% of patients were detected and localized correctly with early SPECT images. 74% of parathyroid adenoma were detected by late SPECT images and 32% of adenoma were correctly localized in this study.^[16] Early Tc-99m MIBI SPECT imaging was found better than late Tc-99m MIBI imaging for localization of parathyroid adenomas according to these researchers.^[15,16] The reason of this rapid washout rate of MIBI from adenomas in late images increases the false negativity. Another study comparing the early and late SPECT images of 52 patients found that 41 parathyroid adenoma (79%) were detected by planar imaging and 50 were (96%) by early SPECT imaging. This study showed that SPECT imaging is superior than planar imaging in PA localization especially in patients with ectopic adenomas and multinodular goiter disease.^[17] A study with 82 PHP patients, published by Pinhas *et al.* reported that the sensitivity of planar imaging for parathyroid adenoma was 78% and early SPECT was 96% for parathyroid adenoma localization detection.^[18] In our study, early MIBI SPECT correctly found PA localization in 34 out of 38 patients, MIBI planar images found PA localization in 30 out of 38 patients. Also the washout rate of the MIBI was calculated to be 0.686 in quantitative evaluation which had been performed with early and late images of PA adenomas.

On the other hand, there are some authors reporting that SPECT does not bring additional information and does not improve the detection rate for adenomas. Chen *et al.* found that the sensitivity of Tc-99 MIBI imaging for PA detection was 95%, the sensitivity of late planar imaging is 98% and the late SPECT imaging of Tc-99 MIBI was 98% in 55 hyperparathyroid patients. They conclude that the latter images subtraction images and SPECT images does not necessarily bring much information other than early images with Tc-99m pertechnetate.^[9] Staudenherz *et al.* performed planar images with Tc-99m-MIBI, SPECT, US, and subtraction scintigraphy with Tl-201 and Tc99m-pertechnetate on patients with thyroid disease (50% of the cases) and previous cervical surgery (21% of the cases) and compared the images with the histopathology of the surgical specimen. They

found that SPECT provide additional information about adenoma localization in 39% of patients with thyroid disease or previous cervical surgery. However, overall detection rates did not increase.^[20]

Some researchers do not advice parathyroid scintigraphy for MNG patients with parathyroid adenomas. Although MNG lowers sensitivity of planar imaging, it does not affect SPECT imaging. However in recent years, SPECT/CT technology gives more information about this kind of MNG patients. In many centers such as our department, US is being used for excluding thyroid nodules. The reason for that is that localization of parathyroid adenomas are more commonly behind thyroid gland. In MNG patients, it is hard to differentiate thyroid nodules from parathyroid nodules if thyroid nodule is MIBI avid. Even though oblique imaging is advised when parathyroid adenomas and thyroid nodules are crossed with each other, it is not useful for parathyroid adenomas. We found that early SPECT is superior to the planar imaging in MNG patients in concordance with the other studies. It is also suggested that in persistent hyperparathyroidism, the accuracy of Tc-99m MIBI SPECT for identification of residual hyperactive glands is considerably lower before reoperation than before initial surgery.^[21] In addition, hypervitaminosis D are more likely to cause false positive results on a sestamibi scan.^[22]

This study showed that early MIBI SPECT imaging is superior than both planar Tc-99m pertechnetate and planar MIBI scintigraphy in PA localization, especially in MNG patients. Since this protocol takes long time, early MIBI SPECT should be performed only if the MIBI planar imaging is negative or suspicious. Our study demonstrated that quantitative statistics of early and late SPECT imaging is necessary.

As a result, our present study suggest an important additive contribution of the SPECT study not only in localization of the parathyroid adenoma but also in the differentiation between a suspect thyroid nodule and a parathyroid gland localization when SPECT/CT is not achieved or US is not performed.

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