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Original Article

Diagnostic value of ultrasonograpy and 99mTc-MIBI scintigraphy for preoperative localization of parathyroid adenomas

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Abstract

Aim: The primary treatment of primary hyperparathyroidism (PHPT) is parathyroidectomy. With its shorter operative time and healing period, lesser general anesthesia duration, lesser hypoparathyroidism risk and better cosmetic results minimally invasive parathyroidectomy is the most commonly performed contemporary surgical procedure. However, in order for this procedure to be successful, it is important to know the location of the parathyroid adenoma. The purpose of this study was to determine the diagnostic value of Ultrasonography (USG) and technetium methoxyisobutylisonitrile scintigraphy (^{99m}Tc-MIBI) in the preoperative localization of parathyroid adenoma.

Materials and Methods: Fifty-two patients diagnosed with parathyroid adenoma were included in the study. Preoperative parathyroid USG and ^{99m}Tc-MIBI were performed on all patients. All patients' preoperative serum calcium, phosphorus, parathormone and Vitamin D levels, parathyroid USG and ^{99m}Tc-MIBI, intraoperative parathyroid lesion location and histopathological examination results were recorded.

Results: Patients aged between 22 and 81 (51.7±15.6) were eventually enrolled. When USG was used alone, the site of the adenoma was correctly determined in 26 of the 52 patients with a sensitivity of 52% and a positive predictive value of 92.8%. When scintigraphy was performed alone, the site of the adenoma was correctly identified in 39 of the 52 patients. Sensitivity was thus 76.4% and positive predictive value 97.5%. When USG and scintigraphy were assessed together, adenoma location was correctly identified in 45 of the 52 patients. Sensitivity for the two tests employed together was 88.2% and positive predictive value was 97.8%.

Conclusions: Due to the high sensitivity of combined use of USG and ^{99m}Tc-MIBI, we recommend the two tests to be assessed together before parathyroid surgery.

Keywords: Primary hyperparathyroidism; technetium methoxyisobutylisonitrile scintigraphy; ultrasonography

INTRODUCTION

Primary hyperparathyroidism (PHPT) is an endocrine disease characterized by hypercalcemia and accompanying high parathormone (PTH) levels (1, 2). The condition most commonly leading to PHPT is parathyroid adenoma, representing 85% of all PHPTs. This is followed, in decreasing order, by parathyroid hyperplasia and parathyroid carcinomas (3). The primary treatment of PHPT is parathyroidectomy. The success rate of parathyroidectomies performed by experienced surgical teams is approximately 95% (4). With its shorter operative time and healing period, less use of general anesthesia, lower risk of hypoparathyroidism and better cosmetic outcomes, minimally invasive parathyroidectomy is the most commonly performed contemporary surgical procedure (5, 6). However, in order for this procedure to be successful it is important to know the location of the parathyroid adenoma (1).

Ultrasonography (USG), technetium methoxyisobutylisonitrile scintigraphy (^{99m}Tc-MIBI), single-photon emission computerized tomography (SPECT) and magnetic resonance imaging (MRI) are used to locate the site of primary adenomas (5). The most commonly employed procedures are USG and ^{99m}Tc-MIBI. USG is a non-invasive, economical and easily applied imaging technique. ^{99m}Tc-MIBI is a non-invasive technique of high diagnostic value (6).

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The purpose of this study was to determine the diagnostic value of USG and ^{99m}Tc-MIBI in the preoperative localization of parathyroid adenoma.

MATERIALS and METHODS

Sixty patients scheduled for surgery with a diagnosis of PHPT were included in the study. Approval for the study was granted by the local ethical committee with number 2017;5:6. Informed consent was obtained from patients. Indication for surgery was based on criteria set out in the NIH 2014 consensus report (7). Diagnosis of PHPT was based on high serum calcium levels and accompanying high parathormone levels with normal status of renal functions. Preoperative parathyroid USG and 99mTc-MIBI were performed on all patients. All operations were performed by the same surgical team using the same technique. The lesion in the parathyroid was excised using a minimally invasive parathyroidectomy procedure. Specimens were sent for histopathological analysis. No recurrence was occurred in any patient at a follow-up period of 6 months. All patients' preoperative serum calcium, phosphorus, parathormone and Vitamin D levels, parathyroid USG and ^{99m}Tc-MIBI, intraoperative parathyroid lesion location and histopathological examination results were recorded. Patient with seconder or tertier hiperparathyroidizm and with histopathological diagnosis reported as not adenoma were excluded from study.

Biochemical Analysis

5-cc blood specimens were collected from all patients in the morning after fasting. PTH and Vitamin D were analyzed using the immunoassay method on a Beckman Coulter DXI (California, USA) device. Biochemical analyses were performed using the photometric method on a Beckman Coulter AUX 5802 (California, USA) device. Calcium values were calculated using the corrected calcium formula [corrected calcium (mg/dl) = serum Ca levels+ [0.8x(4-patients albumin)].

Ultrasonography

USG evaluations were carried out with the assistance of a Toshiba, Aplio 500 device (Tokyo, Japan) equipped with a 7-12 MHz linear probe. Patients were placed in a supine position with their necks hyperextended. A layer of acoustic material was applied to the skin. All USG evaluations were carried out by an experienced endocrinologist blinded to subjects' clinical status. The parathyroid glands were visualized for the purpose of determining lesions indicating parathyroid pathology. Glandular enlargement was defined as hypoechoic, homogeneous, solid masses with regular borders sited exterior to the thyroid lobe.

^{99m}Tc-MIBI Scintigraphy

^{99m}Tc-MIBI scintigraphy was carried out after USG. Radionuclide imaging was carried out (GE Healthcare-Discovery NM-630, Waukesha, USA) following iv injection into an arm vain of 15 mCi (740 MBq) 99mTcmethoxyisobutylisonitrile (Cardio-Spect, Medicheck). Anterior planar images of the neck and chest regions were obtained with the help of a gamma camera 10 and 120 min following radionuclide administration, each process lasting 10 min. Images were obtained within a 128x128 matrix with a 20% window around the 140-kev photo peak employing low-energy, high-resolution parallel collimators. The resulting images were assessed visually. Continued focal activity in both sequences was regarded as indicating parathyroid pathology.

Statistical Analysis

Statistical analysis was performed on SPSS for Windows 17.0 software. Quantitative data were expressed as mean±standard derivation. For the purposes of the study, sensitivity was regarded as the ratio of true-positive results to the sum of true-positive and false-negative results. Positive predictive value was regarded as the ratio of true-positive results to all positives, while accuracy was taken as the ratio of the sum of true-positives and true-negatives in the entire study population.

RESULTS

Eight of the 60 patients operated on for PHPT were excluded from the study due to determination of hyperplasia and carcinoma at postoperative histopathological analysis. Fifty-two patients diagnosed with parathyroid adenoma and aged between 22 and 81 (51.7±15.6) were eventually enrolled. Ten patients were male and 42 were female. Patients' preoperative biochemical results are shown in Table 1.

Table 1. Demographic properties and biochemical results of patients

Age range	22 - 81
Age (Mean±SD)	51.7±15.6
Gender (M/F)	10/42
PTH (Mean±SD)pg/ml	499.5±630.2
Ca (Mean±SD)mg/dl	11.9±0.8
P (Mean±SD) mg/dl	2.3±0.7
Vit D (Mean±SD)ng/ml	19.6±10.8
Location of adenoma	
Upper-left (%)	2/52 (3.8)
Lower-left (%)	27/52 (51.9)
Upper-right (%)	0/52 (0)
Lower-right (%)	19/52 (36.5)
Post of thyroid (%)	2/52 (3.8)
İstmus (%)	1/52 (1.9)
Multipl (%)	1/52 (1.9)

Parathyroid adenoma was in the lower left pole in 27 patients, in the lower right pole in 19, in the upper left pole in two, posterior to the thyroid lobe in two, and above the isthmus in one, while one adenoma each was present in both lower poles in one subject (Table 1).

When USG was used alone, the site of the adenoma was correctly determined in 26 of the 52 patients, adenoma

could not be visualized in 24, and the location was incorrectly evaluated in two. Sensitivity of 52% and a positive predictive value of 92.8% were thus calculated for USG (Table 2).

When scintigraphy was performed alone, the site of the adenoma was correctly identified in 39 of the 52 patients, and was inaccurately determined in one. Adenoma could not be visualized with scintigraphy in 12 cases. Sensitivity was thus 76.4% and positive predictive value 97.5% (Table 2).

When USG and scintigraphy were assessed together, adenoma location was correctly identified in 45 of the 52 patients. Site of adenoma was incorrectly determined in one patient, and adenoma could not be visualized in six. Sensitivity for the two tests employed together was 88.2% and positive predictive value was 97.8% (Table 2).

Table 2. Sensitivity and predictive value of different imaging techniques

	USG	Tc-99m	Both
Sensitivity (%)	52	76.4	88.2
Predictive Value (%)	92.8	97.5	97.8

DISCUSSION

On the basis of our study findings, adenoma location was correctly determined in 26 of the 52 patients using USG and in 39 patients using Tc-99m. When the two tests were assessed together, location of adenoma was accurately determined in 45 of the 52 patients.

Technetium 99m (Tc-99m) sestamibi scanning first emerged in 1989. Tc-99m was first used of myocardial perfusion studies, but later also began being employed to locate parathyroid adenomas (8). Parathyroid adenomas have high metabolic activity in proportion to their size. Scintigraphy assesses the functional status of the gland rather than its anatomical structure. In a meta-analysis of 24 studies involving 784 patients, Denham et al. reported sensitivity of 80-100% for technetium MIBI scanning in locating the site of parathyroid adenoma (9). George et al. reported a diagnostic value of 90% for Tc-99m scanning in preoperative determination of parathyroid adenoma (8). Ersoy et al. also determined a sensitivity level of 77% for Tc-99m scintigraphy in determining the location of parathyroid adenoma (10). The sensitivity level in our study was 76.4%.

In contrast to these studies, other research has reported lower sensitivity in determining the location of parathyroid adenoma for Tc-99m scintigraphy, or even that it is of no value (11,12). It should also be remembered that the sensitivity of Tc-99m scintigraphy may decrease in the presence of a thyroid disease accompanying parathyroid adenoma (13).

USG is a non-invasive, economical and easily applied imaging technique. When performed by experienced radiologists or endocrinologist it plays a significant role in determining the site of parathyroid adenomas. It is therefore used as the technique of choice by many clinics in parathyroid investigations. Depending on the experience of the operator, its sensitivity in locating parathyroid adenomas varies between 51% and 90% (14). The most important difficulty in locating parathyroid adenomas using USG is the presence of accompanying thyroid disease. Sensitivity may decline in the event of multinodular goiter and chronic thyroiditis. Similarly, parathyroid adenoma being in a retro-esophageal or mediastinal location can also reduce the diagnostic value of USG (15).

Ersoy et al. reported sensitivity of 88.6% for USG in determining the site of parathyroid adenomas (10). In addition, they reported the presence of accompanying thyroid disease in four out of five cases in which parathyroid adenoma could not be located using USG. Similarly, Akbaba et al. determined sensitivity of 87.2% for USG in locating parathyroid adenoma (16). We determined sensitivity of 52% for USG.

SPECT and MRI have been reported to provide useful information in case of clinical suspicion of parathyroid adenoma when adenoma cannot be detected using USG and ^{99m}Tc-MIBI (5,17,18). The limitation of the present study is that SPECT and MRI were not applied to our patients.

Combined use of USG and Tc-99m has been reported to improve sensitivity in determining the location of parathyroid adenomas. Indeed, Akbaba et al. reported that sensitivity can be as high as 95% when the two tests are employed together (16). We also determined sensitivity of 88.2% when the two tests were employed in combination.

CONCLUSION

In conclusion, preoperative localization of parathyroid adenomas is important in terms of the surgical procedure to be performed. Due to the high sensitivity of combined use of USG and Tc-99m, we recommend the two tests to be assessed together before parathyroid surgery.

Competing Interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical Approval: Approval for the study was granted by the ethical committee of Ataturk University, Faculty of Medicine with number 2017;5:6.

REFERENCES

1. Huang Z, Lou C. (99m)TcO(4)(-)/(99m)Tc-MIBI dual-tracer scintigraphy for preoperative localization of parathyroid adenomas. J Int Med Res 2019;47:836-45.
2. Gungor A, Bilen H, Akbas EM, et al. Hyperparathyroidism in pregnancy: Report of two cases. Dicle Tip Dergisi 2013;40:501.

3. Ghilardi G, De Pasquale L. Hungry bone syndrome after parathyroidectomy for primary hyperthyroidism. Ghilardi and De Pasquale, Surgery Curr Res 2014;4:2.
4. Sosa JA, Powe NR, Levine MA, et al. Profile of a clinical practice: thresholds for surgery and surgical outcomes for patients with primary hyperparathyroidism: a national survey of endocrine surgeons. J Clin Endocrinol Metab 1998;83:2658-65.
5. Krčálová E, Horáček J, Nováková E, et al. Dual Tracer 99mTc-Pertechnetate/99mTc-MIBI Dual-Time-Point SPECT/CT Parathyroid Gland Assessment Regarding to Parathyroid Gland Size and Biochemical Parameters–Two Years Single Imaging Centre Experience. Acta Medica (Hradec Králové) 2019;62:1-5.
6. Moghadam RN, Amlelshahbaz AP, Namiranian N, et al. Comparative diagnostic performance of ultrasonography and 99mTc-sestamibi scintigraphy for parathyroid adenoma in primary hyperparathyroidism; systematic review and meta-analysis. Asian Pacific journal of cancer prevention: APJCP 2017;18:3195.
7. Bilezikian JP, Brandi ML, Eastell R, et al. Guidelines for the management of asymptomatic primary hyperparathyroidism: summary statement from the Fourth International Workshop. The Journal of Clinical Endocrinology & Metabolism 2014;99:3561-9.
8. George EF, Komisar A, Scharf SC, et al. Diagnostic value of the preoperative sestamibi scan in intraoperative localization of parathyroid adenomas: a case study. The Laryngoscope 1998;108:627-9.
9. Denham DW, James Norman M. Cost-effectiveness of preoperative sestamibi scan for primary hyperparathyroidism is dependent solely upon the surgeon's choice of operative procedure. J Am Coll Surg 1998;186:293-305.
10. Ersoy R, Ersoy O, Ogmen BE, et al. Diagnostic value of endoscopic ultrasonography for preoperative localization of parathyroid adenomas. Endocrine 2014;47:221-6.
11. Shen W, Sabanci U, Morita ET, et al. Sestamibi scanning is inadequate for directing unilateral neck exploration for first-time parathyroidectomy. Archives of Surgery 1997;132:969-76.
12. Lowney JK, Weber B, Johnson S, et al. Minimal incision parathyroidectomy: cure, cosmesis, and cost. World J Surg 2000;24:1442-5.
13. Stanciu M, Boicean LC, Popa FL. The role of combined techniques of scintigraphy and SPECT/CT in the diagnosis of primary hyperparathyroidism: A case report. Medicine 2019;98.
14. Huppert BJ, Reading CC. Parathyroid sonography: imaging and intervention. J Clin Ultrasound 2007;35:144-55.
15. Ozdemir D, Arpaci D, Ucler R, et al. Parathyroid incidentalomas detected during thyroid ultrasonography and effect of chronic thyroiditis on false positive parathyroid lesions. Endocrine 2012;42:616-21.
16. Akbaba G, Berker D, Isik S, et al. A comparative study of pre-operative imaging methods in patients with primary hyperparathyroidism: Ultrasonography, 99m Tc sestamibi, single photon emission computed tomography, and magnetic resonance imaging. J Endocrinol Invest 2012;35:359-64.
17. Tublin ME, Pryma DA, Yim JH, et al. Localization of parathyroid adenomas by sonography and technetium tc 99m sestamibi single-photon emission computed tomography before minimally invasive parathyroidectomy: are both studies really needed? J Ultrasound Med 2009;28:183-90.
18. Lorberboym M, Minski I, Macadziob S, et al. Incremental diagnostic value of preoperative 99mTc-MIBI SPECT in patients with a parathyroid adenoma. J Nucl Med 2003;44:904-8.