REVIEW

Nuclear Medicine Methods for Evaluation of Abnormal Parathyroid Glands in Patients with Primary and Secondary Hyperparathyroidism

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Considered rare disease in the past, primary hyperparathyroidism (PHPT) has dramatically increased in incidence over the past thirty years with the introduction of routine calcium measurements; it is now approximately 42 per 100 000 persons. By far, the most common lesion found in patients with PHPT is the solitary parathyroid adenoma, occurring in 85%-90% of patients, while in the rest 10%-15% primary hyperplasia of the parathyroid glands is present. Currently, the most widely used surgical approach is minimally invasive parathyroidectomy which is associated with less post-surgery complications and shorter operation time. To be successful this procedure needs to rely on a precise preoperative localization of the abnormal parathyroid glands, hence preoperative parathyroid imaging gained so large importance. The rationale for locating abnormal parathyroid tissue prior to surgery is that the glands can be notoriously unpredictable in their location. There is a general consensus that the best imaging procedure identifying abnormal parathyroid glands is the preoperative scintigraphy with ^{99m}Tc-sestamibi or ^{99m}Tc-tetrofosmin. It is characterized with high sensitivity and specificity exceeding those of ultrasound, CT or MRI. Combining scintigraphy with the other imaging techniques increases the precision for topic localization.

INTRODUCTION

Primary hyperparathyroidism (PHPT) is due to excessive production of parathyroid hormone from one or more abnormal parathyroid glands and causes hypercalcemia. Secondary hyperparathyroidism (SHPT) is characterized with increased secretion of PTH, usually much higher than in PHPT, as a result of other concomitant diseases which lead to profound and prolonged hypocalcemia. In SHPT more than one parathyroid gland is affected. Considered rare disease in the past, the incidence of PHPT has changed dramatically during the last thirty years with the introduction of routine calcium measurements and is now considered to be approximately 42 per 100 000 persons. Women are affected more frequently than men, in a ratio of approximately 3:1. PHPT occurs predominantly in individuals in middle age with a peak incidence between ages 50 and 60 years and can reach 4 cases per 1000 persons in women older than 60. At the time of diagnosis, most patients with PHPT do not have classic symptoms like osteitis fibrosa cystica, nephrocalcinosis, nephrolithiasis, or signs associated with disease. Symptomatic PHPT is now exception rather than the rule, with more than three-fourths of patients having no symptoms, making detected changes of the blood values of cal-

cium, phosphorus and parathyroid hormone (PTH) to be the only reason for diagnosis.[1] By far the most common lesion found in patients with PHPT is the solitary parathyroid adenoma, occurring in 85%-90% of patients, while in the rest 10%-15% primary hyperplasia of the parathyroid glands is present.[2] In the past the standard surgical approach for PHPT was the bilateral four-gland parathyroid exploration with the removal of each gland which showed changes macroscopically. While in most of the patients with PHPT only one parathyroid gland is affected, the above mentioned surgical approach is inappropriate in all cases. Unilateral approaches are appealing in a disease in which only a single gland is involved. These procedures include a unilateral operation in which the gland on the same side that harbors the adenoma is ascertained to be normal. So nowadays, the currently most widely used surgical approach is the minimally invasive parathyroidectomy which is connected with less postsurgical complications and shortens the time of operation.[3] The objective is to minimize the length of incisions and the associated increased pain and longer duration of hospital stay. To be successful this procedure needs to rely on a precise preoperative localization of the abnormal parathyroid glands. That's why preoperative parathyroid imaging gained so large importance. The rationale for locating abnormal parathyroid tissue prior to surgery is that the glands can be notoriously unpredictable in their location. There is a general consensus that the best imaging procedure identifying abnormal parathyroid glands is the preoperative scintigraphy with ^{99m}Tc – sestamibi or ^{99m}Tc-tetrofosmin. It is characterized with high sensitivity and specificity exceeding those of ultrasound imaging, CT or MRI. Combining scintigraphy with the other imaging techniques increases the precision for topic localization.

ANATOMY OF THE PARATHYROID GLANDS

Parathyroid glands differ in shape and size. Typically four glands are present and are located adjacent to the dorsal surface of the thyroid lobes - two upper and two lower pairs. Normal glands tend to be flat and oval and normal measurements are 3x5x7 mm.[4] The combined weight of all parathyroid glans is 90 to 130 mg and the superior glands are smaller than the inferior.[5] Autopsy series demonstrate that four glands are found in 91% in subjects, five glands in 4%, and three glands in 5%.[6] Approximately 5% of humans have supernumerary (more than four) parathyroid glands.[7] Supernumerary glands are most

commonly found within the thymus. Although gland distribution may differ widely, the superior parathyroid glands, originating from the fourth pharyngeal pouch, are commonly found along the posterior surface of the upper two-thirds of the thyroid gland (92%). The inferior parathyroid glands have a more variable distribution than the superior ones. They originate from the third pharyngeal pouch together with the thymus. They migrate caudally until they reach the lower pole of the thyroid gland and 17% of them touch the inferior border of the thyroid gland, 26% are within the superior horn of the thymus, and 2% are in the mediastinal thymus.[8] The variable anatomic distribution makes the inferior glands more difficult to locate than the superior ones. Histollogically, parathyroid glands are made of chief, oxyphillic and transient oxyphillic cells mixed with fat tissue. Chief cells produce PTH and the oxyphillic cells, which are rich of mitochondria, are with poorly defined function.[9]

EVOLUTION OF THE SCINTIGRAPHY OF THE PARATHYROID GLANDS

The lack of the perfect imaging method for precise localization of parathyroid adenomas has led to search for an alternative imaging techniques. In the past, one of the most widely used procedure was the ultrasound (US). Because of the great anatomic variations of the parathyroid glands, their small sizes, the presence of more than one abnormal gland and the high frequency of concomitant morphological changes of the thyroid gland, US proved to be specific but with low sensitivity. Later on, other more contemporary and sophisticated methods, like scintigraphy with various nucleotides, computed tomography (CT) and magnetic resonance imaging (MRI) came into consideration. De Feo et al.[10] compared the sensitivity of CT, MRI, US and ^{99m}Tc-sestamibi scintigraphy for proper localization of abnormal parathyroid glands and found to be 13%, 17%, 27% and 57%, respectively. They showed that ^{99m}Tc-sestamibi scintigraphy was the most reliable imaging method, especially combined with US (96%). Historically, the success of scintigraphy had been compromised by the failure of finding pharmaceutical agent with specific topic accumulation in parathyroid glands. Scintigraphy of the parathyroid glands was further complicated by their close localization to the thyroid gland. That's why to find a way to differentiate both glands on obtained images was crucial. This was first achieved by a combined use of two radionucleotides with different uptake in the thyroid and

parathyroid cells. The latter allowed to perform a subtraction of the obtained images of both glands and to visualize only the abnormal parathyroid glands, but this method proved to be time consuming and with greater radiation exposure to the patients.[11] The first widely used radionucleotide for detecting hyperfunctioning parathyroid glands during the 80's was ^{201}Thallium chloride (^{201}Tl). ^{201}Tl chloride accumulates equally in thyroid and parathyroid cells and to make differentiation between both glands possible its application was followed by an injection of ^{99m}Tc-pertechnetate, which uptakes only in the thyroid gland. Afterwards, ^{99m}Tc-pertechnetate thyroid images were digitally subtracted from the images obtained with ^{201}Tl chloride to allow visualization of the parathyroid glands.[12]

PARATHYROID SCINTIGRAPHY WITH ^{99m}TC − SESTAMIBI

Introduced in clinical practice by Coakley et al. in 1989[13], the ^{99m}Tc-sestamibi scintigraphy significantly improved the role of preoperative scintigraphy in patients with hyperparathyroidism. ^{99m}Tc-sestamibi consists of lipophilic cationic molecules. After being intravenously injected these molecules distribute throughout the body depending on the local blood supply and through passive diffusion enter into the cells and intracellularly accumulate into the mitochondria.[14] Visualization of parathyroid adenomas and hyperplastic parathyroid glands depends on the presence of oxyphillic cells, which are rich of mitochondria. Although it was firstly used as a cardiotropic agent, later on it was discovered that this radionucleotide accumulates also in a variety of benign and malignant tumors. Normally ^{99m}Tc-sestamibi distributes in parotid and submandibular salivary glands, thyroid gland, the heart and the liver. No accumulation in normal parathyroid glands is observed. Studying the mechanisms determining the uptake of ^{99m}Tc-sestamibi in different tissues O'Donety et al.[15] discovered that it predominantly accumulated in cells rich of mitochondria. The cells of parathyroid adenomas are such cells[16], while the normal parathyroid cells are not[17]. Apart from the presence of mitochondria, accumulation of ^{99m}Tc-sestamibi into the cells depends also on their metabolic activity, the phases of the cellular cycle, the weight and the size of the tumor. It was established that the highest rates of uptake of ^{99m}Tc-sestamibi is seen in the solitary adenomas of the parathyroid glands. Clarifying the reasons for accumulation of ^{99m}Tc-sestamibi in pathologically changed para-thyroid glands, Carpentier et al.[18] discovered that it depended on the type of cells that build up the adenomas. Not only the amount of intracellular mitochondria was important but also the quantity of oxyphillic cells in the tumors. If the percentage of oxyphillic cells exceeded 25% accumulation of ^{99m}Tc-sestamibi was observed in 78% of cases. False negative results were possible if the oxyphillic cells did not have sufficient amount of mitochondria.[19] This new radionucleotide rapidly replaced ^{201}Tl chloride because it showed better quality of the images and higher sensitivity for detecting abnormal parathyroid glands, with less radiation exposure.[20] Subtraction of thyroid images obtained with ^{123}I or ^{99m}T-pertechnetate (both with predominant thyroid accumulation) from images acquired after previous application of ^{99m}Tc-sestamibi at one and the same visit represents a variation of this procedure.[21] ^{99m}Tc-sestamibi accumulates also in the thyroid gland, but the washout periods differ, showing faster disappearing from the thyroid gland and a delayed one from parathyroid cells. This allows successful visualization of pathologically changed parathyroid glands on the images obtained later - 1.5-2 h after administration of the radionucleotide. This different retention of the tracer in both glands may be related to some down-regulation of the P-glycoprotein system in parathyroid adenomas slowing down the washout of the nucleotide.[22] Conversely, in parathyroid hyperplasia, these so called multidrug-related resistance molecules can be upregulated and can cause faster washout of ^{99m}Tc-sestamibi and cause false negative results.[23,24]

To avoid this disadvantage and to improve sensitivity and specificity, Tailefer et al.[25] recommended the use of single-isotope dual phase (early and late) scintigraphy based upon the suggestion that ^{99m}Tc-sestamibi is washed out faster from the thyroid gland than from the hyperfunctioning parathyroid cells. This single-isotope dual phase scintigraphy gained popularity due to its convenience. The fact that ^{99m}Tc-sestamibi can also be accumulated by solitary thyroid nodules diminishes the specificity of this procedure, especially in areas with higher incidence of nodular goiter.[26] Some parathyroid adenomas can also show rapid washout of ^{99m}Tc-sestamibi and make their visualization difficult during this procedure.[27] This disadvantage can be avoided by performing a subtractional scintigraphy with consecutive use of a second radionucleotide with preferential accumulation in the thyroid gland. D Casara et al.[28]

have used a combination of US examination with dual-isotope scintigraphy with ^{99m}Tc-pertechnetate and ^{99m}Tc-sestamibi for preoperative localization of parathyroid adenomas. Following such a complex diagnostic approach parathyroid adenomas were visualized in 95.2% of the cases (20 patients out of 21). Reaching such high diagnostic precision allows minimization of the extent of surgical procedure and gives way to applying routinely and successfully minimally invasive parathyroidectomy of the pathologically changed glands.[28] Ozkaya et al.[29] evaluated the diagnostic and preoperative localization capacity of ^{99m}Tc-sestamibi scintigraphy and US in patients with PHPT. They concluded that the overall sensitivities of ^{99m}Tc-sestamibi scintigraphy, US and combined techniques were 85.3%, 72,5% and 90.4%, respectively. So the most successful approach seemed to be concurrent application of both modalities. Comparing different imaging methods, Pons et al.[30] and Ishibashi et al.[31] pointed out that ^{99m}Tc-sestamibi scintigraphy has higher sensitivity and specificity than US and CT in detecting adenomas of the parathyroid glands. With regards to the hyperplasia of the parathyroid glands ^{99m}Tc-sestamibi scintigraphy showed to be of less value and the authors concluded that exactly the nature of the pathological cells' changes determined the accumulation of ^{99m}Tc-sestamibi.

Hyperplastic parathyroid glands are visualized in 10% to 62.5% of the cases according to different authors.[32,33] In multiple endocrine neoplasia syndrome, where hyperplasia of the parathyroid glands is frequently seen, only 55% of the abnormal glands are seen on ^{99m}Tc-sestamibi scintigraphy.[30] Kusakabe et al.[34] compared the results of ^{99m}Tc-sestamibi scintigraphy and US evaluation in patients with hyperparathyroidism and discovered that the efficacy of these imaging procedures was 100% and 97%, respectively. ^{99m}Tc-sestamibi scintigraphy showed to be highly effective in discovering ectopic hyperfunctioning parathyroid glands, which according to Rothmund et al.[35] can be observed in 20% of the cases with PHPT and can represent a diagnostic and therapeutic problem. Rubello et al.[36] examined 18 patients with PHPT and determined the sensitivity of ^{99m}Tc-sestamibi scintigraphy and US for discovering abnormal glands to be 100% and 83.3%, respectively.

Visualizing small parathyroid adenomas represents a specific problem. D Moka et al.[17] examined 92 patients with PHPT. Postsurgical evaluation showed that in 39 of the patients the weight of removed

adenomas was less than 0.5 g. In these cases, preoperative US evaluation showed no changes, but in 87% of them ^{99m}Tc-sestamibi scintigraphy discovered adenomas and if combined with SPECT technique sensitivity was increased to 95%.

In patients with SHPT ^{99m}Tc-sestamibi scintigraphy shows different results. Takebayashi et al.[37] compared the sensitivity of ^{99m}Tc-sestamibi scintigraphy in patients with PHPT and SHPT and the results were 91% and 83%, respectively. The authors explained this with the observed differences in the sizes and cellular contents (chief:oxyphillic cells ratio). Torregrosa et al.[38] performed dual-phase single-isotope ^{99m}Tc-sestamibi scintigraphy of the parathyroid glands in 27 patients with SHPT. They found a direct relationship between the rate of ^{99m}Tc-sestamibi accumulation and the serum levels of parathyroid hormone and the phase of the cells' cycles at the tame of examination. The lowest level of accumulation corresponded to G(0) phase and the highest to - phase G(2)+S. No correlation with the weight of the glands was observed. They stated that the fixation of the radionucleotide depended on the functional status of the tissues, i.e. increased accumulation accompanies the active growing phase of the cells. Some authors[32] highlighted the limited potential of ^{99m}Tc-sestamibi scintigraphy, underlying its importance only in clinically manifested disease and in relapses of the hyperparathyroidism. The efficacy of this procedure in PHPT and SHPT was 100% and 71%, respectively. In subclinical cases of hyperparathyroidism the efficacy of this scintigraphy was low. In parathyroid adenomas the accumulation of the radionucleotide did not depend on their size and weight, while in hyperplastic parathyroid glands such correlation was present.

The reason why not all pathologically changed parathyroid glands accumulate radionucleotide remains unclear. This may be due to the different degree of activity and proliferation of the cells of the parathyroid adenomas. It was suggested that there is a relationship between nucleotide accumulation and the degree of autonomy of the cells of the adenoma, i.e. the loss of the suppressive effect of calcium upon the secretion of the parathyroid hormone. The cells of the parathyroid adenomas and these of the hyperplastic glands show higher suppressive threshold for calcium levels or have no threshold at all in comparison with the normal parathyroid cells. Due to this fact, these cells secrete more PTH for any given calcium level, show higher metabolic rate and capability to accumulate more

99mTc-sestamibi. Hyperplastic parathyroid glands are to some extent with preserved functional connection with normal calcium homeostasis, respond to the normal suppressive stimulus, have lower metabolic rate and accumulate less of the radionucleotide.

Due to its higher affinity to the parathyroid adenomas, 99mTc-sestamibi scintigraphy was used in cases of relapse of the hyperparathyroidism after parathyroidectomy or after autotransplantation of parathyroid glands. Hung et al.[39] described positive results after using 99mTc-sestamibi scintigraphy for discovering hyperfunctioning parathyroid glands after successful autotransplantation following surgical removal of all hyperplastic parathyroid glands. This method proved to be highly informative and detects ongoing changes of transplanted parathyroid gland much earlier than other imaging procedures such as MRI, CT and US.

Nowadays there are several imaging methods for discovering hyperplastic parathyroid glands. Decreased sensitivity in multigland disease compared with single-gland disease is well recognized for planar and SPECT imaging. The study of Lomonte et al.[40] aimed to evaluate the value of dual-phase 99mTc-sestamibi scintigraphy in preoperative localization of the hyperplastic parathyroid glands in patients with secondary hyperparathyroidism. Their conclusions were that 99mTc-sestamibi scintigraphy did not show high sensitivity in discovering hyperplastic glands, nevertheless it was of help to discriminate between patients with nodular and diffuse hyperplasia. That's why 99mTc-sestamibi scintigraphy has limited value in preoperative evaluation of patients with secondary hyperparathyroidism. Using 99mTc-sestamibi SPECT/CT didn't show higher sensitivity in multiglandular disease and this was not related to lesion weight or location.[41] For still unknown reasons, 99mTc-sestamibi scintigraphy shows more sensitivity in discovering pathologic changes of the lower pairs of parathyroid glands than in the upper ones.

The role of 99mTc-sestamibi scintigraphy in patients with end-stage renal disease and secondary hyperparathyroidism is still unclear. Olaizola et al.[42] evaluated the value of 99mTc-sestamibi scintigraphy in patients with SHPT. They studied how the uptake of 99mTc-sestamibi was suppressed by the use of calcitriol in these patients and what was its correlation with the levels of parathyroid hormone. 99mTc-sestamibi scintigraphy managed to visualize 1 or more (maximum 3) parathyroid glands in most but not in all patients on chro-

niodialysis with PHT levels above 600 pg/ml. Performing suppressive test with calcitriol (2 mg of calcitriol applied i.v. after each chroniodialysis for two consecutive weeks) showed suppression of 99mTc-sestamibi uptake at least in one parathyroid gland in 57% of the cases and full suppression of all glands in 36%. The basal serum level of PHT or its lowering after this test showed to have no predictive value for the suppression of the uptake of 99mTc-sestamibi in the parathyroid glands. They stated that because of its lower sensitivity, the 99mTc-sestamibi scintigraphy is of limited value in preoperative evaluation in uremic patients with secondary hyperparathyroidism, but its significance grows up in localizing still hyperfunctioning glands left after the first operation.

PARATHYROID SCINTIGRAPHY WITH 99MTC – TETROFOSMIN

99mTc-tetrofosmin, another myocardial perfusion agent, was also used for visualizing parathyroid glands in scintigraphy, but the data for its use so far are limited. 99mTc-tetrofosmin shows some similarities with 99mTc-sestamibi although the way of accumulation is different and it is retained mainly in the cytosol than in the mitochondria of the target cells. When used for parathyroid scintigraphy 99mTc-tetrofosmin shows slower washout from the thyroid gland, which makes it unsuitable for single-isotope dual-phase scintigraphy.[43] Nevertheless, its sensitivity increases when used in the substractional protocol with SPECT.

Hiromatsu et al.[44] aimed to confirm the clinical significance of 99mTc-tetrofosmin scintigraphy for topic localization of the hyperfunctioning parathyroid glands in patients with PHPT. They concluded that this method was useful for the clinical practice and that the accumulation of 99mTc-tetrofosmin depended on the weight of the tumor and the level of PTH. Vallejos et al.[45] also studied the diagnostic value of 99mTc-tetrofosmin parathyroid scintigraphy in patients with PHPT. They stated that 99mTc-tetrofosmin was suitable for preoperative localization of abnormal parathyroid glands and that the early images obtained on the 15th minute were better than those on the 120th minute. 99mTc-tetrofosmin was washed out more slowly from the thyroid gland than 99mTc-sestamibi but both radionucleotides gave better results in comparison with pertechnetate Tl-201 substractional technique. Gallowitsch et al.[46] pointed out that 99mTc-tetrofosmin looked promising alternative of

99mTc-sestamibi with similar properties and capabilities of discovering parathyroid adenomas. Images obtained by SPECT showed clear advantages and better sensitivity in comparison with planar scintigraphy. SPECT should be used in cases with poor or no accumulation of the isotope when using single-isotope dual-phase protocol. In the areas with endemic goiter US should be performed to avoid misinterpretation of the results because of prolonged retention of the tracer in thyroid adenomas. Dual-isotope substractional scintigraphy with 99mTc-tetrofosmin /99mTc-pertechnetate and SPECT are highly sensitive methods for localization of parathyroid adenomas and their combination can further improve the diagnostic precision

Garcheva et al.[47] studied the diagnostic value of combined substractional planar scintigraphy with 99mTc-pertechnetate/99mTc-tetrofosmin (37 MBq and 740 MBq) with SPECT/CT. They concluded that substractional method was useful in patients after thyroid surgery when there were remnants of thyroid tissue and when there were more than one pathologically changed parathyroid gland. Mluchkov N et al.[48] performed 99mTc-sestamibi scintigraphy in patients with clinically and laboratory data for hyperparathyroidism and they concluded that visualization of the hyperfunctoning parathyroid glands correlated with the blood levels of the PHT and was less likely with levels less than 3 times above the upper range (less than 180 pg/ml). Kovatcheva R et al.[49] comparing the diagnostic value of US with color Doppler and 99mTc-sestamibi scintigraphy for localization of abnormal parathyroid glands in patients with PHPT and SHPT concluded that both methods were highly informative and easy to perform.

PROTOCOLS FOR NUCLEAR MEDICINE EXAMINATION OF PARATHYROID GLANDS

Generally, three protocols are used: single-phase dual-isotope subtraction, dual-phase single-isotope and combination of both. In single-phase dual-isotope procedure one isotope (99mTc-sestamibi) is used for visualization of abnormal parathyroid glands and another (123I or 99mTc-pertechnetate) for imaging only the thyroid gland. The latter images are digitally subtracted from the first ones and if there is still a residual radionucleotide accumulation seen on the subtracted images, a hyperfunctioning parathyroid gland can be suspected. Disadvantages of this method are the use of two radionucleotides, the necessity of full collaboration from the patient

to remain calm and motionless during the examination and the need of very precise positioning of the patient. In addition, there is an increased possibility for the presence of artefacts on the subtracted images. Single-isotope protocol is based on the different washout of the nucleotide from the thyroid and parathyroid glands. In this method, after a single injection of radionucleotide early images on 10-15 min and late images at 1.5 - 3 hours are obtained. There are very few studies directly comparing the results from single-isotope dual-phase method with single-phase dual-isotope subtractional technique and the results are conflicting. So far there is no clear confirmed advantages of one method over another. Over the past decades in nuclear medicine were introduced several new methods and devices like SPECT, SPECT/CT gamma cameras, 4D CT and PET/CT. Tomographic images (SPECT) and hybrid ones (SPECT/CT) allow visualization of smaller structures and determination of the precise anatomic localization of the abnormal parathyroid glands. Comparison of 4D CT, US and 99mTc-sestamibi SPECT/CT in localizing single-gland primary hyperparathyroidism showed that 4D CT outperformed the other two methods in terms of sensitivity (P=0.27) and specifity (P=0.01) and provided specific anatomic information and proved helpful in localizing target parathyroid glands of PHPT that were missed by traditional imaging.[50] There are insufficient data for using PET/CT in parathyroid imaging. PET with 18F-fluorodeoxyglucose (18F-FDG) was used with varying success. One study showed that 18F-FDG PET was more sensitive but less specific than 99mTc-sestamibi SPECT. Other authors reported very low sensitivity for detecting abnormal parathyroid glands. Using PET with 11C-methionine in parathyroid examination has been studied in some patients but because of the very short half-life of 11C-methionine, only 20 min, its use is limited only to nuclear medicine centers located near to a cyclotron

CONCLUSIONS

There is general consensus that the best imaging procedure for localization of the abnormal parathyroid glands so far is the scintigraphy with 99mTc-sestamibi or 99mTc-tetrofosmin. With all its advantages and disadvantages it is characterized with sensitivity and specificity exceeding those of ultrasound, CT, MRI or even PET/CT. Combining scintigraphy with the other imaging techniques increases the precision for topic localization but

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it still remains the best single method to visualize hyperfunctionig parathyroid glands. Multidisciplinary approach including nuclear medicine specialists, radiologists, endocrinologists and experienced surgeons is needed to achieve proper treatment of patients with PHPT and SHPT.

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Методы нуклеарной медицины при оценке аномальных паращитовидных желез у пациентов с первичным и вторичным гиперпаратиреозом

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Считавшееся редким заболеванием в прошлом, частота проявления первичного гиперпаратиреоза (ПГПТ) резко повысилась за последние тридцать лет после введения рутинного определения кальция и в наши дни считается, что она составляет 42 случая на 100 000 населения. До последнего времени наиболее часто встречающимся поражением у пациентов с ПГПТ являлась единичная паратиреоаденома, возникающая у 85-90% пациентов, а в остальных 10-15 % случаев наличествует первичная гиперплазия паращитовидных желез. В наши дни наиболее распространённым хирургическим методом является минимально-инвазивная паратиреоидэктомия, ввиду минимальных послеоперационных осложнений и сокращения длительности операции. Для успешного проведения данной процедуры необходима тщательная предоперационная локализация аномальных паращитовидных желез и ввиду этого предоперационная паратиреоидная образная диагностика приобрела такое большое значение. Основной причиной для тщательной локализации аномальной паратиреоидной ткани перед операцией является обстоятельство, что расположение желез может быть действительно непредсказуемым. Сложилось общее мнение, что наилучшей техникой образного исследования для определения аномальных паратиреоидных желез является предоперационная сцинтиграфия с использованием ^{99m}Тс – sestamibi или ^{99m}Tc-tetrofosmin. Она отличается высокой степенью чувствительности и специфичностью, превышающих аналогичные показатели ультразвуковой диагностики, КТ и ЯМР. Совместное применение сцинтографии с другими методами образных исследований увеличивает точность локализации.

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