

Revision Parathyroidectomy Guided by Intraoperative Radionuclide Imaging

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Abstract

Background: Technetium-99m sestamibi scintigraphy has become one of the most popular techniques for localization of the parathyroid gland after failure of primary neck exploration.

Objective: To examine the efficacy of sestamibi with the hand-held gamma ray detecting probe for the identification of parathyroid adenomas during revision parathyroidectomy.

Methods: We reviewed six cases of probe-assisted neck exploration for parathyroid lesions following unsuccessful primary exploration.

Results: In all cases the pathologic glands were successfully detected and removed.

Conclusions: With careful planning, a gamma ray detecting probe can be used optimally 2–3 hours after technetium-99m sestamibi injection. The probe is efficient, easy and convenient to use.

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Several new, sophisticated imaging modalities have been developed to increase the detection rate of parathyroid adenomas at the first operative setting. Nevertheless, the rate of identification has remained about 95% – not much better than that achieved by the surgeon alone without any imaging help. This leaves around 5% of patients who require repeated surgery [1]. The need for re-exploration of the neck in these failures combined with the recent trend among both patients and surgeons favoring minimally invasive surgery over the traditional operative technique [2] have made the choice of imaging technique a crucial preoperative step.

Computed tomography and magnetic resonance imaging have been assessed as possible tools for identifying adenomas, but both were found to be less useful than ultrasound and sestamibi scan [3]. Studies have shown that technetium-99m sestamibi scintigraphy accurately detects parathyroid adenomas, hyperplasia and carcinomas in 50–90% of cases [4–8]. Over the years it has become one of the techniques used for localizing the parathyroid gland, especially after an unsuccessful neck exploration.

We describe our experience with the intraoperative application of sestamibi using the hand-held gamma ray detecting probe for the identification of parathyroid adenomas and hyperplasia.



Figure 1. Gamma detecting probe with two types of collimators for intraoperative parathyroid detection.

Materials and Methods

The Neoprobe 1000 (Neoprobe Corp, Dublin, OH, USA) [Figure 1] and Gammed II (Europrobe-Eurorad C.T.T., France) are portable GDPs that measure gamma radiation intraoperatively. The probes relay the radioactivity through a pre-amplifier and signal processor that produce both an audible signal and a digital display of radioactive counts. The sound generated by the GDP may be eliminated (squelched), so that the background radioactivity in normal tissue is documented only by digital display. When the sound is squelched, the signal processor produces a perceptible sound only when the radioactivity reaches average level plus three standard deviations above background.

^{99m}Tc sestamibi parathyroid scanning is performed prior to revision parathyroidectomy, as part of the preoperative evaluation. Immediately following intravenous injection of 20 mCi (7,400 MBq) ^{99m}Tc sestamibi, a planar scan is done using an Elscint Gamma camera with a parallel-hole energy collimator and 800 K count image of the neck. Scanning is repeated at 15, 60 and 180 minutes

GDP = gamma ray detecting probe

^{99m}Tc = technetium-99m

Table 1. Data on six patients with parathyroid pathology treated by revision parathyroidectomy with the GDP

Patient	Gender/Age (yrs)	Pathologic diagnosis	Time from prior surgery (mos)	Ca/p levels (mg/dl)	Parathyroid-hormone level (pg/ml)	Intraoperative localization	MRI/CT scan localization	Ultrasound localization
1	F/60	Parathyroid adenoma	10	10.7/2.9	108	Upper pole, right thyroid	–	–
2	F/71	Parathyroid adenoma	30	13.2/2.5	189	Carotid sheath	–	2 cm mass adjacent to carotid sheath
3	M/26	Parathyroid hyperplasia	24	10.9/4.6	1,400	1. Retrosternal 2. In SCM	Retrosternal, adjacent left pole, thyroid gland	–
4	M/79	Parathyroid adenoma	11	11.9/3	177	Left lower pole of thyroid	Mediastinum between subclavian artery and vein	Undetected
5	F/53	Parathyroid adenoma	8	12.1/3.0	170	Left lower pole of thyroid	–	Undetected
6	F/74	Parathyroid hyperplasia	10	12.7/2.6	116	Right lower pole #38; mediastinum	–	Undetected

SCM = sternocleidomastoid muscle, Ca/p = calcium/phosphorus

after injection, and the time elapsed from injection to maximal visualization of the parathyroid gland is recorded.

In cases where the lesions are covered by the thyroid gland or the adenoma does not retain the radionuclide, free pertechnetate 10 mCi is injected intravenously and the thyroid is scanned; by subtracting this scan from the sestamibi scan, parathyroid adenomas can be located. On the day of surgery, the patient is injected with 5 mCi (1,850 MBq) ^{99m}Tc sestamibi to ensure that the time to visualization after re-injection overlaps the time of neck exploration.

The criteria for a positive scan are as follows:

- Focal retained accumulation of the radionuclide at the delayed images in the neck or mediastinum
- Foci behind the thyroid gland uncovered by the double-phase study (^{99m}Tc sestamibi followed by ^{99m}Tc pertechnetate) in lesions that did not retain the radionuclide at the delayed images of the first phase.

During surgery, a standard visual and manual exploration of the operative field is performed, followed by a second examination with the GDP. Background radioactivity measured from normal adjacent tissue is recorded, and then the audible signal is squelched and the operative field carefully surveyed again to detect uptake of ^{99m}Tc sestamibi above background. Gamma probe counts are recorded for all tissues. All operative specimens are sent for pathologic evaluation.

Patients

Our department performs approximately 70 parathyroidectomies a year. Unsuccessful primary intervention, despite the routine performance of CT, occurs in two to three cases yearly. In addition, about two or three revision cases are referred to us yearly from other centers in Israel.

During 1997–1998, intraoperative GDP was performed in six consecutive patients with biochemical evidence of hyperparathyroidism in whom ^{99m}Tc-sestamibi scan was positive for parathyroid adenoma or hyperplasia following a negative neck exploration. The patients' medical history and relevant biochemical blood tests, imaging technique results and intraoperative findings are detailed in Table 1. Parathyroid adenomas were found, treated, and cured in patients 1, 2, 4 and 5. Patients 3 and 6 had hyperplasia and their cases were therefore more complicated. They are described in detail below.

Patient 3

This 26 year old man had been treated with hemodialysis for chronic renal failure since the age of 7 years. At age 24 he underwent neck exploration during which four parathyroid glands were detected. Three and a half were removed, and half a gland was implanted in the sternocleidomastoid muscle. However, the lack of a significant postoperative change in blood calcium level raised the suspicion of the presence of more parathyroid glands. This was confirmed by CT and MRI scans that showed a retrosternal parathyroid gland adjacent to the left pole of the thyroid gland. Re-exploration with the GDP detected the parathyroid glands: the previously implanted half-gland in the sternocleidomastoid muscle and a fifth, retrosternal gland, which was removed via the neck with the help of the radioactive probe, without sternotomy. Calcium level decreased postoperatively to within acceptable limits.

Patient 6

A 74 year old woman presented with hypercalcemia and high parathyroid hormone levels. Primary neck exploration was negative. Neck ultrasound, performed prior to a second exploration, was negative, and ^{99m}Tc sestamibi scan was therefore performed. The

latter demonstrated two suspected parathyroid sites, one on the right lower pole of the thyroid and the other in the upper mediastinum. Re-exploration with the GDP detected both these lesions. The first parathyroid adenoma was removed easily, but the second lesion, probably located within the upper mediastinum, was not amenable to the cervical approach. Sternotomy was not performed because the patient had not given consent for this procedure. The patient's postoperative recovery was uneventful, but her calcium levels remained elevated; she was scheduled for a sternotomy to remove the second adenoma.

Discussion

Revision surgery for persistent hyperparathyroidism is associated with additional difficulties and increased morbidity, compared to primary surgery. Failure of the first operation means that not all the parathyroid lesions were detected and removed, or that the surgeon failed to remove the ectopic adenoma or one of the supernumerary glands.

About 5% of parathyroidectomies require re-exploration in spite of the perioperative use of imaging modalities to identify the pathologic lesions. Before considering a second exploration, the surgeon must reevaluate the blood biochemistry findings and review the histologic slide from the first operation. Thereafter the parathyroid glands are scanned using one of several methods: ultrasound, CT, MRI, selective venous sampling, or scintigraphy. In a preoperative ultrasonography study in selected patients after unilateral neck exploration, Preventza et al. [9] found that 88% of the patients were true-positives. They concluded that if a single enlarged parathyroid gland is found, unilateral ultrasound-guided neck exploration is safe and economical. Otherwise, bilateral exploration is recommended. Rotstein et al. [10] compared preoperative MRI, selective venous sampling, sestamibi and ultrasound. Sensitivity was 66%, 50%, 50% and 17%, respectively. CT proved to be a non-localizing technique, and none of the localizing tests were particularly sensitive in detecting the parathyroid glands in primary surgery failures.

Several recent reports have described the use of intraoperative GDP for the detection and localization of bone lesions [11–13] and lymphatic metastatic spread of papillary carcinoma of the thyroid [14] and of the parathyroid glands in the pediatric age group [14,15]. Martinez and co-workers [15] emphasized its advantages for primary neck exploration in children after parathyroid pathology is established. Costello and Norman [2] used the GDP for minimally invasive unilateral neck exploration in cases of solitary parathyroid adenoma. Casara and colleagues [16] found combined scintigraphy with the gamma probe and ultrasound to be helpful during primary surgery in patients with hyperparathyroidism, particularly in those with a solitary parathyroid adenoma. Arici et al. [17] observed that the success rate of this combination was approximately 95%, whereas ultrasonography alone had a sensitivity of only 65%. Other researchers presented similar results [18,19]. In patients with hyperplasia the use of imaging is debatable. There is also disagreement regarding which imaging modality has superior detection capability – ultrasound or sestamibi [20].

The present study reports on the application of the GDP for the detection and localization of the parathyroid glands in revision surgery for parathyroid disease. GDP examination of the specimens after removal as well as the surgical site in the operating room before wound closure confirmed that the gland was removed with minimal delay. The technique proved beneficial to all six patients, four with parathyroid adenoma and two with parathyroid hyperplasia. In patient 3, with hyperplasia, the use of GDP facilitated the quick detection of a previously implanted half-gland, as well as a fifth parathyroid gland that otherwise might have remained undetected.

The time of injection of sestamibi in relation to the surgery must be carefully planned to account for the dynamics of the dissemination and evacuation of the material from the bloodstream. Our patients with adenoma showed a maximal concentration of the radionuclide in the pathologic parathyroid gland 2–3 hours after injection, in agreement with the findings of others [5,6,15]. Obviously, this intraoperative technique is limited to patients with a positive ^{99m}Tc sestamibi scan prior to exploration. This is true for most patients. In patients with negative scans, other imaging techniques should be considered.

Our department combines the use of scintigraphy and ultrasound preoperatively, and uses GDP guidance intraoperatively during neck re-exploration. The ultrasound is incorporated into the initial evaluation because it is non-invasive and inexpensive and has a high yield. While some authors recommend CT or MRI in patients after a failed surgical attempt [3], we no longer do so owing to the high re-exploratory yield in our center for intraoperative GDP. It should be noted that the two patients in our study who were referred from other centers underwent the initial examination according to the practices of that facility.

In summary, this study describes the application of a portable gamma detecting probe for neck re-exploration in six consecutive patients with parathyroid pathology. In all the cases the diseased gland was identified and removed, resulting in a decrease in calcium levels postoperatively. We found the probe very efficient, easy and convenient to use.

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