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My Thoughts / My Surgical Practice

My surgical practice: Radioguided parathyroid surgery, how and why we use it

Radioguided parathyroid surgery has been performed by our group of endocrine surgeons for over 20 years in the treatment of hyperparathyroidism. It involves the use of pre-operative intravenous injection of Tc99 m sestamibi and intraoperative measurement of radioactive counts from the parathyroid glands using a handheld gamma probe. We utilize this technique on all patients undergoing parathyroid surgery for primary, secondary, and tertiary hyperparathyroidism by endocrine surgeons at our institution. We will describe how and why we strongly believe that this technique plays a central role in successful parathyroid surgery.

How

Eligible patients. We utilized radioguided parathyroid surgery in all patients undergoing an operation for hyperparathyroidism with the exception in cases of pregnancy. Prior sestamibi imaging is not necessary for successful intraoperative radioguided approach. We have previously shown that this technique retains its utility and effectiveness even in patients with negative, non-localizing, preoperative sestamibi scans.[1] Aliquots of Tc99 m sestamibi are ordered and prepared by the department of nuclear medicine 24 hours in advance.

Radiotracer Injection. Patients are injected with 10mCI of Tc99 m sestamibi through an existing peripheral intravenous catheter in the pre-operative holding area 30 minutes prior to surgery performed by a nuclear medicine radiology technician (Image 1). This dose is utilized for both adults and children. No radiologic imaging is obtained after injection. Since surgical start times vary and operating room delays are not uncommon, the timing of sestamibi injection has occasionally varied from the aforementioned protocol of 30-min-prior-to-incision: it has been given as early as 4 hours before surgical start and as late as intraoperatively after skin incision has been made, with good success in each scenario. In each instance, the radioactive counts are detectable.

Equipment. There are many different gamma probes available. We utilize the handheld, wireless Neoprobe 2000© with a collimated tip and Bluetooth® connection (Devicor Medical Products, Inc. 2021. Cincinnati, OH) (Image 2). We cover the gamma probe with a sterile, fitted plastic sheath. The base monitor is positioned in a location to facilitate easy viewing by the surgical team, generally situated at the foot of the bed.

Background and In Vivo counts. After positioning, prepping, and draping, a background count is set on the thyroid isthmus and recorded on the base monitor (Image 3). During the dissection

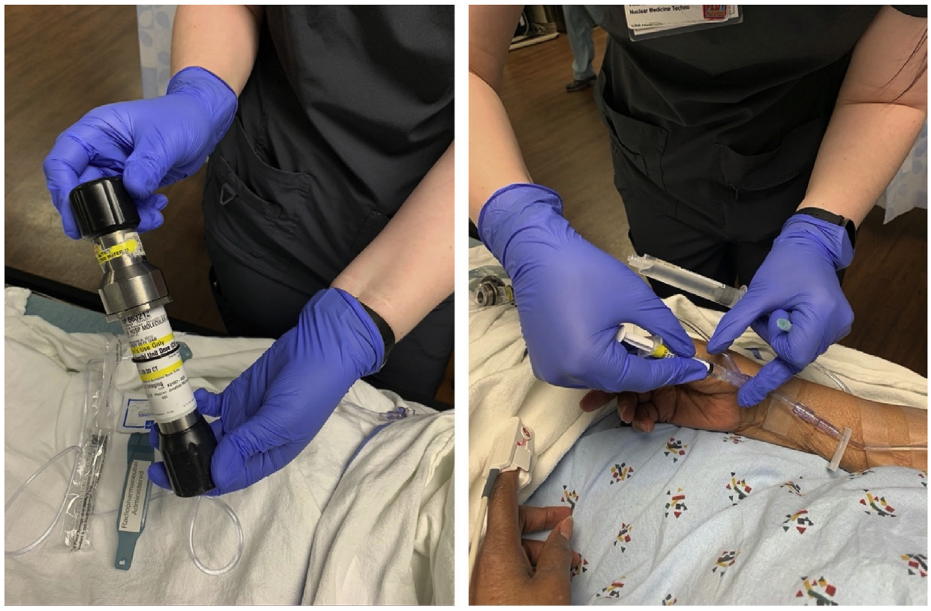

Image 1. Peripheral injection of Tc99 m sestamibi in the pre-operative holding area by nuclear medicine radiology technician.

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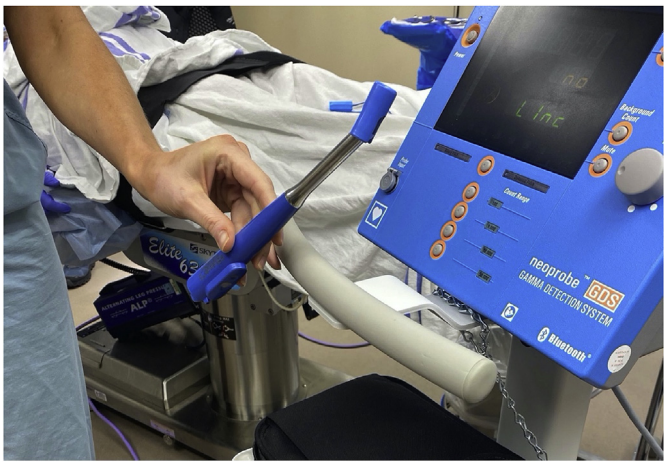

Image 2. Neoprobe 2000© with a collimated tip and Bluetooth® connection (Devicor Medical Products, Inc. 2021. Cincinnati, OH).

to identify the parathyroid glands, the gamma probe is rarely used in-vivo for localization since most parathyroid glands can be found in their normal anatomic locations. However, in cases where the abnormal parathyroid gland(s) cannot be located after thorough operative exploration, we scan the field with the gamma probe to detect areas with radioactivity counts higher than the background count to facilitate in-vivo localization in particularly challenging cases. The gamma probe is especially useful for identification of intrathyroidal parathyroid glands, allowing a limited and focal thyroidotomy with enucleation of the parathyroid gland and preservation of thyroid parenchyma.

Ex Vivo counts. Once the abnormal parathyroid gland(s) are found and resected, the gland is placed on top of the gamma probe with the collimated detector tip directed to the ceiling (to minimize interference of radioactive counts from the patient's body). The radioactive counts measured from the resected gland or specimen is termed the “ex vivo count” (Image 4). An ex-vivo count that is greater than or equal to 20% of the background count is confirmatory of abnormal parathyroid tissue.[2] Generally, adenomas have

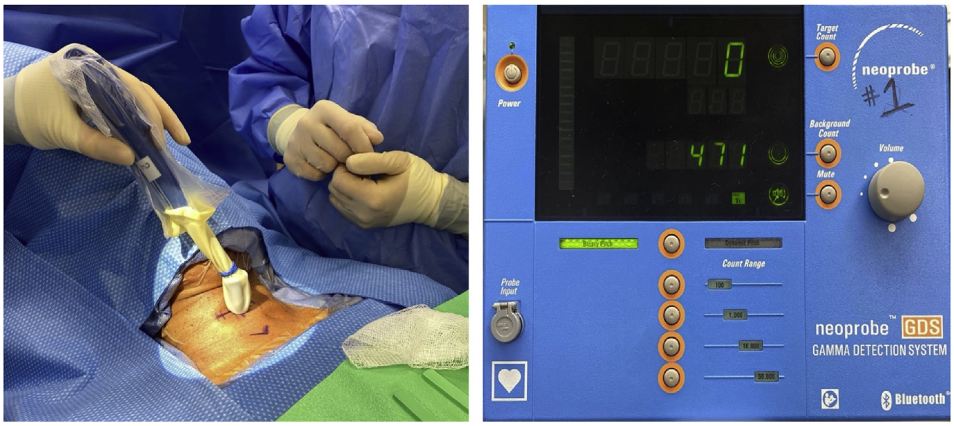

Image 3. Setting background count on thyroid isthmus.

Image 4. Ex-vivo counts of specimen and application of >20% rule.

significantly higher counts than hyperplastic parathyroid glands (>200% of background count, as demonstrated in Image 4). Other tissues such as lymph nodes, thyroid, fat, muscle, and normal parathyroid glands are almost always <20%.

Special intraoperative considerations. The gamma probe measures the gamma irradiation directly at the tip of the probe. Thus, the surgeon must be cognizant of the angulation of the probe. The salivary glands as well as the heart exhibit high levels of sestamibi uptake. Therefore, there are often high counts when the probe is directed at an angle toward the mediastinum in search of a parathyroid gland within the thymus, or if directed toward the angle of the jaw in search of an undescended parathyroid gland. In these circumstances, it is good to triangulate the probe from different directions to confirm high counts.

Safety. Sestamibi has been safely administered to patients for decades. It was initially used for cardiac imaging due to its preferential uptake in tissues with an abundance of mitochondria. This technique is also safe for operating room personnel and individuals handling the resected parathyroid tissue. In a comprehensive study measuring radiation exposure amongst operating room team members during radioguided parathyroidectomy, all personnel had exposure levels much lower than expected and within safe ranges as set by hospital and operating room policies.[3]

Additional Operative Details. It is our practice to not routinely obtain preoperative localization studies and to perform a bilateral neck exploration. We obtain 4D CT imaging in reoperative cases. In addition to a utilization of a radio-guided approach to confirm hyperplastic parathyroid tissue resection, all patients have intraoperative PTH levels drawn at 5, 10, and 15-min post-resection to guide termination of operation. We do not send frozen sections to pathology for intraoperative review.

Why

Radioguided parathyroid surgery has the following benefits for patients undergoing surgery for hyperparathyroidism.

1. Primary, secondary and tertiary hyperparathyroidism: effective for all.[4]
2. Reoperative parathyroidectomy: can facilitate parathyroid localization in scarred tissue beds.[5]
3. All ages eligible including children and elderly patients.[6]
4. Does not require positive imaging studies. Can be the sole intraoperative adjunct.
5. Equipment is generally already available in OR, as it is used for sentinel lymph node biopsies in breast and skin cancer operations, requiring minimal to no additional operational costs.
6. Multi-gland disease/asymmetric hyperplasia: can help delineate which parathyroid glands are more active in the setting of hyperplasia.[7]
7. Mediastinal parathyroid adenomas: can be used in conjunction with video-assisted or robotic-assisted thoracoscopic surgery to localize and resect.
8. Debulking autotransplanted parathyroid implants in the forearm or within neck muscles to ensure parathyroid tissue within specimen and for in-vivo scanning of debulked area to identify residual tissue.[8]
9. Facilitates localization of ectopic parathyroid gland especially in the thyroid and thymus.[9]
10. Limits the time used on waiting for intraoperative frozen section or PTH washings to confirm presence of parathyroid tissue in resected specimens.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2021.06.001.

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