The Ectopic Parathyroid Adenoma

A Cost Justification for Routine Preoperative Localization With Technetium Tc 99m Sestamibi Scan

Robert A. Sofferman, MD; Muriel H. Nathan, MD, PhD

Objectives: To evaluate the cumulative costs of failure to identify the ectopic parathyroid adenoma when exploration without preoperative localization is performed and to compare these costs with the expenses of routine preoperative localization in every patient.

Design: A consecutive series of 59 patients with primary hyperparathyroidism studied with preoperative scans using technetium Tc 99m sestamibi and ultrasound was submitted to a cost analysis. A subset of 5 cases of ectopic adenomas, presumed to be unidentifiable on routine surgery, was similarly analyzed.

Setting: Academic tertiary referral center.

Methods: The operative, anesthesia, hospitalization, imaging, and physician reimbursement costs of a failed exploration are compared with the costs of preoperative technetium Tc 99m sestamibi and ultrasound scans in every patient.

Results: Two cases of mediastinal parathyroid adenomas in this consecutive series of 59 patients were given a theoretical cost, including hospitalization, physician reimbursement, and anesthesia fees. These costs were based on a failed cervical exploration and extracted from the record of an actual patient who underwent such a process at the University of Vermont, Burlington, in 1995. In addition, the records of 2 patients with intrathyroidal adenomas were submitted to the same theoretical cost analysis with the exception that these patients were assumed to have adenomas that could be discovered after prolonged cervical exploration and thyroid lobectomy. The net management and imaging costs for 4 cases of ectopic parathyroid adenomas undergoing theoretical failed exploration are compared with the cost of obtaining routine technetium Tc 99m sestamibi and ultrasound scans for each of the 59 patients.

Conclusion: The added cost of protracted or failed cervical exploration nearly neutralized the costs of a routine preoperative localization with technetium Tc 99m sestamibi and ultrasound scans.


PREOPERATIVE localization in the surgical management of primary hyperparathyroidism has its advocates and opponents. Arguments against the use of thallium-technetium scans have been well supported because of low yield and added cost.1,2 Likewise, ultrasound scans, although relatively inexpensive, have not demonstrated significant reliability and accuracy to warrant use as a predictor of anatomical location of adenomatous parathyroid glands.3-5 Previous experience6 with a 10-MHz probe in a small comparison pilot project suggested that, in experienced hands, a high correlation of size and location can be rendered with ultrasound scans. Since presentation of those data, only 57% of subsequent patients have been accurately evaluated with ultrasound scans. This may have been a result of a lower-resolution (7.5 MHz) transducer or change in ultrasonography staff experience.

The technetium Tc 99m sestamibi scan is a widely used and accepted localization modality, having been conceived initially by Coakley et al7 in 1987 and applied clinically from 1992 to the present. Most adequate series4,5,8-13 report an 85% to 90% success rate in adenoma localization. In 1996, Sofferman et al6 reported experience with 33 scans and demonstrated a 90% sensitivity, including accurate preoperative identification of the double and ectopic adenomas. The effi

This article is also available on our Web site: www.ama-assn.org/oto.
PATIENTS AND METHODS

Of the first 59 consecutive cases of primary hyperparathyroidism addressed by the authors at the University of Vermont, Burlington, from 1992 to 1996 and studied by technetium Tc 99m sestamibi scan, 3 remote mediastinal and 2 intrathyroidal adenomas were identified preoperatively and successfully removed. The last 35 of these patients were also studied with ultrasound imaging, 10 with a 10-MHz linear transducer and 25 with a 7.5-MHz probe. Ultrasound imaging was initially used in the 10 cases to test its efficacy in correlating volumetric estimates with actual size after tumor removal. During this study, a complementary benefit of ultrasound imaging using technetium Tc 99m sestamibi in the identification of intrathyroidal adenomas became apparent.

The scan requires an intravenous infusion of 20 to 25 mCi of technetium Tc 99m sestamibi and sequential cervicothoracic scans at 15 minutes and 2 hours. The patient can be transported to the ultrasonography unit during the interval between the 2 technetium Tc 99m sestamibi scans, and the ultrasound imaging can easily be performed in the same geographical area of the hospital and during the same time devoted to comprehensive imaging. In our experience, an intrathyroidal parathyroid adenoma can be identified within the thyroid parenchyma on an ultrasound image in some circumstances. In other instances when a focal adenoma is suggested at the thyroid axis on the technetium Tc 99m sestamibi scan and the ultrasound scan fails to confirm the presence of an enlarged parathyroid mass extrinsic to the thyroid, an intrathyroidal adenoma should be suspected.

None of the 5 cases of ectopic adenomas in this study were identifiable on routine cervical exploration. Two cases of intrathyroidal adenomas were correctly diagnosed preoperatively by scans, and, in each instance, the tumor was discretely removed from the center of the thyroid gland without the need for thyroid lobectomy. In 1 case, color flow Doppler imaging depicted a unique single vascular pedicle, which helped differentiate the parathyroid adenoma from a simple thyroid adenoma (Figure 1). The 3 mediastinal adenomas were all beyond the reach of cervical surgical techniques, including bilateral thymectomy. In each instance, a cervical approach was attempted first and abandoned in favor of upper median sternotomy after the adenoma mass was found to be unretrievable from the mediastinum. These were all combined cervicothoracic procedures with biopsy confirmation of at least 1 normal gland in the neck. All 5 patients became eucalcemic after resection of the ectopic parathyroid tumor. Other ectopic adenomas within the thymus and retroesophagus in this 59-patient series were not considered appropriate to the cost analysis since the tumors were within the realm of identification by systematic cervical exploration.

One patient in this series was incorrectly diagnosed as having a double adenoma on the basis of the scan and should have been managed conventionally as a case of diffuse hyperplasia with subtotal parathyroidectomy. Failure to correct the initial hypercalcemia in this case was listed as a cost deficit of the technetium Tc 99m sestamibi scan. However, progressive experience with the technetium Tc 99m sestamibi scan and its shortcomings in the management of parathyroid hyperplasia would today mandate bilateral comprehensive cervical exploration and likely surgical success.

There are many hidden costs in consideration of failure to identify an ectopic parathyroid adenoma at cervical exploration. The average surgical search time before the procedure is abandoned is 3 to 5 hours. This entire surgical exercise is futile, and some additional separate procedure is always required. The cost analysis is based on 3 premises: (1) Failure to identify the 3 mediastinal adenomas would have generated a protracted surgery, requiring an extended futile cervical search of the thymus, bilateral carotid sheath, and retroesophagus, and digital exploration of the upper mediastinum. (2) Failure to identify the 2 intrathyroidal tumors would have required an extensive bilateral exploration, also protracted in time. A thyroid lobectomy on the side of an unidentified superior parathyroid gland may be performed as a last resort on the side of the adenoma, but in many instances this will not be accomplished at the initial procedure. (3) After failed exploration, a comprehensive imaging program would be developed to make certain that the tumor was identified at the correct anatomical position. In many centers, this imaging program would include both cervicothoracic computed tomographic and magnetic resonance imaging assessment. In a series of 174 consecutive revision procedures, Rodriguez et al18 recommended ultrasound, technetium Tc 99m sestamibi, and magnetic resonance imaging scans as the ideal imaging combination before revision surgery. Since these imaging programs are not routinely obtained in the initial management schema, they must be considered an added expense. Some investigators argue that technetium Tc 99m sestamibi scan and either computed tomography or magnetic resonance imaging are adequate before subsequent exploration of a previously failed cervical parathyroidectomy. A spectrum of commonly performed localization imaging studies was outlined in the cost analysis to represent the most conservative to the most elaborate programs.

In the failed exploration, the prolonged surgical time generates increased operating room (OR) rental fees, additional anesthesia charges, and a surgical fee often with modifiers attesting to the added degree of surgical difficulty. In addition, preoperative localization allows better surgical planning and a 30-minute reduction in OR time. When considering costs, this OR efficiency should be a financial credit for the scans. Casas et al20 reported a 45-minute saving in OR time as a result of the technetium Tc 99m sestamibi scan. Our experience mirrors that published by Wei and Burke,22 averaging approximately 30 minutes of reduced surgical time. This more conservative figure was used in the cost analysis (Table 1).

Last, the technetium Tc 99m sestamibi scans appear to allow identification of single and double parathyroid adenomas with a high degree of accuracy. Thus, if a single adenoma is identified and removed with confirmation, by pathological examination of a frozen section, of a normal second ipsilateral gland, the chance that a second adenoma will be missed is extremely low.10 Like wise, 1 adenomatous and 1 normal gland confirmed by examination of a frozen section likely excludes diffuse parathyroid hyperplasia. By using technetium Tc 99m sestamibi scan and this method of pathological assay, only 2 frozen sections are required, rather than the traditional 4-gland assay with bilateral nonimaged exploration. These costs should be credited in favor of preoperative localization (Table 1).
cacy of technetium Tc 99m sestamibi has become an accepted standard, although detractors still argue that its cost does not justify routine use in centers where an experienced parathyroid surgeon can successfully manage and cure primary hyperparathyroidism with efficient bi-
lateral cervical exploration. However, parathyroid adenoma can develop in ectopic locations beyond the identification skills of even the most experienced endocrine surgeon and is the most common cause of failed parathyroid surgery. When the adenoma is located in the deep anterior mediastinum, aortopulmonary window, or posterior mediastinum, or within the substance of the thyroid gland, it usually will not be detected by conventional cervical exploration. Many studies11,14-17 have confirmed the efficacy of technetium Tc 99m sestamibi scans in identification of mediastinal adenomas. The failed cervical exploration must be factored into a cost analysis of preoperative localization.

The focus of this inspection of cost is on the ectopic or unusually located parathyroid adenoma. None of the patients in this series had undergone prior parathyroid surgery. These were consecutive cases managed in the same

| Table 1. Unit Costs and Savings With Technetium Tc 99m Sestamibi Scanning* |
|-------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
|                               | Unit costs, $       |                     |                     |                     |                     |                     |
|                               | Technetium scans    | 460                 |                     |                     |                     |                     |
|                               | Ultrasound scans    | 233                 |                     |                     |                     |                     |
|                               | Subtotal            | 693                 |                     |                     |                     |                     |
|                               | CT scans            | 1186                |                     |                     |                     |                     |
|                               | MRI scans           | 1726                |                     |                     |                     |                     |
|                               | Subtotal, per Case  | 191                 |                     |                     |                     |                     |
|                               | Unit savings, $†    |                     |                     |                     |                     |                     |
|                               | 30 min of OR time   | 75                  |                     |                     |                     |                     |
|                               | Anesthesia fee, 2 units | 116             |                     |                     |                     |                     |
|                               | Subtotal, per Case  | 191                 |                     |                     |                     |                     |
|                               | Frozen section fees |                     |                     |                     |                     |                     |
|                               | Processing          | 33                  |                     |                     |                     |                     |
|                               | Interpretation      | 67                  |                     |                     |                     |                     |
|                               | Subtotal            | 100                 |                     |                     |                     |                     |
|                               | Subtotal, per case (2 frozen sections per case) | 200 |                     |                     |                     |                     |

*Unit costs for technetium Tc 99m sestamibi scans (technetium scans and ultrasound scans are routine preoperative imaging. Computed tomographic (CT) and magnetic resonance imaging (MRI) scans are of the chest and neck.
†OR indicates operating room. The per-case savings in frozen section fees reflects the need for 2 fewer frozen section samples to be taken. Each 15-minute time unit of general anesthesia reflects a $58 charge.

| Table 2. Cost Analysis of Failed Explorations and Additional Requirements of Hemithyroidectomy |
|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|
| Hospitalization, $                                    | 6903                                                  | NA                                                     | NA                                                     | 1069                                                  | 2738                                                  | 3808                                                  | 3095                                                  |
| Physician reimbursement, $                             | 3307                                                  | 366                                                    | 2941                                                   | 138                                                   | 2933                                                   | 3071                                                   | -130                                                   |
| Total                                                  | NA                                                     | NA                                                     | NA                                                     | NA                                                     | NA                                                     | NA                                                     | 1323                                                   |
| Failed Parathyroid Exploration*                        |                                                     |                                                         |                                                         |                                                         |                                                         |                                                         |                                                         |
| Physician reimbursement, $†                             | 2165                                                  | 130                                                    | 2035                                                   | 50                                                    | 989                                                    | 1039                                                   | 996                                                    |
| Anesthesia, $†                                         | NA                                                     | NA                                                     | NA                                                     | NA                                                     | NA                                                     | NA                                                     | 232                                                    |
| Total, $                                               | NA                                                     | NA                                                     | NA                                                     | NA                                                     | NA                                                     | NA                                                     | 1228                                                   |

*These data are based on an actual case of ectopic adenoma in June 1995. NA indicates data not applicable.
†This figure reflects 4 time units at $58 per unit. Each 15 minutes of anesthesia represents 1 time unit.
facility by 1 surgeon (R.A.S.) with a uniform imaging technique. One patient with an undescended inferior parathyroid gland with adenoma formation underwent a failed exploration and was referred to one of us (R.A.S.) for subsequent exploration. Comprehensive magnetic resonance imaging and computed tomographic scans were required, but the initial technetium Tc 99m sestamibi scan clearly revealed a suspect lesion in the upper part of the neck adjacent to the submandibular gland. The case was not included in the present series since it was a revision procedure. However, it offered an excellent opportunity to investigate the cost of hospitalization and physician fees in the failed exploration (Table 2). The net reimbursement for this extended failed exploration included variable cost (salaries and benefits of hospital staff), overhead and fixed costs, and contract reduction. A similar assessment for physician and anesthesia reimbursement for thyroid lobectomy was included and was representative of the same time frame and commercial insurance carrier.

The technetium Tc 99m sestamibi scan has many advantages, among which are (1) shortened OR time, (2) identification of ectopic parathyroid adenoma, (3) opportunity to recommend a 1-stage combined cervicothoracic procedure when the tumor is in the mediastinum, and (4) reduced morbidity with unilateral focused surgery in most routine cases. The strongest criticism is the purported added cost of preoperative imaging and, in some series, inconsistent localization performance.22

The efficiency of technetium Tc 99m sestamibi scans in localizing parathyroid adenoma has been documented by many investigators2 since its introduction in 1989. Although directed surgery as a result of preoperative localization can substantially reduce the total operating time, some authors23,24 have argued that the savings in OR efficiency do not offset the cost of the imaging studies. When considering expenses, one must investigate the consequences of a failed exploration. This unbiased consecutive series of 59 patients with primary hyperparathyroidism contains 3 cases of ectopic mediastinal adenomas that would not have been identified on cervical exploration. Two cases of intrathyroidal adenomas were suspected on the basis of the previously described localization algorithm, and the tumors were resected successfully at the initial exploration. Intrathyroidal adenomas are difficult to diagnosis without imaging studies. In the first 1000 patients with hyperparathyroidism who underwent surgical exploration at Massachusetts General Hospital, Boston, 6 procedures failed to identify the adenoma at initial surgery. Each of these tumors eventually proved to be within the thyroid gland.25 Surgeons who do not use routine preoperative localization may suspect an intrathyroidal position when a superior gland cannot be identified after an exhaustive exploration. Often, an ipsilateral thyroid lobectomy is performed in hopes of identifying the occult tumor, but one may elect to abort the procedure and perform localization studies in advance of a subsequent exploration. Our cost projections assumed that a thyroid lobectomy will be performed at the same procedure and included some of the anticipated expenses (Table 2 and Table 3). The total savings based on accurate preoperative localization was calculated according to the following formulas:

- 59 Patients − 5 Patients Without Localization
  Scans = 54 Patients
  54 Patients × $391 Savings per Patient = $21,114.

A failed exploration mandates comprehensive imaging of the cervicothorax. Technetium Tc 99m sestamibi, computed tomographic, and magnetic resonance imaging scans may be performed both to identify a likely ectopic position with the greatest degree of confidence in advance of a second exploration. This cost analysis estimated some potential savings as a result of using technetium Tc 99m sestamibi scans as a preoperative localization modality in every patient to detect the occasional ectopic adenoma beyond the examining hand of the surgeon.

Our conventional algorithm for surgical management of primary hyperparathyroidism is based on pre-
operative technetium Tc 99m sestamibi scan and ultrasound scan localization (Figure 2). Despite the disappointing efficacy of ultrasound scans in identifying cervical parathyroid adenomas, it is the best method of detecting an intrathyroidal adenoma. Magnetic resonance imaging scans often fail to demonstrate intrathyroidal parathyroid adenoma. This algorithm is comprehensive and directs unilateral or bilateral surgical exploration. Since September 1996, we have performed intraoperative rapid parathyroid hormone assay during all parathyroid surgery. Although the assay times for blood samples taken before and 15 minutes after the tissue removal have been dramatically shortened by warming the incubated specimens to 45°C, the technique does not appreciably shorten the actual total time spent in the OR. However, the marriage of preoperative localization with technetium Tc 99m sestamibi scans, directed surgery, and intraoperative parathyroid hormone assay has dramatically reduced other costs. The total elimination of frozen section biopsy samples, the use of local anesthesia in half of our patients, and frequent ability to perform parathyroidectomy in the outpatient setting are now realistic goals in this era of rigid cost containment. Last, the intraoperative confirmation of resolution of the hyperparathyroid state will lead to a significant reduction in failed exploration with the need for further surgery and imaging requirements. Although a comparative cost analysis of the intraoperative parathyroid hormone assay technique was beyond the scope of this article, the efficacy of this method is directly linked to preoperative localization with technetium Tc 99m sestamibi scans.

In summary, this series of 59 consecutive patients with hyperparathyroidism represents an opportunity to evaluate the cost of routine technetium Tc 99m sestamibi and ultrasound scans in every patient. In this series of patients, 5 tumors were beyond the reach of routine bilateral cervical exploration and would have required prolonged futile exploration and specialized imaging, all with added costs. Since there is some variability in the cost of the additional selected images, the full spectrum is outlined to avoid becoming overly restrictive or dogmatic. Documented benefits in OR efficiency and reduced number of frozen biopsy sections are a direct result of accurate preoperative localization and must be recognized as a cost offset. This analysis is conservative and includes the localization benefits of only 54 of the 59 patients. The other 5 patients either did not receive preoperative scans for localization of the tumor or had their scans inappropriately interpreted. Initial surgical exploration failed for the 1 patient whose scans were inappropriately interpreted, and these costs were included as a debit against the preoperative localization process. Rodriguez et al evaluated failed exploration in a large referral population and recommended comprehensive imaging with ultrasound, technetium Tc 99m sestamibi, and magnetic resonance imaging scans before revision surgery. Amalgamating this imaging profile, the cost of failed exploration, and the expenses incurred in prolonged exploration of an ectopic cervical parathyroid adenoma, the costs of technetium Tc 99m sestamibi and ultrasound scans for preoperative localization in every patient were virtually neutralized (Table 4).

Accepted for publication January 7, 1998.


We would like to acknowledge Susannah K. Wells, BS, for her assistance in the cost analyses.

Reprints: Robert A. Sofferman, MD, Department of Surgery, The University of Vermont College of Medicine, 1 S Prospect St, Burlington, VT 05401 (e-mail: rsofferm@salus.uvm.edu).

REFERENCES


