Neck Procedures: Thyroid and Parathyroid

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KEYWORDS

• Ultrasonography • Sonography • Fine needle • Core biopsy • Thyroid

KEY POINTS

- Multiple variations of fine-needle aspirations exist. Using needles between 23-gauge and 27-gauge and making 4 to 6 passes achieves the best results for most nodules.
- Visualization of the biopsy needle in plane with the transducer is the preferred method.
- Parathyroid biopsies have higher sensitivity and specificity if they include needle washout samples to estimate the parathyroid hormone (PTH) concentration.

INTRODUCTION

Ultrasonography is commonly used to guide diagnostic sampling procedures in the neck, primarily targeting thyroid nodules with sonographic findings raising suspicion for thyroid carcinoma. Lymph node diagnostic sampling using sonographic guidance has also been widely adopted and has supplanted surgical excisional biopsy in the evaluation of physically enlarged or image-detected suspicious lymph nodes in patients with known or suspected malignancy at risk for neck nodal metastases. In general, imaging-detected parathyroid adenomas can be reliably characterized based on scintigraphic and sonographic findings, so presurgical diagnostic sampling of hyperparathyroid patients with parathyroid adenomas is reserved for those infrequent instances in which the diagnosis is unclear. However, advances and improvements in ablation technique have allowed ablation treatment of parathyroid adenomas in some patients. Similarly, ablative techniques can be applied to papillary thyroid carcinoma recurrences in the thyroid surgical bed or in neck nodes. This article discusses important practical considerations in performing diagnostic sampling and ablative procedures in the neck in the context of endocrine tumors. Although most of the discussion would also be pertinent to the evaluation of other head and neck masses (including those in the parotid/salivary glands, those related to squamous cell carcinoma and other head and neck primary tumors, those related to lymphoma, and those related to soft tissue lumps and bumps), these other potential diagnostic sampling and therapeutic ablation targets are not addressed here, in keeping with the theme of endocrine imaging. After providing an overview of fine-needle sampling terminology and efficacy, including a review of the role of core biopsy for thyroid nodules, this article goes into practical details regarding our technique for performing thyroid nodule fine-needle sampling, articulates pitfalls and pearls in the application of that technique, and subsequently describes special considerations when this technique is applied to possible parathyroid adenomas or thyroid gland lymphomas. The article concludes by examining emerging ablative techniques applied to thyroid and parathyroid tumors.

FINE-NEEDLE SAMPLING: TERMINOLOGY, EFFICACY, AND QUALITY ASSESSMENT

Although the term fine-needle aspiration (FNA) has become the standard way to describe fine-needle

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sampling of thyroid nodules and other targets, it is important to understand that this broad term applies to 2 different variations in method, and unfortunately 1 of the variations shares the same name. When first introduced, the term aspiration biopsy reflected the method in which the operator applies suction (ie, aspiration) using a syringe, sometimes with a special syringe holder, as a fine needle is moved through a target to draw up cellular material that can then be plated out on a slide for histologic evaluation; this has been termed fine-needle aspiration sampling (FNAS) or fine-needle aspiration cytology (FNAC). A modification of this technique without using aspiration was pioneered in France in the 1980s and first described for thyroid lesions by Santos and Leiman[1] in 1988; this has been termed fine-needle capillary sampling or fine-needle nonaspiration cytology (FNNAC). The use of the term capillary instead of aspiration is unfortunate, because it implies that capillary action is the mechanism by which the cellular material is drawn up into the needle[2]; in fact, the cellular material is pushed into the needle by the scraping effect of the beveled needle edge combined with the repeated excursions in the tissue,[3] and capillary forces serve only to keep the material in the needle bore when the needle is removed. It is likely that this scraping action that loosens cellular material from the nodule architecture also plays a primary role when aspiration is applied, with the aspiration not loosening the material itself but only serving to help draw the material scraped off by the repeated needle excursions into the needle bore. In any case, the broader term fine-needle aspiration and its abbreviation FNA are commonly used to refer to either method, and this broader meaning is implied by the use of the abbreviation FNA in this article unless otherwise specified.

Comparison between the efficacy of FNAC and FNNAC has been a subject of considerable investigation. The principal problem with FNAC is that the application of aspiration increases the chance of bloody smears, which impair cytologic interpretation; this is particularly an issue with thyroid nodules, which tend to yield bloody samples with aspiration. In contrast, the principal problem with FNNAC is that operators may not scrape enough cells into the needle, either because of suboptimal technique or because of fibrotic nodules. There have been several studies that purport to compare the efficacy of FNAC and FNNAC in evaluating thyroid nodules, and a meta-analysis of those studies that eventually reviewed 1842 individual patients with 2221 samples collected by both FNAC and FNNAC showed that both techniques can be useful. The analysis concluded that the method performed likely depends on operator preference,[2] but acknowledged that a combination approach might be best. The Consensus Statement on Thyroid FNA put forward by the Korean Society of Thyroid Radiology advocates that operators start with the FNNAC technique and continue with that technique if samples seem to be adequate, switching to the FNAC technique if initial passes yield only minimal material.[4]

Another factor that can influence the efficacy of fine-needle sampling is needle size. Recognition that the cellular material is scraped off and not sucked out of the nodule when FNA is performed helps to understand why there is usually worse performance of FNA with larger needle size. Larger needles (larger than 23 gauge), especially when used with the aspiration method, only increase the amount of contaminating blood drawn into the needle without significantly increasing the amount of scraped cells.[5] In contrast, as needles get thinner (smaller than 27 gauge), they may be harder to direct through overlying soft tissues and may be less effective in scraping material off the nodule, particularly if there is calcification. As a result, using a needle between 23 gauge and 27 gauge is likely to achieve the best results for most nodules.

Immediate cytopathology assessment of samples to establish sampling adequacy can positively influence FNA efficacy but has workflow drawbacks. Usually in this workflow, a cytopathologist or cytopathology technologist is requested to come with the necessary equipment (microscope) to the room in which the FNA procedure is being performed to evaluate samples as they are collected; after each sampling pass, time is taken for the cytopathologist to review the material, telling the operator to stop taking samples once sample adequacy has been confirmed. This process requires cytopathology resources that are not always available; moreover, resource coordination becomes more challenging in that the FNA procedure cannot begin until the cytopathologist is in the room, introducing workflow delays. In addition, the time taken by the cytopathologist to review the material after each pass adds time to the procedure. In contrast, a nondiagnostic result caused by specimen inadequacy adds considerably more cost because the patient may then return for another procedure or may end up going to surgical evaluation for a nodule that may prove to be benign. A study performed by Zhu and Michael[6] revealed interesting data that highlight how procedural technique can be altered to substantially reduce nondiagnostic thyroid nodule FNA outcomes when immediate assessment of cytologic adequacy is not pursued. The nondiagnostic rate of thyroid nodule FNA for patients

subdivided into groups by the number of passes taken proved to be a function of the number passes, with increasing success rates as the number of passes approached 6 (Table 1). In the group of patients in whom 6 passes were made, the nondiagnostic rate was 1.4%, and this rate did not change significantly for groups with more than 6 passes.

This recognition that operators should optimally take 6 passes when not using immediate assessment of cytologic adequacy is important to consider when trying to understand the role of core needle biopsy (CNB) for thyroid nodules. For example, a team of Korean investigators has published several articles touting the role of CNB in the diagnosis of thyroid malignancy, concluding that core biopsy may even have a role as an initial diagnostic procedure for thyroid nodules instead of FNA.[7,8] In part, this team makes this conclusion because their analysis presumes a nondiagnostic FNA rate of 22.6%, which itself is based on practice in which operators take 3 or fewer FNA samples.[9] With such sparse sampling practice, it is no wonder that FNA compares poorly with CNB; their 22.6% nondiagnostic rate for FNA is concordant with that predicted by the data from Zhu and Michael[6] when taking so few samples (see Table 1). A more robust meta-analysis shows that there is no demonstrable role for core biopsy before FNA in the evaluation of thyroid nodules.[10] Core biopsy might play a role in further evaluation of nodules in which initial FNA outcome is that the nodule has atypia of undetermined significance/follicular lesion of undetermined significance, but evidence suggests that using CNB instead of a second FNA for such lesions does not meaningfully change patient care, because patients typically move on to diagnostic lobectomy anyway.[11]

Table 1
Correlation between number of fine-needle aspiration passes and nondiagnostic fine-needle aspiration rates

FNA Passes Taken	Number of Patients	Number of Nondiagnostic Results	Nondiagnostic Rate (%)
≤3	20	5	25.0
4	100	11	11.0
5	115	6	5.2
6	67	1	1.4
≥7	141	2	2.1

From Zhu W, Michael CW. How important is on-site adequacy assessment for thyroid FNA? An evaluation of 883 cases. Diagn Cytopathol. 2007 Mar;35(3):183-6; with permission.

THYROID AND PARATHYROID FINE-NEEDLE ASPIRATION: OUR APPROACH

Every ultrasonography practice has site-specific variations in how patients are selected for thyroid nodule FNA and how the procedure is performed, reflecting institutional framework and resources, referring clinician desires, patient expectations, and radiologist preferences. Because it can be useful to understand how other practices perform these procedures, this article highlights our approach at Mayo Clinic Arizona.

- Patient selection: it is important to communicate with referring providers when selecting which nodules to sample. Although there has been wide adoption of the American College of Radiology (ACR) Thyroid Imaging Reporting and Data System (TI-RADS) algorithm to stratify the malignancy risk of thyroid nodules using sonographic features,[12] the scheme used at Mayo Clinic Arizona (as articulated in AskMayoExpert) varies in some ways because it represents a collaboration with other stakeholders at our institution who do not agree completely with the ACR model. A full discussion of the exact algorithm in use at Mayo Clinic Arizona is beyond the scope of this article; much of the algorithm is similar to the ACR TI-RADS approach, and it uses the ACR lexicon. The important concept to convey is that ultrasonography practices should try to work with their referring providers and should communicate whatever system they are using in their reports. In our practice, we include a link to the AskMayoExpert guidelines, as well as the ACR lexicon.
- Scheduling notes: we have an agreement with our referring providers to schedule patients for thyroid ultrasonography and FNA when a nodule is clinically suspected. If we find a nodule that meets FNA criteria, we proceed with a biopsy without spending additional time in trying to get the order from the physician for the biopsy. This arrangement is extremely helpful to expedite evaluation of the thyroid nodule and a biopsy, if needed, efficiently.
- Anticoagulation status: in our estimation, thyroid FNA is safe and can be performed on patients who are anticoagulated or on aspirin. This opinion is in accordance with the Society of Interventional Radiology guidelines for quality improvement related to percutaneous

needle biopsy.[13] Anticoagulation does not significantly reduce the success rate for thyroid FNA.[14]

- Patient position: in general, mild hyperextension of the neck is useful and can be achieved by using a small pillow or towel under the shoulders of the patient in a supine position. The patient's face is turned to the opposite direction in relation to the planned biopsy site (head to left for biopsy of a nodule in right lobe and vice versa). Adequate positioning helps in stretching of the skin surface and pushes the thyroid more anteriorly, thus reducing the depth of the biopsy target (**Fig. 1**).
- Transducer: thyroid biopsies are preferred to be performed with a high-frequency, small-footprint, hockey-stick transducer (we use a L8-18i-D transducer). This transducer lends itself well to the subtle manipulations required for adequate trajectory establishment. Sometimes a larger-footprint linear transducer may also be used. We prefer the latter when we need to use part of the transducer to exert pressure on the neck to fix a calcified or fibrous nodule that moves (sideways) when we attempt to insert the FNA needle into the nodule.
- Approach: some operators always prefer a trajectory to the nodule that has a medial to lateral approach (from the tracheal side to the sternocleidomastoid muscle side), whereas others prefer a lateral to medial approach (arguing that a pathway through the hypoechoic sternocleidomastoid muscle helps visualize the needle better). Irrespective of the personal preference, the trajectory chosen should be the shortest and the safest access to the nodule.[15]
- Biopsy tray setup: the equipment required for a thyroid nodule FNA is simple. The biopsy tray we use includes the following items (**Fig. 2**):
  - Disposable 10-mL plastic syringes
  - Disposable 25-gauge and 22-gauge needles, 3.8 cm (1.5 inches) long
  - Glass slides for preparation of cytology smears
  - Sterile gauze pads
  - Lidocaine (1% lidocaine buffered with 8.4% sodium bicarbonate)
  - ChloraPrep: 2% weight per volume chlorhexidine gluconate and 70% volume per volume isopropyl alcohol
  - Koplin jar with alcohol
  - Sterile transducer cover
  - Sterile drape with a hole
- Procedure technique: before beginning the procedure, a time-out is performed to verify the patient's name and date of birth and to confirm the biopsy target as per the requisition. Once the ultrasonography transducer is selected, it is wiped with an alcohol-based swab, and a short sterile transducer cover is used for covering the transducer and maintaining sterility during the procedure (**Fig. 3**). After disinfecting the skin with an antiseptic agent (we use ChloraPrep), a sterile drape is used to cover the neck while centering the hole in the drape over the planned biopsy trajectory mark. A small amount of local anesthesia is injected at the point of entry, and a wheal is created on the dermis. This stage is

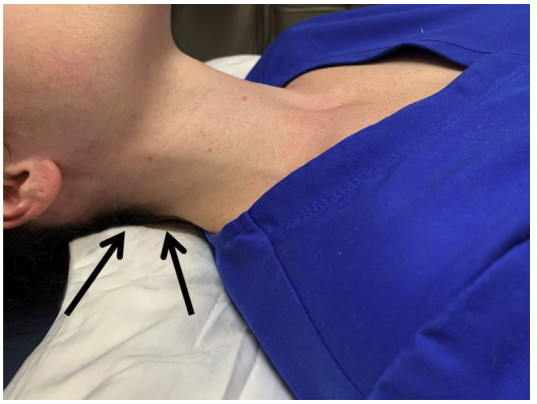

Fig. 1. Positioning for biopsy. A pillow under the upper back and lower neck allows for hyperextension (*arrows*) of the neck, pushing the thyroid anteriorly and also fixing it by stretching the soft tissues.

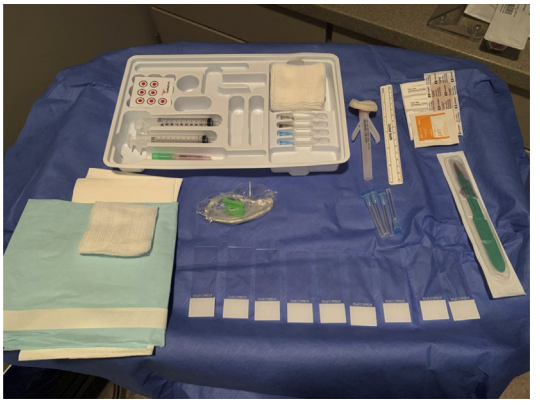

Fig. 2. Biopsy tray setup. A simple setup consists of 10-mL plastics syringes, disposable 25-gauge and 22-gauge needles, glass slides for cytology smears, sterile gauze pads, sterile drape with the hole, ChloraPrep, and transducer cover.

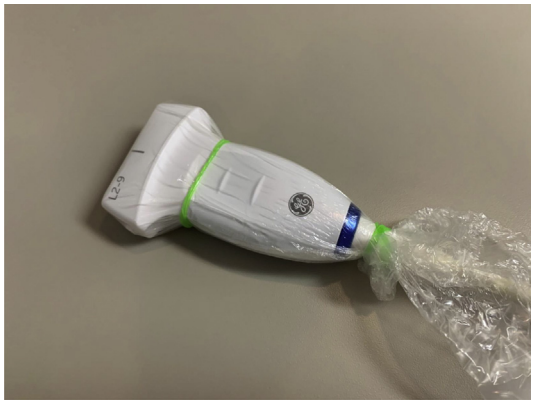

Fig. 3. Covering the transducer with a sterile sheath before the biopsy.

followed by a deeper infiltration of the soft tissues to the thyroid capsule (Fig. 4). Although the wheal on the skin is performed without the use of the transducer, the deeper anesthesia of the subcutaneous fat planes and muscles is obtained by directing the needle under ultrasonography guidance.At our institution, we use a 25-gauge needle to sample the nodule. Most of the time, the scraping effect of the beveled needle edge combined with the repeated excursions in the tissue is enough to procure the cells needed for the diagnosis. In some instances when the nodule is more fibrotic, a syringe may be attached to the needle to apply suction during the procedure. Rarely, a larger-gauge needle, such as 22 to 23 gauge, may be used to obtain adequate material. Very rarely, a longer needle (a spinal needle) may be used if the target lesion is deep in the neck or the patient has a bulky large neck.The visualization of the needle should be oriented in the long-axis plane because the needle is visualized in its entire trajectory (Fig. 5). It makes for good habit to track the needle from its insertion into the skin, its advancement through the soft tissues, and its ultimate entry into the target nodule. In rare situations, a short-axis approach may be performed, wherein the needle is inserted in the short axis along the middle of the transducer. In this instance, only the tip of the needle is visualized and the entire trajectory path is not visualized (Fig. 6). The latter technique has found increased use in interventional radiology for vascular access and is mentioned in this article as an alternate methodology. The authors strongly recommend using the former technique for neck biopsies (ie, the method that visualizes the needle in the long-axis plane in its entire trajectory; see Fig. 5).The process of traversing the nodule with the needle is a skill that has a learning curve. Slow, deliberate excursions of the needle within the nodule are observed in real time. Some experts perform rotation of the needle as the sample is being taken. Conceivably, the rotation of the sharp beveled needle helps scrape more relevant material for cytology. Cystic or necrotic areas within the nodule are best avoided during the FNA. The advantages of using only the needle for procuring the cellular material are the flexibility in manipulation of the needle by holding it from the hub and easier visualization of the appearance of aspirate in the hub as an end point. Attaching a 5-mL or 10-mL syringe to the needle can also help to better control the needle and the ejection of the material after sampling. Adopting 1 of the 2 methods (syringe aspiration or not) is also a matter of personal preference and does not matter as long as the eventual outcome is the procurement of a high-yield aspirate.It is important to keep an eye on the hub of the

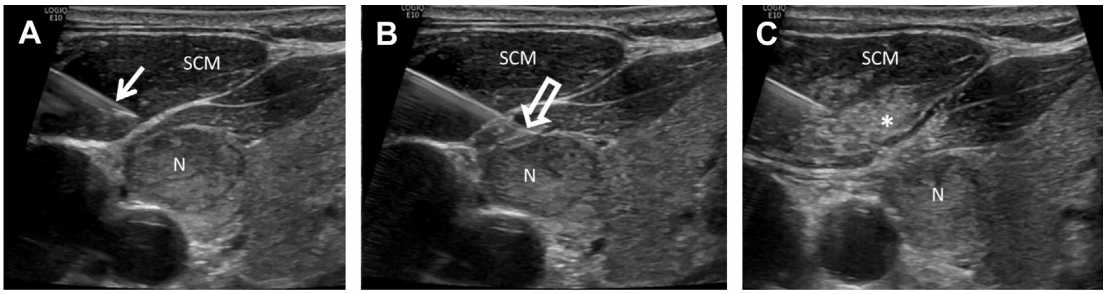

Fig. 4. FNA of the right thyroid nodule (N). Transverse images through the right thyroid. (*A*) The path of the lidocaine infiltration needle (*arrow*) through the sternocleidomastoid (SCM) muscle. (*B*) The infiltration of the lidocaine to the thyroid capsule (*open arrow*). (*C*) Retraction of the lidocaine needle with continuous infiltration of the anesthetic into the muscle making it hyperechoic (*asterisk*).

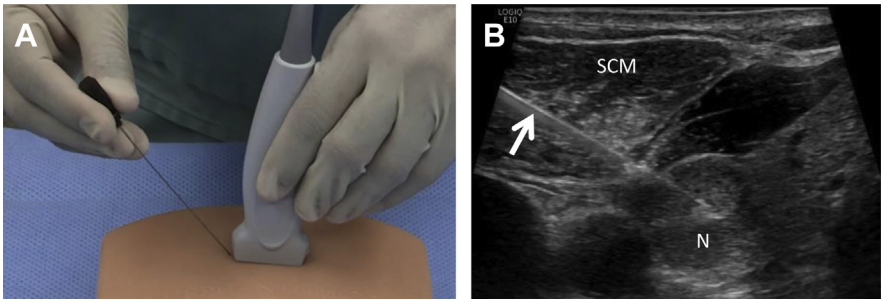

Fig. 5. Technique of needle visualization. (*A*) The alignment of the needle along the long axis of the transducer. (*B*) The entire trajectory of the biopsy needle (*arrow*) through the SCM) into the thyroid nodule (N) in a longitudinal plane.

needle as you perform the excursions. When we see a drop of blood in the hub of the needle, we do not perform further excursions. Excessive blood within the hub of the needle only increases the contamination of the specimen with red blood cells without increasing cellular material. Once the material is obtained, we smear the material on a slide. In addition to the smear, we also flush the needle with Cytolyte solution so that a cell block (cells coalesced using a centrifuge) is available for the cytopathologist for further evaluation if needed. We try to do at least 5 passes to obtain adequate material. In our practice, the smear is prepared by the radiologist performing the procedure. In other practices, the smear may be prepared by a cytology technician or an on-site pathologist. In some instances, the on-site pathologist confirms the presence of adequate cellular material after the first or second pass, thus limiting the total number of passes needed. The slides are sent to the laboratory, usually placed in alcohol; in some cases, air-dried slides can be of diagnostic value.

- Use of thyroglobulin (Tg) assay: in patients who have had prior thyroidectomy for thyroid cancer, sampling of morphologically abnormal lymph nodes or small nodules in the paratracheal postsurgical bed can be useful to evaluate for recurrent neoplasm. In addition to the FNA samples obtained in a similar fashion to thyroid nodule biopsy, additional needle washout samples are sent for measurement of Tg levels. The process of acquisition of samples for Tg assay may vary in some laboratories, but we generally perform the following:
  1. After an FNA has been done with a 25-gauge needle and the material in the needle has been expelled onto a slide for cytologic analysis, attach the used FNA needle to an empty 10-mL syringe.
  2. Place the needle tip into the pool of saline, apply suction to the syringe, and withdraw a small amount of saline up through the needle until the saline starts to fill the hub of the needle or end of the syringe (probably only 0.125–0.25 mL of fluid).
  3. Expel this fluid forcefully back through the needle, into a separate test tube. This is the needle washing used for analysis.
  4. Repeat for each needle pass of the biopsied site (usually 3–6 needle passes),

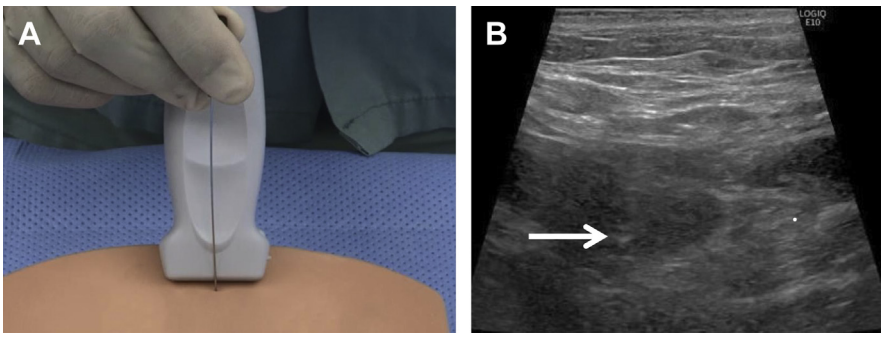

Fig. 6. Technique of needle visualization. (*A*) The alignment of the needle along the short axis of the transducer. (*B*) Only the tip of the biopsy needle (*arrow*) into the lymph node in a longitudinal plane.

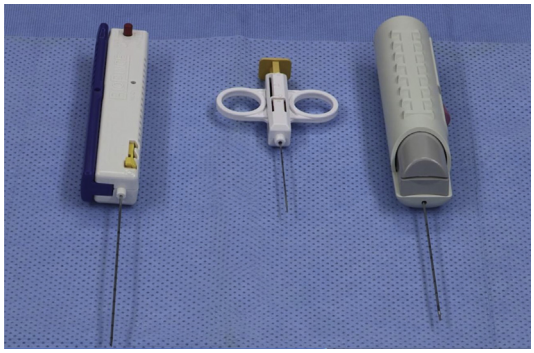

Fig. 7. Types of core biopsy needles. Full-core biopsy needle with end-fire mechanism (*left*), a hemicore biopsy needle with a slotted mechanism (*right*), and a semiautomatic biopsy needle with slotted mechanism that allows more control of the deployment of the inner stylet (*center*).

and empty into the same test tube, accumulating a total of about 0.5 to 1.0 mL of fluid to be sent to the laboratory.

Tg level less than 1 ng per FNA is considered normal. Tg level between 1 and 10 ng per FNA is indeterminate, and the chance that the sample target is related to recurrent disease is based on the degree of suspicion from the morphology of the sonographic findings. Tg level more than 10 ng per FNA is consistent with recurrent malignancy.

- Core biopsy needle and technique: core biopsies of the thyroid are generally avoided secondary to increased vascularity of the thyroid gland. In some instances in which repeat FNA sampling is suboptimal or inadequate and the concern for malignancy is high, core biopsy may be performed. If the differential diagnosis includes thyroid lymphoma, a core biopsy may be performed to obtain more tissue material for a definitive diagnosis. The core biopsy needles are usually 18 gauge and can use devices with an end-fire mechanism, which yields a full core sample, or slotted mechanism, which yields a hemicore sample (**Fig. 7**). A discussion on the different types of core biopsy needles is beyond the scope of this article; the slotted mechanism devices may allow more control of the deployment of the inner stylet, but yield less tissue. The example shown in **Fig. 8** was anaplastic carcinoma that underwent a core biopsy with an 18-gauge needle. Unlike FNA, the core biopsy tissue samples are sent to the laboratory in formalin.
- Pitfalls and special situations:
  - Rim calcified nodules are harder to biopsy. It can help to identify a break in the rim calcification and allow use of that break as the point of entry for the FNA (**Fig. 9**).
  - Thyroid nodules in the isthmus can be mobile during the FNA, and pressure from the transducer can be used from the opposite direction to limit movement of the thyroid nodule (**Fig. 10**).
  - If a nodule is positioned on posterior aspect of the thyroid, particularly on the left, make sure that you exclude an esophageal diverticulum masquerading as nodule. A simple maneuver of swallowing by the patient can help differentiate between the two: the diverticulum shows air within the lumen (**Fig. 11**).
  - The tubercle of Zuckerkandl can simulate the presence of the nodule. Scan in both planes; usually the images in the longitudinal plane show a connection of the structure with the thyroid body (**Fig. 12**).
- Parathyroid adenoma: FNA of a parathyroid gland that is enlarged or a parathyroid nodule has similar technique to FNA being performed for the thyroid nodule, but usually requires additional techniques because the cytologic features of a parathyroid adenoma can be indistinguishable from a benign thyroid

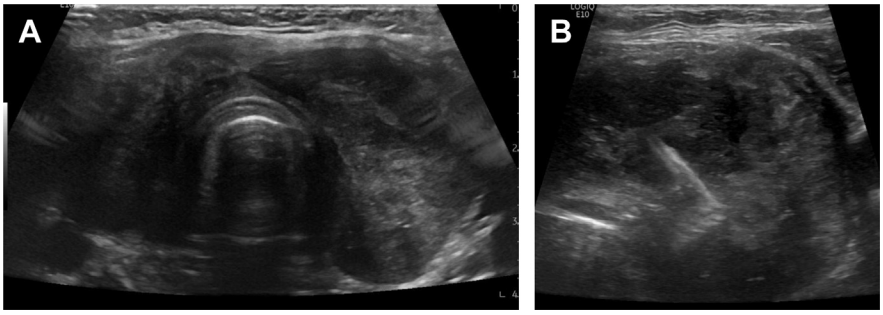

Fig. 8. Core biopsy. (*A*) A large infiltrative mass lesion involving both the lobes of the thyroid gland. (*B*) The trajectory of an 18-gauge core biopsy needle.

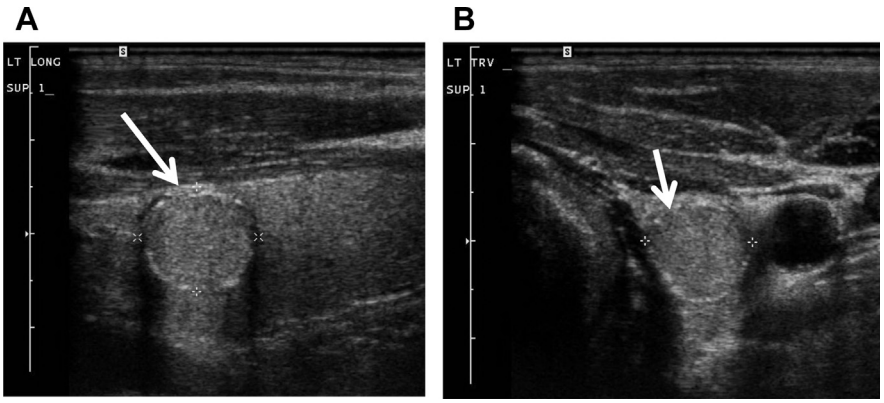

Fig. 9. Rim calcified nodule. Longitudinal (*A*) and transverse (*B*) images of a rim calcified nodule. Biopsy can be attempted through the small breaks in the calcifications along the rim (*arrows*) in either plane.

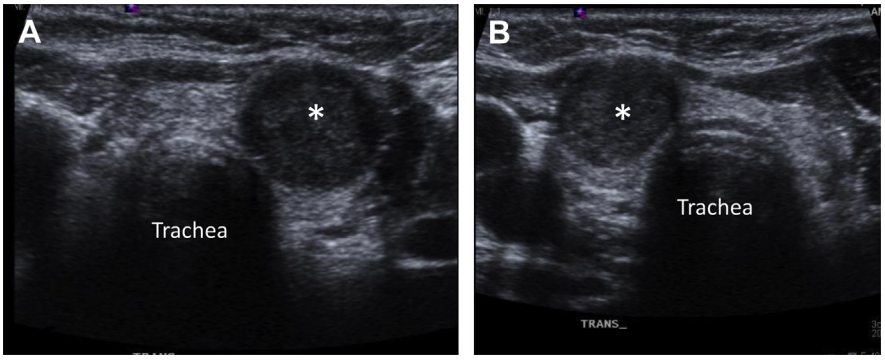

Fig. 10. Mobile nodule in isthmus. Transverse images from the neck. (*A*) A thyroid nodule (*asterisk*) on the left of the trachea. (*B*) The same nodule displaced to the right of the trachea. Transducer pressure from one side can limit the mobility of the nodule.

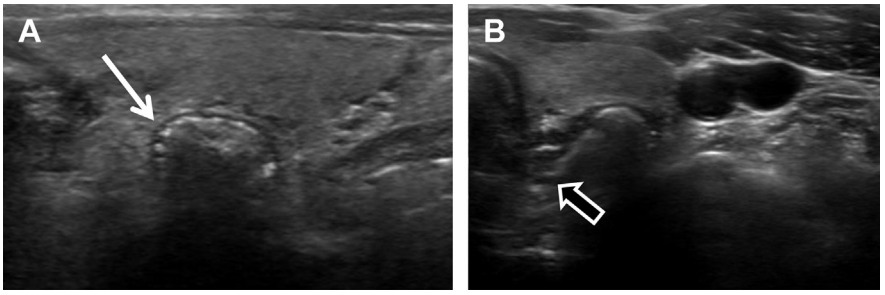

Fig. 11. Esophageal diverticulum. Longitudinal (*A*) and transverse (*B*) images through the left thyroid. (*A*) An echogenic lesion (*arrow*) posterior to the thyroid simulating a rim calcified thyroid nodule. (*B*) Medial extension of this echogenic lesion toward the esophagus (*open arrow*).

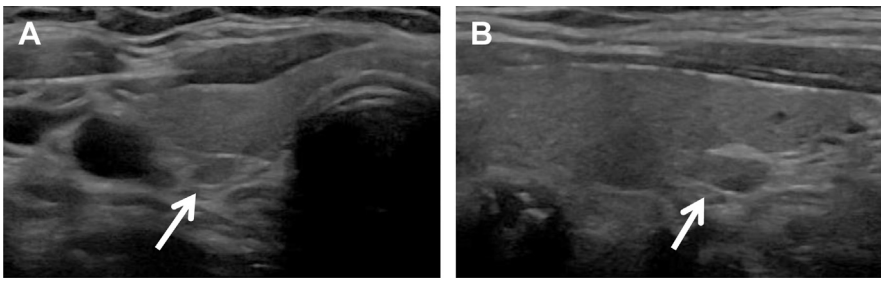

Fig. 12. Tubercle of Zuckerkandl. Transverse (*A*) and longitudinal (*B*) images through the right thyroid show an isoechoic nodule (*arrows*) in posterior aspect of the thyroid. The longitudinal plane image clearly shows the connection of the structure to the body of the thyroid posteriorly.

adenoma. In addition to samples obtained for making cytologic smears, additional samples are obtained to estimate the parathyroid hormone (PTH) concentration in needle washout. This PTH analysis in the rinse material obtained during the FNA procedure helps differentiate thyroid tissue from enlarged parathyroid glands. A positive cutoff value for PTH washout is usually higher than the serum PTH level.[16] The utility of this technique has specificity and sensitivity ranging from 91% to 100%. The FNA needle is rinsed with a small volume of normal saline solution immediately after a specimen for cytologic examination has been expelled from the needle for a smear. Specimen collection is critical for the performance of the assay, and the needle should be rinsed with a minimal volume of saline. Each FNA needle from a single biopsied area is washed with 0.1 to 0.5 mL of normal saline. The washes from a single area are pooled (final volume 1–1.5 mL). PTH levels are measured in the saline wash. This process is similar to the one described for Tg assay.

- Postprocedure: following a thyroid sampling procedure, there is usually no need to hold the patient in the nursing area. Compression of the biopsy spot for few minutes, followed by an adhesive bandage, is sufficient before discharging the patient. In some instances, providing the patient with an ice pack to hold over the biopsy site for 15 to 20 minutes helps with the healing process and decreases the extent of the bruise.

ULTRASONOGRAPHY-GUIDED ABLATIONS IN THE HEAD AND NECK

Ablation of Thyroid and Local Thyroidal Metastatic Disease

Several ablative technologies have been investigated for hyperfunctioning, benign or malignant, and cystic or solid thyroid masses.

Ethanol ablation (EA) has been used since the late 1980s for the treatment of thyroid nodules in patients not desiring surgical intervention, particularly for high-surgical-risk patients or for cosmetic outcome concerns.[17] Local instillation or infiltration leads to cellular apoptosis by inducing cell membrane lysis, protein denaturation, and vascular thrombosis.[18] EA has been used for both benign or malignant and cystic or solid masses. However, the advent of more complete ablative technologies, such as radiofrequency ablation (RFA), has largely segregated the role of EA to cystic thyroid nodules (50% or greater cystic component) that either have mass effect on adjacent structures, particularly the esophagus and trachea, or create a visible neck mass. Such masses are ideal candidates for EA because the procedure yields no cosmetic injury, is technically simple, is low risk, and uses very-low-cost materials.[19]

Protocols for cystic thyroid nodule ablation vary, but one technique is to access the cystic component of the nodule with a 20-gauge to 22-gauge needle or angiocatheter of a length appropriate to the depth of the nodule under sterile conditions, after local anesthesia of the skin and subcutaneous tissue with 1% lidocaine. Care is taken to avoid puncturing the deep wall of the cyst. If the liquid component is too viscous for aspiration with a 22-gauge catheter, a needle or catheter up to 20-gauge can be used. The entire cystic component is aspirated and the volume noted. Absolute ethanol is then slowly instilled up to 50% of the aspirated volume. If the patient expresses any discomfort during the slow instillation, the injection should be stopped. Dwell times vary from 5 to 20 minutes in the literature. In our practice, we allow the ethanol to dwell for 5 minutes, aspirate it completely, and then reinstill the same quantity of fresh ethanol into the cavity, on the theory that thyroid nodules typically rapidly refill with fluid when aspirated and the potential

dilution of the first aliquot may impair the activity of the ethanol on the cyst wall. A second dwell time of 5 to 10 minutes is typical. Patients should be monitored for discomfort. Patients typically report no pain during the procedure, and skin discomfort should raise concern for leakage of ethanol along the needle or catheter path. When the dwell time is complete, the ethanol is aspirated completely, the tissue is compressed to coapt the walls for a few minutes, and a simple skin bandage is then applied. A typical treatment response is an 80% reduction in the cystic volume of the lesion at 3-month follow-up.[19] If satisfactory results are not achieved or the cystic component recurs, the procedure may be repeated as needed. An example of the technique is shown in **Fig. 13**. Other cystic lesions of the neck (in particular, thyroglossal duct cysts and nonhyperfunctioning parathyroid cysts) can be similarly ablated.[20,21]

EA is also a useful alternative to surgical resection for nodal recurrence of differentiated thyroid cancer (DTC). EA is usually reserved for patients who are unwilling or unable to undergo surgical resection. Elderly patients and others with significant comorbidities or patients who have had multiple nodal recurrences in whom extensive scarring may make additional resection difficult or disfiguring are ideal candidates. Goals of EA for nodal DTC include decreased lesion size and serum Tg level, absent color flow, and increased lesion echogenicity. Ample direct comparison with surgical intervention is lacking, but a success rate of 87.5%, compared with 94.8% for surgery, and a low complication rate were shown in a pooled analysis.[22,23]

Patient preparation is similar to routine thyroid FNA. Skin anesthesia is achieved with 1% lidocaine. Deep perilesional anesthesia is usually avoided, especially for central compartment (level

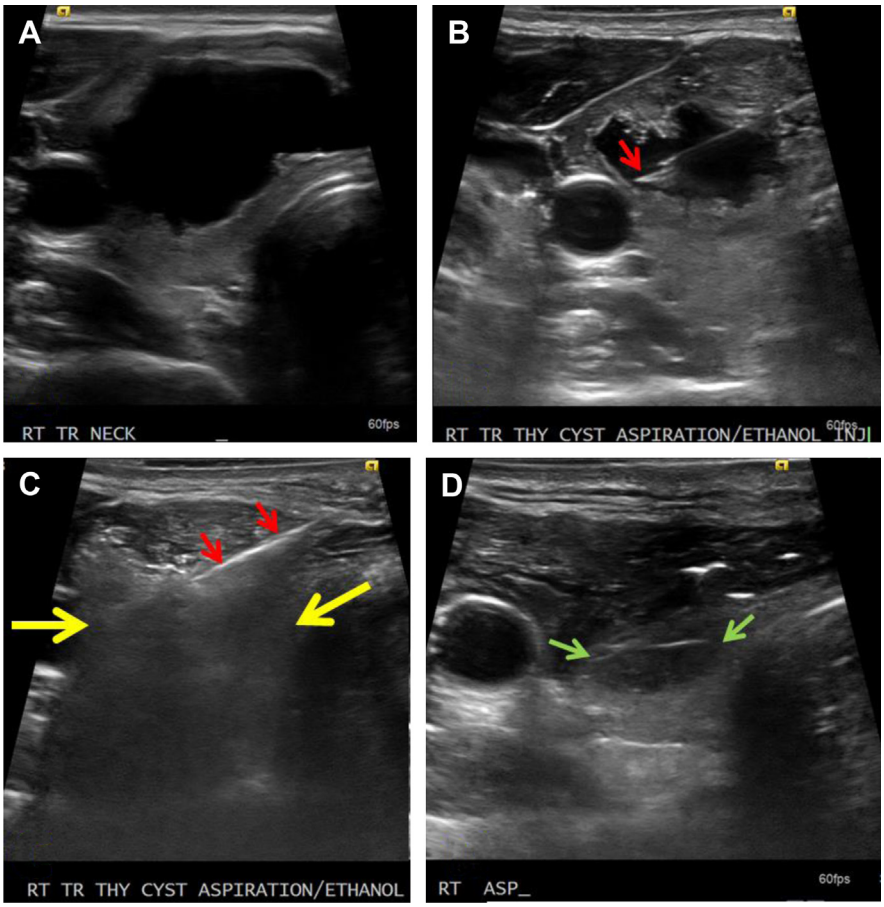

Fig. 13. Ethanol ablation. (*A*) A large predominantly cystic nodule in the right thyroid lobe. (*B*) Aspiration from a transisthmus approach with a 22-gauge needle (*red arrow at tip*). (*C*) Ethanol instillation with the indwelling needle (*red arrows*) and reverberation artifact related to ethanol interacting with the cyst wall, creating gas (*yellow arrows*). (*D*) Greater than 80% reduction in cyst volume after 2 sessions, 3 months later (*green arrows*).

VI) nodes, to preserve patient feedback regarding sudden increases in pain, which can indicate leakage of ethanol from the target nodule. If hydrodissection is desired to increase the distance from critical structures such as the esophagus or recurrent laryngeal nerve, saline instillation can be performed.

Ethanol is instilled in the node using a 22-gauge or 25-gauge needle. A 1-mL (tuberculin) syringe allows careful deposition of small aliquots within the target. For small lesions, such as those 5 mm or less, central deposition is usually adequate. For larger lesions, ethanol deposition should begin with the deepest part of the lesion, moving to more superficial areas as the lesion becomes echogenic, obscuring the needle tip. Intermittent imaging with color flow is helpful to determine the adequacy of vascular thrombosis. If an area still shows flow, the operator can wait a few minutes until the hyperechogenicity subsides and the needle can be repositioned accurately. For large nodes (>1 cm), the proceduralist should try to locate the area of color inflow and directly inject into the inflow within the periphery of the node. This technique can result in a rapid devascularization of the node. Our protocol brings the patient back 1 to 2 days later for a reassessment of color flow in the target node or nodes, and additional EA is performed as needed. Typically, between 1 and 4 nodes are treated in each paired session. For large or deeply situated nodes, contrast-enhanced ultrasonography or microvascular flow settings can be helpful to augment flow detection, may provide better feedback to the operator, and could improve response. Future trials are needed in this area. EA of a level IV lymph node with subsequent devascularization in a patient with metastatic papillary thyroid carcinoma is shown in **Fig. 14**.

Ultrasonography-guided RFA of thyroid nodules is a safe and feasible alternative to surgery for DTC in high-surgical-risk patients or patients not desiring surgery when active surveillance is not desired or medically appropriate.[24] A straight, 1-cm active tip, 17-gauge internally cooled RFA device used at low wattage (typically 30 W) provides

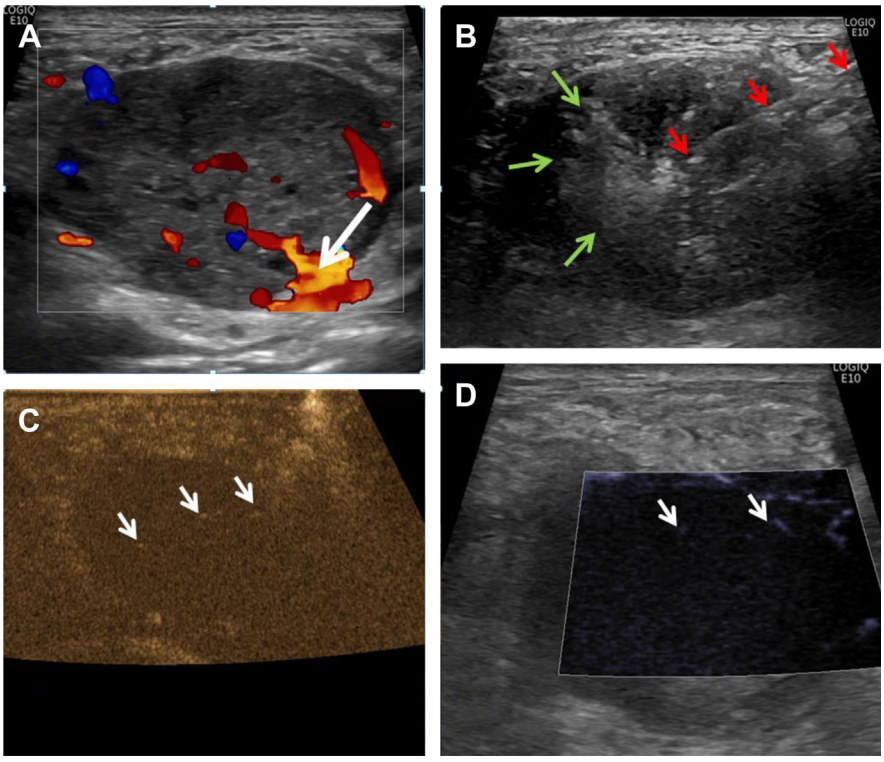

Fig. 14. Ethanol ablation of tumor. Color flow imaging (*A*) shows site of vascular inflow into a large, level IV, proven papillary thyroid nodal metastasis. Injection of 0.2 mL of absolute ethanol (*white arrow*) led to a rapid devascularization of the node. (*B*) Additional ethanol is injected (*red arrows* show needle trajectory) in small (typically 0.1-mL) aliquots throughout the node with echogenic dispersal through the lesion (*green arrows*). Contrast-enhanced (*C*) and microvascular flow (*D*) settings show minimal residual flow 2 days later (*white arrows*). Additional ethanol was injected in these areas targeted by flow detection.

appropriate control of the ablation field to avoid adjacent tissue injury. Under appropriate anesthesia, the RFA device is initially placed in the deepest, most medial portion of the nodule, usually from a transisthmus approach. Owing to this location's proximity to the recurrent laryngeal nerve and esophagus, this is the most critical part of the technique. The RFA device is activated at 30 W and continuously monitored until hyperechogenicity is noted surrounding the device; subsequently, it is immediately deactivated, and the device tip is repositioned in an unablated section of the nodule, working from posteromedial to anterolateral (**Fig. 15**). If the hyperechoic effect of ablation is not achieved at 30 W, gradually higher wattage can be applied. Longer ablation times can be tolerated toward the center of the nodule if it is large. This moving-shot technique allows careful but adequate coverage of benign or malignant nodules.[25,26] The operator should remain mindful that the risk of clinically relevant DTC morbidity is low, especially in older individuals, and that great care should be taken to avoid thermal injury to surrounding structures, even if this means that the edges of the tumor are suboptimally treated. This technique, therefore, differs from the goals of solid organ tumor ablation in the abdomen, where 5-mm to 10-mm ablative margins are the standard goal.

This RFA technique can be applied to large or growing benign thyroid nodules with mass effect achieving volume reduction between 50% and 80%.[27–30] Ablation of hyperfunctioning thyroid nodules, using EA or RFA, is also performed but has not made its way into mainstream US practice, likely owing to the efficacy and low-risk profile of radioiodine ablation (RIA), despite the potential advantage of improved targeting using RFA compared with RIA. RIA is well established and remains the American Thyroid Association intervention of choice for most patients.[31]

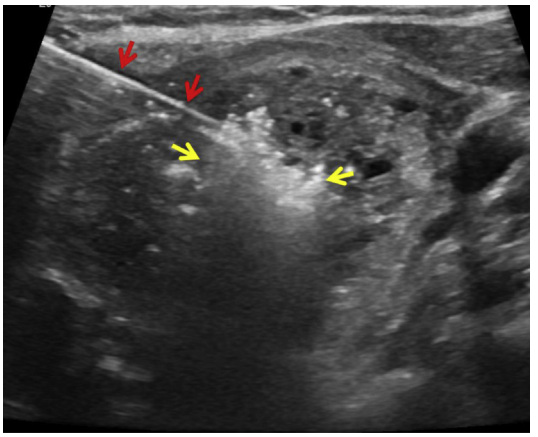

Fig. 15. Percutaneous RFA of a large benign thyroid nodule for symptomatic compression. Red arrows indicate the straight-tipped RFA antenna. Echogenic gas (*yellow arrows*) surrounds and obscures the antenna tip during the moving-shot technique. The peripheral 5 mm of the lesion are intentionally spared when treating benign symptomatic nodules to avoid thermal injury to adjacent structures.

Microwave ablation (MWA) is a more powerful ablative technology with a larger field effect; therefore, its use near thermally sensitive critical structures in the neck has been limited compared with RFA. Continuous hydrodissection to protect the surrounding structures has been advocated, along with the moving-shot technique with safe and effective results in the treatment of large thyroid nodules.[32]

Parathyroid and other nonthyroidal sites

Sparse literature exists for ablative head and neck procedures outside the thyroid and DTC-related nodal disease. However, cryoablation has been advocated for locally aggressive thyroidal and nonthyroidal head and neck malignancies that cannot undergo resection.[33] Ultrasonography guidance is useful in the positioning of cyroprobes, but monitoring of the resulting ablation is most appropriately performed with computed tomography or magnetic resonance, because the cryozone creates dense specular reflection, obscuring sonographic visualization of deep structures. Cryoablation is effective for local tumor and pain control in bone metastases, including those related to thyroid and other head and neck malignancies.[31,34]

EA, RFA, and MWA have all been described as having a potential role in the nonsurgical treatment of hyperfunctioning parathyroid adenoma in centers outside the United States.[35–37] However, the safety and efficacy of these treatments have not yet been established in US practice.

DISCLOSURE

The authors have nothing to disclose.

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