Role of Sonography After Total Thyroidectomy for Thyroid Cancer

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Abstract: High-resolution neck ultrasound plays a vital role in the evaluation and management of patients after total thyroidectomy for thyroid cancer. This technique is increasingly used by endocrinologists and head and neck surgeons to detect potential locoregional recurrences or metastases and map malignant lymph nodes before reoperation. It is also invaluable as guidance for fine-needle aspiration of suspicious lesions.

Thorough knowledge of the compartments of the neck and meticulous scanning technique are essential for success.

The purpose of this article is to review the common pattern of recurrences of differentiated thyroid cancer, describe our scanning protocol, and depict the characteristics of benign, indeterminate, and suspicious lesions in the postthyroidectomy neck.

Key Words: thyroid cancer recurrence, postthyroidectomy ultrasound, malignant cervical lymph nodes

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LEARNING OBJECTIVES

1. Summarize the role of high-resolution ultrasonography (US) in the management of patients after total thyroidectomy for thyroid carcinoma.
2. Explain the importance of accurate mapping of suspicious cervical nodes for surgical planning in patients scheduled for reoperation.
3. Identify the sonographic features that help differentiate benign cervical nodes from metastases from thyroid carcinoma.

Papillary thyroid cancer (PTC) is the most common malignant tumor of the thyroid gland, accounting for more than 80% of all histological types.[1,2] In 2002, there were 8.7 PTC detected per 100,000 in the United States, a 2.4-fold increase since the early 1970s. This apparent increase seems to result in great part from improved detection of small tumors as diagnostic tools have become more refined.[3] During the same period, the incidence of follicular, medullary, and anaplastic cancers has remained stable. Total or near total thyroidectomy is the standard surgical treatment and is accompanied by compartment-oriented node dissection if suspicious lymph nodes are detected on preoperative imaging or during surgery.

Papillary and follicular thyroid cancers, the so-called differentiated thyroid cancers (DTC), have a greater than 70% to 90% survival rate at 5 years and reach 86% to 90% survival at 10 years after successful total thyroidectomy.[4] However, 9% to 30% of patients have locoregional recurrences.[5] Factors influencing the prognosis include age at diagnosis, tumor burden (including extension of the tumor beyond the thyroid capsule), nodal metastases at the time of initial diagnosis, and the histological subtype.[6]

Long-term management of patients treated for thyroid cancer needs to include an effective strategy for diagnosing potential recurrences. High-resolution neck ultrasound has become an integral part of this strategy, allowing the detection and precise localization of abnormal nodes. It is also invaluable in guiding fine-needle aspirations (FNAs) to confirm the presence of recurrence. In specialized centers, the endocrinologists and head and neck surgeons have embraced neck US and rely on its results to offer optimal therapeutic options. With this success come certain responsibilities for the interpreting physician, including knowledge of the common pathways by which DTC spreads, surgical techniques, meticulous scanning technique, and clear reporting using terminology that will be useful for the referring surgeon.

In this article, we will briefly review current strategies for the long-term management of patients after thyroidectomy for thryoid carcinoma, describe patterns of recurrences of DTC, review sonographic techniques in the postthyroidectomy neck, and describe the sonographic appearances of potentially malignant cervical nodes and recurrences in this group of patients.

STRATEGIES FOR MONITORING PATIENTS AFTER TOTAL THYROIDECTOMY FOR DTC

In 2006, the European Thyroid Association adopted consensus guidelines for the management of patients with DTC before and after thyroidectomy.[7] Similar recommendations have been advocated by the National Comprehensive Cancer

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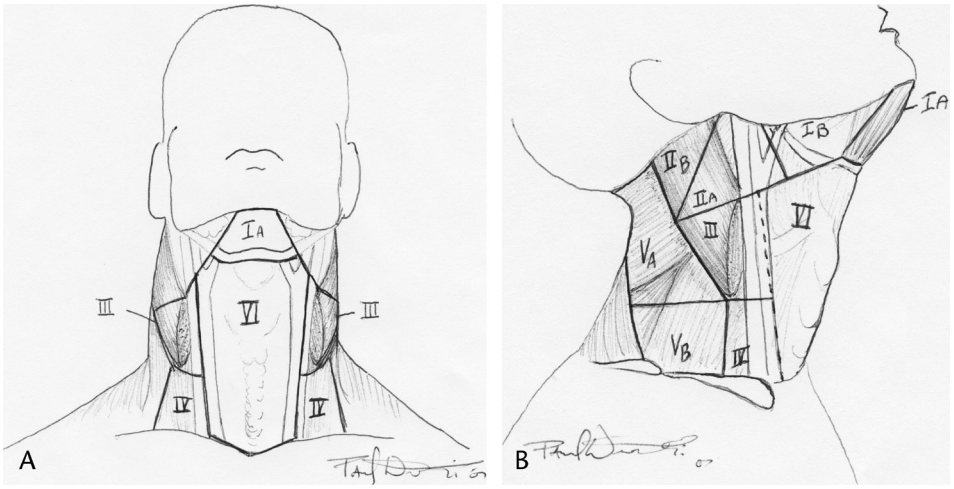

FIGURE 1. Diagram of neck after total thyroidectomy. A, Frontal image. B, Lateral/oblique image. We use such diagram to mark indeterminate or suspicious masses and nodes.

Network and the American Thyroid Association in the United States.[5,8] These guidelines recommend serial serum thyroglobulin levels and neck US as primary tests to diagnose recurrences.

Serum Markers

Tumor markers, such as recombinant human thyrotropin-stimulated thyroglobulin and antithyroglobulin antibodies for papillary and follicular cancers or calcitonin for medullary cancer, allow potential early detection of even small recurrences if their serum levels rise above the expected undetectable or near undetectable levels postoperatively.

High-Resolution Neck Ultrasound

High-resolution neck US provides anatomical survey and precise localization of potential recurrences to specific neck compartment. It has become an indispensable tool to guide subsequent surgical approach. In a Mayo Clinic series of 216 patients scheduled for reoperative surgery published in 2006, 75% of cases had abnormal nodes diagnosed exclusively by sonography, and in an additional 40% of patients with palpable adenopathy, sonographic findings altered the reoperation by depicting additional pathological nodes.[9] Other series have confirmed that neck US is far superior to physical examination. Neck US has also been shown to detect small nodal metastases in patients with undetectable thyroglobulin and I131 scan.[2,10,11] It is recommended that neck US be performed in these patients annually for a minimum of 3 to 5 years.[7] Neck US has also been found effective in the follow-up of patients diagnosed with medullary cancer.[12]

TABLE 1. Scanning Protocol

Level	Landmark	Transducer, MHz
I A	Midline above thyroid bed	Linear 8–12
II A right and left	Submandibular glands	Linear 8–12
III right and left	Lateral to CCA midneck	Linear 8–12
IV right and left	Lateral to CCA lower neck	Linear 8–12
VI right and left Up, middle, low	Medial to CCA thyroid bed	Linear 8–12
Supraclavicular regions right and left		Sector 4–6

Radioiodine Ablation and Other Imaging Modalities

Postthyroidectomy ablation using whole body scan with I131 is indicated at least in patients with a high risk of recurrence or documented residual disease.

In selected patients, computed tomography (CT) of the neck and chest to detect lung metastases, magnetic resonance imaging, and fluorodeoxyglucose–positron emission tomography may provide additional information[7] and are being used with increasing frequency. Although published series are small at the present time, preliminary results indicate a high accuracy of fluorodeoxyglucose–positron emission

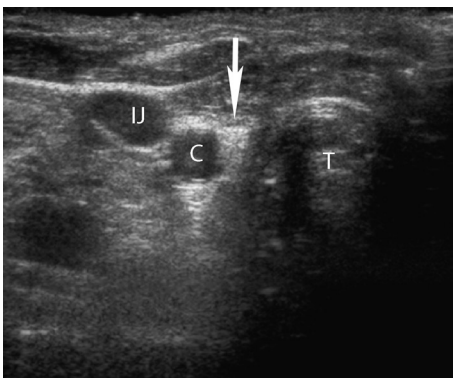

FIGURE 2. A 42-year-old woman with a history of thyroidectomy for PTC. Transverse US of the right side of the neck shows a normal thyroidectomy fossa, with a small amount of echogenic tissue (arrow) between the trachea (T) and the common carotid artery (C). IJ indicates internal jugular vein.

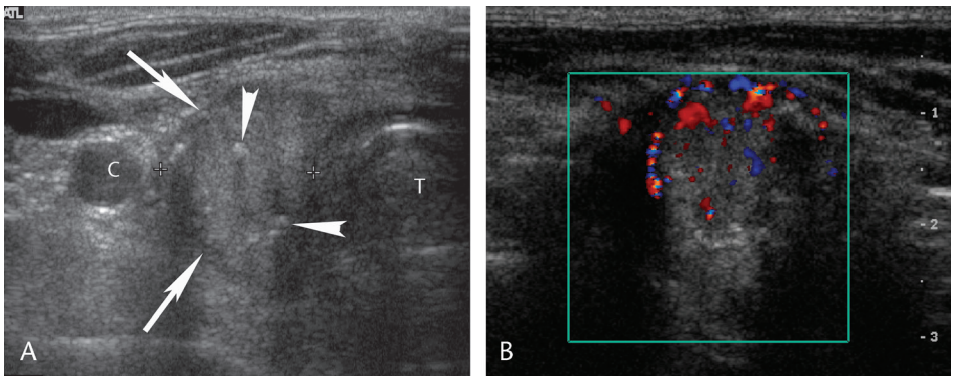

FIGURE 3. A 66-year-old man with a history of thyroidectomy for PTC 2 years ago with suspected residual tumor at the time of surgery. A, Transverse US of the right side of the neck, level VI, shows a 1.2 × 1.4 heterogeneous mass (arrows) with punctate calcifications (arrowheads) in the right surgical bed. The mass is displacing the common carotid artery (C) laterally. T indicates trachea. B, Color Doppler US of the mass shows increased vascularity. The US-guided FNA of this mass yielded metastatic PTC.

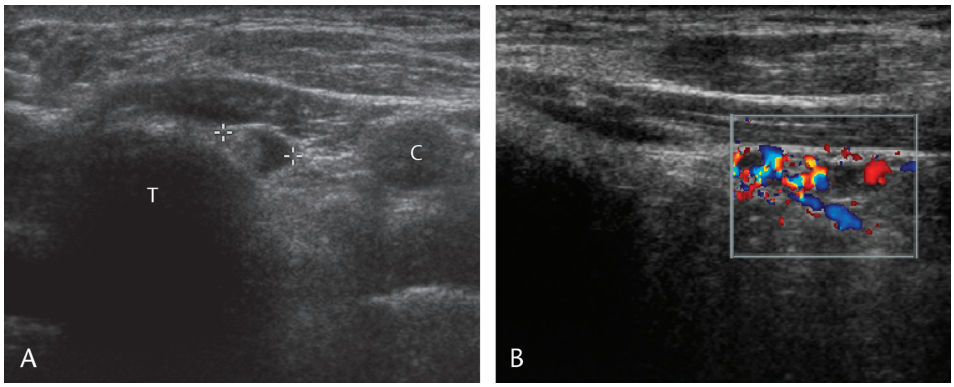

FIGURE 4. A 48-year-old man with a history of thyroidectomy for PTC 16 years ago and rising stimulated Tg levels. A, Transverse US of the left side of the neck, level VI, shows a 1.2 × 0.4 × 0.7 hypoechoic mass adjacent to the trachea (T) (between calibers). C indicates common carotid artery. B, Sagittal Color Doppler US of the mass shows increased vascularity (arrow). The US-guided FNA of this mass yielded metastatic PTC.

tomography, with a 100% positive predictive value in a small cohort of 12 patients.[13]

PATTERNS OF RECURRENCE OF DTC

Description of Nodal Compartments

Accurate localization of suspicious lymph nodes in specific compartments is essential to facilitate surgical resection and minimize potential complications. It is particularly important to differentiate central neck from lateral neck metastases as it influences the surgical approach and morbidity. Reoperative surgery for nonpalpable central neck recurrence can be challenging because of fibrotic scar tissue and the risk of injury to the recurrent laryngeal nerve. We use the following classification as described by Machens et al[14] (Fig. 1).

Central Compartment

This compartment harbors the paratracheal and paraesophageal nodal chain as well as the thyroid bed, which are classified as level VI in our diagram. Level I or submental and submandibular nodes are also included.

On sonography, the central compartment lies lateral to the trachea and medial to the carotid sheath.

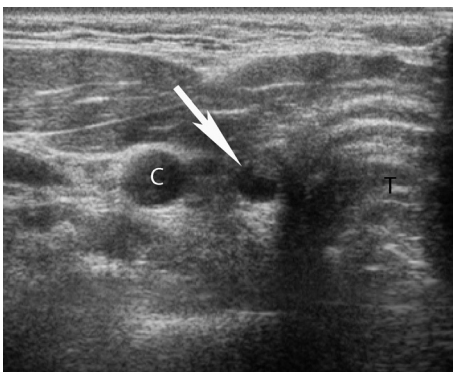

FIGURE 5. A 20-year-old man with a history of thyroidectomy for PTC 7 months ago followed by I131 ablation. Transverse US of the right side of the neck, level VI, shows a 7-mm partially cystic nodule (arrow). The US-guided FNA of this node yielded metastatic PTC. C indicates common carotid artery.

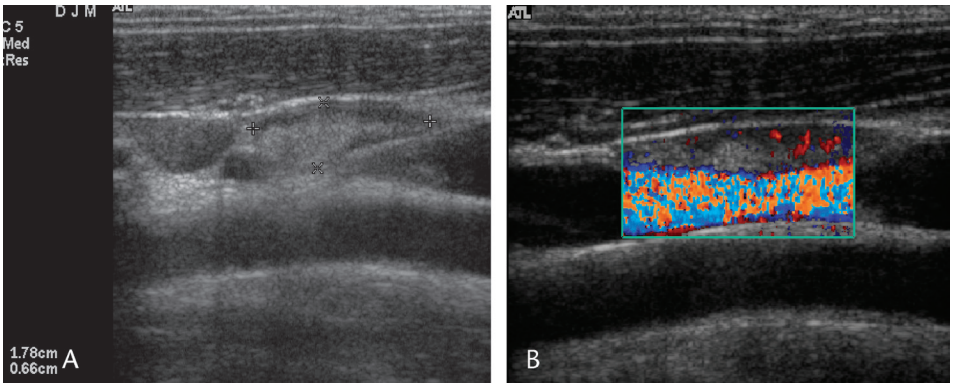

FIGURE 6. A 47-year-old man with a history of follicular carcinoma. Sagittal US of the right side of the neck, level III, shows an elongated node with a small anteroposterior diameter, thin cortex, and prominent echogenic hilum. B, Color Doppler US shows central branching vascularity. This node has a benign appearance.

Lateral Compartment

The lateral cervical compartment contains superior, middle, and inferior jugular nodes (levels II–IV) as well as the dorsal cervical and supraclavicular nodes (level V).

Sonographic landmarks include the carotid sheath medially, the trapezoid muscle laterally, and the subclavian vein inferiorly.

Location of Recurrences

Metastases from DTC affect the ipsilateral neck in two thirds of cases and are multiple in at least 50% of patients.[2] Levels III and IV are most commonly involved, followed by levels VI (central compartment) and V.[2,9,15] Level II nodes are less frequently affected. Patients treated for medullary thyroid cancer tend to harbor contralateral and mediastinal metastases more frequently.[14]

SONOGRAPHIC TECHNIQUE

Meticulous scanning technique is paramount to the success of this sometimes tedious examination. There is an undeniable steep learning curve as both the physician interpreting the study and the sonographer performing the examination need to invest sufficient time and effort and work closely together. If there are ambiguous findings, the interpreting physician should perform or at the very least observe that portion of the examination in real time.

The entire neck, including the thyroid bed (central compartment), is imaged using high-frequency linear transducers, 8 to 12 MHz, depending on the thickness of the patient's neck. Transverse and sagittal images are recorded at each level. Occasionally, in large patients, additional scanning with a 6-MHz linear transducer may prove beneficial. Color Doppler capability is used to differentiate small nodes from vessels and evaluate nodal vascularity.

We complete the examination with a curved or sector array transducer to image the supraclavicular area (low level IV).

Precise labeling of the hard copy images of any suspicious or indeterminate node or mass according to the classification described previously is crucial for communicating with the referring surgeon and planning of FNA. This should also be reflected in the final dictated report. For maximum clarity, we focus our report on the size and location of abnormal lesions rather then describing every likely benign node. We have found that an accompanying diagram is invaluable (Fig. 1).

Our scanning protocol is outlined in Table 1.

ULTRASOUND APPEARANCE

The Normal Postthyroidectomy Neck

After thyroidectomy, the residual bed appears as a narrow region of increased echogenicity between the common carotid arteries (CCAs) laterally and the trachea medially[10,11] (Fig. 2). Small cervical nodes are commonly seen in the lateral compartment of the neck.

Central Compartment Recurrences

Any focal mass in the central compartment should be considered a potential recurrence. However, lesions that are echogenic or anechoic have been found to be benign.[11] Most recurrences in the surgical bed (level VI) present as hypoechoic

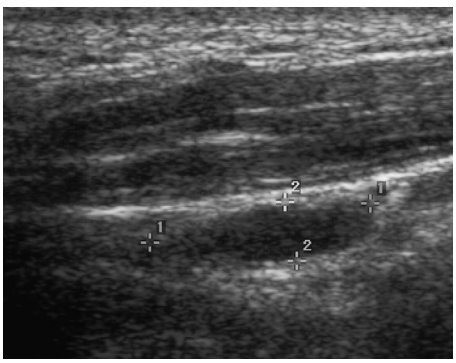

FIGURE 7. A 50-year-old man with a history of thyroidectomy for PTC 2 years ago. A, Sagittal US of the right side of the neck, level II, shows an elongated thin node. The echogenic hilum is not visible. The patient had recurrence in both thyroid bed (not shown). The US-guided FNA of this node yielded benign reactive node.

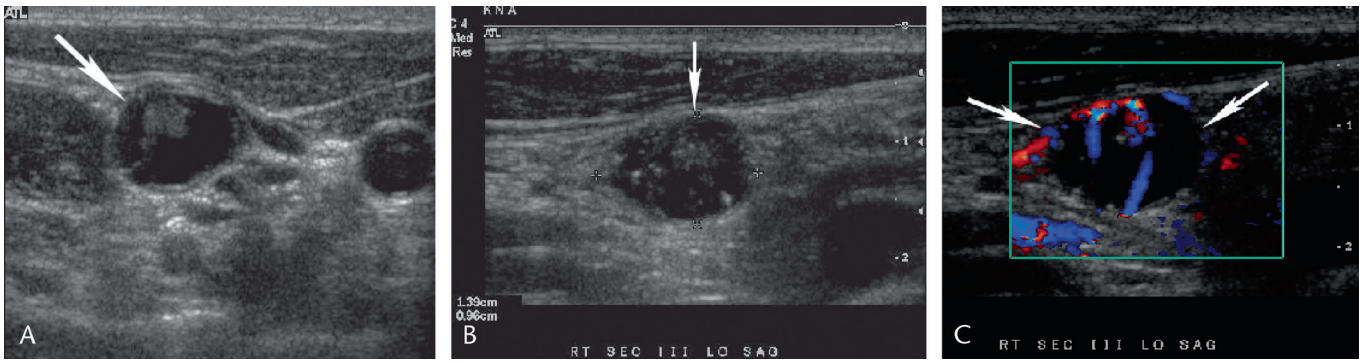

FIGURE 8. A 41-year-old woman with a history of thyroidectomy for PTC 3 years ago and undetectable stimulated Tg levels. A, Transverse US of the right side of the neck, level III, shows a round partially cystic node with a soft tissue nodule (arrow). B, Sagittal US of the right side of the neck shows foci of microcalcifications within the node. C, Color Doppler US of the node (arrows) shows disorganized increased vascularity. The US-guided FNA of this node yielded metastatic PTC, confirmed at surgery.

or markedly hypoechoic masses with a variety of shapes, including round, oval, or taller than wide[11] (Figs. 3, 4). Punctate echogenic foci, representing microcalcifications, and cystic areas within a mass are infrequently seen (Fig. 5), but when present should heighten the level of concern.

Ultrasound Characteristics of Normal and Abnormal Nodes

Cervical lymph nodes are detected in most normal subjects. The challenge for the sonologist is to be able to reliably distinguish likely benign from suspicious or frankly malignant nodes.

As proposed in the literature, several characteristics of each visualized node need to be carefully analyzed, including size, shape, echotexture, and vascularity.[15–17]

Benign Cervical Nodes

Benign nodes have several characteristic sonographic features. Their size is generally small, 1 cm or less in short axis. Submental and submandibular (levels II A and B) tend

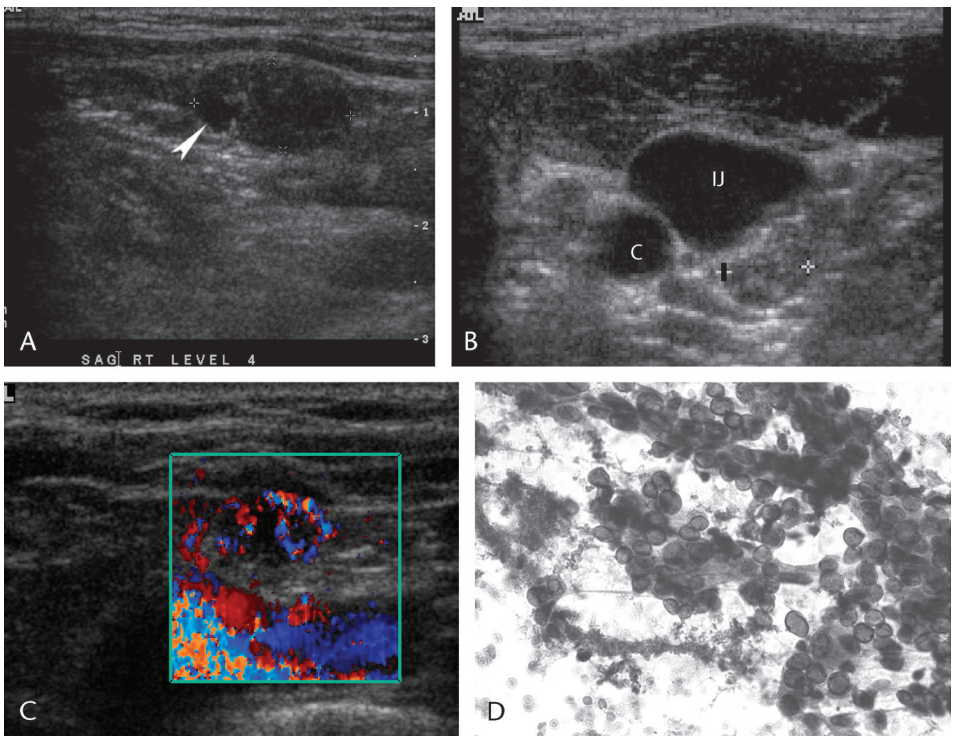

FIGURE 9. A 40-year-old woman with a history of thyroidectomy for PTC 8 months ago. A, Transverse US of the right side of the neck, level IV, shows a hypoechoic node (between calibers) with punctate calcifications and a small cystic area (arrowhead). B, Transverse US of the left side of the neck, level IV, shows a smaller node with microcalcifications (between calibers). C indicates common carotid artery; IJ, internal jugular vein. C, Color Doppler US of the small left node shows disorganized increased vascularity. D, The US-guided FNA of the larger right node yielded metastatic PTC, confirmed at surgery.

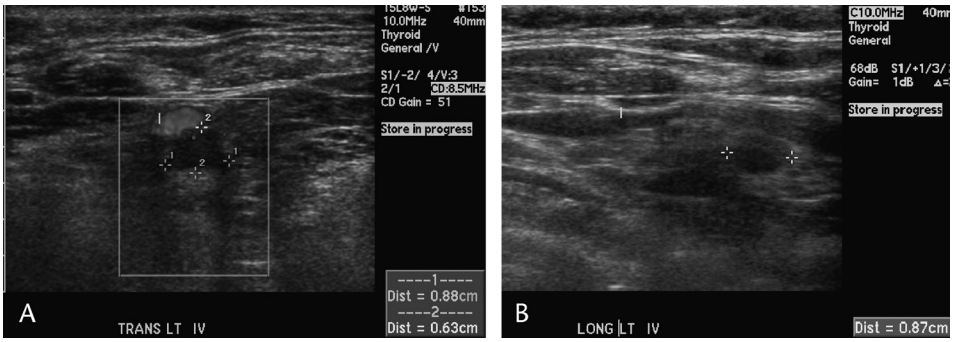

FIGURE 10. A 67-year-old woman with a history of thyroidectomy for MTC 2 months ago at another institution. A, Transverse US of the left side of the neck, level IV, shows a round hypoechoic node measuring 0.9 × 0.9 × 0.6 cm (between calipers). B, Sagittal US of the left side of the neck confirms the lack of echogenic hilum and round shape. The US-guided FNA of this node yielded metastatic MTC, and the patient underwent left modified radical neck dissection in addition to the planned central neck dissection.

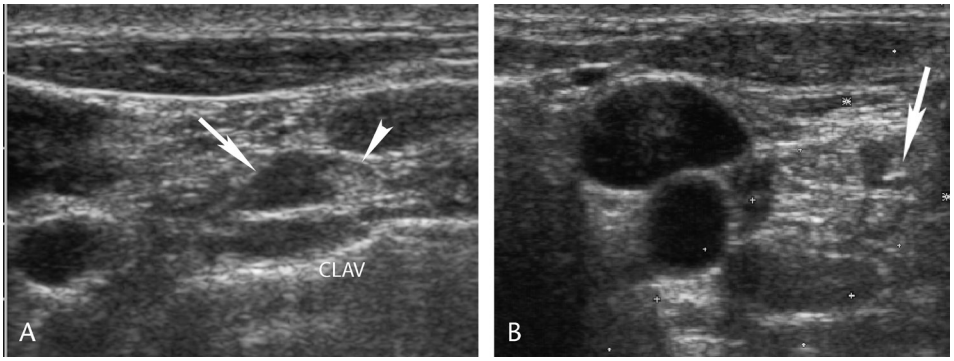

FIGURE 11. A 70-year-old man with a history of thyroidectomy for MTC 5 months ago and persistently elevated serum calcitonin levels. A, Transverse US of the left side of the neck, level IV, shows a small node (arrow) with an eccentric fatty hilum (arrowhead) and asymmetric cortical thickening. B, Transverse US of the left side of the neck during the US-guided FNA shows the echogenic needle tip within the lesion (arrow). The US-guided FNA of this node yielded metastatic MTC. CLAV indicates clavicle.

to be larger, up to 1.5 cm and may be more round in shape. They are oblong or resemble a kidney bean in shape. They have a thin homogeneous hypoechoic cortex surrounding a central echogenic hilus (Fig. 6). This echogenic hilus has been attributed to fat, as shown on CT or the convergence of lymph-collecting tubules presenting a great number of reflectors to the ultrasound beam.[18] In small benign nodes, this central hilum may be difficult to demonstrate, but the elongated shape should be preserved (Fig. 7). Color or power Doppler may demonstrate central branching (hilar) vascularity (Fig. 6).

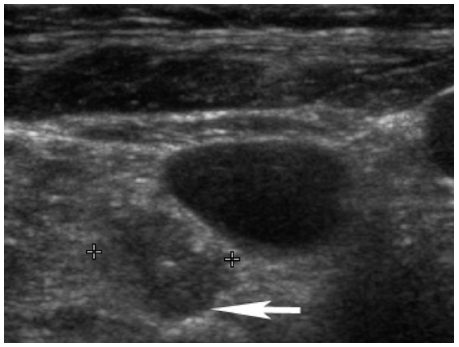

FIGURE 12. A 60-year-old woman with a history of recurrent metastatic PTC. Transverse US of the right side of the neck, level IV, shows a small node without fatty hilum (between calibers). Note the lobulated margins (arrow) and a few tiny hyperechoic foci. Surgical resection confirmed metastatic PTC.

Malignant Cervical Nodes

Malignant nodes tend to be larger in size compared with their benign counterparts (Figs. 8, 9). In fact, size is an important criterion used at CT. Malignant nodes also tend to be round in shape, with a ratio of long axis over short axis smaller than 2, and they lack a central echogenic hilus, as malignant cells infiltrate the hilus and distort cortical architecture early[18] (Fig. 10). Eccentric thickening of the hypoechoic nodal cortex (Fig. 11), irregular or nodular borders, punctate echogenic foci representing microcalcifications and cystic changes are other features of metastatic nodes (Figs. 8, 9, 12). Increased echogenicity relative to surrounding muscle is another feature associated with malignant nodes.[19] Color Doppler displays peripheral irregular vessels[15] (Figs. 8, 9, 13).

Several studies have assessed the use of these various sonographic criteria (Table 2) in distinguishing benign or reactive nodes from metastases.[15,16] Nodal size or largest

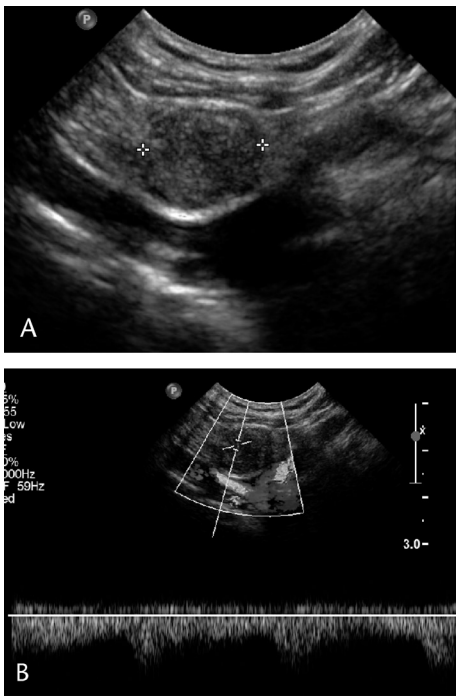

FIGURE 13. A 33-year-old woman with a history of recurrent metastatic PTC. A, Transverse US of the left side of the neck, level IV, shows a supraclavicular round node with suggestion of microcalcifications. Note the use of curvilinear transducer to image nodes located low in the neck. B, Duplex Doppler US demonstrates arterial flow within the node. Surgical resection confirmed metastatic PTC.

diameter does not appear to be a good discriminator between benign and cancerous nodes. It is well recognized that small nodes with a short axis diameter of 5 mm or less may harbor malignant cells.[16] Whereas a round shape and loss of the echogenic hilum and hypoechoic cortex have been suggested as potential indicators of malignancy, these criteria, if isolated, were not deemed specific for malignancy by Leboulleux et al.[15] The central echogenic hilum is particularly difficult to demonstrate in small subcentimeter nodes. By contrast, nodes with cystic changes or punctate calcifications were 100% specific for metastatic thyroid cancer in their study. Unfortunately, the sensitivity of these

TABLE 2. Ultrasound Criteria for Cervical Nodes

Ultrasound Criteria	Benign Nodes	Malignant Nodes
Size	<1 cm	>1 cm
Shape	Oval kidney bean shape	Round
Long axis/short axis	>2	<2
Echogenic hilus	Present	Absent (or eccentric)
Hypoechoic rim	Present, homogeneous	Absent or eccentric widening
Punctate hyperechoic foci	Absent	Present
Cystic areas	Absent	Present
Vascularity	Central, sparse	Peripheral, irregular

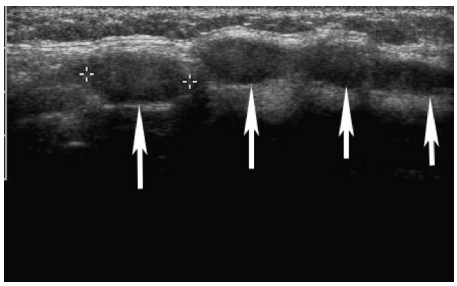

FIGURE 14. A 74-year-old woman with a history of thyroidectomy for MTC 3 years ago and gradually rising calcitonin levels. Sagittal US of the left side of the neck, level III, shows a chain of oval nodes without clear fatty hilum (arrows). The US-guided FNA of this node yielded metastatic MTC.

criteria was low at 11% to 46%. In our experience, it is not uncommon to encounter nodes that are still oval in shape but lack a clear fatty center, and we choose to label these *indeterminate* and recommend FNA, particularly if there is a chain of such nodes (Fig. 14).

Lesions Mimicking Recurrences

Several entities may present as small masses in the thyroidectomy bed. When comparing recurrent tumors from benign lesions in 58 patients with suspicious sonographic findings in the thyroid bed, Shin et al[11] found that only 20

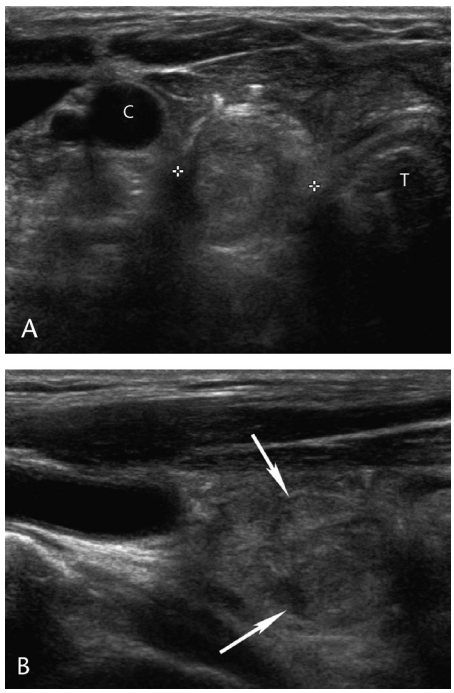

FIGURE 15. A 66-year-old woman with a history of thyroidectomy for MTC 6 months ago. A, Transverse US of the right side of the neck, level VI shows a 1.5-cm somewhat echogenic mass in the right surgical bed. B, Sagittal US of the right side of the neck, level VI, confirms the finding. The US-guided FNA of this mass yielded benign follicular epithelium consistent with thyroid remnant. C indicates common carotid artery.

of the 59 lesions they aspirated were proven to be malignant. Fine-needle aspiration revealed a variety of benign etiologies including thyroid remnant, postoperative scar, suture granuloma, muscle tissue, and fat necrosis (Fig. 15). These authors were not able to establish sonographic criteria that allow differentiation between benign masses in the surgical bed and recurrence. It has been our experience as well, and this difficulty is compounded by the small size of many of these lesions.[11]

In the lateral compartment of the neck, the most common benign lesion we encounter is a reactive lymph node.

ULTRASOUND-GUIDED FINE-NEEDLE ASPIRATION

At our institution, US-guided FNA to confirm the malignant nature of a suspicious or indeterminate lesion is requested by the ears, nose, and throat surgeon before reoperation. If suspicious nodes are demonstrated in multiple separate compartments of the neck (eg, ipsilateral central, level VI and lateral, level III or IV or bilateral compartments), multiple FNAs in different compartments are performed to guide reoperation.

The technique we use is similar to US-guided thyroid FNA, although small lesions may be more challenging (Fig. 11). We perform the procedure using 25-gauge spinal needles, with the US needle guide attachment after instillation of 1% lidocaine in the skin and needle tract to provide adequate anesthesia. The specimen is collected using a capillary technique and immediately expressed onto glass slides for Diff-Quick staining as well as alcohol fixation. Adequacy is assessed by an experienced on-site pathologist to minimize insufficient sampling and maximize diagnostic yield for subsequent Papanicolaou smears.

CONCLUSIONS

Neck US is now routinely incorporated in the surveillance protocol after total thyroidectomy for DTC and has proven to be an effective tool to diagnose local recurrences. Ultrasound is invaluable for preoperative planning because of its ability to precisely locate the site(s) of recurrence. It is best used in conjunction with serum markers as well as I131 imaging when indicated. It is thus incumbent upon the physicians supervising and interpreting this examination to develop a protocol in conjunction with the referring surgeons, train dedicated sonographers, and adopt meticulous scanning techniques.

Despite these undeniable advances in imaging, some controversy remains. In particular, it has not been shown with clarity that discovering and treating very small recurrences actually affects the prognosis.[2] However, until this question gets resolved, most patients are referred for surgery, and a multidisciplinary approach with sophisticated ultrasound remains essential to minimize operative risks and avoid fruitless dissection.[9]

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