Elastography of Thyroid Masses

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KEYWORDS

• Elastography • Thyroid • Papillary carcinoma • Nodule

KEY POINTS

- Techniques of elastography are available to evaluate the thyroid nodule.
- Many reasons exist for false positive and false negative results in elastography.
- Appropriate use of elastography is an adjunct to ultrasound and not a replacement.

DISCUSSION OF PROBLEM/CLINICAL PRESENTATION

The prevalence of thyroid nodules is approximately 3% to 8% in the general population[1–4] but increases to almost 50% after 65 years of age.[5] With advances in technology, incidence of thyroid nodules on ultrasound (US) has increased to almost 60%; however, the incidence of malignancy in thyroid is low at 5% to 15%.[6,7] In addition, B-mode and Doppler US have been found to have low accuracy. Fine needle aspiration (FNA) is the standard procedure to determine if a nodule is cancerous or not; however, FNA is an invasive procedure and would result in an inadequate sample in 10% to 20% of cases leading to rebiopsy.[6] Palpation has been used in clinical examination to assess if a thyroid nodule is firm or palpable; however, palpation is subjective and will vary depending on the size and location of the nodule.[8]

IMAGING PROTOCOLS

Imaging Findings

US elastography is a promising new technique in the evaluation of the thyroid nodule. It allows for "virtual palpation" of the nodule, which may not be otherwise palpable. US elastography was developed to obtain information on tissue stiffness noninvasively.[9–11] Due to the superficial location of the thyroid gland, it is feasible to obtain information regarding the stiffness in the organ or nodule.

Most malignant tumors are characterized by the presence of abnormally firm stroma due to the presence of collagen and myofibroblasts, which is the desmoplastic transformation. This tumor stroma promotes the proliferation of malignant cells (and could even initiate them).[12] However, certain benign fibrous tumors can be very stiff as well (histiocytofibromas, for example). Previous ex vivo studies had suggested that there is considerable difference between the stiffness in normal thyroid tissue and thyroid tumors.[13,14] Based on this observation, multiple in vivo studies were then performed to differentiate benign from malignant thyroid nodules. Various techniques exist for performing elastography as outlined in the other articles. A brief description of these techniques and their utility in thyroid elastography are mentioned here.

Quasi-static or strain elastography or sonoelastography

In quasi-static or strain elastography, the US probe is placed on the neck with gel interposition and compression is generated by pressure applied by the operator with the US probe on the skin. Improvement in the sensitivity of very small tissue movement detection has made it possible to use

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carotid pulsation to induce this tissue deformation.[15] Classification using 4 or 5 visual categorical scores (**Figs. 1** and **2**), either color coded or in gray scale, has been proposed.[16] Semi-quantitative analysis provides numerical values that correspond to the deformation ratios. The machine calculates a ratio between the zones of interest (regions of interest [ROI]) placed by the operator on the nodule and on the healthy tissue. The calculation can thus be made using the rates of deformation of the structure ("strain rate") (**Figs. 3** and **4**).[17]

A recent meta-analysis by Bojunga and colleagues,[18] which included 639 nodules, reported a mean sensitivity of 92% and a specificity of 90% using strain elastography for the diagnosis of malignant thyroid nodules; however, the patient population was highly selected with a 24% prevalence of malignancy and many patients were sent to surgery.

Two recent studies[19,20] with 309 and 97 patients, respectively, used strain values and ratios to determine thyroid nodule stiffness. All patients were referred to surgery. Vorländer and colleagues[19] used a proprietary absolute measurement of strain value, which ranged from 1.0 (maximum soft) to 0.1 (maximum hard) and reported a negative predictive value (NPV) for malignancy of 100% using a strain ratio cutoff of greater than 0.31 and a positive predictive value (PPV) of 42% using a cutoff of less than 0.15. Cantisani and colleagues[20] reported a sensitivity, specificity, PPV, and NPV of 97.3%, 91.7%, 87.8%, and 98.2%, respectively, for the prediction of malignancy using a strain ratio $\geq$2 (ratio of lesion strain to surrounding parenchyma). Elastography was more sensitive and specific than all conventional US features.

Another study compared strain elastography based on 4 point scores and the strain ratios between the nodule and the surrounding thyroid at the same depth.[21] The diagnostic accuracy of the strain ratio evaluation was slightly higher (0.88 vs 0.79, P<.001) than that of the elastography score, with a higher specificity. Another prospective study[22] evaluated strain elastography in 51 patients with small single solid nodules of 3 to 10 mm submitted to surgical resection. The 5-point scale developed by Itoh and colleagues[16] for the breast elastography was used in this study; with a cutoff at 3/4, a sensitivity of 91%, specificity of 89%, PPV 94%, and NPV 85% for the diagnosis of malignant nodules was found. Thus, strain elastography seems to have a potential even in small nodules.

However, additional studies, including only a few follicular carcinomas, revealed inconclusive data on the value of elastography. Most malignant nodules missed by elastography were follicular carcinomas, which can be soft and difficult to differentiate from benign nodules.[18] Strain elastography was evaluated in 102 patients with indeterminate cytology who went to surgery.[23] Histology revealed 64 follicular adenomas, 32 follicular variants of papillary thyroid cancer, 4 follicular carcinomas, and 2 hyperplastic nodules. In this selected population, strain elastography (4-point scale) only reached a PPV of 34% and an NPV

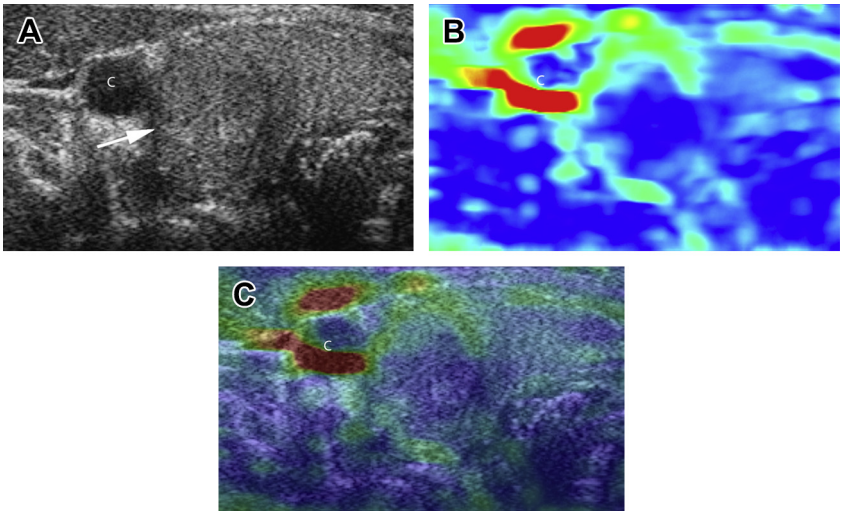

Fig. 1. Strain elastography: B-mode US image (*A*) showing a nodule in the right thyroid gland (*arrow*). This lesion showed increased stiffness on elastography (*B*) and the overlay image (*color overlayed* on B-mode) (*C*) with predominantly blue color (high stiffness), which was shown to be a follicular adenoma on histopathology. C, carotid artery.