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● *Original Contribution*

THYROID NODULE PARAMETERS INFLUENCING PERFORMANCE OF ULTRASOUND ELASTOGRAPHY USING INTRINSIC COMPRESSION

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Abstract—The influence of nodule parameters on the diagnostic accuracy of ultrasound (US) elastography in differentiating thyroid nodules was evaluated. One hundred seventy-six nodules (83 benign, 93 malignant) from 156 patients were included. Conventional B-mode and elastography examinations were performed. External compression with a transducer was not applied, as the pulsation from the carotid artery was used. Three nodule parameters (size, depth and distance to the carotid artery) were measured. The elasticity contrast index, in which increases with the stiffness of the nodules, was correlated with distance to the carotid artery (correlation coefficient = 0.283 in all nodules and 0.415 in malignant nodules, $p < 0.01$ in both groups). The diagnostic accuracy of elastography was significantly associated with a nodule's distance to the carotid artery ($p < 0.05$). No significant correlation was found between the diagnostic accuracy of elastography and the other parameters. Elastography results for nodules close to the carotid artery should be interpreted with caution. (E-mail: ldj6026@catholic.ac.kr) © 2015 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Elastography, Thyroid nodule, Parameter, Diagnostic accuracy.**

INTRODUCTION

Many thyroid nodules are detected incidentally as a result of the increasing use of imaging studies, such as computed tomography and ultrasound (US) (Frates et al. 2005; Yeung and Serpell 2008). Although most incidentally detected thyroid nodules are benign, malignancy of a thyroid nodule cannot be excluded without referral for fine-needle aspiration (FNA) biopsy except in some cases, such as hot nodules on a radionuclide thyroid scan and spongiform nodules on US (American Thyroid Association [ATA] Guidelines Taskforce on Thyroid Nodules and Differentiated Thyroid Cancer et al. 2009).

Ultrasound elastography measures the deformation of tissue in response to an applied force and derives and displays its stiffness (Ophir et al. 1991). It has been applied to differentiate non-invasively between benign and malignant thyroid nodules based on the fact that malignant nodules are stiffer than benign nodules (Dighe et al. 2008, 2010; Hong et al. 2009; Lyshchik et al. 2005; Rago et al. 2007). Rago et al. (2007) reported sensitivity and specificity values as high as 97% and 100% in the detection of malignant thyroid nodules using US elastography. In another study, Hong et al. (2009) reported a sensitivity of 88% and specificity of 90% for 145 surgery-bound thyroid nodules. However, these results were not quite reproducible, as reported in recent studies (Moon et al. 2012; Unlütürk et al. 2012).

Most US elastography studies have used the external compression force applied by the operator with a transducer (Hong et al. 2009; Lyshchik et al. 2005; Rago et al. 2007). A major limitation of US elastography with externally applied compression could be low reproducibility. Even though a relatively high degree of agreement was reported recently (Ragazzoni et al. 2012), Park et al. (2009) found no inter-observer

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agreement among three radiologists for thyroid US elastography using external compression. The inter-observer and intra-observer variability could be substantially reduced when the intrinsic carotid artery pulsation was used as the compression source (Lim et al. 2012), which suggests that thyroid elastography with intrinsic compression could render more reproducible results compared with external compression elastography.

Another shortcoming of US elastography is that the elastography image quality and diagnostic accuracy of the elastography image can be influenced by a nodule's parameters, such as size and location. For example, elastography image quality decreases with deep-seated nodules (from the compression source) because these nodules receive less compression. Chang et al. (2011) studied the factors influencing elastography image quality in evaluating suspicious breast masses. They found that lesion size, lesion depth and breast thickness were significantly associated with elastography image quality. Sensitivity in detecting malignant breast masses was significantly increased with higher image quality. Although there are quite a few studies using US elastography to evaluate thyroid nodules, there has been no study on how the parameters of a thyroid nodule influence the diagnostic accuracy of elastography.

Thus, the aim of the work described here was to evaluate thyroid nodule parameters that could influence the diagnostic performance of thyroid US elastography using intrinsic compression.

METHODS

Patients

From August 2010 to March 2011, 167 patients were recruited for US B-mode and elastography examinations in our institution; 56 of these 167 patients had initially been enrolled in our prior study (Lim et al. 2012). Seven patients with unsatisfactory FNA results and four patients with atypical cells of undetermined significance (ACUS) were excluded from the study. Thus, a total of 156 patients with 176 nodules formed the study population. The mean age was 47.3 ± 12.7 years, and 82.1% of the patients were female.

On the basis of the FNA biopsy results, nodules were classified using The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) as negative for malignancy (79 nodules), follicular neoplasm (five nodules), Hurthle cell neoplasm (three nodules) and malignancy (including suspicious for malignancy, 89 nodules). Eight patients with follicular neoplasm and Hurthle cell neoplasm underwent surgery, and based on the histopathologic results, there were three papillary thyroid carcinomas (PTCs), three follicular adenomas, one Hurthle cell adenoma and one follicular thyroid carcinoma. Eighty-one of the 89 patients (86 nodules) with cytologic findings of malignancy and suspected malignancy underwent surgery in our institution. The histopathologic findings confirmed that all 86 nodules were PTCs. As the histopathologic findings for the three nodules classified as malignant by FNA were not available (surgery was not performed at our institution), their cytologic results were used in the study. Thus, there were a total of 83 benign and 93 malignant nodules (92 papillary carcinomas and one follicular carcinoma) enrolled in the study. Between patients with benign and malignant nodules, there was no significant difference in mean age (49.7 ± 13.2 vs. 45.5 ± 12.1, $p = 0.055$) or proportion of women (87% vs. 78%, $p = 0.210$). This study was approved by the institutional review board of our hospital, and written informed consent was obtained from all patients.

Real-time US elastography examination and nodule parameter measurements

B-Mode US and elastography examinations were performed by one of three endocrinologists (M.K., D.L., S.K.) using a commercial US machine (Accuvix V20, Samsung Medison, Seoul, Korea) with a L5-13 linear transducer.

In many previous elastography studies, an observer would assign a score (out of 5–6 different scores) to a nodule after visually inspecting the pseudo-color pattern in a selected elastography image (Hong et al. 2009; Rago et al. 2007). In the current study, the elasticity contrast index (ECI), which quantifies the local strain contrast within a nodule, was interactively calculated (Luo et al. 2012). For the elastography image (Fig. 1) of a malignant nodule, the difference between areas of low and high strain is large, and the transition from high to low (or low to high) strain occurs over a short distance, leading to a high local strain contrast and a large ECI value. On the other hand, the benign nodule in Figure 2, for which there is a relatively small difference in stiffness compared with normal thyroid tissue, has a small ECI value.

To perform the elastography examination, the operator searched for the transverse plane showing both the common carotid artery and the largest diameter of the thyroid nodule using B-mode. Once the imaging plane was identified, the patient was asked to hold his or her breath, and the operator acquired the US data for ~4 s. No external compression was applied during data acquisition as carotid artery pulsation was used as an intrinsic compression source. The strain frames were generated using the acquired data (Luo et al. 2012). The ECI value was computed and displayed on the monitor of the US machine after the nodule boundary was delineated by the operator. A larger ECI value indicates a stiffer nodule and, thus, an increased likelihood of malignancy.