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● *Original Contribution*

ARTIFACTS IN SHEAR WAVE ELASTOGRAPHY IMAGES OF THYROID NODULES

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Abstract—The purpose of the study described here was to evaluate the presence and types of artifacts seen in color elastograms in thyroid elastography using shear wave elastography. This Health Insurance Portability and Accountability Act of 1996 (HIPAA)-compliant study was approved by the ethics committee of our institution, and all patients provided written informed consent. One hundred seventy-eight patients (40 men and 138 women; mean age, 49 y; range, 19–84 y) were enrolled for a total of 241 thyroid nodules. After a short ultrasound (US) examination, SWE images were acquired at multiple levels in the nodule in transverse and longitudinal orientations. A total of 1297 images were obtained from 241 nodules for an average of 5.4 ± 2.7 (mean ± standard deviation) images per nodule. A retrospective review of all images was performed by one reviewer experienced in thyroid elastography. Two hundred eighty images (21.6%) were rated as good quality, and 112 (8.6%) were rated as moderate quality without artifacts. A total of 905 (69.8%) images had some artifact present, though most of these images (73.4%) were still interpretable. Two hundred forty-one images (18.6% of all images) were considered uninterpretable because of artifact. The most common types of artifacts were due to operator error (44.6% of all images), primarily compression (36.5% of all images). Other artifacts seen were due to anatomy (presence of carotid pulsation or adjacent to thyroid or location in isthmus, 11% of all images), nodule characteristics (cystic and calcified nodules or large nodules with lack of penetration, 17% of all images) and other artifacts that could not be explained by the prior mentioned causes (13% of all images). Our study indicates that artifacts are common in elastography images. Operator error was the most common type of artifact we saw. This should be easily correctable by adequate knowledge and recognition with subsequent correction of the artifacts. (E-mail: dighe@uw.edu) © 2018 World Federation for Ultrasound in Medicine & Biology. All rights reserved.

Key Words: **Elastography, Thyroid, Artifacts.**

INTRODUCTION

Thyroid elastography is commonly used in combination with thyroid ultrasound (US) in the evaluation of nodules for the risk of malignancy. Its use is particularly prevalent outside of the United States, in Europe and Asia (Andrioli and Persani 2014). US can identify nodule features that are associated with higher risk of malignancy as well as benign features, both of which help determine which nodules are appropriate to biopsy (Frates et al. 2005).

Shear wave elastography (SWE) is a relatively new diagnostic tool that measures tissue stiffness by estimating the speed of shear waves generated by the acoustic radiation force of ultrasound push pulses. In this approach, a planar shear wave is generated from push pulses focused at increasing depths (Kim et al. 2012). A Doppler-like acquisition is used to detect and track the resulting tissue displacements generated from the passing shear wave, which is used to estimate the local tissue's shear wave speed. Because the shear wave speed can be directly related to the elastic or Young's modulus, a quantitative estimate of tissue stiffness (in kilopascals) can be obtained (Lyshchik et al. 2005a, 2005b). SWE is currently the most reproducible and least operator-dependent technique among the different elastographic techniques available today (Lim et al. 2012). SWE has been studied to differentiate benign from malignant thyroid nodules, as most of the malignant nodules are stiffer than the benign nodules (Andrioli and Persani 2014). However, various factors influence the elastographic evaluation of thyroid nodules including carotid pulsation, patient body habitus, tracheal motion, rim calcification, compressive force, and so forth (Kim et al. 2012; Lim et al. 2012). Due in part to these factors, SWE imaging has a number of different artifacts that can influence the true thyroid stiffness

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measurement. In our experience, we have seen multiple artifacts in the SWE images of the thyroid gland, and these artifacts, as of yet, have not been described in the literature. Knowledge of the artifacts is important to avoid mistakes in interpretation of images and also to be able to modify the acquisition technique to acquire the best and most consistent images for accurate diagnosis. Our objective was to describe the artifacts encountered in SWE imaging of thyroid nodules so as to avoid them in future studies and improve diagnostic performance.

METHODS

This study was Health Insurance Portability and Accountability Act of 1996 (HIPAA) compliant, approved by the institutional review board. All patients provided written informed consent. The authors were the study guarantors and had complete control of the data.

Patients

Patients were referred to the US clinic for preoperative mapping of the neck for lymph nodes in patients undergoing partial or complete thyroidectomy or guided fine-needle aspiration (FNA). Society of Radiologists in Ultrasound (SRU) guidelines for thyroid nodule biopsy are implemented at our institution, and these patients were invited to participate in the study. Patients were selected for FNA based on the SRU guidelines (Frates et al. 2005) or because they were at high risk based on their history, such as radiation exposure or family history of thyroid cancer. Patients less than 18 y of age, who were unable to consent, or with a diffuse abnormality of the thyroid without discrete nodules were excluded. Both gray-scale US and color Doppler (CD) were performed, followed by SWE. US gray-scale and CD images were not evaluated for the purpose of this study.

Elastography

Shear wave elastography was performed prior to the FNA or after the clinical US for pre-operative mapping with an ultrasound machine (SuperSonic Imagine's Aixplorer, Aix en Provence, France) with a broadband (4–15 MHz) linear array transducer. After B-mode and CD images were obtained, SWE images were obtained for the thyroid nodules by seven sonographers trained in elastography for at least 5 y, though they were relatively new to SWE imaging. The exam was performed with the patient in the supine position with mild extension of the neck. After application of adequate US gel, imaging was performed by lightly placing the transducer on the patient's neck. Patients were asked to hold their breath for a short time while elastography images were acquired.

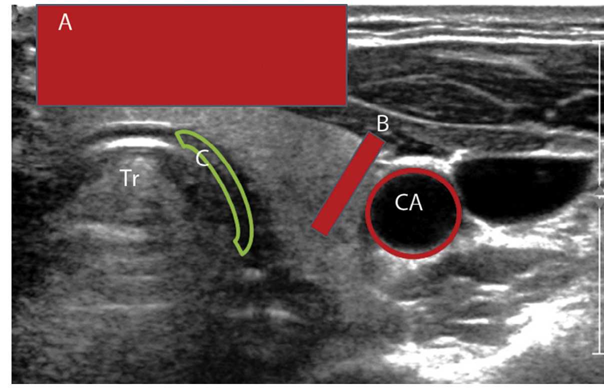

Fig. 1. Various types of artifacts seen in the thyroid during shear wave elastography imaging. (A) Artifact caused by compression. (B) Artifact caused by carotid artery pulsation. (C) Artifact caused by compression against hard surface—trachea. Tr = trachea; CA = carotid artery.

Retrospective review of images for artifacts

The authors in the study evaluated a subset of the images for quality and defined which images would be considered as good, moderate-quality artifacts present with either interpretable or non-interpretable images. In addition, the types of artifacts seen were listed by the authors by consensus. Overall image quality was rated as good without artifacts, moderate without artifacts, artifacts present but interpretable and artifacts present and not interpretable. Images were also classified by each type of artifact present, if any. Artifacts were categorized as caused by patient anatomy (trachea, common carotid artery pulsation, jugular vein and vertebral bodies), nodule characteristics (cystic, calcified shell, macrocalcifications and depth >3 cm), operator-dependent factors (compression, probe frequency too high, blurring caused by probe motion and lack of contact of probe with neck) and lack of SWE signal not otherwise explained by the preceding factors (noise/low signal-to-noise ratio [SNR] and incomplete/weak SWE signal in nodule). One of the authors (J.T.), who was blinded to cytopathology or histopathology results, then retrospectively reviewed the images for presence of artifacts. For each type of artifact, the reviewer also indicated whether the artifact made the SWE images uninterpretable or not. Some examples are provided in Figure 1.

Statistical analysis

The frequencies of each type of artifact were summarized as count (percentage). The frequencies of each type of artifact were further broken down by whether the artifact made the image interpretable or not. The rates of each major type of artifact were further broken down by sonographer. Mixed-effect logistic regression models were used to test for variation in the artifact rates between