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Correlation between the size of incidental thyroid nodules detected on CT, MRI or PET-CT and subsequent ultrasound

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ABSTRACT

Purpose: The aim of this study was to assess the relationship between size of thyroid nodules at computed tomography (CT), magnetic resonance imaging (MRI) or positron emission tomography CT (PET-CT), and size at ultrasound.
Materials and methods: We performed a retrospective review of thyroid ultrasound studies over a 2-year period.
Results: A total of 307 patients were included in the study. There was a statistically significant difference between the size of nodules measured on ultrasound compared with cross-sectional imaging ($P < .001$). American College of Radiology white paper recommendations would have decreased ultrasound referrals by 24% without any additional missed malignancies.
Conclusion: Cross-sectional imaging underestimates the size of thyroid nodules; however, the difference is small and likely not clinically significant.

1. Introduction

Incidental thyroid nodules are commonly encountered at computed tomography (CT), magnetic resonance imaging (MRI) or positron emission tomography CT (PET-CT). However, the imaging features of thyroid nodules on these modalities are nonspecific, resulting in a need for additional evaluation when characterization of the incidental finding is warranted. This represents a significant clinical problem because incidental thyroid nodules are detected in approximately 16% of CT studies [1]. Recommending further evaluation for all thyroid nodules found at nonsonographic cross-sectional imaging would be prohibitively expensive and would subject many patients to the stress and uncertainty of further diagnostic workup. Perhaps for this reason, currently, practices for reporting incidentally detected thyroid nodules at nonsonographic examinations are variable [2–4].

Ultrasound is the preferred imaging modality for evaluation of the features of thyroid nodules [5]. Several societies have published guidelines for management of thyroid nodules utilizing ultrasound criteria [6–8]. Although these guidelines vary in their recommendations and center upon nodule morphologic features, the size of the nodule at ultrasound is a component of each of these systems [6–8]. More recently, the American College of Radiology (ACR) has published a white paper recommending using a combination of age, lesion size and imaging features to determine recommendations for thyroid ultrasound [9]. To our knowledge, however, no study has specifically evaluated the relationship between the size of thyroid nodules as measured at nonsonographic cross-sectional imaging with their size as measured by ultrasound. The aims of this study are to assess the correlation of the size of incidentally detected thyroid nodules, as measured at nonsonographic cross-sectional imaging (CT, MR or PET-CT) with their size at subsequent ultrasound and to determine the impact of applying the ACR white paper recommendations with regard to thyroid nodule follow-up.

2. Materials and methods

This study was institutional review board approved and Health Insurance Portability and Accountability Act compliant. A power calculation indicated that 300 cases were needed to detect a difference of 3 mm between ultrasound and cross-sectional imaging measurements ($P > 95\%$). Cases were identified through a retrospective search of the institutional PACS (Centricity, GE, Waukesha, WI). The study group included all patients having thyroid ultrasound during a 2-year period for which the clinical indication referenced prior CT, MRI or PET-CT findings. Cases were excluded if antecedent cross-sectional imaging was not available for review or if more than 6 months had elapsed between the initial cross-sectional imaging and the date of the ultrasound. Patients with a history of thyroid cancer or thyroid surgery were excluded because these would not represent true incidental nodules. Clinical data recorded included patient age, gender, and history of malignancy.

2.1. Pre-ultrasound imaging

CT studies were performed on MDCT scanners with 64-320 detector rows (Siemens, GE, Phillips). MRI studies were performed at 1.5 or 3

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Tesla (Siemens; GE). PET-CT studies were performed on a single machine (Discovery LS, GE). Imaging protocol and use of contrast media varied; PET-CT examinations were performed without intravenous contrast material.

2.2. Ultrasound imaging

Thyroid ultrasound studies were performed using 10–12 MHz linear transducers (HDI 5000 and IU22, Philips; Logiq 9, GE) using a standard protocol including transverse and sagittal images through both thyroid lobes and the isthmus. Each nodule was measured in three dimensions (transverse, anteroposterior and craniocaudal).

Size of nodules as given in clinical ultrasound, CT, MR and PET-CT reports was recorded. Retrospective image analysis was performed by a single investigator (JNM, with 5 years of experience in thyroid imaging). Nodules were remeasured in three dimensions (transverse, anteroposterior, and craniocaudal). When coronal or sagittal reformations were not present at CT or PET-CT examinations, craniocaudal measurements were not possible. Remeasured sizes were compared with sizes reported in clinical imaging reports, and remeasured sizes were otherwise used for study purposes. On CT, MRI or PET-CT, data recorded included the presence of discrete thyroid nodules or diffuse thyroid abnormality, number of nodules, reported and remeasured size and presence or absence of calcification (for CT or PET-CT). On ultrasound, the following data were recorded: presence or absence of nodules, number of nodules, size in three dimensions and the presence or absence of calcification. Ultrasound images were reviewed in conjunction with antecedent CT, MRI or PET-CT imaging to ensure that the same nodule was evaluated in both studies. In addition, data were recorded on any recommendation for biopsy with subsequent review of the electronic medical record to document the results of any biopsies.

2.3. Statistical methods

Data were analyzed using SPSS v18 for Windows. Continuous data were compared using the Student's *t* test; categorical data were compared using the chi-squared test. A paired *t* test was used to compare measurements of nodule size in different imaging modalities. The maximum reported and remeasured diameter for each nodule was used as the comparator for each modality. The ultrasound measurement was considered the gold standard. Measurements were compared using both correlation coefficients and by calculating the absolute error in measurements. Receiver operator characteristic curve analysis was used to assess the range of sensitivities and specificities for detection of a nodule measuring 1 cm or greater at ultrasound, resulting from the measurements on cross-sectional imaging.

3. Results

3.1. Patients

During the 2-year study period, there were 458 patients with no prior history of known thyroid cancer who underwent thyroid ultrasound with an indication that referenced a finding at prior CT, MRI or PET-CT. A total of 123 patients were ineligible as preceding cross-sectional imaging was performed at an outside institution and were not available for review. Twenty-eight patients were excluded due to an interval of >6 months between the preceding cross-sectional imaging study and the ultrasound examination. The resultant study group consisted of 307 patients [79 (26%) male; 228 (74%) female; mean age, 60 years; range, 21–93 years]. A total of 246 patients had no history of malignancy (80.1%); 61 patients had a history of nonthyroid malignancy [breast (n = 20), endometrial (n =7), colon (n =5), lung (n = 4), lymphoma (n =4), myeloma (n =4), renal (n =3), hepatocellular (n =2), prostate (n =2), seminoma (n =2), and one case each of bladder, brain, carcinoid, head/neck, leukemia, liposarcoma, and squamous cell skin cancers, respectively].

3.2. Cross-sectional imaging findings

Presonographic imaging consisted of 229 CT (74.6%), 69 MRI (22.5%) and 9 PET-CT studies (2.9%). Mean interval between cross-sectional imaging and ultrasound was 41 days (range, 0–179). Mean slice thickness was 2.7 mm (range, 1–5 mm). Intravenous contrast was administered in 49.8% (n = 153). In 282 (90.6%) cases, discrete thyroid nodules prompted recommendation for ultrasound. Multiple nodules were seen in 84 (27.4%) cases. Other findings resulting in recommendation for ultrasound included thyroid calcification (n = 40 (16.5%) and diffuse thyroid abnormality (n =25, 8.1%).

3.3. Comparison of reported size and remeasured size at CT/MR/PET-CT

Nodule sizes were indicated in the clinical radiology report in 184 of 282 (65.2%) cases. The mean reported nodule size was 13.9 mm (range, 2.5–62 mm). Mean nodule size based on repeat measurement (remeasured nodule size) was 15.6 mm (range, 3–62 mm). Longest nodule measurement was from the coronal or sagittal plane in 131 (47%) of nodules. There was a very high correlation between reported and remeasured nodule sizes (r = 0.948, P<.001). Mean difference between reported and remeasured nodule size was 2.2 mm.

3.4. Ultrasound imaging findings

Of 307 patients, 285 had nodules at ultrasound (92.8%), with multiple nodules in 226 of 285 (79.3%) patients. Mean nodule size was 17.5 mm (range, 3–54 mm).

3.5. Comparison of ultrasound and cross-sectional imaging findings

In 268 of 285 (94%) patients with thyroid nodules, nodules corresponded to the finding measured at prior cross-sectional imaging. In the remaining 17 of 285 (6%) cases, nodules were identified on ultrasound, but previous cross-sectional imaging had shown diffuse heterogeneity or enlargement of the thyroid gland, without measurable correlates for comparison. There was a statistically significant difference between the size of nodules as measured at nonsonographic cross-sectional imaging and ultrasound, with a slight tendency of nonsonographic measurement to underestimate nodule size (mean, 15.7 mm) with respect to ultrasound measurement (mean, 17.5 mm) (P < .001). Using sonographic measurements as gold standard, lesion size was accurate by nonsonographic imaging in 42 (16%) cases, underestimated nodule size in 159 (59%) cases, and overestimated nodule size in 67 (25%) cases (Fig. 1). Including all lesions, mean measurement error was 3.8 mm; mean underestimation error was 4.7 mm and mean overestimation error was 3.9 mm. There was no significant difference between the mean measurement errors for CT (3.9 mm), MRI (3.3 mm) and PET-CT (3.5 mm) (P = .684) (Fig. 2).

3.6. Discrepancies between nonsonographic imaging studies and sonographic findings

In 25 of 307 (8%) patients, ultrasound was recommended on the basis of diffuse thyroid gland enlargement or asymmetry, with nodules seen on ultrasound in 17 cases, 16 of which demonstrated multinodular goiters. The mean size of the largest nodules found in these cases was 21 mm (range, 5–51 mm). Seven of these nodules were recommended for biopsy, with none of the resultant specimens positive for malignancy. In 14 of 307 (5%) of patients, a nodule was suspected (on 10 CT, 2 PET-CT and 2 MRI studies), but no nodules were seen on ultrasound. In one case, the CT demonstrated calcification within the right lobe of the thyroid and an adjacent lymph node. Ultrasound did not show a