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Comparison of Imaging Modalities in Pediatric Thyroglossal Duct Cysts

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Objectives/Hypothesis: To determine and compare the accuracy of different imaging modalities including ultrasound (US), magnetic resonance imaging (MRI), and computed tomography (CT) in the diagnosis of thyroglossal duct cysts (TGDC) in children.

Study Design: Retrospective chart review.

Methods: A retrospective chart review was performed on patients under the age of 18 years who had undergone surgical excision of midline neck masses between January 2002 and June 2011. All patients had preoperative imaging. Data including age at surgery, preoperative imaging results, and postoperative pathology results were recorded. Preoperative imaging diagnoses were then compared to postoperative pathologic diagnoses. Diagnostic test statistics were performed.

Results: A total of 44 patients met the study criteria. There were 15 patients who underwent more than one modality of imaging study. US had a sensitivity of 75% in diagnosis of TGDC. MRI sensitivity was 60% and CT was 82%. None of the tests had high specificity for TGDC; US was the highest at 80%. All three modalities had positive predictive values higher than 90%. US had the highest positive likelihood ratio (3.8), although the 95% confidence interval was not statistically significant.

Conclusions: In a comparison of the three most commonly used imaging modalities for pediatric TGDC, US was the preferred exam given its comparable accuracy, ease of administration, and lower cost. In addition, the added risks of general anesthesia with MRI and ionizing radiation with CT are not justified in this setting given their equivalent or inferior performance when compared to US in this cohort.

Key Words: Congenital neck mass, radiology, thyroglossal duct cyst.

Level of Evidence: 4

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INTRODUCTION

Thyroglossal duct cysts (TGDC) are the most common congenital midline neck masses in children.[1] Due to their congenital origin, TGDC typically present in childhood, although the lesions may be diagnosed in adults as well. TGDC occur as midline masses in the region of the hyoid bone but can be found anywhere from the submental triangle to the clavicle.[1] Because of the potential for infection and the small risk of coexisting thyroid carcinoma within TGDC, surgical excision is recommended.

Radiologic imaging serves an important role in the diagnosis of TGDC. Imaging studies can further characterize the lesion as well as provide conclusive evidence of the presence of the normal thyroid gland. In a small proportion of cases (1% to 2%),[1] TGDC may contain ectopic thyroid tissue, and the patient may not have any other functioning thyroid tissue leading to the need for lifelong thyroid hormone supplementation after TGDC excision. In addition, accurate diagnostic imaging can assist in preoperative counseling of the need for more extensive surgical excision than other common midline neck masses.

Traditionally, ultrasound (US) has been the preferred imaging modality for midline neck masses in children. However, reports have offered conflicting evidence on the accuracy of US examination in this setting. Gupta and Maddalozzo describe high accuracy for US in diagnosis of TGDC with a specificity of over 90%.[1] However, in a study by Sidell and Shapiro, ultrasound was not found to be an accurate diagnostic tool in the setting of TGDC with a specificity of 20%.[2]

Given the conflicting current literature on the accuracy of US diagnosis of TGDC, we aimed to determine whether magnetic resonance imaging (MRI) or computed tomography (CT) offers improved diagnostic accuracy over US in this clinical setting by correlating preoperative imaging diagnoses to final pathologic diagnoses. Although previous studies have suggested MRI and CT to be more accurate,[1–4] there are no studies in the current literature that directly compare these modalities to US in a quantitative fashion.

MATERIALS AND METHODS

After obtaining institutional review board approval, a retrospective chart review was performed at our institution for the time interval between January 2002 to June 2011. Inclusion

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TABLE I.
Diagnoses of Study Subjects.

Diagnosis	Pathology, No. (%), n = 44	Ultrasound, No. (%), n = 25	MRI, No. (%), n = 22	CT, No. (%), n = 13
TGDC	38 (86)	16 (64)	13 (59)	10 (77)
Lymph node	2 (4.5)	2 (8)	0	0
Ectopic thyroid	1 (2.3)	0	0	0
Epidermal inclusion cyst	1 (2.3)	0	0	0
Thymic cyst	1 (2.3)	0	2 (9.1)	0
Dermoid	1 (2.3)	1 (4)	2 (9.1)	0
Cyst	0	1 (4)	0	0
Bronchogenic cyst	0	0	1 (4.5)	0
Inflammatory change	0	0	1 (4.5)	1 (7.7)
Vascular malformation	0	0	1 (4.5)	0
No diagnosis	0	5 (20)	2 (9.1)	2 (15)

MRI = magnetic resonance imaging; CT = computed tomography; TGDC = thyroglossal duct cyst.

criteria included age 18 years or younger and surgical excision of a midline neck mass. Patients who did not have preoperative imaging were excluded. A total of 44 patients were identified.

All patients underwent preoperative imaging with US, MRI, or CT. Some patients had more than one modality of imaging. When a differential diagnosis was listed in the radiology report, one diagnosis was usually termed as likely. This was the diagnosis used in our tabulation. Reports without a diagnosis or with multiple diagnoses linked by "or" were tabulated as no diagnosis or equivocal diagnosis.

Charts were reviewed for preoperative imaging diagnosis and postoperative pathologic diagnosis. Results were recorded in a standard spreadsheet format. Statistical analysis was performed using SPSS version 13.0 (SPSS, Inc., Chicago, IL). Test accuracies were calculated in a standard two-by-two contingency table format with appropriate diagnostic test probabilities. Likelihood ratios were calculated with a 95% confidence interval (CI).

RESULTS

The average age at the time of surgery was 6.5 years (range, 1–14 years). Ten patients were imaged with only US, 13 only with MRI, and six only with CT. Some underwent more than one type of imaging study: eight US/MRI, six US/CT, and one patient underwent all three. The most common diagnosis on pathology was TGDC (38/44, 86%). Preoperative imaging findings were tabulated for each modality (Table I).

Preoperative imaging findings were then correlated with postoperative pathologic diagnoses and tabulated in a standard two-by-two contingency table (Table II). Fisher exact test was performed. The only statistically significant correlation between the preoperative imaging diagnoses and postoperative pathological diagnoses was for US ($P < .05$).

Sensitivities, specificities, positive predictive values (PPV), and negative predictive values (NPV) were then calculated. CT was the most sensitive diagnostic test (82%), followed by US (75%), and MRI (60%), respectively. All three modalities had high PPVs ($\geq$90%.) Specificities and NPVs were considerably lower due to the high incidence of false negatives for US and MRI (Table III).

Positive and negative likelihood ratios for the different imaging modalities were calculated. For the 95% CIs, all ratios included 1 except for the negative likelihood ratio of US. This implies that no diagnostic modality had a statistically significant likelihood of predicting TGDC. However, US did have the highest positive likelihood ratio at 3.8 (Table IV).

There were eight patients who underwent both US and MRI. In four of these individuals, the US and MRI were both accurate in predicting the presence of a TGDC. In one patient, both studies were inaccurate; the US diagnosed an unspecified cystic lesion and then MRI diagnosed inflammatory change, whereas the pathologic outcome was TGDC. In the remaining three patients, the MRI and US were discordant, with one modality accurately predicting the final pathologic diagnosis (Table V).

Six patients underwent both US and CT. In one patient, both studies were accurate in diagnosing TGDC. In another patient, both studies were inaccurate in the diagnosis of a TGDC, as the US was equivocal and the

TABLE II.
Accuracy of Imaging Correlated With Pathology.

	Pathology	
	+TGDC	−TGDC
Ultrasound*		
+TGDC	15	1
−TGDC	5	4
MRI†		
+TGDC	12	1
−TGDC	8	1
CT‡		
+TGDC	9	1
−TGDC	2	1

*Fisher exact $P < .05$.
†Fisher exact $P > .99$.
‡Fisher exact $P = .42$.
TGDC = thyroglossal duct cyst; MRI = magnetic resonance imaging; CT = computed tomography.

TABLE III.
Comparison of Diagnostic Test Characteristics.

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
US	75% (51%-90%)	80% (30%-99%)	94% (68%-100%)	44% (15%-77%)
MRI	60% (36%-80%)	50% (3%-97%)	92% (62%-100%)	11% (0.6%-49%)
CT	82% (48%-97%)	50% (3%-97%)	90% (54%-99%)	33% (2%-87%)

CI = confidence interval; PPV = positive predictive value; NPV = negative predictive value; US = ultrasound; MRI = magnetic resonance imaging; CT = computed tomography.

CT finding was infection/inflammation. One patient had equivocal diagnoses on both modalities and ultimately had a dermoid on final pathology. In three patients, the two imaging studies were discordant, with one modality agreeing with the final pathologic diagnosis. All three of these patients were ultimately diagnosed with TGDC (Table V).

In one patient, all three imaging modalities were used. An initial US rendered a diagnosis of TGDC. An MRI subsequently was not diagnostic, whereas a subsequent CT scan was read as TGDC, which was ultimately consistent with the final pathologic diagnosis.

DISCUSSION

TGDC is the most commonly diagnosed congenital midline neck mass in children. Embryologically, TGDC results from abnormal development of the thyroid gland, which originates from the foramen cecum at the junction between the anterior two-thirds and the posterior one-third of the tongue.[3] As the thyroid descends in the neck, it remains connected to its origin at the foramen cecum by a tubular structure called the thyroglossal duct. Failure of the duct to involute during gestation can result in local infection, inflammation, and cyst formation.[3]

Although most TGDC present as asymptomatic midline neck lesions,[4] some children will present with midline neck abscesses as a result of entrapped secretions along the remnant thyroglossal duct. The rate of preoperative infection has been quoted as high as 41% of patients.[4] Because of the potential for infection requiring intervention, surgical excision is typically recommended for TGDC. In addition, there is a small risk of coexisting thyroid carcinoma in the range of 0.7% to 1.6%.[5]

The diagnosis of TGDC is made by a combination of clinical exam and imaging. Not only does imaging provide further information on the nature of the midline neck mass, but in the case of TGDC, imaging confirms the presence of thyroid tissue in the normal anatomical location. In a small proportion of cases, a TGDC contains ectopic thyroid tissue, which is the only functioning thyroid tissue in the body.[1,6] This information is critical preoperatively to provide counseling about potential need for lifelong thyroid hormone supplementation after surgery.

TABLE IV.
Likelihood Ratios.

	+LR (95% CI)	−LR (95% CI)
US	3.8 (0.64-22)	0.31 (0.13-0.74)
MRI	1.2 (0.29-5.0)	0.80 (0.18-3.6)
CT	1.6 (0.40-6.7)	0.36 (0.04-3.4)

LR = likelihood ratio, CI = confidence interval; US = ultrasound; MRI = magnetic resonance imaging; CT = computed tomography.

In the initial evaluation of a suspected pediatric TGDC, US is the preferred imaging modality due to the exposure of ionizing radiation during CT scans and the frequent need for general anesthesia with MRI studies in children. Although previous reports have described the utility of US for the confirmation of the presence of a normal thyroid gland, there is a lack of consensus in the current literature on the utility of ultrasound in the diagnosis of TGDC.[1,2]

Aside from the confirmation of a normal thyroid gland, imaging is also critical for preoperative counseling regarding the extent of surgery and subsequent associated risks. Whereas a dermoid generally requires only a superficial dissection, TGDC require removal of the middle third of the hyoid bone to reduce the chance of recurrence and placement of a drain.[7] Although studies have quoted complication rates in the range of 24% to 29%,[4,8] these complications tend to be minor and include wound complications such as seroma, wound infection, stitch abscess, and wound dehiscence.[8] However, serious complications including inadvertent airway entry and hypoglossal nerve paralysis have been reported. Therefore, if there is a more accurate diagnostic test available with a higher sensitivity and specificity than US for TGDC, it may offer the surgeon more confidence in preoperative diagnosis and assist in parental counseling.

Some have suggested that due to the risk of general anesthesia for MRI and ionizing radiation exposure for CT, these tests are not practical for use in TGDC.[2] In our cohort, MRI and CT were not significantly more accurate in the diagnosis of TGDC than US. MRI had lower sensitivity and specificity than US, and CT had only a slight advantage in sensitivity over US. The PPV for each of the three studies was quite high, implying that a positive imaging diagnosis of TGDC with any modality is predictive of the real diagnosis. However, the NPV was low for all the studies due to the fact that there were many false negatives.

In examining the cases in which more than one imaging modality was obtained, we tried to assess whether the additional imaging modality changed patient management. In all of these cases, US was the initial study obtained, followed by either MRI or CT. In one patient, MRI diagnosed a thymic cyst whereas the US diagnosed a TGDC. In the other case, the US was equivocal whereas the MRI diagnosed a TGDC.

TABLE V.
Cases of Ultrasound, Magnetic Resonance Imaging, and Computed Tomography Discordance.

	Pathology	US	MRI
US correct	TGDC	TGDC	Epidermoid, less likely TGDC
MRI correct	Thymic cyst	TGDC	Thymic cyst
	TGDC	No diagnosis	TGDC
	Pathology	US	CT
US correct	TGDC	TGDC	Equivocal (TGDC or epidermoid)
CT correct	TGDC	Dermoid	TGDC
	TGDC	No diagnosis	TGDC

US = ultrasound; MRI = magnetic resonance imaging; TGDC = thyroglossal duct cyst; CT = computed tomography.

In two separate cases, CT scans made correct diagnoses of TGDC after the US interpretation was wrong (dermoid) or equivocal. It can be argued that the CT offered both the surgeon and the parent better preoperative preparation than with US alone.

It has been acknowledged that TDGCs have variable imaging characteristics on US.[9] They can range in appearance from anechoic masses to heterogeneous cystic lesions. Previous infection or hemorrhage can influence their appearance greatly.[3,9] In addition, US is an operator-dependent procedure, and often the interpreting radiologists are not present during the real-time examination, which may further affect the diagnostic accuracy.

CT criteria for diagnosis of TGDC are less variable and usually include well circumscribed cystic structures lying in the expected location in the midline, adjacent to the hyoid bone.[3] On MRI, criteria for TGDC involve homogeneous low signal on T1-weighted images and homogeneous high signal on T2-weighted images. On T2-weighted fat saturated images, the thyroglossal duct tract can be identified in approximately 18% of cases.[3]

One factor that may affect the diagnostic value of all imaging modalities is the willingness of the radiologist to commit to a diagnosis. In two patients who had US exams diagnostic of TGDC, both the MRI and CT reports mention TGDC; the MRI radiologist opined "less likely TGDC" and the CT radiologist made an equivocal diagnosis of "TGDC or epidermoid." In this litigious era of medicine, radiologists may feel less empowered to commit to a diagnosis for fear of misdiagnosis. It is also possible that radiologists may not fully understand the implication of a diagnosis of TGDC as compared to a simple cyst, which would not require a Sistrunk operation. Real-time performance and interpretation of neck ultrasound is becoming increasingly incorporated into the armamentarium of clinical otolaryngology and may result in more accurate interpretations. None of the ultrasounds in this study were performed or interpreted primarily by an otolaryngologist.

There are some limitations to our current study design. Although a prospective randomized study would be ideal, it is not practical in this setting in which MRI and CT are vastly different than US with respect to patient risk and comfort. Another limitation is our relatively small sample size. The total size of our cohort compares favorably to two previously published studies examining preoperative imaging of TGDC.[1,2] However, there were fewer patients in each subdivided group by imaging modality. There is also some degree of subjectivity in both the performance of US and the interpretation of radiographic images that can result in bias. Because one of the goals of this study was to try to provide practical recommendations for imaging work-up of TGDC in clinical practice, we feel that the way we analyzed the radiologic data most closely simulates how the data are used in the clinical setting.

Therefore, although MRI and CT are sensitive diagnostic tests for TGDC, this study demonstrates that they do not confer a significant diagnostic advantage over US. As clinicians, it is important that we be able to offer safe and cost-effective preoperative testing to our patients. MRI and CT may still be indicated in complex or recurrent TGDC.

CONCLUSION

Accurate preoperative diagnosis of TGDC allows for better preoperative counseling of potential perioperative risks. Our study supports the use of US as equally accurate compared to MRI and CT with superiority over the other two modalities in cost and safety.

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