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Original Research Article

A Study of Efficacy of High-Resolution Sonography in Differentiating Benign and Malignant Nodules of Thyroid

Srinivas Varkala[1], S Srikanth Rao[2]

[1]Associate Professor, Department of Radiology, Prathima Institute of Medical Sciences, Naganoor, Karimnagar.
[2]Associate Professor, Department of Radiology, Prathima Institute of Medical Sciences, Naganoor, Karimnagar.

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Corresponding Author: Dr. S Srikanth Rao
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Abstract:

Background: Thyroid nodules are common. Their clinical significance lies in the need to rule out malignancy, which accounts for 4.0% to 6.5% of all nodules, assess their functional status, and determine the presence of any pressure symptoms. The use of advanced and highly sensitive imaging techniques has led to an increased detection rate of incidental thyroid nodules in recent years. This study evaluated the efficacy of high-resolution sonography in cases of thyroid nodules presenting to our hospital.

Methods: Thyroid nodules were examined on SIEMENS ACUSON 300 machine via a 5-10 MHZ linear probe. Sonographic findings of each thyroid nodule were assessed just before the FNA examination. USG and pathological findings were blinded to each other. Nodules were evaluated for their size, shape, margins, echogenicity, presence of calcification, presence of peri lesional halo, and internal composition. The margins were smooth or irregular, the shape was lobulated or round and echogenicity was iso, hypo, or hyperechoic regarding thyroid.

Results: This study of 135 thyroid nodules in 100 patients (91 female, 9 male) evaluated ultrasound (USG) features for malignancy prediction. Histopathology confirmed 18.5% as malignant. Smooth margins (98% specificity) and predominantly cystic content (98.5% NPV) strongly suggested benignity. Poorly defined margins, calcifications, absent/thick halo, and marked hypoechogenicity were more frequent in malignant nodules, though with varying sensitivity and PPV. Combining USG features, as in TIRADS, proved crucial for accurate risk stratification, with high NPVs aiding in ruling out malignancy.

Conclusion: Grayscale USG findings proved valuable in identifying clinically significant thyroid nodules and distinguishing between malignant and benign ones. Our study highlighted that malignant nodules commonly exhibited features such as poorly defined margins, microcalcifications, marked hypoechogenicity, and cystic predominance, all of which demonstrated high diagnostic accuracy.

Keywords: Nodules, Calcification, Margins, Halo, FNAC, USG.

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Introduction

Thyroid nodules are common and can be identified in approximately 5 – 7% of adults. However, thyroid malignancy is not very widespread there are about twenty-five thousand cases in the United States alone annually [1, 2]. Thyroid nodular hyperplasia is the most common cause of benign thyroid nodules [3]. However, because only 5–7% of thyroid nodules are malignant, there is a need to identify malignant nodules [3] correctly. High-resolution ultrasonography has been crowned the gold standard imaging modality to be used in assessing thyroid nodule pathology. Specifically, concerning the predictive accuracy when multiple signs of malignancy are present, the US proves useful. Moreover, fine needle aspiration (FNA) has also proven useful in the assessment of nodules [4].

It has been established that the identification of certain morphologic patterns in the US constitutes a reliable means for diagnosing benign thyroid nodules that are unlikely to necessitate cytological examination, thus avoiding biopsy [5]. Owing to the perceived variability in the characterization and reporting of thyroid lesions, Horvath et al. [6] propounded TIRADS. Even though many people have thyroid nodules, thyroid cancer is rare – only 5-7% of thyroid nodules are cancerous [7]. In light of this high incidence, a proper pathway in differentiating who requires excision and who would benefit from a more conservative approach must be established. About margins, echogenicity, calcification, halo characteristics, and internal compositions, there are defining attributes that can

be used to determine malignant potential. This research seeks to compare solid, benign, and malignant thyroid nodules using their sonographic features with pathological confirmations of the results except for purely cystic nodules.

Material and Methods

The prospective study was conducted in the Department of Radiology, Prathima Institute of Medical Sciences, Naganoor, Karimnagar. Institutional Ethical approval was obtained for the study. Written consent was obtained from all the participants of the study after explaining the nature of the study in the vernacular language.

Inclusion Criteria

1. Patients present with thyroid nodules
2. Males and Females
3. Aged 20 years and above
4. Willing to participate in the study

Exclusion Criteria

1. On treatment for thyroid malignancies
2. History of thyroid surgeries
3. Not willing to participate in the study

Approximately 100 patients with thyroid nodules were taken in our study and referred from OPD. In our study 9 were males and 91 were females. Approximately 135 nodules were detected sonographically in 100 patients. All nodules were preceded for FNA examination. The age range of patients is from 18 to 72 years, and written informed consent was taken from each patient. Thyroid nodules were examined on the SIEMENS ACUSON 300 machine via a 5-10 MHZ linear probe.

Sonographic findings of each thyroid nodule were assessed just before the FNA examination. USG and pathological findings were blinded to each other. Nodules were evaluated for their size, shape, margins, echogenicity, presence of calcification, presence of peri lesional halo, and internal composition. The margins were smooth or irregular, the shape was lobulated or round and echogenicity was iso, hypo, or hyperechoic in relation to the thyroid. The nodule is also classified based on solid, predominantly solid with a cystic component predominantly cystic with a solid component, or purely cystic. Another basis of classification is micro or macro calcification in the nodule. The patients had multiple nodules; each nodule was taken as a separate nodule. Nodules less than 1cm and purely cystic lesions were excluded from our study. Most of the FNACs were performed under USG guidance and histopathological findings were considered as final diagnoses. Approximately 25 nodules were surgically resected.

Statistical Analysis: Data analysis was conducted using SPSS version 22. Tables and graphs were created with SPSS and Microsoft Excel. Descriptive statistics, including frequencies, standard deviations, and percentages, were calculated for all variables. Categorical data were analyzed using the Chi-square test for statistical significance. A two-tailed p-value of <0.05 was considered statistically significant.

Results

Approximately 100 patients with thyroid nodules were taken in our study and referred from OPD. In our study 9 were males and 91 were females. Approximately 135 nodules were detected sonographically in 100 patients. Histopathology examination found 25/135(18.5%) were malignant nodules and the rest 110/135 (76.3%) were found to be benign. Table 1 presents data on the ultrasound (USG) characteristics of thyroid nodules, comparing benign and malignant cases. There is a higher number of female patients overall, the proportion of malignant nodules is notably higher in the male group (4 out of 14 male nodules were malignant, approximately 28.6%) than in the female group (21 out of 121 female nodules were malignant, approximately 17.4%). This suggests that while thyroid nodules are more common in females, male nodules may carry a higher risk of malignancy. Margins: The results demonstrate a strong association between poorly defined margins and malignancy. 21 out of 25 malignant nodules (84%) had poorly defined margins, whereas only 2 out of 110 benign nodules (1.8%) showed this characteristic. Smooth margins were predominantly found in benign nodules (96 out of 110, 87.3%), with only 2 out of 25 malignant nodules (8%) having smooth margins. Lobulated margins were present in a small number of both benign and malignant nodules. This highlights poorly defined margins as a strong predictor of malignancy. Calcifications were more frequently observed in malignant nodules (20 out of 25, 80%) compared to benign nodules (30 out of 110, 27.3%). While calcifications are not exclusive to malignant nodules, their presence significantly increases the suspicion of malignancy.

Table 1: USG characteristics of benign and malignant thyroid nodule cases included in the study.

	Malignant	Benign	Total
Sex distribution			
Female	21	100	121
Male	4	10	14
Total	25	110	135
Margins			
Smooth	2	96	98
Lobulated	2	12	14
Poorly defined	21	2	23
Calcification			
Present	20	30	50
Absent	5	80	85

Table 2 presents data on the internal ultrasound (USG) characteristics of benign and malignant thyroid nodules. Internal Content: Solid nodules were found in equal numbers in both malignant and benign groups (20 each). This indicates that solid content alone is not a reliable differentiator. Predominantly solid nodules were more common in the benign group (31) compared to the malignant group (3). Predominantly cystic nodules were overwhelmingly benign (59 vs. 2 malignant). This aligns with the general understanding that predominantly cystic nodules have a very low risk of malignancy. Perilesional Halo of Solid Lesions: This characteristic is only evaluated in solid nodules (as the name suggests). A thin and regular halo was predominantly observed in benign solid nodules (19 vs. 2 malignant). An absent or thick halo was strongly associated with malignant solid nodules (18 vs. 1 benign). This suggests that the halo characteristic, when present, can be a useful differentiating feature. Echogenicity: Hyperechoic nodules were exclusively benign in this dataset (12 vs. 0 malignant). This is a strong indicator of benignity. Hypoechoic nodules were more common in the benign group (48 vs. 1 malignant). While hypoechogenicity can be seen in both benign and malignant nodules, its prevalence in the benign group is much higher in this data. Markedly hypoechoic nodules were more frequent in the malignant group (20 vs. 15 benign). This is a key finding, as marked hypoechogenicity is a well-established risk factor for malignancy. Isoechoic nodules were more common in the benign group (35 vs. 4 malignant).

Table 2: Internal USG characteristics of benign and malignant thyroid nodule cases

	Malignant	Benign	Total
Internal content			
Solid	20	20	40
Predominantly solid	3	31	34
Predominantly Cystic	2	59	61
Perilesional Halo of solid lesions			
Thin and regular	2	19	21
Absent or thick	18	1	19
Echogenecitiy			
Hyperechoic	0	12	12
Hypoechoic	1	48	49
Markedly Hypoechoic	20	15	35
Isoechoic	4	35	39

Table 3 presents the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of various ultrasound (USG) characteristics in differentiating benign from malignant thyroid nodules. Margins**:** Margins show high specificity (98%), meaning a smooth margin is very reliable in predicting a benign nodule, as also shown in Table 1 where 96/98 nodules with smooth margins were benign. However, the sensitivity is moderate (66.5%), suggesting that poorly defined margins are not always present in malignant nodules. The high NPV (95.5%) means that if margins are smooth, there's a very high chance the nodule is benign. The PPV is only 66.8%, meaning that if margins are irregular, there's a 33.2% chance it's still benign. Calcification: Calcifications have moderate sensitivity (69.5%) and specificity (80.5%). While Table 1 showed calcifications were more common in malignant nodules, this table reveals that they are not highly specific. The low PPV (42.5%) indicates that many nodules with calcifications are benign, while the high NPV (94.5%) indicates that if calcifications are absent, it is likely that the nodule is benign. Internal Content:

Internal content has moderate sensitivity (75.5%) but lower specificity (66.5%). As shown in Table 2, solid content was present in both benign and malignant nodules, explaining the low specificity. The very high NPV (98.5%) indicates that if a nodule is predominantly cystic, it is highly likely to be benign. The low PPV (32.5%) indicates that if a nodule is solid or predominantly solid, it is not very predictive of malignancy. Peripheral Halo: The peripheral halo has moderate sensitivity (66.5%) and good specificity (91.5%). As shown in Table 2, the absence or thickness of the halo was more indicative of malignancy. The relatively good NPV (94.6%) indicates that if a thin regular halo is present, the nodule is likely benign. Echogenicity: Echogenicity has moderate sensitivity (66.5%) and reasonable specificity (85.6%). Table 2 showed that hyperechogenicity was exclusively seen in benign nodules, explaining the reasonable specificity. Markedly hypoechoic nodules were more frequent in malignant nodules, but not exclusively, explaining the moderate sensitivity. The NPV is high (94.2%), meaning if a nodule isn't markedly hypoechoic, it's likely benign. The high NPVs for most features, especially internal content and margins, are clinically useful. They help rule out malignancy when these features suggest benignity. However, the lower PPVs highlight the need for combining multiple USG features for better diagnostic accuracy.

Table 3: Showing the sensitivity, specificity PPV, and NPV values of USG thyroid nodules

Characteristic	Sensitivity	Specificity	PPV	NPV	Accuracy
Margins	66.5%	98.0%	66.8%	95.5%	92.0%
Calcification	69.5%	80.5%	42.5%	94.5%	91.5%
Internal Content	75.5%	66.5%	32.5%	98.5%	68.5%
Peripheral Halo	66.5%	91.5%	55.9%	94.6%	88.1%
Echogenicity	66.5%	85.6%	39.5%	94.2%	84.2%

Discussion

In this study, the diagnostic performance of different USG features of thyroid nodules was assessed in approximately 100 patients with 135 sonographically detected nodules. This study underscores the need for factoring in multiple characteristics of USG to produce an accurate risk assessment. The subjects in the study were mostly females, which was multiplied by the fact that thyroid nodules are more common in females [8, 9]. Again, with an overall malignancy rate of 18.5% (25/135), it is within the range documented in the literature and may vary with the institution's referral base and/or patient population [9].

From the margin characteristics provided in Tables 1 and 3, our assessment of margin mode showed a sensitivity of 98% for smooth margins, which confirmed its strong correlation with benign disease. This is to other research findings, pointing towards the importance of accurately described margins in prediction [10]. However, these differences manifest only a moderate sensitivity of 66.5% for poorly defined margins, indicating that this feature cannot be relied on when diagnosing malignancy. While the sensitivity and specificity of normal scan cut-points are moderate, a notably high negative predictive value NPV of 95.5 % for margins indicates that a smooth margin may definitively exclude benign nodules, possibly avoiding biopsy. Although calcifications were more commonly present in malignant nodules than in benign nodules, their sensitivities (69.5%) and specificities (80.5%) were moderate (Table 3). This finding is in line with earlier studies pointing to the fact that calcifications, which are suspicious signs, may be present in benign nodules, such as colloid nodules and Hashimoto's thyroiditis [11]. It is also supported by the relatively low value of positive predictive value (PPV = 42.5%). A high NPV (94.5%) for calcifications, as observed with margins, indicates that their absence is a good sign.

Analysis of internal content (Table 2 and Table 3) revealed that predominantly cystic nodules were almost exclusively benign, reflected in the very high NPV of 98.5%. This supports the established understanding that purely or predominantly cystic nodules carry a very low risk of malignancy [12]. However, solid content alone was not a reliable differentiator, as it was found in both benign and malignant nodules. The perilesional halo, assessed in solid nodules (Table 2 and Table 3), proved to be a valuable differentiating feature. A thin, regular halo was strongly associated with benignity, while an absent or thick halo was more indicative of malignancy. This is reflected in the good specificity (91.5%) and reasonable NPV (94.6%) for the halo. This finding aligns with previous reports highlighting the importance of halo characteristics in risk stratification [13].

Echogenicity (Table 2 and Table 3) showed that hyperechogenicity was exclusively found in benign nodules, conferring high specificity. Conversely, marked hypoechogenicity, a well-established risk factor for malignancy [14], was more frequent in malignant nodules. Our study demonstrates that using a combination of USG features significantly enhances diagnostic accuracy. For instance, a nodule with smooth margins, predominantly cystic content, and a thin regular halo is highly likely to be benign. Conversely, a nodule exhibiting poorly

defined margins, calcifications, and marked hypoechogenicity raises a strong suspicion of malignancy. This approach aligns with the principles of the Thyroid Imaging Reporting and Data System (TIRADS), which emphasizes the integrated assessment of multiple USG features for risk stratification [15].

Limitations: This study has limitations, including a relatively small sample size, especially within certain subgroups (e.g., male patients), which may limit statistical power. The OPD-based referral pattern may introduce selection bias. Future studies with larger, more diverse populations and standardized USG protocols are needed to validate these findings.

Conclusion

In conclusion, grayscale USG findings proved valuable in identifying clinically significant thyroid nodules and distinguishing between malignant and benign ones. Our study highlighted that malignant nodules commonly exhibited features such as poorly defined margins, microcalcifications, marked hypoechogenicity, and cystic predominance, all of which demonstrated high diagnostic accuracy. Conversely, benign lesions were characterized by solid consistency, well-defined margins, and a regular peripheral halo.

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