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Indian Journal of Medical Sciences

Original Article

Thyroid nodule diagnosis: A comparative analysis of ultrasonography and fine-needle aspiration cytology

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ABSTRACT

Objectives: This paper aimed to investigate the association between Ultrasonography (USG) results and fine-needle aspiration cytology (FNAC) in the diagnosis of thyroid nodules (TNs) in private and public hospitals in Yemen. In addition, it aimed to determine the sensitivity, specificity of USG and FNAC in diagnosing thyroid nodules (TNs).

Materials and Methods: The study utilized a retrospective comparative study design, analyzing medical records of patients diagnosed with TNs between June 01, 2022 and May 01, 2023, in four private and public hospitals in Yemen. USG and FNAC reports, along with demographic data were collected. The author categorized the USG findings based on the American Thyroid Association guidelines, while FNAC results were classified according to the Bethesda reporting system for thyroid cytopathology.

Results: The study included 94 diverse participants with TNs. The average age was 39.96 years, with a majority of female participants (85.1%). The distribution of nodules revealed varying consistencies, sizes, and shapes. The association between USG and FNAC diagnoses showed a significant relationship ($\chi^2 = 34.914$, $P < 0.001$), with a high proportion of benign cases in both USG and FNAC results. Validity analysis demonstrated a sensitivity of 88.68% and a specificity of 70.73% for USG in diagnosing thyroid carcinoma. The positive predictive value was 79.66%, and the negative predictive value was 82.86%. The overall accuracy of USG compared to FNAC was 80.85%.

Conclusion: This study shows USG's potential as a diagnostic tool for TNs in Yemen. Insights improve understanding of TN diagnosis in Yemen's healthcare settings.

Keywords: Ultrasonography, Fine-needle aspiration cytology, Thyroid nodules

INTRODUCTION

Thyroid nodules (TNs) are abnormal growths in thyroid cells that can form solid, fluid-filled, or mixed masses within the thyroid gland.[1-3] They are quite common, with a prevalence ranging from 20% to 76% in the population.[4] Studies have shown that the occurrence of TNs ranges from 2% to 6% through palpation, 19–35% with ultrasonography (USG), and 8–65% based on autopsy findings.[5] The incidence of TNs is more frequent in females compared to males and rises with increasing age.[4]

TNs, common growths or lumps, develop within the front of the neck in the thyroid gland.[6-8] TN prevalence is increasing due to factors such as heightened awareness, improved diagnostic techniques, and widespread use of imaging, particularly ultrasound (US).[7-9] While most nodules are usually benign (non-cancerous), there is a fraction of nodules that can potentially be malignant (cancerous).[10,11] This is why it is important to have an accurate and timely diagnosis to determine the nature of the nodule and to plan appropriate treatment, if necessary.[12] As thyroid cancer rates rise globally, the importance of effective diagnostic approaches becomes paramount to ensure early detection and appropriate management.[13,14]

USG, a non-invasive imaging technique using sound waves, plays a crucial role in diagnosing and monitoring medical conditions, including the evaluation of TNs. It allows for a detailed examination of nodules, assessing their size, shape, and internal characteristics.[15-21] In contrast, fine-needle aspiration cytology (FNAC) is a medical procedure employed for evaluating TNs.[11,22] Using a thin needle, FNAC extracts a small sample of cells from the TN under US guidance to ensure precision.[23,24] The extracted sample undergoes cytological examination by a pathologist to study cellular structure and characteristics.[25,26]

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Received: 22 October 2023 **Accepted:** 16 December 2023 **EPub Ahead of Print:** 10 February 2024 **Published:** 06 July 2024 **DOI:** 10.25259/IJMS_212_2023

This study compares two methods for diagnosing TNs in Yemen: US and FNAC. It aims to identify potential differences in diagnostic practices and outcomes across public and private hospitals, considering resource disparities. The findings aim to improve TN diagnosis in Yemen, leading to better health outcomes.

MATERIALS AND METHODS

Study setting and design

This research adopted a retrospective comparative study design to examine and compare the diagnostic accuracy of USG and FNAC in diagnosing TNs within Yemeni private and public hospitals. The study assessed the performance of these diagnostic modalities by analyzing medical records from patients diagnosed with TNs from June 2022 to May 2023.

Study participants

The study included a diverse sample of (94) patients with TNs. The patients were of both genders and ranged in age from young, adults to the elderly. The participants were selected from four referral hospitals in Yemen, two of which were private and two were public. This diversity in the sample helped to ensure that the results of the study were generalizable to a wider population of patients with TNs.

Patients with confirmed TNs diagnosed through USG and FNAC during the study period were included in the study. Patients with incomplete medical records, prior history of TNs, or missing essential diagnostic data will be excluded from the study.

Methodology and data collection

The data of this study were obtained from medical records, radiology reports, and pathology reports of patients with TNs. The data were collected from four private and public hospitals in Yemen within the specified period of the study. To ensure confidentiality, the data are anonymized and encoded to protect the privacy of patients.

US assessment and categories

In this study, US reports a total of 94 patients with TNs were collected from the files of four hospitals. The classification of these TNs was done following the guidelines set by the American thyroid association for US assessment of TNs.[25,27] Afterward, the results obtained from the US assessments were compared with the histopathology results to establish the accuracy of the US diagnoses. TNs were categorized into different groups based on their US characteristics, as outlined below:[28] (i) Benign: This category includes purely cystic nodules without any solid component; (ii) Very low suspicion: Nodules in this group display spongiform or partially cystic features and lack any of the US characteristics associated with low, intermediate, or high suspicion patterns; (iii) Low suspicion: TNs falling into this category are either isoechoic or hyperechoic solid nodules, or partially cystic nodules with eccentric solid areas; (iv) Intermediate suspicion: This group comprises hypoechoic solid nodules with smooth margins; and (v) Highly suspicious: Solid hypoechoic nodule or solid hypoechoic component of a partially cystic nodule with one or more of the following features: irregular margins (infiltrative, microlobulated), microcalcifications, taller than wide shape, rim calcifications with small extrusive soft-tissue component, and evidence of extra-thyroid extension.

FNAC assessment and categories:

Reports and slides of 94 patients with TNs were retrieved from the four hospitals patients' files. FNA adequacy is defined as the presence of at least five groups of follicular cells each with 12 cells. The FNA results were then compared with histopathology results. TNs were classified according to the Bethesda reporting system for thyroid cytopathology and were scored according to the following:[25,27]

I. Non-diagnostic or unsatisfactory
II. Benign: A non-neoplastic FNAC includes colloid nodules, chronic autoimmune thyroiditis, and adenomatoid nodules
III. Atypia of undetermined significance or follicular lesion of undetermined a. significance
IV. Follicular neoplasm/suspicious for follicular neoplasm
V. Suspicious for malignancy VI. Malignant. The non-diagnostic or unsatisfactory (category I) was excluded from this study because there was no thyroid surgery or histopathological examination.

Data variables

The following data variables are collected for each participant: (i) Demographic information: Age, gender, and clinical history; (ii) USG findings: Nodule size, shape, consistency, and (iii) FNAC results: Cytological results (benign and malignant).

Outcomes studied

The outcomes studied were as follows: (i) To assess the association between USG results and FNAC in the diagnosis of TNs in Yemeni private and public hospitals and (ii) to determine the sensitivity, specificity, and area under the curve for USG and FNAC in the diagnosis of TNs.

Data analysis

Statistical analyses are performed using software (the Statistical Package for the Social Sciences version 28) to compare the diagnostic accuracy of USG and FNAC

in diagnosing TNs. Descriptive statistics were used to summarize demographic characteristics and diagnostic outcomes. These performance measures of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) are tabulated to evaluate how accurately both diagnostic techniques can identify true positives and negatives. Chi-square test or Crammer's V test is used to analyze categorical data, and *t*-test was applied for continuous variables, as appropriate. In this study, the significance level is set at <0.05, indicating that results below this threshold are considered statistically significant.

RESULTS

According to the age distribution, the average age of participants was 39.96 years, with a standard deviation of 12.90. The participants were divided into four age groups, with the largest group being 30–45 years (46.8%). According to the gender distribution, 85.1% of participants are female, while 14.9% are male.

Nodules characteristics

Nodule characteristics are shown in Table 1. The findings suggest that the majority of nodules are firm (65.2%) and 1–4 cm in size (56.5%). In addition, multiple nodules in the gland are more common than solitary nodules (55.4% vs. 35.9%). This information can be used to identify the characteristics associated with each type of nodule, which may be helpful for diagnosis and treatment.

Association of US results with FNAC results

Table 2 shows a significant association between US and FNAC diagnoses ($P < 0.001$). While 88.7% of cases were benign by US, only 29.3% were benign by FNAC. This suggests that US may overestimate benign cases.

Table 1: Characteristics of nodules.

	n	%
Consistency		
Solid	17	18.5
Firm	60	65.2
Soft	15	16.3
Size		
<1 cm	3	3.3
1–4 cm	52	56.5
>4 cm	37	40.2
Shape		
Diffuse	8	8.7
MNG	51	55.4
Solitary nodule	33	35.9

MNG: Multiple nodules in the gland.

The association between US and FNAC findings according to the size of the nodule

Table 3 analysis showed that US and FNAC results were significantly associated with nodules 1–4 cm and >4 cm ($P < 0.001$), but not for those <1 cm. This suggests a size-dependent relationship between US findings and FNAC results.

Validity of US in the diagnosis of thyroid carcinoma

Table 4 shows the important measures comparing US and FNAC results. The sensitivity of 88.68% indicates US effectively detects the condition. Specificity of 70.73% suggests that US has some limitations in excluding those

Table 2: Association between USG and FNAC.

	FNAC results				χ^2	*P*
	Bening		Malignant			
	n	%	*n*	%		
US final result						
Benign	47	88.7	12	29.3	34.914	<0.001
Malignant	6	11.3	29	70.7		

FNAC: Fine-needle aspiration cytology. USG: Ultrasonography, US: Ultrasound

Table 3: Association between US and FNAC findings according to the size of the nodule.

Size of nodule	FNAC		Crammer *P*-value
	Bening	Malignant	
<1 cm			
US final result			
Benign			0.333
N	1	0	
%	100.0	0.0	
Malignant			
N	0	2	
%	0.0	100.0	
1–4 cm			
US final result			
Benign			<0.001
N	30	7	
%	93.8	35.0	
Malignant			
N	2	13	
%	6.3	65.0	
>4 cm			
US final result			
Benign			<0.001
N	16	4	
%	80.0	23.5	
Malignant			
N	4	13	
%	20.0	76.5	

FNAC: Fine-needle aspiration cytology. US: Ultrasound.

Table 4: Validity of ultrasound in the diagnosis of thyroid carcinoma.

	Value (%)	95% CI
Sensitivity	88.68	76.97–95.73%
Specificity	70.73	54.46–83.87%
PPV	79.66	70.68–86.42%
NPV	82.86	68.93–91.33%
Accuracy (*)	80.85	71.44–88.24%

PPV: Positive predictive value, NPV: Negative predictive value, CI: Confidence interval. *P<0.05

without the condition. The PPV of 79.66% indicates a high likelihood of the condition if US is positive. The NPV of 82.86% suggests a high probability of no condition if US is negative. The overall accuracy of US compared to FNAC is 80.85%, reflecting moderate but reasonable correctness.

DISCUSSION

Identification of TNs has been recommended using a variety of diagnostic techniques, primarily to rule out thyroid cancer. B-mode US is a vital diagnostic imaging method in the evaluation of TN before surgery.[2] However, the established reference standard for TN evaluation continues to be FNAC.[29] In this study, we compared the detection and classification of TNs using US results and results from FNAC. Along with measuring diagnostic accuracy, our analysis also looked at sample and nodule characteristics and the relationship between US and FNAC diagnoses.

Regarding the sample characteristics, our findings revealed that the average age of the participants was 39.96 (±12.90). This results are consistent with Alshoabi and Binnuhaid, Cesur *et al*., and Ram *et al*., who reported the mean age of 41.2 ± 15, 43.2 ± 9.4, and 43 ± 13, respectively.[4,30,31] The distribution of participants across age groups showed a larger proportion in the 30–45 years group (46.8%) followed by the 16–29 years group (25.5%). The majority of participants were female (85.1%), while males accounted for 14.9%. This finding is in line with Ebrahim *et al*. and Ram *et al*. who reported that 80% of the cases are female.[6,31]

The association between US results and FNAC diagnoses was investigated to assess the relationship between these two diagnostic modalities. The Chi-square test results indicated a significant association between the US final result and the FNAC diagnoses ($\chi^2 = 34.914$, $P < 0.001$). This finding is also reported by Dev *et al*., who concluded that the US features are associated with FNAC results.[32] Adding to that, this finding was confirmed by Kumar *et al*., who concluded that USG is a sensitive modality in the assessment of thyroid swellings with good accuracy.[33] Further, the finding is consistent with those of Salman *et al*. who reported that US is an effective method in diagnosing TNs and it can reduce the role of FNAC.[2]

The size of the nodules showed a significant association between US and FNAC. TNs larger than 1 cm showed an association between US and FNAC results. However, TNs smaller than 1 cm showed no established correlation. This finding is supported by what was stated by Tamhane and Gharib who reported that nodules smaller than 1 cm do not entail undergoing FNAC.[34] The same finding was reported by Ebrahim *et al*. who stated that no association between nodule size and FNAC results.[6]

To further evaluate the diagnostic performance of US compared to FNAC, we analyzed the diagnostic accuracy measures. The sensitivity of the US results was found to be 88.68%, indicating that a high proportion of true-positive cases were correctly identified. This finding is somehow different from that of Salman *et al*., De *et al*., and Osseis *et al*. who reported that US had a sensitivity of 73.9%.[2,15,35] The specificity value of 70.73% suggests that the US results correctly identified a moderate proportion of true-negative cases. This finding is consistent with that of Salman *et al*., Alshoabi and Binnuhaid, and Kaur *et al*.[2,4,36]

CONCLUSION

Our study demonstrates that US results have a relatively accurate performance in detecting and classifying TNs when compared to FNAC. The significant association between US results and FNAC diagnoses highlights the potential of US as a valuable diagnostic tool for TNs. Future research and larger-scale studies are warranted to validate these findings and further explore the diagnostic utility of US in TN evaluation.

The reliability of US for assessing TNs is a topic that shows significant variation in the literature. Some studies and the general consensus suggest that US alone is not sufficient to diagnose TNs and should be used in conjunction with FNAC. Conversely, other studies propose that advancements in US quality and techniques have improved its accuracy and made it comparable to FNAC. As imaging techniques continue to develop, US scans are expected to become increasingly reliable. Specialized radiology centers with modern equipment and expertise may soon achieve results comparable to FNAC without the need for invasive procedures. Therefore, it is recommended to conduct large studies in these centers to assess and compare the reliability of modern US scans in diagnosing TNs against the current gold standard of FNAC. Future research studies are required to compare the results of the two modalities using updated US modalities.

Potential limitations of the study may include the retrospective nature of data collection, which may result in missing information or incomplete records. In addition, variations in the expertise and experience of healthcare professionals performing USG and FNAC across different hospitals could influence diagnostic accuracy.

Future research directions are suggested to conduct prospective studies comparing the diagnostic accuracy of modern US modalities (such as high-resolution US, elastography, or contrast-enhanced US) with FNAC in the assessment of TNs. This will help validate the potential improvements in reliability that is expected with advancements in US technology.

Ethical approval

The research/study complied with the Helsinki Declaration of 1964.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The author confirms that they have used artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript or image creations.

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How to cite this article: Nassar OH. Thyroid nodule diagnosis: A comparative analysis of ultrasonography and fine-needle aspiration cytology. Indian J Med Sci. 2024;76:83-8. doi: 10.25259/IJMS_212_2023