Meta-analyses

Thyroid nodule ultrasound accuracy in predicting thyroid malignancy based on TIRADS system

Wanlu Nie[1,A], Lili Zhu[2,C], Ping Yan[1,B], Jie Sun[1,E,F]

[1] Department of Ultrasound, Penglai People's Hospital, Yantai, China

[2] Deptartment of Endocrinology, Penglai People's Hospital, Yantai, China

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

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Address for correspondence
Wanlu Nie
E-mail: niewanlu1979@sina.com

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Abstract

Background. A frequent prevalence of thyroid nodules in patients prioritizes the need for an accurate method that characterizes them as benign or malignant. Fine-needle aspiration biopsy (FNAB) and thyroid ultrasonography (USG) are currently used for this purpose. However, since FNAB is complicated, time-consuming and expensive, thyroid USG, a fast and highly sensitive method, is preferably used. Although USG is reported as a suitable method for characterization of thyroid nodules, there are some contrasting studies available which report its limited use in the differentiation of benign and malignant thyroid nodules.

Objectives. This meta-analysis aims to assess the accuracy of ultrasound in predicting thyroid cancer in terms of sensitivity, specificity and diagnostic odds ratios (ORs) for positive and negative results.

Materials and methods. Systematic and extensive literature search on the use of ultrasound (US) to predict thyroid cancer was conducted in the databases of Scopus, CINAHL (via EBSCO), MEDLINE (via PubMed), and Web of Science, covering the period from 2010 till 2021. The morphological features of thyroid nodules observed during the USG were analyzed based on Thyroid Imaging Reporting And Data System (TIRADS) guidelines. The accuracy of thyroid US was determined using parameters such as sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), and diagnostic ORs. Moreover, the respective forest plot and hierarchical summary receiver operating characteristics (HSROC) curve were plotted.

Results. A total of 2765 reference studies were examined, and among them, 15 relevant references were selected. The selected studies were heterogeneous and included retrospective and prospective studies. The risk of publication bias is low as the p-value for both Egger's and Begg's tests is >0.05. The overall sensitivity of 92.53% (95% confidence interval (95% CI): [84.55%; 96.33%]), specificity of 33.88% (95% CI: [23.16%; 45.53%]) and diagnostic OR of 12.36 (95% CI: [3.90%; 54.11%]) are achieved. These results were statistically significant with a p-value < 0.001 and are predictive of US accuracy in detecting cancer.

Conclusions. The present meta-analysis, on the basis of statistically significant results, demonstrated the high accuracy of thyroid ultrasound in detection of malignant nature of nodules in patients suspected with a worrisome thyroid nodule.

Key words: ultrasound, thyroid nodule, fine-needle aspiration biopsy (FNAB), thyroid imaging – reporting and data system (TIRADS), benign and malignant nodule

Introduction

All cancers are tumors, but not all tumors are cancerous. Therefore, it is imperative to have a concrete diagnosis in patients with thyroid nodules in order to differentiate between benign and malignant nodules. With a rapid rise in the number of patients with suspicious thyroid nodules, it is a medical emergency to characterize the nature of these nodules as either malignant or benign. In order to assess the malignancy and cancerous nature of the suspected thyroid nodule, fine-needle aspiration biopsy (FNAB) is performed.[1] However, it is a high cost and time-consuming invasive surgical procedure and it is not an easy diagnostic procedure for patients. Therefore, to simplify the nodule diagnosis, current thyroid guidelines (Thyroid Imaging Reporting And Data System (TIRADS)) advocate the use of ultrasonography (USG) as a preliminary test for all patients suspected of having thyroid nodule.[2,3]

Clinical variables and ultrasound (US) findings as per the TIRADS guidelines are recommended as a primary criterion to assess the benign and malignant nature of a nodule. Based on these results, the clinician further advises an additional confirmatory testing (FNAB) or simple routine US follow-up. A surgical procedure is considered based on both US and FNAB results with cytology (FNAC).

Currently, different TIRADS guidelines[4–8] are available, including American College of Radiology (ACR) – TIRADS, American Thyroid Association (ATA) – TIRADS, American Association of Clinical Endocrinology/American Clinical Endocrinology/American Medical Endocrinology (AACE/ACE/AME) – TIRADS, Korean Society of Thyroid Radiology (KSR)/(KSThR) – TIRADS, and European Thyroid Association (ETA)/(EU) – TIRADS. These TIRADS provide a list of notable morphological features reported in the US images as a gold standard to classify a suspected nodule as malignant or benign. These features are internal calcifications, hypoechogenicity, vascularity, shape, and nodule size.

As per these guidelines (Fig. 1), if the nodule is round to ovoid with no solid portion, isoechoic, spongiform, grows across the normal tissue plane in a parallel fashion, has smooth margins and increased peripheral blood flow, and either has no calcification or egg-shell calcification, it is considered as benign. In contrast, if the nodule is solid, non-oval, taller than wider cells with irregular margins, and has an increased central blood flow with marked hypoechogenicity and microcalcifications,

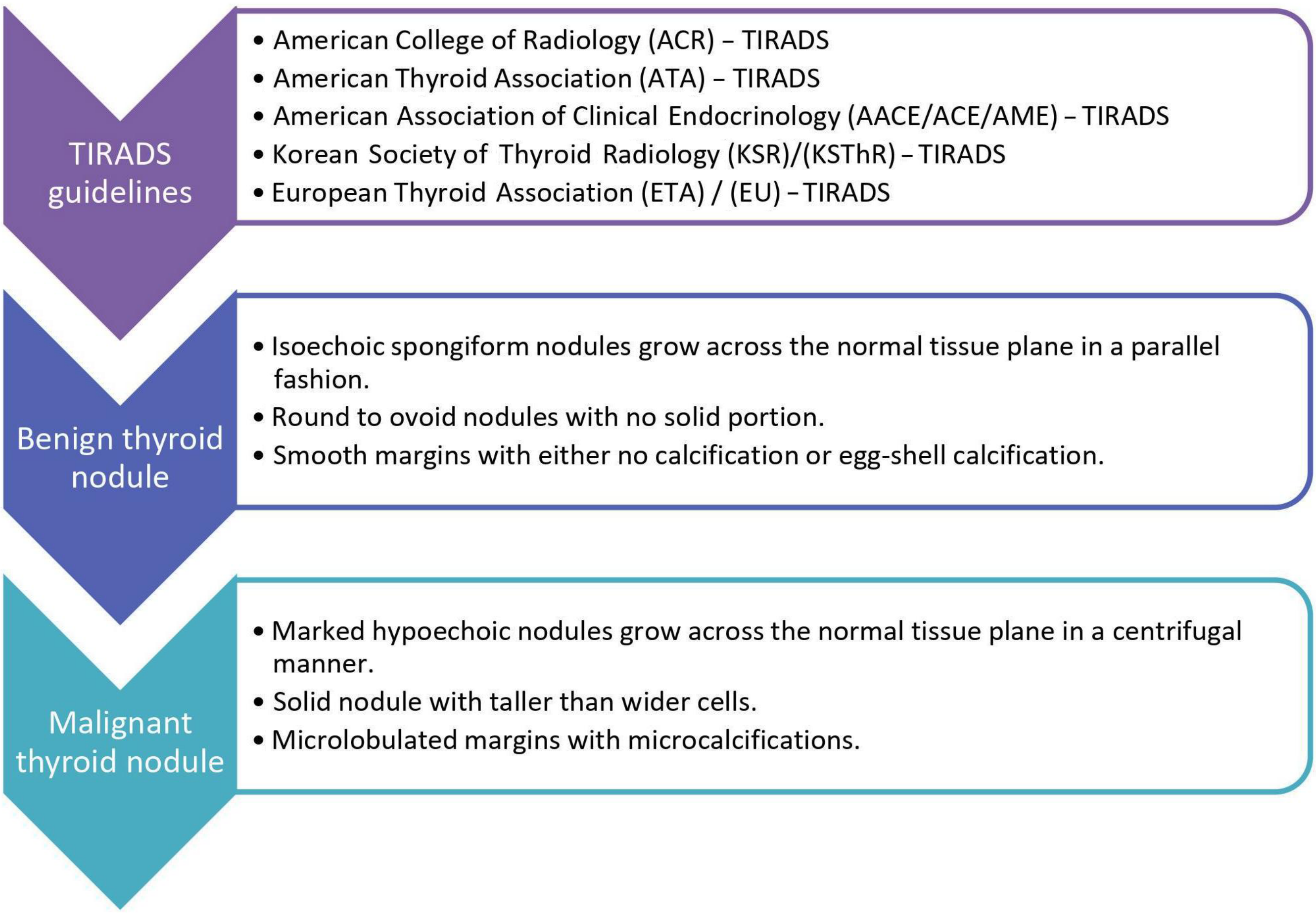

Fig. 1. Thyroid Imaging Reporting and Data System (TIRADS) guidelines

it is believed to be malignant and considered for further analysis.

Among these morphological features of the thyroid, USG and solid nodule are the most preferred criteria for assessing nodular malignancy. Therefore, many random clinical trials were performed to assess similar US and FNAB results in predicting nodular malignancy in terms of sensitivity and specificity. As a result, the sensitivity and specificity of various randomized controlled trials (RCTs) were reported in the range of 98% and 30%, respectively. These results align with the sensitivity and specificity values in the range of 98% and 70%, respectively, reported for FNAB.[9–11]

Based on these studies, the use of US examination has become widely accepted as a significant diagnostic step in stratifying the risk of malignancy in the patients; still, the diagnostic accuracy of several of examined sonographic parameters is a subject of much debate. Therefore, this meta-analysis was performed to understand the traits of US that help in establishing the diagnosis of a thyroid nodule, either benign or malignant. The positive outcomes suggest its accuracy and comparable diagnostic efficiency to FNAB, and highly recommend its use in the medical practice. The US examination enables patients to get their nodule tested in a short time with no surgical procedures. In addition, it could save their money on confirmatory tests and thus, have a significant impact on both clinical practice and guideline recommendations.

Objectives

The current study is an attempt to analyze thyroid US results according to TIRADS guidelines and the associated nodule management, in order to establish this method as reliable for predicting thyroid cancer in terms of sensitivity and specificity for positive and negative US results.

Materials and methods

This study, with the registration No. SUYP#/IRB/2021/1254, followed the normative requirements of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Search strategy

From 2010 until the end of March 2021, an exhaustive search was undertaken in MEDLINE (through PubMed), CINAHL (via EBSCO), Scopus, and Web of Science databases. Keywords like [ultrasonography], [FNAB], [thyroid nodules, malignancy], [TIRADS recommendations], [US-based risk stratification methods] and [diagnostic accuracy] were used in this search. The PRISMA criteria were used to assess all of the papers. The language, publication status and prospective or retrospective nature of the study had no bearing on the study selection. Table 1 presents the demographic features of the studies included in the MEDLINE database search query along with the evaluated factors.[12–26]

The main goal of this study was to evaluate the effectiveness of USGat detecting thyroid nodules in people of various ages. In order to assess the efficiency of US for nodule examination, patients of varied age groups were studied, and statistical parameters such as sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), and diagnostic odds ratios (ORs) were calculated with the help of true positive (TP), false positive (FP), true negative (TN), and false negative (FN) values.

Two authors (WN and LZ) independently searched the sources for similar studies. Full-text articles were collected, and abstracts were analyzed if sufficient information could be retrieved. Obsolete references were removed, and only valuable studies were included. Data from the included research were obtained separately by 2 researchers (PY and JS).

Inclusion and exclusion criteria

Studies from the years 2010–2021 that examined the diagnostic accuracy of USG for thyroid nodule assessment in the individuals of all ages with a suspected thyroid nodule and subsequent nodule therapy were included in the study. Only full-text data were included in this analysis; publications with inadequate data, reference standards other than US/FNAB report and comparable studies published before 2010 were all excluded, as shown in Fig. 2.

Evaluation of the analytical standard

Two authors (WN and LZ) independently examined the methodological validity of the included studies using the quality evaluation of diagnostic accuracy test assessment instrument to establish their methodological quality (QUADAS-2). One author (JS) was also in charge of addressing any issues that arose among other co-authors of this study.

Statistical analyses

A 2 × 2 table was created to determine the pooled sensitivity, specificity and diagnostic OR using the DerSimonian and Laird approach. A higher diagnostic OR number suggests that the test is more accurate in its diagnosis. The I^2 index and the Cochran's Q statistic were used to determine the heterogeneity of the studies. MedCalc software (MedCalc Software Ltd., Ostend, Belgium) was used to create the forest plots. The sensitivity and specificity data from the various studies are displayed in a hierarchical summary receiver operating characteristics (HSROC) curve with their respective 95% confidence intervals (95% CIs).

Table 1. Demographic summary of included studies with thyroid ultrasound in suspected cases of thyroid malignancy

Study ID and year	Study type	Study duration	Total sample size	Age [years]	Gender M/F	Type of US probe
Arpana et al. 2018[12]	cross-sectional	1 year	85	14–70	15/70	NR
Al-Ghanimi et al. 2020[13]	retrospective	2 years	68	8–82	20/48	Esaote US machine (MyLab™ ClassC, Esaote, Genoa, Italy) and electronically focused near-field probes with a bandwidth of 7–12 MHz
Smith-Bindman et al. 2013[14]	retrospective	5 years	11618	30–70	2277/9341	NR
Liu et al. 2019[15]	retrospective	5 years	1568	18–80	412/1156	IU22 device (Philips Medical Systems, Bothell, USA; 5–12 MHz linear probe) or the S3000 device (Siemens Medical Solutions, Mountain View, USA; 5–14 MHz linear probe)
Luo et al. 2020[16]	retrospective	2 years	296	30–50	54/168	The Mylab™ 90 (Esaote SpA, Genoa, Italy) ultrasound image system was used for US examination, the L522 probe (4–9 MHz; Esaote SpA) for CEUS and the L523 probe (7.5–13.0 MHz, Esaote SpA) for conventional gray-scale US, CDUS and ES.
Kwak et al. 2011[17]	retrospective	8 months	1638	11–81	265/1373	5–12 MHz linear-array transducer (iU22; Philips Medical Systems.
Srinivas et al. 2016[18]	prospective	4 years	365	18–68	22/334	GE VOLUSON 730 PRO machine (GE Healthcare, Milwaukee, USA) equipped with a 7.5–12 MHz high-frequency linear array transducer with color and power Doppler capability.
Mohanty et al. 2019[19]	prospective	1 year	50	40–50	10/40	GE Logic F8 ultrasound machine with a 6–12 MHz linear array transducer and Samsung HS70A ultrasound machine with 4–18 MHz linear array transducer (Samsung Neurologica Corp., Danvers, USA)
Nabahati et al. 2019[20]	cross-sectional	2 years	718	14–83	NR	Samsung H60 ultrasound machine, with a 3–14 MHz linear array transducer (Samsung Neurologica Corp.)
Ghani et al. 2018[21]	retrospective	2 years	91	27–80	21/83	linear array transducer (5–12 MHz) on ultrasound scanners HD11/HD11 XE/iU22 (Phillips Medical Systems) or Toshiba Xario200 (Toshiba Corp., Tokyo, Japan)
Ram et al. 2015[22]	cross-sectional	2 years	101	15–73	20/81	High frequency linear probe with 7.5 MHz bandwidth (models Zario and Nemio; Toshiba Corp.)
Wettasinghe et al. 2019[23]	prospective	1.5 years	263	16–74	16/247	NR
Azizi et al. 2021[24]	prospective	1 year	355	40–50	45/310	virtual organ computer-aided analysis; (VOCAL; GE Healthcare) and a 3-D multi-planar display with rendering in HDLive and HDLive Silhouette (GE Healthcare).
Zayadeen et al. 2016[25]	retrospective	3 years	1466	11–96	265/1201	5–12 MHz linear probe (iU22, Philips Healthcare) or a 6–15-MHz linear probe (Logiq E9, GE Healthcare)
Richie and Mellonie 2021[26]	retrospective	2 years	226	18–62	39/187	NR

US – ultrasound; NR – not reported; CEUS – contrast-enhanced ultrasound; CDUS – color Doppler ultrasonography: ES – elastosonography.

Analysis of sensitivity

Excluding individuals with equivocal results might cause diagnostic test accuracy to be overestimated. As a result, the sensitivity analysis was carried out, with uninterpretable data factored into the analysis. Finally, we compared the outcomes of the primary analysis, which excluded uninterpretable data, to those of the diagnostic precision analysis, which included all uninterpretable results.

Investigation of sources of heterogeneity

Meta-regression was used to investigate heterogeneity of the included experiments, introducing various sources of heterogeneity as covariates and fitting a bivariate model. To assess the covariate effect on the sensitivity and precision, probability ratio test was used. A p-value <0.05 was considered statistically significant for any of the subgroups. Full-text publications compared to abstracts, high compared to low risk of bias (RoB) in included studies, prospective compared to retrospective studies, studies that

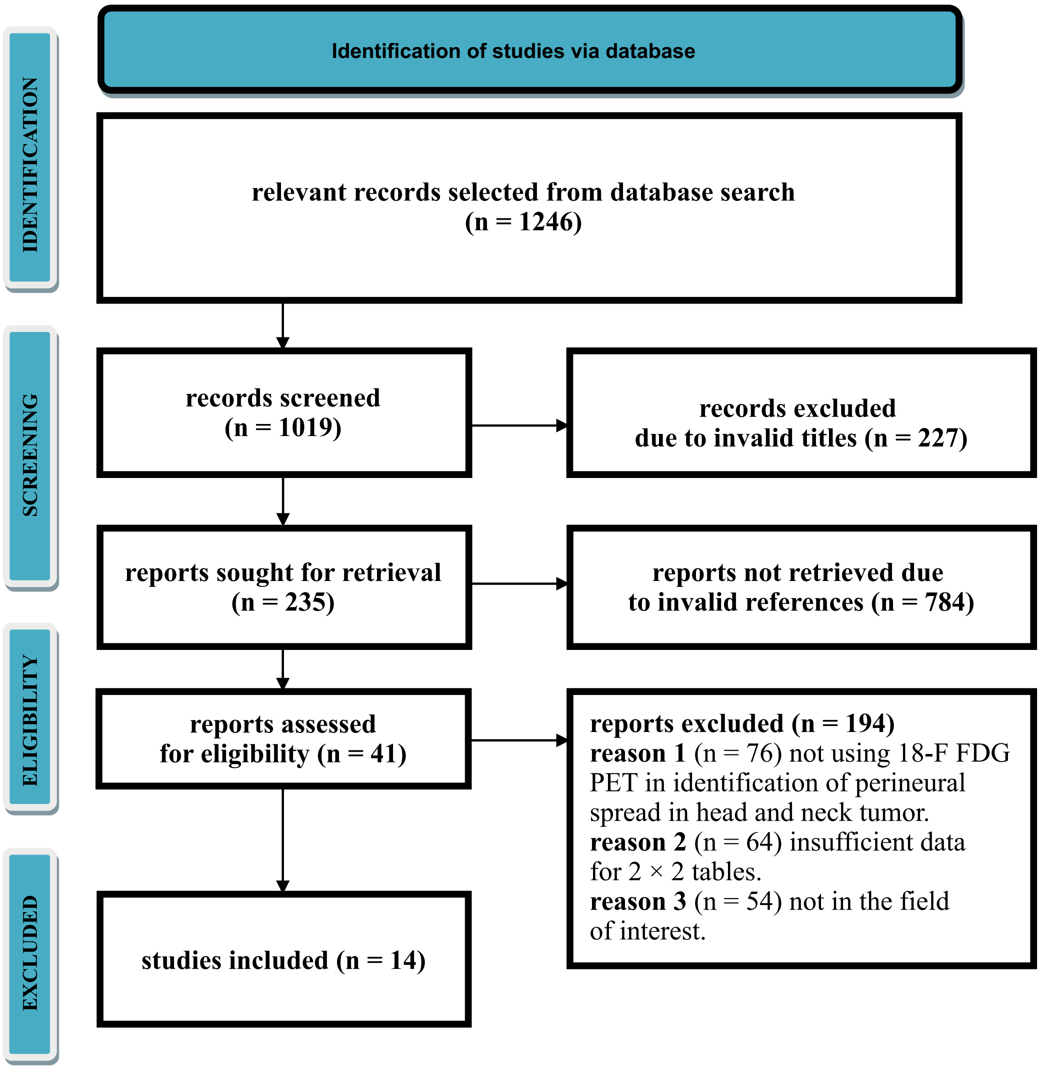

Fig. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram

TIRADS – Thyroid Imaging Reporting And Data System; 18-FDG PET – 18-fluorodeoxyglucose, positron emission tomography.

included only adults compared to mixed adult and pediatric population studies, the proportion of female participants, the proportion of obese patients, type of US probe, and ultrasonographer experience were among the investigated heterogeneity sources.

Results

Literature search results

Through computerized scanning, a total of 2765 studies were retrieved. We eliminated 745 articles based on their titles and abstracts, and 1825 papers due to faulty references. Owing to duplicity, about 165 out of the remaining 195 studies were removed. Finally, 30 full-text publications were screened. Among these, 15 were eliminated due to inclusion requirements. As a result, as shown in Fig. 2, this meta-analysis included 15 papers that satisfied the inclusion criteria, namely morphological characteristics of thyroid USG as per TIRADS standards. The main grounds for omission were inadequate evidence and improper comparison criteria needed for creating 2 × 2 tables for review.

The demographic details of the studies included in this meta-analysis are shown in Table 1. It describes the authors of each included study, year of publication, type of study, duration of the study, total sample size, type of US probe used in the study, age, gender, and the total number of nodules on which US was conducted. In addition, the morphological features of the thyroid nodule, as suggested by TIRADS guidelines (Fig. 1), are set as a gold standard for its characterization. A total of 18,908 patients were included in all analyzed studies. Four of the studies were prospective, 8 were retrospective and 3 were cross-sectional, and they were all published as full-text publications. The participants' age ranged from 8 to 80 years, and the information regarding the type of utilized US probe was provided.

Risk of bias assessment

The estimated sensitivity value ranged from 74% to 98%, whereas the estimated specificity value ranged from 8% to 84%. According to the QUADAS-2 tool, all of the included experiments had a low likelihood of bias, as indicated in Table 2. Figure 3 shows a Duke funnel plot used to assess the possibility of publication bias.

Meta-analysis results

The overall sensitivity of the US scan for thyroid nodule was 92.53% (95% CI: [84.55%; 96.33%]) and overall specificity was 33.88% (95% CI: [23.16%; 45.53%]) with $p < 0.001$, indicative of statistical significance. The value of the overall PLR was 6.90 (95% CI: [2.66; 23.8]), and the overall NLR value was 0.71 (95% CI: [0.59; 0.85]), as shown in Table 3. These results proved the high accuracy of US scan in detecting only positive nodules as malignant. The summary receiver operating characteristic (SROC) plot showing an estimate of sensitivity compared to specificity and area under the SROC curve, as shown in Fig. 4, indicates its positive efficiency. The box and whisker plot (Fig. 5) clearly shows that the diagnostic accuracy of thyroid US is high, as the number of TP results is high, similarly to the results of FNAB, while number of FP results is low. The diagnostic OR was 12.36 (95% CI: [3.90; 54.11]), as shown in Table 4. As reported, the diagnostic OR higher than 10 indicates the positive outcome of a test, as shown in the forest plot in Fig. 6. Our results are congruent with those reports and suggest a greater accuracy of thyroid US in diagnosing thyroid cancer.

Discussion

Accurate diagnosis of a worrisome thyroid nodule for malignancy has always been challenging because initial symptoms of both nodules, either benign or malignant, are usually the same.[9,10] Therefore, early nodule characterization is of extreme importance since a benign nodule can be easily cured, but treating a malignant nodule is complex and depends on its stage. Therefore, the early detection of malignant nodules increases a patient's chances of treatment and survival rate; otherwise, thyroid cancer can be fatal.

Fine-needle aspiration biopsy is the gold standard[1,2,9–11] for accurately detecting malignancy in thyroid nodule patients, with a substantial sensitivity of 98%, according to numerous studies.[12–26] It is, however, rarely chosen since

Table 2. Exploration of heterogeneity sources; the impact of sample subgroups or participant characteristics on overall sensitivity and specificity

Subgroup	p-value
Full texts compared to abstracts	NA
High compared to low risk of bias	NA
Prospective compared to retrospective studies	0.024*
Adults compared to mixed population	0.924
Proportion of female participants	0.05*
Proportion of obese participants	NA
Type of ultrasound probe	0.034*
Ultrasonographer experience	0.001*
Clinical probability of TC	0.001*

TC – thyroid cancer; NA – not available. The details could not be retrieved from the report, or only one party was present; *significant impact of the subgroup on summary results.

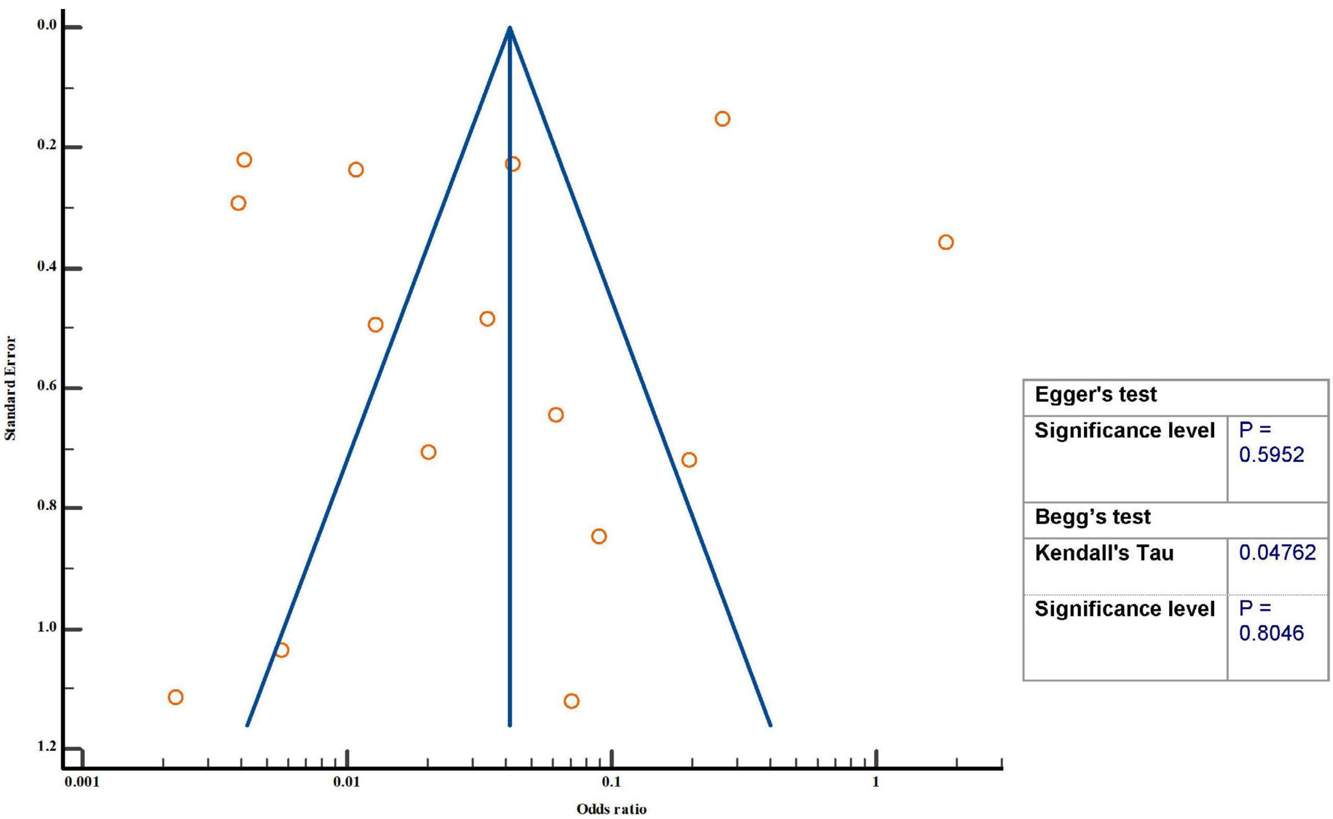

Fig. 3. Duke funnel plot test for publication bias

Table 3. Sensitivity and specificity of different studies

Study ID and year	Specificity [%]	95% CI upper limit	95% CI lower limit	Sensitivity [%]	95% CI upper limit	95% CI lower limit
Kwak et al. 2011[17]	24.06	21.51	26.75	96.66	94.88	97.95
Smith-Bindman et al. 2013[14]	23.61	18.83	28.95	87.94	83.56	91.50
Ram et al. 2015[22]	8.06	2.67	17.83	97.50	86.84	99.94
Zayadeen et al. 2016[25]	14.25	11.98	16.78	97.57	96.46	98.41
Srinivas et al. 2016[18]	48.15	28.67	68.05	96.45	93.88	98.15
Ghani et al. 2018[21]	23.08	11.13	39.33	93.62	82.46	98.66
Arpana et al. 2018[12]	32.35	17.39	50.53	88.57	73.26	96.80
Wettasinghe et al. 2019[23]	13.68	9.55	18.75	96.55	82.24	99.91
Luo et al. 2020[16]	84.52	77.84	89.82	74.63	62.51	84.47
Liu et al. 2019[15]	57.93	55.12	60.71	84.00	79.89	87.56
Nabahati et al. 2019[20]	8.98	6.37	12.21	96.18	94.09	97.68
Mohanty et al. 2019[19]	60.00	36.05	80.88	95.45	77.16	99.88
Azizi et al. 2021[24]	14.08	10.21	18.74	92.65	83.67	97.57
Al-Ghanimi et al. 2020[13]	50.00	15.70	84.30	91.67	81.61	97.24
Richie and Mellonie 2021[26]	45.45	24.39	67.79	98.53	95.76	99.70

95% CI – 95% confidence interval.

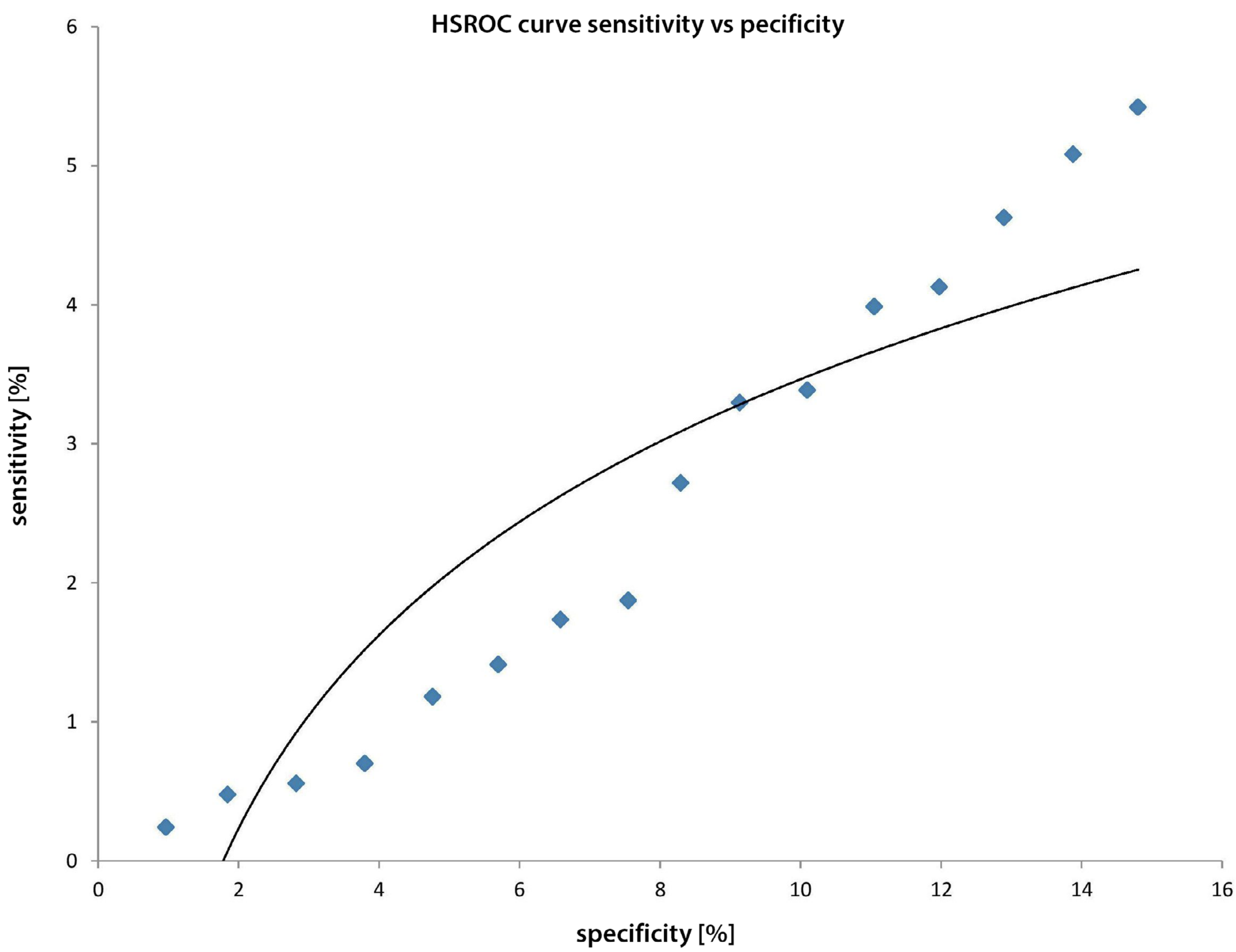

Fig. 4. Hierarchical summary receiver operating characteristics (HSROC) curve sensitivity compared to specificity

Table 4. Diagnostic OR of cases studied

Study ID and year	Benign nodule (simple cyst)	Benign nodule (solid cyst)	Malignant nodule (solid cyst)	Malignant nodule (simple/mixed cyst)	Diagnostic odds ratio	95% CI upper limit	95% CI lower limit
Kwak et al. 2011[17]	578.00	805.00	255.00	20.00	9.15	5.74	14.61
Bindmann et al. 2013[14]	248.00	220.00	68.00	34.00	2.25	1.44	3.54
Ram et al. 2015[22]	39.00	57.00	5.00	1.00	3.42	0.38	30.43
Zayadeen et al. 2016[25]	1043.00	734.00	122.00	26.00	6.67	4.32	10.29
Srinivas et al. 2016[18]	326.00	14.00	13.00	12.00	25.23	9.76	65.20
Ghani et al. 2017[21]	44.00	30.00	9.00	3.00	4.40	1.09	17.60
Arpana et al. 2018[12]	31.00	23.00	11.00	4.00	3.71	1.05	13.13
Wettasinghe et al. 2019[23]	28.00	202.00	32.00	1.00	4.44	0.58	33.75
Luo et al. 2020[16]	50.00	24.00	131.00	17.00	16.05	7.50	32.37
Liu et al. 2019[15]	315.00	517.00	712.00	60.00	7.23	5.36	9.74
Nabahati et al. 2019[20]	478.00	365.00	36.00	19.00	2.48	1.40	4.39
Mohanty et al. 2019[19]	21.00	8.00	12.00	1.00	31.50	3.50	283.30
Azizi et al. 2021[24]	63.00	238.00	39.00	5.00	2.06	0.78	5.45
Ghanimi et al. 2021[13]	55.00	4.00	4.00	5.00	11.00	2.08	57.91
Richi et al. 2021[26]	201.00	3.00	10.00	12.00	55.80	13.50	229.90

OR – odds ratio; 95% CI – 95% confidence interval.

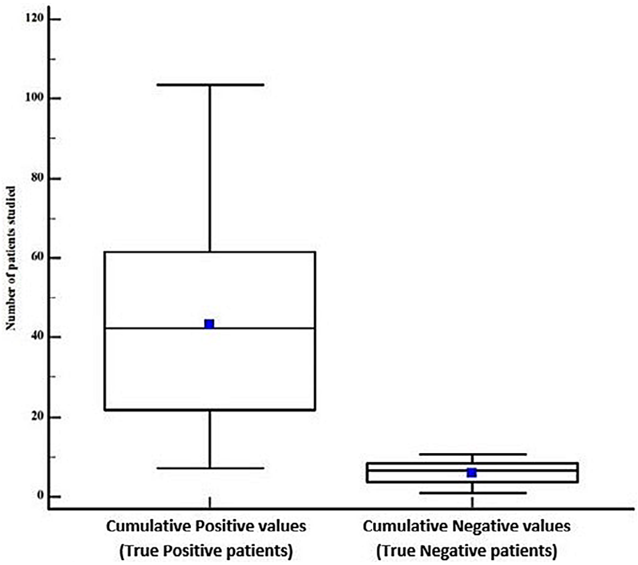

Fig. 5. Box and whisker plot for cumulative positive value (CPV) compared to cumulative negative value (CNV) of samples studied

it is time-consuming, intrusive and costly. The current meta-analysis is an excellent step in simplifying the nodule characterization technique by demonstrating that thyroid USG and FNAB are equally effective in diagnosing probable thyroid cancer in patients of all ages.

In this meta-analysis, a total of 15 publications were chosen to predict the specificity, sensitivity, PLR, NLR, and diagnostic ORs. Overall sensitivity of 92.53% (95% CI: [84.55%; 96.33%]) and specificity of 33.88% (95% CI: [23.16%; 45.53%]) were found in this study. The diagnostic OR was found to be 12.36 (95% CI: [3.90; 54.11]). The studies covered a wide range of sensitivity, ranging from 74% to 95% with a 95% CI of [60%; 95%], while included studies revealed a wide specificity range ranging from 8% to 85% (95% CI: [2%; 90%]). Latif et al., in a research similar to ours, evaluated FNAB and USG to diagnose benign and malignant thyroid nodules.[27] The gold standard in this investigation was surgery or follow-up.

In this study, the combined sensitivity and specificity in the adult population were 90% and 77%, respectively, supporting the use of US in diagnosing thyroid cancer. Similarly, Ghani et al.[21] showed a sensitivity of 100% and specificity of 91.4%, Wettasinghe et al.[23] calculated sensitivity and specificity of 0.13% and 0.95%, respectively, Luo et al.[16] showed a sensitivity and specificity of 0.72% and 0.83%, respectively, and Richie and Mellonie showed the high specifcity of 45%.[12,23,16,26] All these studies, similarly to the present study, are in support of the application of US imaging for the detection of the malignant tumor. However, in contrast to the present analysis, Jiang et al.[28] observed different results and concluded that the US should not be used for diagnosing thyroid cancer cases.

Thyroid USG was very accurate when combined with FNAB by Salam et al., although, unlike the current study, that study did not employ any reference standards (morphological properties of the nodule) to limit the chances of FN results.[4] The positive and negative probability ratios were 6.90 (95% CI: [2.66; 23.8]) and 0.71 (95% CI: [2.66; 23.8]), respectively. The diagnostic OR in this research was 12.36 (95% CI: [3.90; 54.11]), indicating that thyroid USG has a substantial accuracy rate in predicting thyroid cancer. The SROC curve of the current study indicates

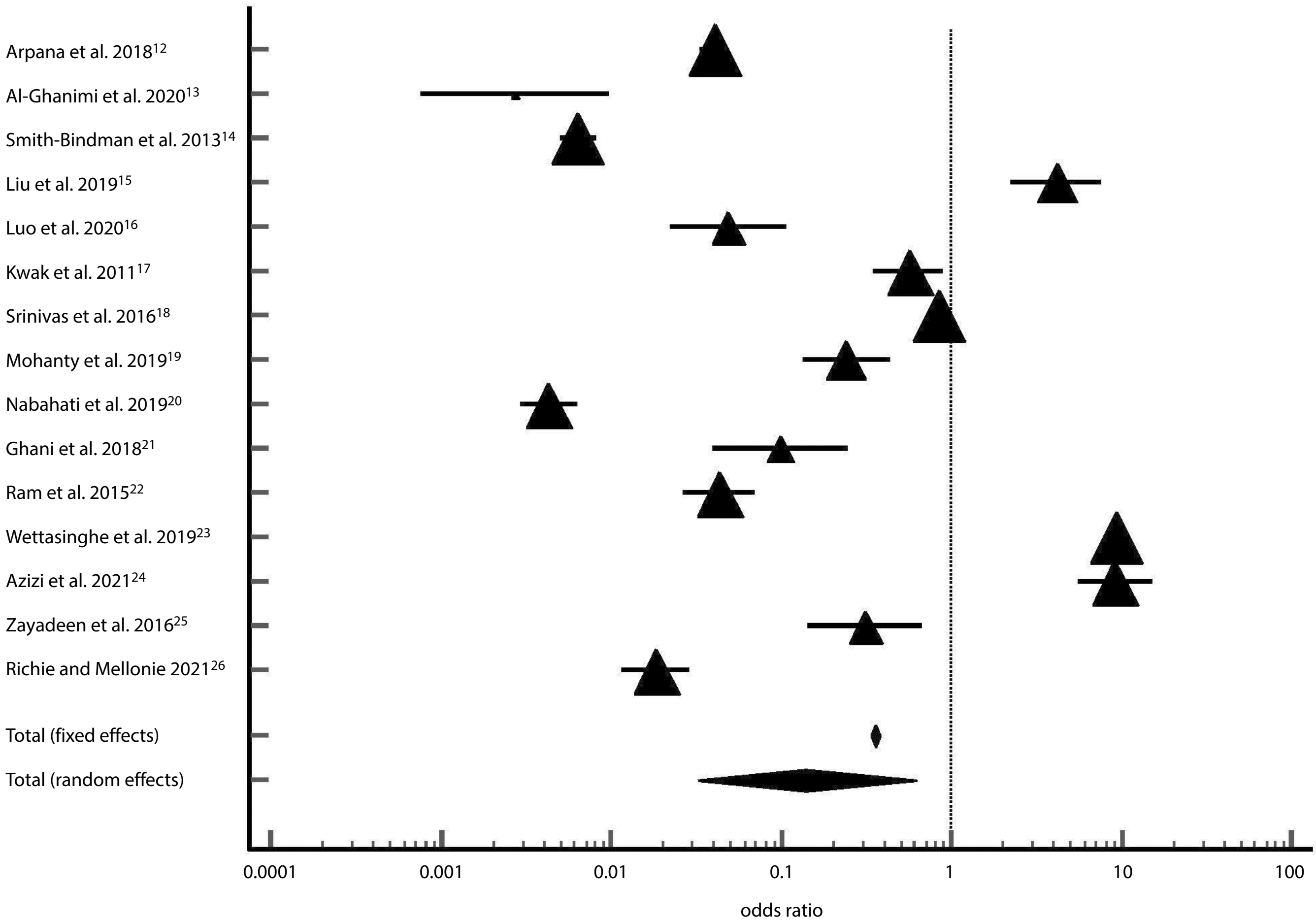

Fig. 6. Forest plot for the diagnostic odds ratio (OR) of case studies100100

the combined effect of sensitivity and specificity, with an inclination of the curve towards the upper left, showing high quality of thyroid US diagnostic accuracy.

Azizi et al. investigated the hypothesis stating that three-dimensional ultrasound (3-D-US) allows for distinguishing benign from malignant thyroid nodules with better sensitivity and specificity than two-dimensional ultrasound (2-D-US).[24] They used both 2-D-US and 3-D-US to examine 344 thyroid nodules, followed by a FNAB. Based on the appearance of the margins in 3-D-US, TNs were categorized into 4 categories. The researchers employed bivariate and multivariate analyses. In 40 individuals, surgical pathology revealed 44 thyroid malignancies. In malignant TNs, uneven margins and microcalcifications ($p < 0.001$) were more common on 2-D-US. The sensitivity and specificity of irregular margins on 2-D-US were 61.4% and 79.3%, respectively.[27] The sensitivity and specificity of irregular margins on 3-D-US were 86.4% and 83.3%, respectively. Microcalcifications and irregular margins on 2-D-US had better sensitivity, specificity, as well as positive and negative predictive values than irregular margins on 3-D-US. The 3-D-US evaluation of TN margins had higher sensitivity and specificity than 2-D-US in distinguishing benign TNs from malignant ones.

Limitations

The diversity of US equipment utilized and tests performed by various sonographers influence the probability of FN results and are a drawback of this study. Similar diagnosis with FNAB was not specified in many types of research, having an influence on the appropriate analysis of the comparability of data. Data from other relevant studies that demonstrate the diagnostic accuracy of US in contrast to other diagnostic imaging modalities might also be provided to emphasize its significance. To clearly distinguish between a benign and a malignant nodule, specific information about a patient's case history, physical examination and pathological testing can help to improve the diagnostic accuracy rate of USG in predicting thyroid cancer.

Conclusions

Ultrasound is a widespread diagnostic investigation tool since it is easy to use, inexpensive and efficient, even though FNAB has considerably reduced the mortality rate owing to its complex surgical technique and high cost. It is a noninvasive, nonionizing radiation approach for nodule identification in patients of all ages and an efficient diagnostic method to decrease the difficulties associated with FNAB.

ORCID iDs

Wanlu Nie https://orcid.org/0000-0003-4565-7631
Lili Zhu https://orcid.org/0000-0002-6734-4647
Ping Yan https://orcid.org/0000-0002-3533-9413
Jie Sun https://orcid.org/0000-0003-0644-3657

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