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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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Содержание:

APPLICATION OF SHELL TECHNIQUE IN C-TIRADS COMBINED WITH STE IN DIAGNOSIS OF C-TIRADS GRADE 4-5 NODULES

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Abstract.

Objective: To analyze the diagnostic value of the Shell technique in the Chinese Thyroid Imaging Reporting and Data System (C-TIRADS) combined with Shear Wave Elastography (STE) for differentiating benign and malignant C-TIRADS grade 4-5 nodules.

Methods: A retrospective analysis was performed on 279 patients (with a total of 286 C-TIRADS grade 4-5 nodules) who underwent thyroid fine-needle aspiration biopsy (FNA) or surgery. Nodules were differentiated as benign or malignant using C-TIRADS classification, STE, and their combination. Taking cytopathological or postoperative pathological diagnosis as the gold standard, Receiver Operating Characteristic (ROC) curves were plotted, and the Area Under the Curve (AUC), sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) were calculated to compare the diagnostic efficacy.

Results: Pathological results showed that among 286 nodules, 94 were benign and 192 were malignant. C-TIRADS diagnosed 122 benign and 164 malignant nodules; STE diagnosed 115 benign and 171 malignant nodules; the combination diagnosed 108 benign and 178 malignant nodules. The AUC of the combined diagnosis for C-TIRADS grade 4-5 nodules was significantly larger than that of C-TIRADS classification and STE alone ($Z=5.195$, $P<0.001$; $Z=3.602$, $P<0.001$). The sensitivity of the combined diagnosis was higher than that of C-TIRADS classification and STE alone ($\chi^2=8.649$, $P=0.003$; $\chi^2=5.488$, $P=0.019$). The accuracy of the combined diagnosis was higher than that of C-TIRADS classification and STE alone ($\chi^2=11.457$, $P<0.001$; $\chi^2=9.527$, $P=0.002$). The NPV of the combined diagnosis was higher than that of C-TIRADS classification and STE alone ($\chi^2=6.685$, $P=0.010$; $\chi^2=4.997$, $P=0.025$).

Conclusion: Compared with single application, C-TIRADS combined with the Shell technique in STE significantly improves the diagnostic sensitivity, accuracy, and NPV for C-TIRADS grade 4-5 thyroid nodules, demonstrating certain clinical application value.

Key words. Shear Wave Elastography (STE), thyroid nodules, Chinese Thyroid Imaging Reporting and Data System (C-TIRADS).

Introduction.

Thyroid nodules are common diseases in the head and neck and endocrine systems. Palpable nodules account for 5%, while those detected by ultrasound account for up to 70%, with a malignant tumor rate of approximately 3%-10% [1]. Only a small proportion require clinical intervention, and many benign and low-risk papillary thyroid carcinomas are only recommended for active monitoring [2]. Therefore, the Chinese Society of Ultrasound Medicine released the C-TIRADS guidelines in 2020 [3], which adopt a scoring method: suspicious ultrasound signs are counted, with each malignant risk sign assigned 1 point and comet tail signs deducted 1 point. Clinicians optimize treatment plans based on nodule classification. Since C-TIRADS classification is limited to the two-dimensional ultrasound signs of nodules without involving nodule hardness, and the theoretical malignant rate of C-TIRADS grade 4-5 thyroid nodules ranges from <2% to >90% with a large span, and the sonograms of benign and malignant nodules overlap [4], it is challenging to accurately diagnose nodule nature from conventional sonograms alone. Ultrasound elastography has been proven to improve the ability to differentiate between benign and malignant thyroid nodules [5-8]. The STE and Shell measurement functions can quantitatively assess the hardness of the thyroid nodule and its surrounding area. Relevant literature [9-11] has shown that the hardness of tissues around malignant thyroid lesions may be higher than that of the lesion area. However, few studies have applied the ratio of internal and surrounding nodule hardness combined with C-TIRADS to differentiate between benign and malignant thyroid nodules. This study aims to analyze the diagnostic value of C-TIRADS combined with STE in C-TIRADS grade 4-5 nodules to assist clinical diagnosis and avoid over-treatment.

Materials and Methods.

Clinical Data:

A total of 279 patients (51 males and 228 females) with C-TIRADS grade 4-5 thyroid nodules treated at Yijishan Hospital of Wannan Medical College from February to August 2023 were selected, with a total of 286 nodules. The age range was 18-76 years, with an average age of 46.25±12.00 years. All nodules had cytopathological or surgical pathological results, and conventional ultrasound images and STE images were collected simultaneously.

Inclusion and Exclusion Criteria:

Inclusion criteria: □ C-TIRADS grade 4-5 nodules without prior clinical intervention; □ Clear two-dimensional ultrasound and STE images; □ Complete clinical data.

Exclusion criteria: □ Nodules with maximum diameter >3 cm or cystic components; □ Nodules with coarse calcification and obvious acoustic shadow inside or around; □ The region of interest (ROI) of STE could not include 2 mm around the nodule.

Instruments and Methods:

A Mindray Resona7T ultrasound diagnostic □ (L14-5 linear array probe, 5-14 MHz) was used. Conventional two-dimensional

ultrasound images and STE images were collected respectively. The STE image acquisition process was as follows: select the longest axis section of the nodule, place the probe vertically and lightly on the skin surface, adjust to the shear wave elastography mode, freeze the image after stabilization, trace the nodule boundary, apply the built-in "Shell" analysis tool, set the Shell key to the 1.0 mm area, record the mean Young's modulus of the 1.0 mm area around the nodule (Eshell1.0mmmean) and the mean Young's modulus inside the nodule (Emean). Each nodule was collected 3 times, and the average value was taken to calculate the ratio of the two.

C-TIRADS Classification:

According to the 2020 C-TIRADS classification guidelines [3], thyroid nodules were classified (see Table 1). Each malignant ultrasound sign was +1 point, and the total score was accumulated. If only punctate echogenic foci with comet tail signs were present, -1 point was deducted. 0 points indicated C-TIRADS grade 3, 1 point indicated grade 4A, 2 points indicated grade 4B, 3-4 points indicated grade 4C, and 5 points indicated grade 5.

Table 1. *C-TIRADS Classification Criteria.*

Positive Indicators	Score	Negative Indicator	Score
Aspect ratio >1	+1	Punctate echogenic foci with comet tail signs	-1
Solid component	+1		
Extremely hypoechoic	+1		
Suspicious microcalcification	+1		
Blurred/irregular margin or extrathyroidal invasion	+1		

STE, Combined Diagnosis, and Benign/Malignant Criteria:

Based on the above C-TIRADS classification, the ratio of Eshell1.0mmmean to Emean in STE was scored. Scholars such as LIU et al. [11] defined the STE scoring criteria as follows: Eshell1.0mmmean/Emean >1 was judged as a malignant nodule; Eshell1.0mmmean/Emean ≤1 was judged as a benign nodule. The combined judgment criteria were: if the nodule had Eshell1.0mm/Emean >1 in STE, the C-TIRADS classification was upgraded by 1 level; conversely, it was downgraded by

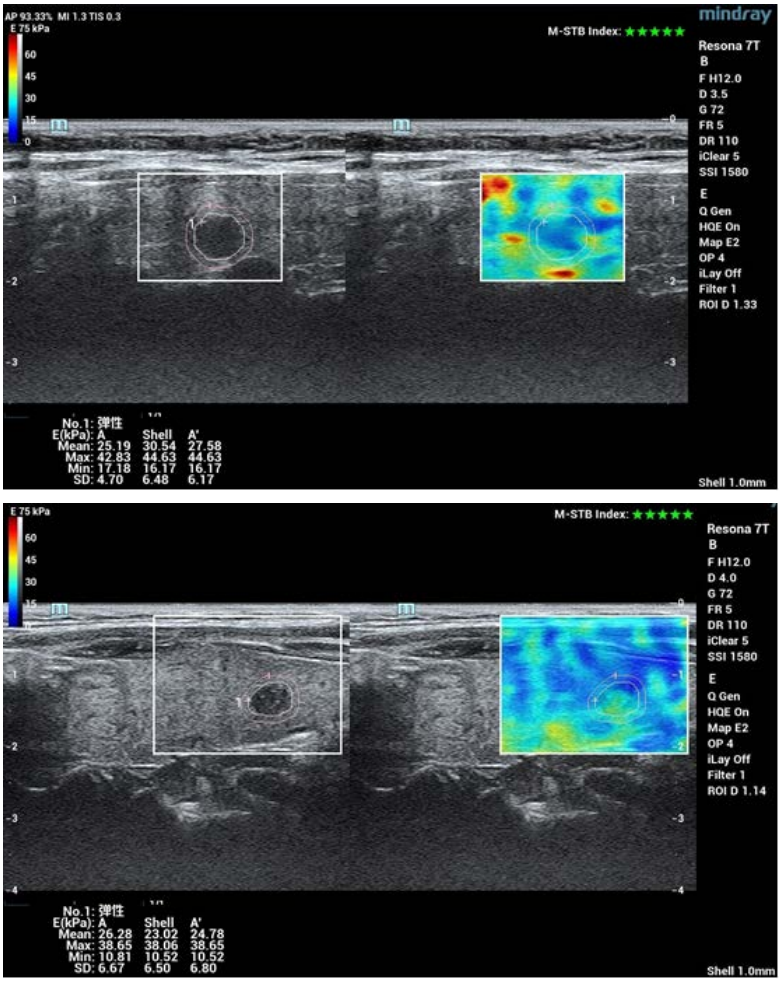

Figure 1. *Shear Wave Elastography Images of Thyroid Nodule.*
A: *A 31-year-old female with a nodule in the middle of the left thyroid lobe. C-TIRADS score: 2 points (grade 4B). STE: Eshell1.0mm/Emean >1, upgraded by 1 level to grade 4C, diagnosed as a malignant nodule.*
B: *A 57-year-old male with a nodule in the lower part of the left thyroid lobe. C-TIRADS score: 3 points (grade 4C). STE: Eshell1.0mm/Emean <1, downgraded by 1 level to grade 4B, diagnosed as a benign nodule.*

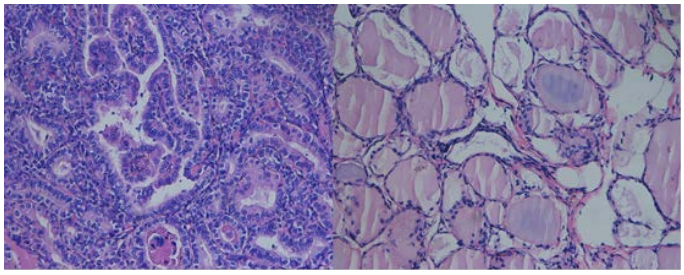

Figure 2. *Pathological Results of Thyroid Nodules.*
Left: *Pathological result of Figure 1A: Thyroid papillary carcinoma (HE ×200).*
Right: *Pathological result of Figure 1B: Nodular goiter (HE ×200).*

1 level. Both diagnostic methods considered nodules with a classification ≥4C as malignant and those <4C as benign (see Figures 1 and 2).

Statistical Methods:

SPSS26.0 statistical software was used for analysis. Measurement data conforming to normal distribution were expressed as mean ± standard deviation (x±s), and the independent sample t-test was used for comparison of means between groups. The chi-square test was used for comparison of count data between groups. ROC curves were drawn to calculate AUC, sensitivity, specificity, PPV, and NPV. The Z-test was used to compare the areas under the curves. A P<0.05 was considered statistically significant.

Results.

General Characteristics of Patients and Pathological Diagnosis Results:

In this study, 279 patients (279 with single nodule and 7 with two nodules) had a total of 286 C-TIRADS grade 4-5 thyroid nodules, including 34 grade 4A, 88 grade 4B, 132 grade 4C, and 32 grade 5 nodules. Pathological diagnosis confirmed 94 benign and 192 malignant nodules (Table 2). There was a statistically significant difference in mean age between benign and malignant nodules (P<0.05), but no significant difference in gender distribution (P>0.05) (Table 3).

Ultrasound Findings of Nodules:

Conventional ultrasound characteristics showed statistically significant differences in echo, composition, aspect ratio, irregular boundary/capsular invasion, and calcification between benign and malignant nodules (P<0.05).

Comparison of STE, C-TIRADS Classification, and Combined Diagnosis with Pathological Results:

Pathological results showed 94 benign and 192 malignant nodules among 286 nodules. C-TIRADS diagnosed 122 benign and 164 malignant nodules; STE diagnosed 115 benign and 171 malignant nodules; the combination diagnosed 108 benign and 178 malignant nodules. The consistency between single C-TIRADS or STE diagnosis and pathological results for C-TIRADS grade 4-5 nodules was moderate (Kappa coefficients 0.543 and 0.558, respectively), while the consistency between combined diagnosis and pathological results was good (Kappa coefficient 0.756), with all P<0.01 (Table 4).

Diagnostic Efficacy of C-TIRADS Classification, STE, and Their Combination for C-TIRADS Grade 4-5 Nodules:

The AUC values of C-TIRADS classification, STE, and their combination were 0.795, 0.792, and 0.892, respectively (Figure 3). The AUC of the combined diagnosis for C-TIRADS grade 4-5 nodules was higher than that of C-TIRADS classification (AUC difference 0.100) and STE (AUC difference 0.097). The diagnostic efficacy of STE was similar to that of C-TIRADS classification for C-TIRADS grade 4-5 nodules, with no statistical difference (P>0.05) (Tables 5 and 6).

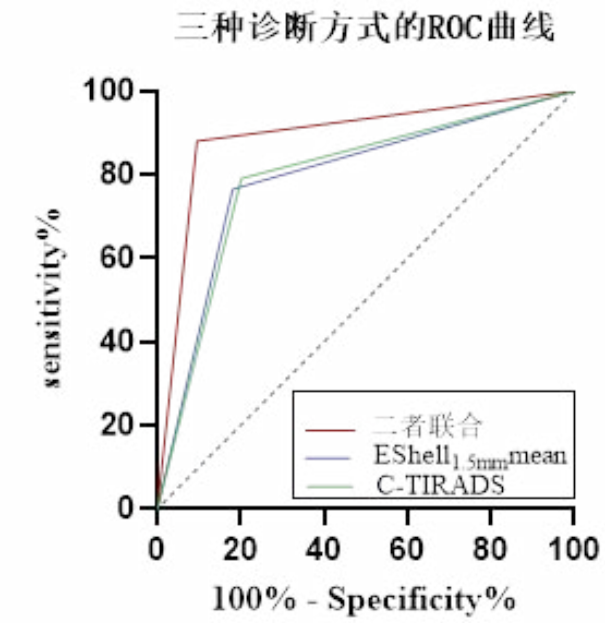

Figure 3. *ROC Curves of STE, C-TIRADS Classification, and Their Combination.*

Table 2. *Comparison of C-TIRADS Classification and Pathological Results.*

C-TIRADS Classification	Score	Pathological Results	Total (n)	Actual Malignant Rate (%)	Theoretical Malignant Rate (%)
		Benign	Malignant		
4A	1	31	3	34	8.82
4B	2	46	42	88	47.72
4C	3-4	17	115	132	87.12
5	5	0	32	32	100
Total nodules		94	192	286	67.13

Table 3. *Relationship Between Thyroid Nodules and Age/Gender (x±s).*

Parameters	Number of Nodules	Patients	Pathological Results	P Value
			Benign	Malignant
All nodules	286	279	94	192
Age (years)		46.25±12.00	50.49±11.79	44.12±11.56
Female	232	228	76	156
Male	54	51	18	36

Table 4. *Comparison of Three Diagnostic Methods with Pathological Results.*

Pathological Type	**STE**	**C-TIRADS**	**Corrected C-TIRADS**	**Total**
	Benign	**Malignant**	**Benign**	**Malignant**
Benign nodules (n)	75	40	77	45
Malignant nodules (n)	19	152	17	147
Kappa coefficient	0.558	
P value	<0.01	

Table 5. *Diagnostic Efficacy of Three Diagnostic Methods for C-TIRADS Grade 4-5 Thyroid Nodules (n/%).*

Diagnostic Method	**AUC**	**Sensitivity**	**Specificity**	**Accuracy**	**PPV**	**NPV**
C-TIRADS	0.792	147/192 (76.6)	77/94 (81.9)	224/286 (78.3)	147/164 (89.6)	77/122 (63.1)
STE	0.795	152/192 (79.2)	75/94 (79.8)	227/286 (79.4)	152/171 (88.9)	75/115 (65.2)
C-TIRADS+STE	0.892	169/192 (88.0)	85/94 (90.4)	254/286 (88.8)	169/178 (94.9)	85/108 (78.7)
χ^2		9.094	4.442	13.029	4.761	7.444
P value		0.011	0.108	0.001	0.093	0.024

***Note:** PPV = Positive Predictive Value; N*

Table 6. *Pairwise Differences in Areas Under ROC Curves of Three Diagnostic Methods.*

Diagnostic Methods	**Z Value**	**P Value**	**AUC Difference**
Combination ~ STE	3.602	<0.001	0.097
Combination ~ C-TIRADS	5.195	<0.001	0.100
STE ~ C-TIRADS	0.081	0.935	0.003

Discussion.

Conventional ultrasound examination, with its convenience, speed, and cost-effectiveness, has become the preferred method for clinical diagnosis of thyroid nodules. The C-TIRADS grade 4-5 classification has a wide span of malignant risk, and overlapping images exist between benign and malignant thyroid nodules, which poses challenges for accurate diagnosis. Elastography technology provides good reflection of nodule hardness, especially the Shell technique in STE, which can reflect and quantify the hardness of the nodule itself and its surrounding area. Compared with traditional strain elastography, STE does not require manual pressure, objectively reflecting nodule hardness and providing Young's modulus values. Deng Zihui et al. [12] showed that the mean value of Eshell1.0mm (AUC=0.824) had diagnostic efficacy for differentiating nodule nature (P<0.05). Shi Liying et al. [9] found that Eshellmean of malignant nodules was higher than nodular Emean, possibly because the noise in the lesion area decreases under low shear wave amplitude, reducing the shear energy in the tumor area, while surrounding tissues exhibit relatively higher hardness. In this study, it was considered that Eshell1.0mmmean of malignant thyroid nodules was higher than Emean, with an AUC of 0.795, similar to previous results (AUC=0.824). The area under the ROC curve of STE alone for diagnosing thyroid nodules was slightly higher than that of C-TIRADS classification, but the difference was not statistically significant (P>0.05), indicating that single use of STE had no obvious advantage over C-TIRADS classification. Therefore, nodule nature cannot be judged solely by two-dimensional ultrasound features or elastography.

In this study, the sensitivity, specificity, PPV, and NPV of C-TIRADS combined with the Shell technique in STE for diagnosing C-TIRADS grade 4-5 thyroid nodules were 88.0%, 90.4%, 88.8%, 94.9%, and 78.7%, respectively. The sensitivity, accuracy, and NPV of the combined diagnosis were all higher than those of C-TIRADS or STE alone, suggesting that C-TIRADS combined with the Shell technique in STE has higher diagnostic efficacy for C-TIRADS grade 4-5 nodules than single application. The consistency between the combined diagnosis and pathological results was good (Kappa coefficient 0.756), which was higher than that of single STE (Kappa coefficient 0.558) or C-TIRADS classification (Kappa coefficient 0.543). The ROC curve showed that single STE (0.795) was similar to C-TIRADS classification (0.792) (P>0.05), and both were lower than the combination (0.892) (both P<0.05). Compared with pathology, pure C-TIRADS classification had 45 false negatives and 19 false positives, while the combined diagnosis had 23 false positives and 9 false negatives. Possible reasons for this include: Some inflammatory nodules and nodular goiters have overlapping sonograms with malignant nodules, making differentiation difficult from two-dimensional sonograms alone. Combining STE to quantitatively analyse the hardness of the nodule and surrounding tissues provides additional diagnostic information; In benign cystic-solid nodules with cystic component absorption, solid component fibrosis, or calcification, misjudgement may occur based solely on internal nodule hardness. Simultaneously evaluating and comparing internal nodule hardness and surrounding tissue hardness can improve judgment accuracy; Long-term background of diffuse thyroid diseases may lead to sclerosis and fibrosis of surrounding tissues of benign nodules; Except for papillary thyroid carcinoma, other pathological types are more complex, with varying impacts on nodular internal hardness and surrounding tissue hardness; When malignant nodules have internal liquefaction or necrosis, the internal hardness value decreases, potentially causing misjudgement; When malignant nodules stimulate collagen

fiber hyperplasia in surrounding tissues without obvious coarse calcification, false negatives rarely occur.

This study has limitations.

 Nodules were not grouped by diameter (>10 mm vs. ≤10 mm), possibly ignoring the impact of nodule size on surrounding tissue compression and Young's modulus values, which requires further detailed research. Nodules with or without diffuse thyroid disease background were not grouped, potentially causing deviations in surrounding nodule hardness values and STE parameters. All malignant nodules were papillary thyroid carcinoma, unable to evaluate other pathological types. Static image classification assessment cannot observe as accurately as dynamic images, possibly leading to misclassification. In the later stage of this study, sample size will be increased to reduce errors.

Conclusion.

C-TIRADS combined with the Shell technique in STE significantly improves diagnostic sensitivity, accuracy, and negative predictive value for C-TIRADS grade 4-5 nodules compared with single application, demonstrating high clinical application value and deserving promotion. Single application of STE and C-TIRADS classification both have certain clinical diagnostic value for C-TIRADS grade 4-5 nodules, but both have limitations.

Competing of interests.

The authors declare that this research was conducted in the absence of any business or financial relationships that could be construed as potential conflicts of interest.

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