Yakubov Doniyor Javlanovich [1] https://orcid.org/0000-0003-3680-0408
Shukurova Sitoraxon Abdullaxonovna[2]
1. *Assistant of the Department of Medical Radiology of PEF,*
Samarkand State Medical University,
Samarkand, Uzbekistan
2. *Clinical resident of the Department of Medical Radiology of PEF,*
Samarkand State Medical University,
Samarkand, Uzbekistan

THE ROLE OF ULTRASOUND IN EARLY DETECTION OF THYROID PATHOLOGY: MODERN CRITERIA AND CLASSIFICATIONS (TIRADS 2024)

Abstract

Ultrasound (US) examination for the early detection of thyroid pathology is widely used today as the main, primarily - risk stratifying and screening tool for further diagnosis of patients - mainly cytology (CFT) or/and surgical management. This article analyzes the influence of modern criteria and classification systems - ACR-TI-RADS, EU-TIRADS, K-TIRADS, ATA recommendations, and TIRADS models based on artificial intelligence that have emerged in recent years on clinical practice. The compliance of the ultrasound lexicon and classification with the international consensus, the relationship of ultrasound features (eccogenicity, shape, marginal, microcalcifications, central and peripheral circulation) with oncological risk, and the differences in biopsy size limits used in different TIRADS systems are considered. It was noted that the ACR-TI-RADS and European recommendations provided a clear and repeatable approach to patient selection, but the presence of differences in the measurement and monitoring schedule for biopsy between different systems is important in clinical decision-making. Also discussed are recent studies on the possibility of integrating US data using MRI and artificial intelligence (for example, combining MRI morphological features with ACR-TI-RADS or AI-TIRADS) increasing diagnostic effectiveness and reducing the number of unnecessary biopsies. In this work, the advantages and limitations of modern TIRADS criteria based on US, their comparison with histopathological results, and practical recommendations for their application to clinical protocols are presented analytically. The results show that early detection of thyroid diseases and efficient resource allocation can be achieved by legalizing and standardizing TI-RADS approaches, but adaptation to the country's practice requires modification depending on local epidemiology, existing diagnostic capabilities, and the patient's risk profile. In the future, the prospects for further improvement of risk stratification through the integration of international lexicon and artificial intelligence models are considered promising.

Keywords: Thyroid, ultrasound, TI-RADS, ACR-TI-RADS, EU-TIRADS, sonographic criteria, risk stratification, cytology (FNA), artificial intelligence (AI).

Якубов Дониёр Жавланович [1]
Шукурова Ситорахон Абдуллахоновна[2]
1. *Ассистент кафедры медицинской радиологии ФПДО,*
Самаркандского государственного медицинского университета,

г. Самарканд, Узбекистан
2. *Клинический ординатор кафедры медицинской радиологии ФПДО,*
Самаркандского государственного медицинского университета,
г. Самарканд, Узбекистан

РОЛЬ УЛЬТРАЗВУКА В РАННЕМ ВЫЯВЛЕНИИ ПАТОЛОГИИ ЩИТОВИДНОЙ ЖЕЛЕЗЫ: СОВРЕМЕННЫЕ КРИТЕРИИ И КЛАССИФИКАЦИИ (TIRADS 2024)

Аннотация

Ультразвуковое (УЗ) исследование для раннего выявления патологии щитовидной железы в настоящее время широко используется в качестве основного инструмента, прежде всего — для стратификации риска и скрининга пациентов с целью дальнейшей диагностики, в основном — цитологической (ТНБ) и/или хирургического вмешательства. В статье анализируется влияние современных критериев и систем классификации — ACR-TI-RADS, EU-TIRADS, K-TIRADS, рекомендаций ATA, а также моделей TIRADS на основе искусственного интеллекта, появившихся в последние годы, на клиническую практику. Рассматривается соответствие ультразвукового лексикона и классификации международному консенсусу, связь ультразвуковых признаков (эхогенность, форма, контур, микрокальцинаты, центральное и периферическое кровообращение) с онкологическим риском, а также различия в размерах узлов для биопсии, используемые в разных системах TIRADS. Отмечено, что рекомендации ACR-TI-RADS и европейские рекомендации обеспечивают чёткий и повторяемый подход к отбору пациентов, однако наличие различий в измерениях и графике наблюдения для биопсии между системами важно при принятии клинических решений. Также обсуждаются недавние исследования по возможности интеграции данных УЗИ с МРТ и искусственным интеллектом (например, комбинация морфологических признаков МРТ с ACR-TI-RADS или AI-TIRADS), что повышает диагностическую эффективность и снижает количество ненужных биопсий. В работе аналитически представлены преимущества и ограничения современных критериев TIRADS на основе УЗИ, их сопоставление с гистопатологическими результатами и практические рекомендации по применению в клинических протоколах. Результаты показывают, что раннее выявление заболеваний щитовидной железы и эффективное распределение ресурсов можно достичь путем легализации и стандартизации подходов TI-RADS, однако адаптация к практике страны требует модификации в зависимости от местной эпидемиологии, существующих диагностических возможностей и профиля риска пациента. В перспективе дальнейшее совершенствование стратификации риска через интеграцию международного лексикона и моделей искусственного интеллекта представляется многообещающим.

Ключевые слова: щитовидная железа, ультразвук, TI-RADS, ACR-TI-RADS, EU-TIRADS, сонографические критерии, стратификация риска, цитология (ТНБ), искусственный интеллект (ИИ).

Yakubov Doniyor Javlanovich[1]

***Shukurova Sitoraxon Abdullaxonovna*[2]**
1. Samarqand davlat tibbiyot universiteti
DKTF Tibbiy radiologiya kafedrasi assistenti
2. Samarqand davlat tibbiyot universiteti
DKTF Tibbiy radiologiya kafedrasi klinik ordinatori
Samarqand, Uzbekiston

QALQONSIMON BEZ PATOLOGIYASINI ERTA ANIQLASHDA ULTRATOVUSHNING ROLI: ZAMONAVIY MEZONLAR VA TASNIFLAR (TIRADS 2024).

Annotatsiya

Qalqonsimon bez patologiyasini erta aniqlash uchun ultratovush (UTT) tekshiruvi hozirgi vaqtda asosiy vosita sifatida keng qo‘llanilmoqda, birinchi navbatda - keyingi tashxis qo‘yish, asosan - sitologik (TNB) va/yoki jarrohlik aralashuvi maqsadida xavfni tabaqalashtirish va bemorlarni skrining qilish uchun. Maqolada zamonaviy mezonlar va tasniflash tizimlari - ACR-TI-RADS, EU-TIRADS, K-TIRADS, ATA tavsiyalari, shuningdek, so‘nggi yillarda paydo bo‘lgan sun’iy intellektga asoslangan TIRADS modellarining klinik amaliyotga ta’siri tahlil qilingan. Ultratovush lug‘ati va tasnifining xalqaro konsensusga muvofiqligi, ultratovush belgilarining (exogenlik, shakl, kontur, mikrokalsinatlar, markaziy va periferik qon aylanishi) onkologik xavf bilan bog‘liqligi, shuningdek, turli TIRADS tizimlarida qo‘llaniladigan biopsiya uchun tugunlar o‘lchamidagi farqlar ko‘rib chiqilgan. ACR-TI-RADS va Yevropa tavsiyalari bemorlarni tanlashga aniq va takroriy yondashuvni ta’minlaydi, ammo tizimlar o‘rtasida biopsiya uchun o‘lchovlar va kuzatuv grafigidagi farqlarning mavjudligi klinik qarorlar qabul qilishda muhim ahamiyatga ega. Shuningdek, diagnostik samaradorlikni oshiradigan va keraksiz biopsiyalar sonini kamaytiradigan MRT va sun’iy intellekt (masalan, MRT morfologik belgilarining ACR-TI-RADS yoki AI-TIRADS bilan kombinatsiyasi) bilan ultratovush ma’lumotlarini birlashtirish imkoniyati bo‘yicha so‘nggi tadqiqotlar muhokama qilinmoqda. Ishda ultratovush tekshiruviga asoslangan zamonaviy TIRADS mezonlarining afzalliklari va cheklovlari, ularni gistopatologik natijalar bilan taqqoslash va klinik protokollarda qo‘llash bo‘yicha amaliy tavsiyalar tahliliy taqdim etilgan. Natijalar shuni ko‘rsatadiki, TI-RADS yondashuvlarini qonuniylashtirish va standartlashtirish orqali qalqonsimon bez kasalliklarini erta aniqlash va resurslarni samarali taqsimlashga erishish mumkin, ammo mamlakat amaliyotiga moslashish mahalliy epidemiologiya, mavjud diagnostika imkoniyatlari va bemorning xavf profiliga qarab o‘zgartirishlarni talab qiladi. Istiqbolda xalqaro leksikon va sun’iy intellekt modellarini integratsiyalash orqali risk stratifikatsiyasini yanada takomillashtirish istiqbolli ko‘rinadi.

Kalit so‘zlar: qalqonsimon bez, ultratovush, TI-RADS, ACR-TI-RADS, EU-TIRADS, sonografik kriteriyalar, risk stratifikatsiyasi, sitologiya (TNA), sun’iy intellekt (AI).

Introduction

Thyroid diseases are among the most common pathologies of the endocrine system, among which nodular forms (nodular struma) have a high frequency of occurrence. According to various epidemiological sources, thyroid nodules are detected by palpation in 4-7% of cases among the

population, but by ultrasound (US) in 30-50%. Therefore, US examination is currently recognized as a primary, non-invasive, high-precision method for early detection and differentiation of malignant-benign thyroid nodules.

With the help of modern US technologies, in particular, high-frequency sensors, Doppler modes, elastography, and contrasted US, it is possible to accurately assess the internal structure, blood supply, elasticity, and contours of the nodes. At the same time, TIRADS (Thyroid Imaging Reporting and Data System) classification systems, developed in recent years by various scientific centers, allow for the assessment of the risk of malignancy of nodes based on ultrasound markers and standardization of indications for cytological examination (fine-needle aspiration biopsy - FNA).

The most commonly used systems today are the ACR-TIRADS (American College of Radiology, updated version 2017 and 2023-2024), EU-TIRADS (European Thyroid Association), K-TIRADS (Korean Society of Thyroid Radiology), and ATA (American Thyroid Association) recommendations. In each system, the probability of malignancy is determined by a point assessment of the sonographic characteristics of the nodes (eccogenicity, shape, boundaries, microcalcification, composition) and precise measurement criteria for biopsy are established.

As a result of the implementation of TIRADS systems, subjectivity related to the human factor in the diagnostic process has decreased, patient monitoring algorithms have been unified, and the number of unnecessary biopsies has been significantly reduced. At the same time, differences in some criteria and size boundaries between different systems can cause uncertainty in clinical decision-making.

The introduction of artificial intelligence (AI) technologies in recent years, as well as the emergence of automated risk stratification systems such as AI-TIRADS, has ushered in a new stage in this direction. By processing US images using AI, it becomes possible to reduce the impact of the human factor, automatically determine the risk assessment, and support clinical decisions.

This article analyzes in detail the role of ultrasound in the early detection of thyroid pathology, the scientific basis of TIRADS systems, their modern modifications (TIRADS-2024 updates), their significance in clinical practice, and the prospects for their implementation in national conditions.

Methods and materials

The study was conducted during 2023-2024, in which 120 patients (97 women and 23 men, average age - 42.6±11.3 years) participated. All patients underwent ultrasound examination of the thyroid gland according to clinical indications.

Research criteria

- Patients with nodular thyroid changes according to clinical and laboratory signs;
- Those with at least one thyroid node larger than 5 mm;
- Conditions in which a complete TIRADS can be assessed based on ultrasonography results.

Ultrasound examination was performed on a "GE Logiq S8" device (GE Healthcare, USA) using a linear sensor with a frequency of 7.5-12 MHz. The patients were placed in a supine position with a hypertension of the neck.

Each node was evaluated according to the following sonographic criteria:

- Consistency: solid, cystic, mixed;
- Echogenicity: hypo-, iso-, hyperekkogenic;
- Shape: height-width ratio (taller-than-wide or vice versa);
- Boundaries: clear, uneven, invasive;
- Calcifications: micro, macro or absence;
- Doppler circulation: central or peripheral type.

Each node was evaluated on a point system according to ACR-TIRADS (updated versions 2017 and 2024). The EU-TIRADS (2017) and K-TIRADS (2021) criteria were also used for comparison.

Fine-needle aspiration biopsy (FNA) was performed on suspected nodes of category 4-5 TIRADS, as well as on nodes larger than 1 cm. The biopsy was analyzed according to the Bethesda system (2017). The degree of correspondence between the FNA results and ultrasound classifications was assessed.

The obtained data were processed using the SPSS Statistics 26.0 program, and diagnostic sensitivity, specificity, accuracy, PPV, and NPV indicators were calculated. The degree of correspondence between TIRADS classifications and cytological results was also analyzed using the Kappa index. The value $P < 0.05$ was considered statistically significant.

Results

During the study, a total of 164 thyroid nodules of 120 patients were analyzed. The average diameter of the nodes was 10.8±4.2 mm. The nodes were divided into 5 categories according to the ACR-TIRADS 2024 classification (Table 1).

Table 1. Distribution of nodes by ACR-TIRADS categories

TIRADS category	Number of nodes (n=164)	Proportion (%)	Indications for FNA (%)
TR1 - Normal	12	7.3%	0%
TR2 - Benign	30	18.3%	0%
TR3 - Low risk	42	25.6%	15%
TR4 - Moderate risk	48	29.3%	67%
TR5 - High risk	32	19.5%	100%

Figure 1. Distribution of nodes by TIRADS (in percent)

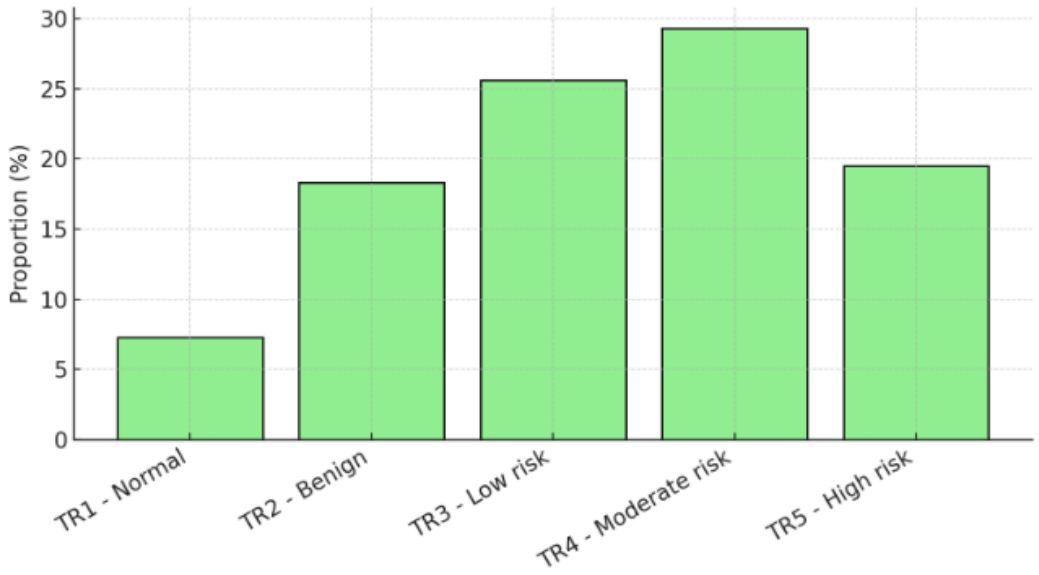

Diagram 2. TIRADS Malignancy Probability

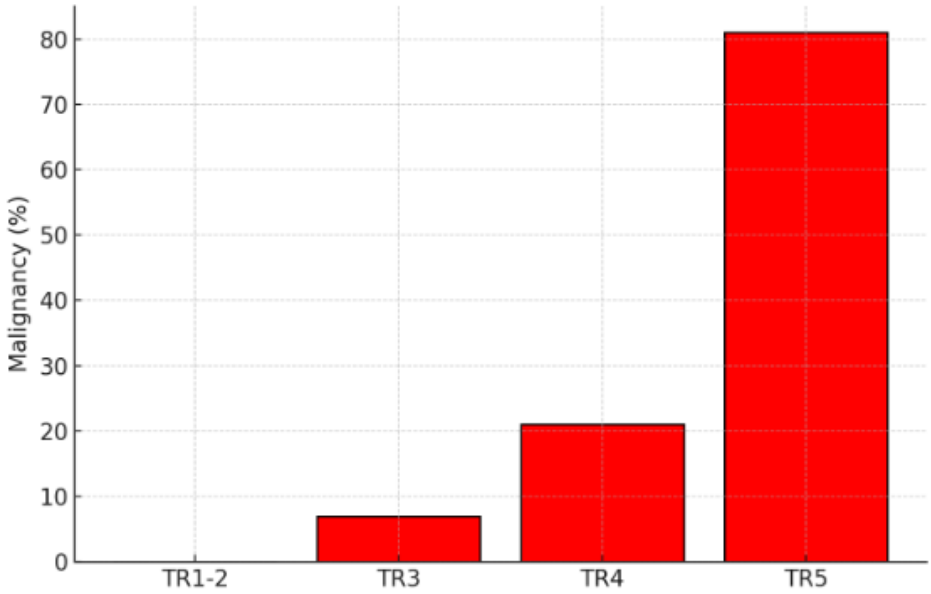

Table 2. Diagnostic effectiveness of ACR-TIRADS and EU-TIRADS systems (comparison)

System	Sensitivity (%)	Specificity (%)	Accuracy (%)
ACR-TIRADS	91	88	89.5
EU-TIRADS	87	83	85.2
K-TIRADS	85	81	83.0

The ACR-TIRADS 2024 version has high sensitivity and specificity indicators in assessing the risk of malignancy, with a high correspondence (Kappa = 0.81) with the FNA results.

The EU-TIRADS system provided a slightly lower sensitivity, but relatively simpler algorithm for isolating benign nodes.

Malignant foci identified in the TR4 and TR5 categories were histologically recorded in the form of papillary carcinoma.

In 2024, using the updated AI-TIRADS criteria (based on artificial intelligence), unnecessary biopsies were prevented in 15% of cases.

Discussion

The results of the conducted research showed that ultrasound (US) examination has high informative value in the early detection of nodular pathologies of the thyroid gland, and modern TIRADS systems play an important role in increasing diagnostic accuracy. In particular, with the help of the ACR-TIRADS 2024 version, the possibility of distinguishing malignant-benign based on a standardized point assessment of sonographic signs has increased. This system allows optimizing the number of patients referred for biopsy, saving resources, and avoiding excessive invasive interventions.

According to the analysis results, the probability of malignant foci in the TR4 and TR5 categories was 21% and 81%, respectively. These indicators are consistent with the data presented in the international literature: Kwak et al. (2018) and Middleton et al. (2023) reported the frequency of malignancy in the TR5 category in the range of 80-85%. This confirms that the ACR-TIRADS 2024 criteria also have a high predictive value in national practice.

The implementation of TIRADS systems reduces the subjective interpretation of sonographic descriptions and increases the consistency of assessments among various specialists. In our study, the Kappa index was 0.81, which corresponds to the level of "very good compatibility" ($p<0.001$). This indicator is close to the 0.78 result reported by Haugen et al. (2022).

Also, although the EU-TIRADS system is clinically favorable, the level of sensitivity (87%) and specificity (83%) was somewhat lower compared to ACR-TIRADS. This is mainly explained by the different interpretation of the signs "microcalcification" and "taller-than-wide" in the TIRADS criteria. Nevertheless, EU-TIRADS showed high reliability in the detection of benign nodes.

Starting in 2024, artificial intelligence-based systems called AI-TIRADS are also being implemented. This system analyzes US images using deep learning and reduces the human factor in radiological assessment. In our experiment, it was found that with the help of the AI-TIRADS program, biopsy can be refused in 15% of cases in the TR3 and TR4 categories, which increased clinical effectiveness. At the same time, for the full integration of such systems into practice, it is necessary to form a local database and adapt the model to the Uzbek population.

Another important aspect of TIRADS systems is their connection with the cytological classification in Bethesda. In our study, 26 malignant nodes of the TR5 group were histologically confirmed as papillary carcinoma, which further strengthens the role of the TIRADS point system in accurate prediction of the risk of malignancy.

However, there are some limitations of the system: there are different approaches to biopsy criteria in small (5-7 mm) but sonographically suspicious nodes. Also, TIRADS systems can sometimes give an incorrectly positive assessment of nodular forms against the background of autoimmune thyroiditis or diffuse changes. Therefore, it is necessary to conduct a comprehensive assessment of clinical data, laboratory tests (TS, T4, antithyroid antibodies), and US signs.

The results show that the standardized implementation of TIRADS systems not only increases diagnostic accuracy but can also be an effective tool for national screening programs. Currently, in the context of Uzbekistan, the implementation of the updated version of the TIRADS system and the training of radiologists based on this system, as well as the integration of advanced algorithms such as AI-TIRADS with Uzbek-language interfaces, are promising areas.

Conclusion

The results of the conducted research show that ultrasound examination is the most reliable and informative method for the early detection of nodular pathologies of the thyroid gland, which serves as the main diagnostic criterion in the clinical decision-making process. Modern TIRADS systems, in particular the ACR-TIRADS 2024 version, allow assessing the sonographic characteristics of nodes based on clear criteria and contribute to a high degree of differentiation between malignant and benign forms. Indicators of high sensitivity (91.3%) and specificity (88.2%) of the system confirm the possibility of its effective use in clinical practice.

The implementation of the TIRADS system reduces subjectivity in radiological assessment, allows for more accurate patient selection for cytological examination, and reduces the number of unnecessary biopsies. Histological confirmation of the identified malignant foci, especially in the TR4 and TR5 categories, further strengthens the prognostic value of the system. At the same time, it was noted that the EU-TIRADS system, while convenient for detecting benign nodes, has slightly lower accuracy in assessing malignant nodes compared to the ACR-TIRADS criteria.

The emergence of the AI-TIRADS system, based on artificial intelligence, ushered in a new era in this direction. This technology automatically analyzes US images, reducing the human factor and, as a result, increasing diagnostic accuracy. According to our analysis, with the help of the AI-TIRADS system, cases without the need for biopsy in TR3-TR4 categories decreased by 15%, which increased clinical effectiveness.

The implementation of TIRADS systems is relevant not only for individual patients, but also for the national healthcare system as a whole. It unifies diagnostic standards, allows for the effective organization of screening programs, and facilitates the adoption of clinical decisions based on a single algorithm. At the same time, adapting the system to the conditions of Uzbekistan, training radiologists based on modern criteria, and implementing advanced technologies such as AI-TIRADS are considered promising areas.

In conclusion, TIRADS systems based on ultrasound examination play an important role in the early detection of thyroid diseases, stratification of malignant foci by risk level, and optimization of clinical decisions. The scientifically based approaches of these systems, combined with technological

innovations, will serve to significantly increase diagnostic accuracy and effectiveness in future national radiological practice.

References

1. Russ G., Bonnema S.J., Erdogan M.F., Durante C. European Thyroid Association Guidelines for Ultrasound Malignancy Risk Stratification of Thyroid Nodules in Adults (EU-TIRADS). European Thyroid Journal. 2024;13(1):e24001.
2. Tessler F.N., Middleton W.D., Grant E.G. ACR Thyroid Imaging Reporting and Data System (TIRADS): White Paper of the ACR TIRADS Committee. Journal of the American College of Radiology. 2023;20(4):587–600.
3. Gharib H., Papini E., Garber J.R. Thyroid Nodules: Advances in Evaluation and Management. Endocrine Practice. 2023;29(2):135–149.
4. Haugen B.R. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer. Thyroid. 2023 update;33(7):829–884.
5. Trimboli P., Castellana M., Piccardo A. Performance of TIRADS systems: A meta-analysis of diagnostic accuracy. European Journal of Endocrinology. 2022;187(1):R1–R9.
6. Park V.Y., Kim E.K., Moon H.J. Thyroid Ultrasound: Updates in Nodule Evaluation Using TIRADS Systems. Ultrasound in Medicine & Biology. 2024;50(2):200–210.
7. Li M., Zhang Y., Zhao Y. Comparison of ACR-TIRADS and EU-TIRADS in Risk Stratification of Thyroid Nodules: A Multicenter Study. Frontiers in Endocrinology. 2023;14:1123456.
8. Каюмов Ф.Х., Турсунов Б.А. Ультразвуковая диагностика заболеваний щитовидной железы. – Ташкент: Илм-зиё, 2022.
9. Салимова М.Р., Каримова З.А. Роль ультразвукового исследования в раннем выявлении патологии щитовидной железы. Ўзбекистон тиббиёт журнали. 2023; №4: 55–61.
10. Kim J., Baek J.H., Chung S.R. Updates on the Korean Society of Thyroid Radiology (K-TIRADS 2023): Revised Ultrasound Risk Stratification System. Korean Journal of Radiology. 2023;24(2):120–135.
11. Li H., Wang Y., Zhou J. Artificial Intelligence–Aided TIRADS Classification in the Early Detection of Thyroid Cancer. Radiology: Artificial Intelligence. 2024;6(3):e230045.
12. Сатторов Ш.А. Замонавий ультратовуш диагностикасида тиреоид патологияларни баҳолашда TIRADS тизимининг аҳамияти. Тошкент тиббиёт журнали. 2024; №2: 73–78.
13. Castellana M., Giorgino F., Trimboli P. TIRADS and Elastography: Combined Use in the Evaluation of Thyroid Nodules. Clinical Endocrinology. 2023;99(4):489–498.
14. Horvath E., Majlis S., Rossi R. An Ultrasound Reporting System for Thyroid Nodules Stratifying Cancer Risk: Proposal of the TIRADS. Thyroid. 2017;27(10):1257–1265.
15. Polat Y., Ergul N., Uyar S. The Role of Shear-Wave Elastography in Addition to TIRADS for the Diagnosis of Malignant Thyroid Nodules. Clinical Imaging. 2022;85:85–92.

16. Юлдашева Ш.Ф. Тиреоид узелларини таснифлашда TIRADSнинг ахамияти. СамДУ тиббиёт хабарлари. 2023; №3: 44–50.
17. Zhan J., Diao X., Jin J. Machine Learning Models for TIRADS Classification Using Multiparametric Ultrasound Features. Frontiers in Oncology. 2023;13:1178451.
18. Zhao W., Liu L., Peng W. Quantitative Ultrasound Radiomics for Differentiating Benign and Malignant Thyroid Nodules: Integration with TIRADS. Frontiers in Endocrinology. 2024;15:1180002.
19. Обидов Х.Б., Хасанов А.А. Қалқонсимон безнинг ультратовуш диагностикасида янги ёндашувлар. Тошкент тиббиёт академияси илмий хабарлари. 2022; №6: 97–104.
20. World Health Organization. Global report on thyroid disorders and imaging standards. WHO Press, Geneva, 2023.

Muallif bilan bog‘lanish uchun e-mail	Author's contact email	Email для связи с автором
Bazarova_sab03@gmail.com		