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The AI-enabled future of ultrasound in thyroid imaging

How artificial intelligence is assisting radiologists in thyroid nodule management

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Applying artificial intelligence to the analysis of ultrasound thyroid images shows considerable promise in helping to reduce unnecessary biopsies while allowing radiologists to maintain workflow efficiency.

Thyroid nodules are extremely common. By age 60, about half of the U.S. population will have a thyroid nodule that can be found either through examination or with imaging.[1] Fortunately, more than 90% of thyroid nodules are benign.[1] Thyroid cancers are typically slow-growing and most can be managed through observation and, as needed, surgical intervention.

Following a physical exam and blood tests, a patient is typically referred to a radiologist who has two tools at their disposal — ultrasound and fine needle aspiration — to evaluate potential malignancies in thyroid nodules.

Ultrasound, a non-invasive imaging test, is the first line of interrogation in evaluating a thyroid nodule. Ultrasound demonstrates high sensitivity in detecting thyroid nodules, but its specificity for characterizing the nodule is low. Fine needle aspiration, on the other hand, is the gold standard for accuracy in non-surgical thyroid nodule evaluation but, as an invasive procedure, is more difficult for patients to undergo.

The goal for radiologists has long been to find a way to use ultrasound to characterize thyroid nodules with greater accuracy to avoid unnecessary biopsies — and to do so in a way that enables them to maintain workflow efficiency.

About the author

Dr. Timothy W. Deyer is the head of Interventional Radiology at East River Medical Imaging, a privately owned, independent, multi-modality radiology center in New York City on the Upper East Side of Manhattan and in White Plains, Westchester County. Established over 40 years ago, the practice sees about 75,000 patients a year. Dr. Deyer is also Clinical Assistant Professor of Radiology at Weill Cornell Medical Center in New York City.

TI-RADS: A step forward, but challenges exist

The ACR® Thyroid Imaging Reporting and Data System (TI-RADS™) is the main classification scheme used in the United States to determine the risk of cancer in thyroid nodules based on ultrasound characteristics. TI-RADS was released in 2017 to address the low specificity of ultrasound for thyroid cancer and reduce the number of unnecessary biopsies of benign nodules.

In my experience, radiologists encounter several challenges in using TI-RADS: reduced operational efficiency, high variability, and low negative predictive value.

Operational efficiency

TI-RADS evaluates five sonographic feature categories: composition, echogenicity, shape, margin, and echogenic foci. Identifying and measuring the thyroid nodules to populate these categories is a time-consuming process that, in the estimation of many radiologists, does not add enough useful diagnostic information to warrant significantly increasing the reading time per study.

Variability

TI-RADS findings are highly inconsistent, as these studies indicate:

- Interobserver variability – 0.25-0.39 agreement for echogenic foci and margin[2]
- Intraobserver variability – 0.42-0.46 agreement for TI-RADS category[3]

This means that different radiologists agree on nodule margin and presence of echogenic foci less than 40% of the time. And if a radiologist looks at a nodule once and again several weeks later, that radiologist will make the same classification decision less than 50% of the time.

Negative predictive value (NPV)

According to one study, TI-RADS reduces the number of unnecessary biopsies of benign thyroid nodules by 19.9-46.5% compared with other risk stratification systems.[4] Another reported a 40% NPV for TI-RADS.[5] As someone who conducts all the biopsies in our practice, I would like to see consistently higher NPV scores. If I can't be confident in the algorithm, then I don't know whether to do the biopsy.

Applying AI to thyroid nodule management

There's been exciting work done in the past few years to apply artificial intelligence to ultrasound and the evaluation of thyroid nodules.

For several months, our practice has been using Koios Thyroid DS,™ an AI-powered software platform that analyzes ultrasound images to help diagnose thyroid cancer. The objective of the developers at Koios is to integrate powerful AI models directly into software that is easy for radiologists and technologists to use.

I had three goals in adding AI to our thyroid evaluation process:

1. **Higher reliability.** One of the issues with TI-RADS is intra and interobserver variability. When AI algorithms look at a nodule, I want to get the same answer every time.
2. **Greater efficiency.** All radiologists want to improve efficiency. Even the best tool in the world has to support productive workflow, rather than requiring radiologists to spend more time on every thyroid ultrasound.
3. **More accurate nodule characterization.** Any time you perform a fine needle aspiration, you're causing anxiety for the patient. I would prefer to never biopsy another benign thyroid nodule again.

The Koios Thyroid DS AI algorithms have been trained on more than 350,000 thyroid nodule images with confirmed diagnoses, collected from 48 sites around the world.[6] The software analyzes the ultrasound images of the current patient based on this learning.

TI-RADS is integrated into the Koios platform. So, you not only get the malignancy risk based on the AI evaluation, you also get the TI-RADS nodule descriptors. In terms of decision support, this richer dataset enables the radiologist to make a better decision about whether a thyroid nodule should be biopsied.

> *"…this richer dataset enables the radiologist to make a better decision about whether a thyroid nodule should be biopsied."*

AI results in our practice

I applied the Koios Thyroid DS software to every patient I biopsied over a three-week period. Those biopsies resulted from a combination of the TI-RADS scores and the recommendation of referring doctors in consultation with their patients. In my practice on the upper east side of New York City, we see many patients who insist on having even very small nodules biopsied. So, the results reflect a nice mix of benign and not benign nodules.

For these patients, I recorded the radiologist's TI-RADS evaluation; the Koios TI-RADS evaluation from two sets of patient images (diagnostic and biopsy); and the Koios TI-RADS plus AI evaluation. I also noted subjective feedback from the sonographer and radiologist doing the study.

Objective results

I biopsied 107 patients with 148 nodules, and received the following scores from the Bethesda classification system for fine-needle aspiration cytology:

Bethesda score	Nodules
II – Benign	105
III – Atypia of Undetermined Significance or Follicular Lesion of Undetermined Significance	31
IV – Follicular Neoplasm or Suspicious for a Follicular Neoplasm	8
V – Suspicious for Malignancy	4

Table 1: Bethesda scores for 148 nodules in the study.

All Bethesda III, IV, and V nodules underwent ThyroSeq® testing:

Not benign nodules	ThyroSeq results
III N=15	22 negative 9 not negative (mix of intermediate and high)
IV N=2	3 negative 5 positive
V N=2	4 positive

Table 2: ThyroSeq findings for not benign nodules.

Negative predictive value

My study revealed 105 benign (Bethesda II) nodules and the central question was: How many benign biopsies could have been avoided by following the recommendations? When I compared the results with the other data I recorded, the Koios software — both with and without AI — had significantly less variability than the radiologists' TI-RADS evaluations.

Evaluation method	Benign biopsies avoided
Radiologist TI-RADS	27% (N=40)
Koios TI-RADS	41% (N=61)
Koios TI-RADS + AI	57% (N=84)

Table 3: Comparison of NPV for different thyroid nodule evaluation methods.

The extra data gained through the AI training using hundreds of thousands of previous thyroid cases enabled the Koios + AI software to fine-tune the TI-RADS score. This adjustment resulted in a huge improvement in the negative predictive value of the recommendation: **the Koios + AI NPV was 16 percentage points higher than Koios without AI and 30 percentage points higher than the radiologists' TI-RADS recommendations.**

> *"The extra data gained through the AI training using hundreds of thousands of previous thyroid cases enabled the Koios + AI software to fine-tune the TI-RADS score."*

Positive predictive value

For the 18 nodules that were not benign per ThyroSeq, the recommendations can be seen in Table 4.

Radiologists using TI-RADS were the least accurate, attributable primarily to the fact that the nodules were a smaller size than TI-RADS criteria for probable malignancy. Koios TI-RADS, with and without AI, was slightly more accurate, but still missed some biopsy recommendations. Again, the small size of the nodules was a factor.

Size	Radiologist TI-RADS Bx?	AI TI-RADS Bx?	AI TI-RADS + RADIOMICS Bx?	Bethesda	Thyroid genetic mutation panel
1.3 x 1.1 x 1 cm	No	No	No	III	Intermediate
1.3 x 1.4 x 1 cm	No	No	No	V	High
4.2 x 2.8 x 3.9 cm	Yes	Yes	No	IV	High
0.5 x 0.6 x 0.5 cm	No	No	No	V	High
1.2 x 0.6 x 0.7 cm	No	Yes	Yes	III	Intermediate
0.8 x 0.8 x 0.8 cm	No	No	No	III	Intermediate
2.7 x 1.5 x 2 cm	No	Yes	No	III	Intermediate
1.5 x 1.1 x 1 cm	Yes	Yes	Yes	IV	High
2.6 x 1.7 x 1.3	Yes	Yes	Yes	IV	Intermediate
3.7 x 2.1 x 2.5	Yes	Yes	No	IV	Intermediate
1.2 x 1 x 1	No	No	No	III	Low-intermediate
1.7 x 1.3 x 1.5	No	No	No	IV	Intermediate
1.3 x 0.9 x 1	Yes	Yes	Yes	III	High
1.6 x 1.4 x 1.5	Yes	Yes	Yes	V	High
1.1 x 0.7 x 0.9	No	No	No	III	Intermediate
0.7 x 0.7 x 0.7	No	No	No	III	High
1.8 x 0.8 x 1.4	No	No	Yes	III	Intermediate
2.9 x 1.9 x 2.3	Yes	Yes	Yes	V	High

Table 4: Comparison of PPV of various thyroid nodule evaluation methods.

Radiology workflow with AI

The Koios TI-RADS software can be added into the radiologist's workflow via PACS and integrated directly on the ultrasound scanner.

PACS-based AI workflow

In this method (Fig. 1), the ultrasound images are sent to PACS. The radiologist prompts the Koios server to get the images via DICOM® Send. On a separate window on the PACS screen, the radiologist can measure the nodule and identify its location. The Koios evaluation – including the TI-RADS descriptor and the AI predictor – is sent back to PACS.

Scanner-based AI workflow

The best AI solutions work in the background rather than requiring the radiologist to go to several websites and move data around. That's why I was pleased to see the Koios software integrated into the LOGIQ™ E10 scanner (Fig. 2). In our process (Figs. 3-6), the sonographer manages the upfront workflow, while the radiologist reviews and signs off on the results.

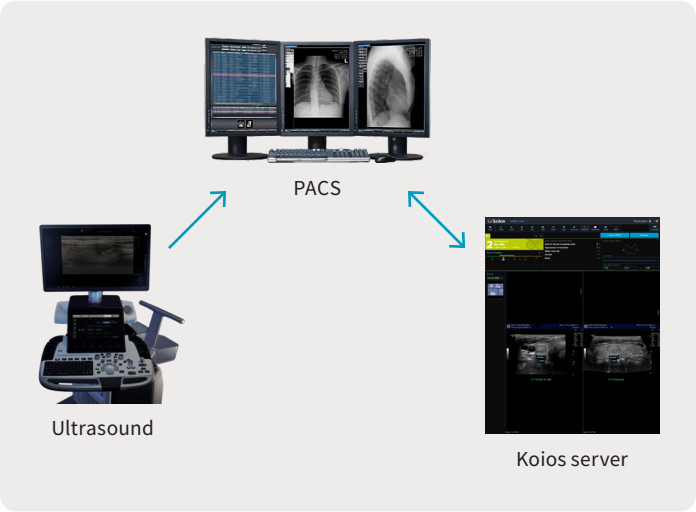

Figure 1: Overview of PACS-based AI workflow.

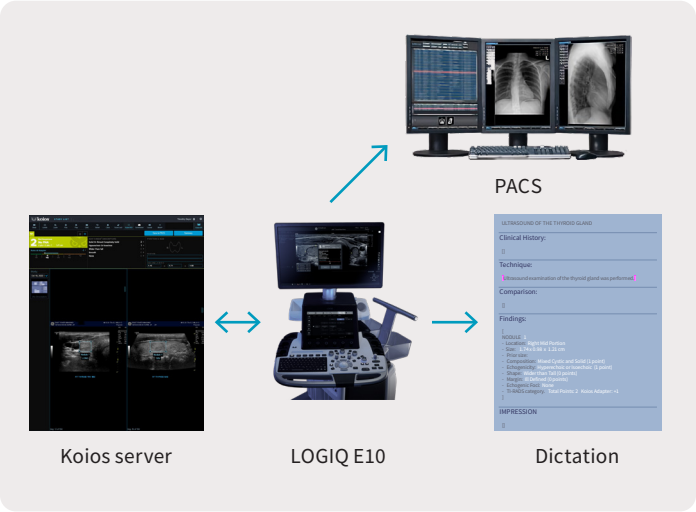

Figure 2: Overview of scanner-based AI workflow.

> *"The radiologist makes the final decision on the evaluation, signing off only after looking at all the data and agreeing with or modifying the AI analysis."*

Scanner-based AI workflow for sonographer and radiologist

Since the sonographer manages the upfront AI process, there is no extra work for the radiologist.

Step 1:

Sonographer measures the nodule & initiates AI analysis.

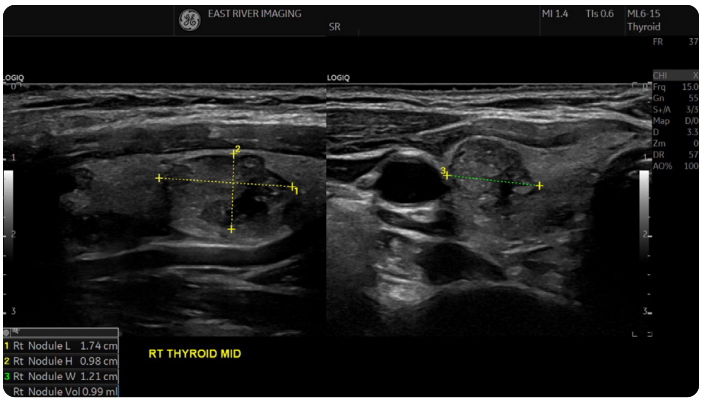

Figure 3: The sonographer measures the nodule with the Thyroid Measurement Package and initiates the Koios evaluation via a touch-button on the ultrasound scanner screen.

Step 2:

Sonographer receives AI analysis within seconds.

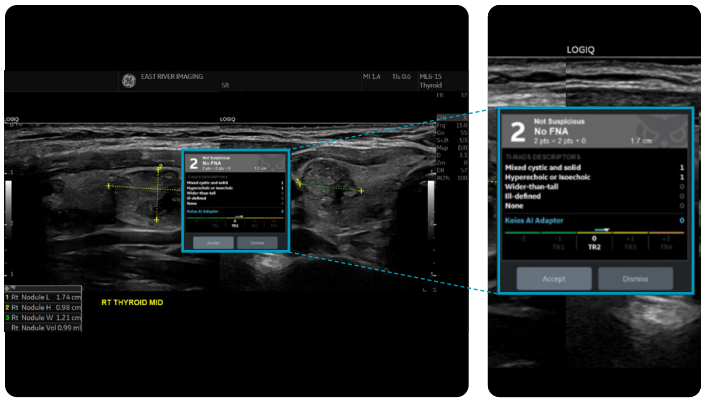

Figure 4: The Koios analysis arrives back at the scanner within seconds. After accepting or modifying the results, the sonographer sends the analysis and images to PACS or to the dictation system.

Step 3:

Radiologist reviews images and AI analysis.

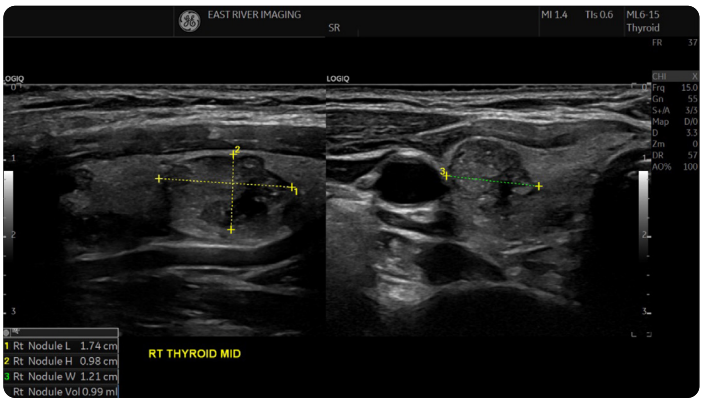

Figure 5: The image with the Koios analysis that the radiologist evaluates.

Rt Nodule 1	
Size (LxHxW)	**1.74 cm x 0.98 cm x 1.21 cm**
Volume	**0.99 ml**
Composition	**Mixed cystic and solid (1 point)**
Echogenicity	**Hyperechoic or Isoechoic (1 point)**
Shape	**Wider-than-tall (0 points)**
Margin	**Ill-defined (0 points)**
EchogenicFoci	**None (0 points)**
Koios AI Adapter	-2 -2 0 **+1** +2
Total points	**3**
TI-RADS level	**Aligned Risk TR3**
TI-RADS source	**ACR 2017**
Koios Version	**3.2.0**

ULTRASOUND OF THE THYROID GLAND

Clinical History:

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Technique:

[Ultrasound examination of the thyroid gland was performed.]

Comparison:

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Findings:

[
NODULE 1
- Location: Right Mid Portion
- Size: 1.74 x 0.98 x 1.21 cm
- Prior size:
- Composition: Mixed Cystic and Solid (1 point)
- Echogenicity: Hyperechoic or Isoechoic (1 point)
- Shape: Wider than Tall (0 points)
- Margin: Ill Defined (0 points)
- Echogenic Foci: None
- TI-RADS category. Total Points: 2 Koios Adapter: +1
]

IMPRESSION

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Figure 6: The radiologist reviews the Koios analysis either as a PACS printout or as a structured report in the dictation system.

Feedback from radiologists and sonographers

In addition to objectively evaluating the clinical effectiveness of Koios TI-RADS + AI software, we gathered subjective feedback from users. Radiologists and sonographers were positive about using the software, with the radiologists identifying several advantages for the thyroid evaluation process:

- **Greater efficiency.** Having the TI-RADS information presented to them "front and center" was a time-saver compared with generating the categories on their own.
- **Decision support.** The data helped especially in borderline cases where they were having a tough time deciding what to recommend to the referring physician. The Koios findings acted as a decision-support aid for them.
- **Faster reporting.** Generating the ultrasound report was much easier and quicker.

> *"From a sonographer's perspective, the only workflow change was to remember to press the Koios button. With results back in seconds, there was virtually no interruption to flow."*

Summary

Clinical advantages

The Koios TI-RADS + AI software provided real utility in helping our radiologists make decisions about thyroid nodule biopsies.

- **Less variability.** Our study showed much less variability in results with the Koios TI-RADS + AI software versus radiologists' TI-RADS evaluations. We could feel more confident in acting upon the results because of the accuracy and consistency.
- **Significant reduction in unnecessary biopsies.** This is a huge win for patients. The costs associated with fine-needle aspiration can be burdensome, and the procedure itself can cause discomfort and anxiety.

Operational advantages

For a practice that is considering some form of AI, it's critical to determine how well it integrates with the operational side. If the AI tool doesn't contribute to efficient workflow, the radiologists won't use it.

- **Scanner-based workflow was key** – The Koios TI-RADS + AI software was very efficient when integrated into the LOGIQ E10 scanner. There was no extra work for the radiologist and the sonographer only had to remember to press the Koios button to get the analysis.
- **Greater reporting efficiency** – Getting the results in the structured report sped up the reporting process. All the radiologists had to do was check the results to see if they agree and sign off.

References:

1. *American Thyroid Association*, 2023.
2. *American Journal of Roentgenology.* 2021;216: 570-578.
3. *Asia Ocean J Nucl Med Biol.* 2022 Winter; 10(1): 28–35.
4. *American Journal of Roentgenology.* 2021;216: 570-578.
5. Int J Clin Exp Med. 2015 Apr 15;8(4):5911-7. eCollection 2015.
6. Koios Medical internal data. Available upon request.

Learn more

Thyroid Assistant, powered by Koios DS, is available on select LOGIQ ultrasound systems from GE HealthCare. Thyroid Assistant is clinical decision support software that automatically populates all TI-RADS descriptors and offers an AI-based cancer risk assessment. Results are available in seconds and provide decision support to help radiologists make accurate and efficient thyroid nodule evaluations. To learn more, contact your GE HealthCare representative.

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