Original Article

Thyroid Imaging Reporting and Data System on the Basis of Cost and Effectiveness

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Abstract

Background: We aim to evaluate thyroid imaging reporting and data system (TIRADS) on the basis of cost and effectiveness through the numbers of fine-needle aspiration biopsies (FNABs) and sonographic examinations in a tertiary health-care institution. **Methods:** The 50-day intervals before and after the start of TIRADS use (October 10, 2022) were evaluated to carry out this assessment. The reason for choosing 50-day periods was because it covers the initial phase when the study is most optimally performed in our hospital. The number of thyroid ultrasound (US) and FNAB procedures carried out in our facility during that time was tallied. Exclusion standards were not applied. **Results:** One thousand nine hundred eighty-two people made up the study population. Fifty days before the October 10, 2022, there were 975 instances (49.2%), and 50 days after that, there were 1007 cases (50.8%). Out of 1982 cases, it was discovered that 190 (9.6%) underwent a biopsy, and 1792 (90.4%) underwent a US examination. It was found that the first period's rate of biopsy examination was significantly higher than the second period's rates of 11.1% and 8.1%, respectively. The rate of biopsy examination in males during the first period was found to be substantially higher than the second period. Individuals between the ages of 35 and 50 years had a rate of biopsy examination that was considerably higher in the first period than the second period. **Conclusion:** The TIRADS Risk Scale has the capacity to reduce unnecessary biopsies, hence mitigating potential psychological distress, burden, and financial expenses for the patient.

Keywords: Fine-needle aspiration biopsy, thyroid imaging reporting and data system, ultrasound

Introduction

The incidence of thyroid nodules has been increasing recently. In this case, although other factors are effective, one of the most important reasons for the increase is thyroid nodules that are detected incidentally during the examination of the thyroid itself or different structures.

Ultrasound (US) is the most effective imaging method for detecting thyroid nodules and many other thyroid pathologies. However, because some findings are nonspecific, a thyroid fine-needle aspiration biopsy (FNAB) may be needed. At this point, the thyroid image reporting and data system (TIRADS) presents a risk scale from 1 to 5 according to the solid-cystic character of a nodule in the thyroid, echogenicity, edge features, shape, characteristics of the calcific foci it contains, and in addition to these features, the size of the nodule and plays a facilitating role in the diagnosis–treatment stages.

TIRADS provides significant gains in terms of performance and cost-effectiveness in the classification of thyroid nodules, then in diagnosis and treatment steps. Although its effectiveness in adults has been proven in many studies, it has been seen that it is also effective in the pediatric age group in a few studies. In one of these studies, the use of TIRADS in the pediatric age group showed a lower incidence of malignant nodules, especially when compared to adults; however, it has been observed that the nodules encountered are malignant at a high rate of approximately 1 in 4. It has been shown to be more effective in TR4 and TR5 nodules.[1]

In one study, US follow-up before immediate FNAB was found to be a more cost-effective method for thyroid nodules 1 cm and below with a moderately suspicious pattern when evaluated with TIRADS. In this study, the importance of US

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follow-up and TIRADS classification based on data was once again emphasized.[2]

As a different result, Cawood *et al*. stated that the use of TIRADS classification in their study was similar in cost compared to spontaneous biopsy and that the use of TIRADS did not contribute to cost-effectiveness. However, in this study, the control group consisted of a hypothetical patient population and did not contain real-life data. This is the most important limitation of the aforementioned study.[3]

In this study, we aim to evaluate TIRADS on the basis of cost and effectiveness through the number of FNABs and sonographic examinations in a tertiary health-care institution.

Materials and Methods

This retrospective study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional research ethics committee of Erzincan Binali Yıldırım University with (approval number: EBYU-KAEK-2022-2018; approval date: 15.12.2022). Informed consent was waived because the study was retrospective.

Since our study is a retrospective study, there are no obvious limitations other than the difficulty of reaching the patients again if necessary.

Within the scope of this study, to analyze the changes in thyroid US and thyroid FNABs numbers due to the use of TIRADS on the basis of cost-effectiveness, the numerical changes of the following parameters were evaluated in an equal time interval before and after the use of TIRADS.

To implement this assessment, the 50-day periods before and after the start of TIRADS use (October 10, 2022) were examined. The details of the TIRADS classification are shown in Table 1.[4] During the mentioned time, the number of thyroid US and FNAB performed in our hospital were compiled. Exclusion criteria were not used. In accordance with these principles, the study population consists of 1982 people: 365 males and 1617 females.

US examinations were performed using high-frequency linear array transducers in the longitudinal and transverse planes (iU22 Philips Healthcare [Best, Netherlands] and Aplio [Toshiba Medical Systems, Tokyo, Japan]).

Changes in thyroid US and FNAB numbers over the specified period were evaluated by dividing the participants into four groups by age: 35 years and younger (500 patients), 35–50 years old (650 patients), 50–65 years old (562 patients), and 65 years and older (270 patients). In addition to the age range, the mentioned change was also analyzed against the gender variable.

The cost calculation was also made using the numerical change in the specified parameters. While performing the cost calculation, the pricing of the institution where the study was carried out was taken as the basis. In this context, the unit price of the thyroid US examination was determined as $3.3, and the unit price of the FNAB procedure was determined as $11.94. Within the scope of the FNAB procedure, the cost of a biopsy and the cost of pathological evaluation are included together.

Statistical analysis

Mean ± standard deviation and minimum–maximum were given for numerical variables as descriptive statistics, number, and percentage (%) values were given for categorical variables. At the qualitative measurement level, the correlation of the features with each other was examined with Fisher's exact test or Pearson's Chi-square test. SPSS 25.0 (IBM Corporation, Armonk, New York, United States) program was used for statistical analysis.

Results

The sociodemographic characteristics of the cases are presented in Table 2. Of the cases, 365 (18.4%) were male and 1617 (81.6%) were female. The mean age of the cases was 47.64 ± 16.78 (0–96). Nine hundred seventy-five (49.2%) cases in period I (50 days before October 10, 2022) and 1007 (50.8%) cases in period II (50 days after October 10, 2022). A biopsy was performed in 190 (9.6%) of the 1982 cases, and US examination was performed in 1792 (90.4%) cases.

The distributions of US and biopsy tests between periods were examined [Table 3]. It was determined that the distribution of biopsy and US examinations in different periods were statistically significantly different ($P = 0.027$). In the first period, the number of biopsies was 108 (11.1%), whereas in the second period, it was found to be significantly fewer, with a number of 85 (8.1%).

The distributions of US and biopsy performed between periods in men and women were analyzed [Table 4]. It was determined that the distribution of biopsy and US examinations between periods in men was statistically significant ($P < 0.001$). It was determined that the rate of biopsy examination in men in the first period was significantly higher.

The distributions of US and biopsy performed between periods in age groups were analyzed [Table 5]. It was determined that the biopsy and US distributions between the periods were statistically significantly different in cases aged 35–50 years ($P = 0.043$). In individuals aged 35–50, the rate of biopsy examination was found to be significantly higher in the first period than in the second one.

Before the use of TIRADS, 89 biopsies were taken within 50 days, 11 in people under 35 years of age, 41 in the 35–50 age range, and 47 in the 50–65 age range. After the use of TIRADS, 63 biopsies were taken within 50 days, 9 in people under the age of 35, 29 in the 35–50 age range, and 25 in the 50–65 age range [Table 5]. The rate of detecting malignancy in biopsies is 11 out of 89 patients (12.3%) in the first 50-day period and 9 out of 63 patients (14.2%) in the second 50-day period, with an increase of approximately 1.9%. Similar rates were observed in the study of Bolland and Grey.[5]

Table 1: American College of Radiology thyroid imaging reporting and data system

TI-RADS

0 Points TR 1 Benign No FNA	2 Points TR 2 Not Suspicious No FNA	3 Points TR 3 Mildly Suspicious FNA if ≥ 2.5 cm Follow if ≥ 1.5 cm	4 to 6 Points TR 4 Moderately Suspicious FNA if ≥ 1.5 cm Follow if ≥ 1 cm	7 Points or More TR 5 Highly Suspicious FNA if ≥ 1 cm Follow if ≥ 0.5 cm
COMPOSITION Spongiform: Composed predominantly of small cystic spaces. Do not add further points for other categories. Mixed cystic and solid: Assign points for predominant solid komponent. Assign 2 points if composition cannot be determined because of calcification.	ECHOGENICITY Anechoic: Applies to cystic or almost completely cystic nodules. Hyperechoic/isoechoic/hypo echoic: Compared to adjacent parenchyma. Very hypoechoic: More hypoechoic than strap muscles. Assign 1 point if echogenicity cannot be determined.	SHAPE Taller-than-wide: Should be assessed on a transverse image with measurements paralel to sound beam for height and perpendicular to sound beam for width. This can usualy be assessed by visual inspection.	MARGIN Lobulated: Protrusions into adjacent tissue. Irregular: Jagged, spiculated or sharp angles. Extrathyroidal extension: Obvious invasion=malignancy Assign 0 points if margin cannot be determined.	ECHOGENIC FOCI Large cornet-tail artifacts: V-shaped, >1 mm, in cystic components. Macrocalcifications: Cause or incomplete along margin. Punctate echogenic foci: May have small cornet-tail artifacts.
		Add Points From All Categories to Determine TI-RADS Level		
COMPOSITION (Choose 1) Cystic or almost completely cystic: 0 points Spongiform: 0 points Mixed cystic and solid: 1 point Solid or almost completely solid: 2 points	ECHOGENICITY (Choose 1) Anechoic: 0 points Hyperechoic or isoechoic: 1 points Hypoechoic: 2 points Very hypoechoic: 3 points	SHAPE (Choose 1) Wider-than-tall: 0 points Taller-than-wide: 3 points	MARGIN (Choose 1) Smooth: 0 points Il-defined: 0 points Lobulated or irregular: 2 points Extra-thyroidal extension: 3 points	ECHOGENIC FOCI (Choose All That Apply) Nonen or large cornet-tail artifacts: 0 points Macrocalcifications: 1 points Peripheral (rim) calcifications: 2 points Punctate echogenic foci: 3 points

Table 2: Sociodemographic characteristics of the cases

	n (%)
Gender	
Male	365 (18.4)
Female	1617 (81.6)
The average age±SD (minimum–maximum)	47.64±16.78 (0–96)
<35	500 (25.2)
35–50	650 (32.8)
50–65	562 (28.4)
>65	270 (13.6)

SD: Standard deviation

Table 3: Distribution of biopsy and ultrasound numbers between periods

	Period I, *n* (%)	Period II, *n* (%)	*P*
Examination			
Biopsy	108 (11.1)	82 (8.1)	0.027
US	867 (88.9)	925 (91.9)	
Total	975 (49.2)	1007 (50.8)	

P value was obtained from the Pearson Chi-square test. Period I: 50 days before October 10, 2022, Period II: 50 days after October 10, 2022, US: Ultrasound

In our study, it was divided into period I and period II, as 50-day periods before October 10 and after October 10. October 10 is the date when the TIRADS scale was added to the thyroid US reports in our clinic, and its active use was started in nodule follow-up and biopsy priority. One hundred and eight biopsies were performed in period I; in period II, 82 biopsies were performed. A significant decrease in the number of biopsies draws attention between periods. A cost of $1289.52 was calculated for 108 biopsies (108 × $11.94= $1289.52) in period I. In period II, 82 biopsies (82 × $11.94= $979.08) with a cost of $979.08 were calculated. Between the two periods, a cost decrease of $310.44 was found.

Discussion

The primary aim of this study is to evaluate the TIRADS classification in terms of cost-effectiveness by determining the effect of TIRADS use on FNAB and thyroid US counts. Although clinical follow-up of the patient is also very important at this level, the study tried to make it more comprehensive by evaluating other aspects. It has been shown that with the use of TIRADS, the number of biopsies and US decreased and, thus the costs of health-care institutions decreased.

TIRADS is a scale that is widely and actively used in clinics today, where various parameters are used.[6,7] TIRADS presents a risk scale that is scored from 1 to 5 according to the solid-cystic character of a nodule detected in the thyroid gland, its echogenicity, shape, edge features, the nature of the calcific foci it contains, and in addition to these features, the size of the nodule.

TIRADS provides significant gains in the diagnosis, treatment steps, and cost-effectiveness of thyroid nodules.[8,9] Kuo *et al*. reported in their study that US follow-up of nodules

Table 4: Comparison of the parameters between periods in terms of gender

	Period I, *n* (%)	Period II, *n* (%)	*P*
Female			
Examination			
Biopsy	69 (8.6)	66 (8.1)	0.691
US	731 (91.4)	751 (91.9)	
Total	800 (49.5)	817 (50.5)	
Male			
Examination			
Biopsy	39 (22.3)	16 (8.4)	<0.001
US	136 (77.7)	174 (91.6)	
Total	175 (47.9)	190 (52.1)	

P value was obtained from Pearson Chi-square test. Period I: 50 days before October 10, 2022, Period II: 50 days after October 10, 2022, US: Ultrasound

Table 5: Comparison of examination distributions between periods in terms of age groups

	Period I, *n* (%)	Period II, *n* (%)	*P*
<35			
Examination			
Biopsy	11 (4.4)	9 (3.6)	0.622
US	237 (95.6)	243 (96.4)	
Total	248 (49.6)	252 (50.4)	
35–50			
Examination			
Biopsy	41 (13.1)	29 (8.6)	0.043
US	272 (86.9)	308 (91.4)	
Total	313 (48.2)	337 (51.8)	
50–65			
Examination			
Biopsy	37 (13.3)	25 (8.8)	0.094
US	242 (86.7)	258 (91.2)	
Total	279 (49.6)	283 (50.4)	
>65			
Examination			
Biopsy	19 (14.1)	19 (14.1)	0.999
US	116 (85.9)	116 (85.9)	
Total	135 (50)	135 (50)	

P was obtained from Pearson Chi-square test. Period I: 50 days before October 10, 2022, Period II: 50 days after October 10, 2022, US: Ultrasound

smaller than 1 cm and which are moderately suspicious according to TIRADS is more cost-effective than biopsy.[2] Although the effectiveness of TIRADS in adults has been demonstrated in many studies, there are also studies showing that it is also effective in the pediatric age group, although it is less common.[1,10] In one of them, the Uner *et al*.'s study, it was found that approximately 1 out of every 4 nodules in the pediatric group is malignant, and TIRADS is a more cost-effective method, especially in TR4 and TR5 nodules.[1]

Today, health-care costs are increasing unsustainably. More effort to control costs has become a necessity. While keeping the cost under control, it is a basic requirement that the quality and efficiency of the processes applied should not be reduced. Owens *et al*.'s study is one of many on this topic. Three key ideas were covered in this study. As a first concept, it is an important basis for evaluating the benefits and harms of a test, as well as its costs. If we look at the second concept, evaluating the cost of a test can be done not only by evaluating the cost of that test but also indirectly by evaluating the cost of subtests and in other cases. Third and lastly, the cost-effectiveness ratio estimates the amount of additional costs required to obtain additional health benefits and provides an important measure of the value of the health-care test being evaluated.[11]

If we look at a few important pieces of information we obtained in our study, with the use of TIRADS, a greater reduction in biopsy rates was seen in men than in women. Since the risk of thyroid malignancy is higher in women,[12] less confidence in the TIRADS data in female patients by clinicians and insistence on pathological diagnosis can be shown as a reason for this situation.

No significant change was observed in the number of biopsies with the use of TIRADS in the groups under 35 and over 50 years of age. As mentioned in the Uner *et al*.'s study, since the rate of malignant nodules is higher than in adults, scoring with TIRADS at the time of nodule detection and then immediate biopsy is preferred before US follow-up.[1] This may be a reason for the mentioned result in the biopsy rates in young patients. In the groups over 50 years old, based on our observations in daily practice, recurrent hospital admissions, and follow-ups are not welcomed by the patients and their relatives, and follow-ups are interrupted from time to time. For this reason, instead of TIRADS-based follow-up, it is preferable to get results with a biopsy at once. It was determined that the number of biopsies decreased effectively with the use of TIRADS in the 35–50-year age group. This situation encourages the use of TIRADS by the relevant clinician and radiologist in cases in the aforementioned age group.

If we look at the cost-effectiveness of TIRADS, there are very few studies on this subject. The study of Kuo *et al*.'s[2] considering the quality-adjusted life years with the TIRADS-based US follow-up method, an annual saving of $1829 per patient was achieved. There are also data in the literature that contradict the results of Kuo *et al*.[2] and Cawood *et al*.[3] They state that the use of TIRADS does not have an active and positive effect on costs.[3]

Kuo *et al*. in their study, the cost of neck US was determined as $129 and the cost of FNAB was $394.[2] In our study, thyroid US was used instead of neck US, and the unit cost was determined as 3.3 $, and the unit cost of FNAB and pathology was 11.94 $.

If we compare our data with the data of some other studies, Cawood *et al*.[3] does not support the data found in their study, Kuo *et al*.[2] supports the data found in his study. With the transition to the TIRADS-based evaluation method, a saving of $310.44 was achieved during the 50-day period examined within the scope of the study.

In our study, it was divided into period I and period II, with 50-day periods before and after 10 transplants. October 10 is the date when the TIRADS Scale was added to thyroid US reports in our clinic and its active use began in nodule follow-up and biopsy priority. One hundred eight biopsies in period I; In period II, 82 biopsies were performed. When looked at between periods, a significant decrease in the number of biopsies is noteworthy. In period I, 108 biopsies (108 × 11.94$ =1289.52) cost $1289.52. In period II, 82 biopsies (82 × 11.94 $ =979.08) cost 979.08. After switching to TIRADS-based US follow-up between the two periods, a cost gain of $310.44 is noteworthy.

However, although it is explained in more detail in the results section, an approximately 2% increase in the rate of malignancy detection is noteworthy when comparing the 50-day period before and after the use of TIRADS.

Our results and Kuo *et al*.'s[2] are similar, showing that the use of TIRADS reduces costs. In our study, a cost saving of approximately $310 was achieved in 50-day periods after the use of TIRADS in our clinic. On the other hand, Cawood *et al*.[3] stated different results; however, they studied a hypotethical population. We presented real-life data. With this aspect, one can speculate that our results are more reliable than the mentioned study.

Conclusion

Although there are many studies evaluating the effectiveness of TIRADS, there are few studies evaluating the cost of TIRADS. Our study has one of the largest sample sizes among these studies.

The use of the TIRADS Risk Scale has the potential to reduce possible stress, workload, and cost by removing the patient from unnecessary biopsies. In addition, since the number of more advanced and invasive procedures such as extra imaging and surgery has decreased in patients, significant improvements in satisfaction and comfort of life have been noted.

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Conflicts of interest

There are no conflicts of interest.

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