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ULTRASOUND ASSESSMENT OF EXTERNAL CAROTID ARTERY DOPPLER HEMODYNAMICS IN PATIENTS WITH MALIGNANT THYROID NODULES

Rubab Rehmat
Leader, Student, Bachelor of Medical Imaging Technology, Superior University Lahore
Isbah Khanum
Isbah.khanam@superior.edu.pk
Supervisor, Lecturer, Faculty of Allied Health Sciences, Superior University Lahore
Ume Hifza
Member, Student, Bachelor of Medical Imaging Technology, Superior University Lahore
Tehreem
Member, Student, Bachelor of Medical Imaging Technology, Superior University Lahore
Hafza mukhtar
Member, Student, Bachelor of Medical Imaging Technology, Superior University Lahore
Umer Farooq
Member, Student, Bachelor of Medical Imaging Technology, Superior University Lahore

Author Details

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Corresponding E-mails & Authors*:
Isbah Khanum
Isbah.khanam@superior.edu.pk

Abstract

Thyroid nodules represent a relatively prevalent endocrine disease, with increasing incidence due to the use of high-resolution ultrasonography. Although the majority of nodules are benign, a small but clinically significant proportion are malignant, making early and accurate diagnosis essential. Risk stratification is commonly performed using grayscale ultrasound and Thyroid Imaging Reporting and Data System (TI-RADS); however, their diagnostic accuracy may be limited due to overlapping imaging features.

This study was conducted to evaluate the Doppler hemodynamic parameters of the external carotid artery (ECA) in patients with malignant thyroid nodules and to determine their relationship with TI-RADS classification. A cross-sectional analytical study was carried out on 55 patients with

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malignant thyroid nodules. All patients underwent grayscale ultrasound, TI-RADS classification, and Doppler examination of the external carotid artery. Doppler parameters including peak systolic velocity (PSV), end diastolic velocity (EDV), and resistive index (RI) were recorded.

The results demonstrated that hypoechogenicity, irregular margins, taller-than-wide shape, and microcalcifications were common grayscale ultrasound findings associated with malignancy. Doppler evaluation showed a mean PSV of 99.49 ± 7.62 cm/s, mean EDV of 27.60 ± 4.18 cm/s, and mean RI of 0.79 ± 0.04. A statistically significant positive correlation was observed between TI-RADS category and PSV ($r = 0.41$, $p = 0.003$) as well as RI ($r = 0.56$, $p < 0.001$), while no significant association was found with EDV ($p = 0.162$).

It is concluded that external carotid artery Doppler parameters, particularly PSV and RI, have a strong association with malignant thyroid nodules and can serve as a useful non-invasive adjunct to conventional ultrasound.

INTRODUCTION

The thyroid gland is a very important endocrine gland, which is situated in the anterior part of the neck. Thyroid gland plays a key functional role in metabolism, growth and development regulation through the secretion of thyroid hormones, of which thyroxine (T4) and triiodothyronine (T3) are the major ones [1]. The thyroid gland is a gland with one of the highest blood flow rates per gram of tissue in the human body due to its high metabolism rate [2].

Thyroid gland has a large well-structured blood circulation. The branches of the external carotid artery are the primary source of it, and the main source of its provision is the superior thyroid artery [3]. Structural or functional pathology of the thyroid gland can have impact on the hemodynamic character of the supplying arteries including external carotid artery (ECA) [4].

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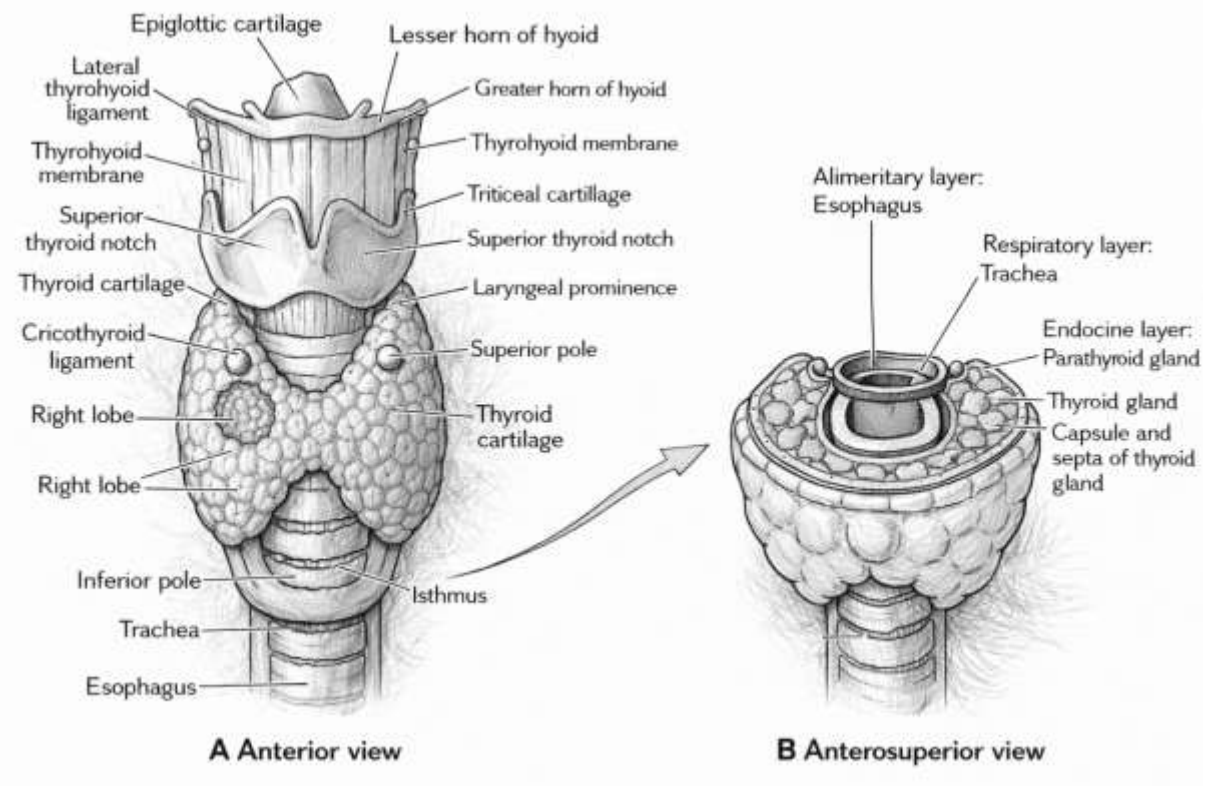

Figure 4.1 Thyroid anatomy

Thyroid nodules are one of the most common endocrine disorders. During the last 20 years, the rate of detection has increased due to high-resolution ultrasonography [5]. About 7-15 per cent are malignant [6], which supports the need to develop effective diagnostic methods [7].

Grayscale ultrasound evaluates morphological characteristics including nodule size, shape, margins, echogenicity and calcification [9]. However, overlap between benign and malignant nodules can lead to diagnostic uncertainty [10]. FNAC is considered as the gold standard but is invasive and may give inconclusive results [11,12].

Doppler ultrasonography gives functional data on blood flow and vascular resistance [13]. Malignant nodules show increased angiogenesis and altered blood flow properties [14]. These changes can be

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measured by Doppler parameters like peak systolic velocity (PSV), end-diastolic velocity (EDV) and resistive index (RI) [16].

Assessment of upstream arteries is more standardized. The external carotid artery directly supplies the thyroid gland and its flow may be affected by thyroid pathology [3,19]. Studies have shown increased PSV and RI in malignant nodules due to angiogenesis [20,21].

Objective

To measure the Doppler hemodynamic parameters of the external carotid artery in patients with malignant thyroid nodules and to determine their relationship with TI-RADS classification.

Methodology

This cross-sectional analytical study was conducted at the Radiology Department of Social security Hospital Lahore. A total of 55 patients with malignant thyroid nodules were included using a consecutive sampling technique.

Patients of any age and gender with thyroid nodules detected on ultrasound and undergoing FNAC or histopathology were included. Patients with previous thyroid surgery, known treated thyroid malignancy, or inability to provide consent were excluded.

All patients underwent grayscale ultrasound examination followed by TI-RADS classification. Doppler ultrasound of the external carotid artery was performed to measure peak systolic velocity (PSV), end diastolic velocity (EDV), and resistive index (RI).

Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as percentages. Statistical tests included Chi-square test, one-way ANOVA, and Spearman correlation. A p-value less than 0.05 was considered statistically significant.

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Results

The study included 55 patients with malignant thyroid nodules, with a higher proportion of females compared to males. The most commonly affected age group was 45–54 years.

On grayscale ultrasound, malignant nodules commonly showed hypoechogenicity, irregular margins, taller-than-wide shape, and microcalcifications, which are characteristic features associated with higher TI-RADS categories.

Doppler evaluation demonstrated a mean PSV of 99.49 ± 7.62 cm/s, mean EDV of 27.60 ± 4.18 cm/s, and mean RI of 0.79 ± 0.04, indicating increased vascular resistance and altered hemodynamics.

Statistical analysis revealed a significant positive correlation between TI-RADS category and PSV ($r = 0.41$, $p = 0.003$) as well as between TI-RADS and RI ($r = 0.56$, $p < 0.001$). In contrast, no statistically significant association was observed between TI-RADS category and EDV ($p = 0.162$).

These findings suggest that PSV and RI increase with higher TI-RADS categories, reflecting increased malignancy risk.

Table 1: External Carotid Artery Doppler Parameters

Doppler Parameters	Mean ± SD	Minimum	Maximum
PSV(cm/s)	99.49 ± 7.62	87.3	115.0
EDV(cm/s)	27.60 ± 4.18	20.1	34.7
RI	0.79 ± 0.04	0.72	0.88

Table 2: Correlation Between TI-RADS Category and External Carotid Artery Doppler Parameters

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Doppler Parameter	Correlation coefficient	p-value	Significance
TI-RADS vs PSV	0.41	0.003	Significant
TI-RADS vs EDV	-0.91	0.162	Not Significant
TI-RADS vs RI	0.56	<0.001	Significant

Table 3: Statistical Comparison of TI-RADS Category with Ultrasound and Doppler Parameters

Chi-square test	Test Statistic	p-value	Result
TI-RADS × Vascularity Pattern	$\chi^2 = 6.72$	0.010	Significant
One-way ANOVA			
TI-RADS × PSV (cm/s)	F=9.84	0.003	Significant
TI-RADS × EDV (cm/s)	F=1.98	0.162	Not Significant
TI-RADS × RI	F-15.62	<0.001	Significant

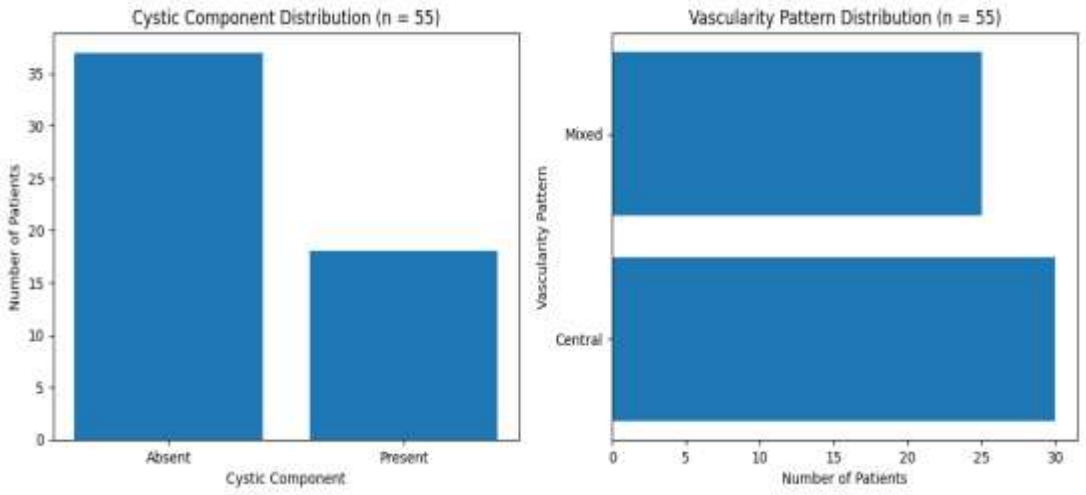

Figure 2 : Cystic Component & Vascularity Pattern

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Discussion

The findings of this study indicate that malignant thyroid nodules are associated with both characteristic grayscale ultrasound features and significant changes in external carotid artery Doppler parameters.

The observed increase in peak systolic velocity can be attributed to increased metabolic demand and tumor-induced angiogenesis, which leads to higher blood flow in supplying arteries. Similarly, the elevated resistive index reflects increased downstream vascular resistance caused by abnormal tumor vasculature.

These results are consistent with previous studies that have demonstrated higher PSV and RI values in malignant thyroid nodules compared to benign ones.

In contrast, end diastolic velocity did not show a significant association with TI-RADS classification. This may be due to its dependence on systemic hemodynamic factors, making it a less reliable parameter for assessing malignancy.

An important strength of this study is the evaluation of the external carotid artery rather than intranodular vascularity. This approach is more reproducible and less dependent on operator technique, making it suitable for routine clinical practice.

The combination of Doppler parameters with TI-RADS classification enhances diagnostic confidence and may help reduce unnecessary invasive procedures such as FNAC, particularly in indeterminate cases.

Conclusion

External carotid artery Doppler hemodynamic assessment is a valuable non-invasive adjunct in the evaluation of malignant thyroid nodules.

Peak systolic velocity and resistive index show a strong association with higher TI-RADS categories and can improve diagnostic accuracy. In contrast, end diastolic velocity has limited diagnostic significance.

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The integration of Doppler parameters with conventional ultrasound and TI-RADS classification can enhance risk stratification and support better clinical decision-making in patients with thyroid nodules.

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