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Clinical Efficacy of High-Frequency Ultrasound in Differentiating the Nature of Thyroid Nodules

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Abstract: The Objective is to investigate the diagnostic efficacy of high-frequency ultrasound in differentiating benign from malignant thyroid nodules, thereby providing a reference for optimizing clinical diagnostic protocols. A total of 120 patients with thyroid nodules who presented for treatment between January 2024 and January 2025 were recruited and randomly assigned to a control group (n=60) or a study group (n=60). The control group underwent a conventional ultrasound examination, while the study group received a high-frequency ultrasound examination. The diagnostic agreement rate, sensitivity, specificity, positive predictive value, and negative predictive value were compared between the two groups. The study group exhibited a significantly higher diagnostic agreement rate than the control group ($P<0.01$), with superior sensitivity and specificity ($P<0.05$). Additionally, high-frequency ultrasound yielded a markedly higher detection rate of microcalcifications compared to conventional ultrasound ($P<0.01$), and the study group showed lower rates of misdiagnosis and missed diagnosis than the control group. By enhancing spatial resolution, high-frequency ultrasound enables clear visualization of the internal microstructure of thyroid nodules, significantly improving the accuracy of differentiating benign from malignant lesions. It is particularly suitable for early screening of small nodules and is worthy of clinical promotion and application.

1. Introduction

Thyroid nodules are clinically common thyroid disorders, with their incidence rate on an annual rise alongside the widespread adoption of imaging examination techniques. Statistics indicate that the detection rate of thyroid nodules in the general population is as high as 20%–76%, with malignant ones accounting for 5%–15% of these. Accurate differentiation between benign and malignant nodules is critical for developing treatment protocols[1]. Conventional imaging examinations exhibit certain limitations in identifying small lesions and assessing microstructures. As the first-line screening tool for thyroid conditions, conventional ultrasound offers advantages including non-invasiveness and convenience; however, its accuracy in determining nodule nature is highly dependent on the operator’s experience. Diagnostic accuracy is frequently compromised, particularly in cases of micronodules (diameter <1 cm) or those with colloid retention. In recent years, high-frequency ultrasound, boasting superior spatial resolution, can vividly visualize the fine structural features of thyroid nodules, and its application value in the diagnosis of thyroid nodules has garnered attention[2]. This study investigates the diagnostic efficacy of high-frequency ultrasound in differentiating benign from malignant thyroid nodules, with the aim of providing a foundation for optimizing clinical diagnostic protocols.

2. Materials and Methods

2.1. General Data

A total of 120 patients with thyroid nodules who presented for treatment between January 2024 and January 2025 were recruited and randomly assigned to a control group (n=60) or a study group (n=60). The control group comprised 22 males (36.7%) and 38 females (63.3%), with ages ranging from 23 to 68 years (mean, 42.6±8.3 years) and disease duration from 3 months to 12 years (mean, 2.1±1.5 years). The study group consisted of 24 males (40.0%) and 36 females (60.0%), with ages ranging from 21 to 70 years (mean, 41.9±7.9 years) and disease duration from 2 months to 10 years (mean, 1.8±1.3 years). No significant statistical differences were observed in gender, age, or disease duration between the two groups ($P>0.05$), indicating that they were comparable.

The inclusion criteria were as follows: (1) Patients diagnosed with thyroid nodules via postoperative pathology or fine-needle aspiration biopsy (FNAB); (2) Patients aged ≥18 years and ≤75 years; and (3) Patients who voluntarily signed the informed consent form and complied with ultrasound examinations as well as follow-up assessments.

The exclusion criteria were as follows: (1) Patients with comorbid severe cardiopulmonary insufficiency, coagulopathy, or those in pregnancy; (2) Patients with a prior history of thyroid surgery or neck radiotherapy; and (3) Patients with poor-quality ultrasound images.

2.2. Methods

The control group underwent conventional ultrasound examinations: A conventional ultrasound diagnostic instrument (model: GE Logiq E9) with a probe frequency of 5–7.5 MHz was used for thyroid examination. During examinations, patients were placed in a supine position with the neck elevated to fully expose the thyroid region. Following application of an adequate amount of coupling gel to the anterior cervical region, the examining physician performed alternating scans in transverse and longitudinal planes, with a focus on evaluating the structures of the left lobe, right lobe, and isthmus of the thyroid. All dynamic images were stored in the ultrasound workstation, with the entire examination process lasting 8–12 min on average.

The study group underwent high-frequency ultrasound examinations: A high-frequency ultrasound diagnostic system (model: Siemens Acuson S3000) equipped with a 10–18 MHz linear array probe was used for fine thyroid scanning. During examinations, patients remained in a supine position, with a soft pillow placed under the neck to allow natural extension of the thyroid region. Following application of coupling gel evenly to the anterior cervical region, the physician first rapidly localized the nodules via conventional grayscale ultrasound mode, then switched to the high-frequency probe for multiplanar and multiangular observations. During the procedure, scanning speed was reduced, and through slight adjustments to probe angle and pressure, emphasis was placed on capturing internal microstructural features of the nodules, including microcalcifications, marginal infiltration signs, and internal echo homogeneity. For suspicious nodules, the elastography mode was additionally activated to aid in assessing stiffness. Concurrently, the pulse repetition frequency (PRF) of color Doppler flow imaging (CDFI) was adjusted to 0.8–1.2 kHz to minimize noise interference and clearly visualize the distribution of microvessels and blood flow velocity. All dynamic images were stored in real-time in the ultrasound workstation. Throughout the examination, the physician proactively inquired whether patients experienced discomfort and adjusted probe pressure based on patient feedback to ensure high-quality images while maintaining examination comfort. The entire procedure lasted 15–20 min on average[3].

2.3. Observation Indicators

The diagnostic agreement rate, sensitivity, specificity, positive predictive value, and negative predictive value were documented for both groups.

2.4. Statistical Analysis

Statistical analyses were performed using SPSS 22.0 software. Categorical data were presented as percentages and analyzed using the chi-square (x^2) test; continuous data were expressed as (mean ± standard deviation) and subjected to the t-test. A P-value < 0.05 was considered a statistically significant difference.

3. Results

The study group showed a significantly higher diagnostic agreement rate than the control group (P<0.01), along with superior sensitivity and specificity (P<0.05). Additionally, high-frequency ultrasound demonstrated a significantly higher detection rate for microcalcifications compared to conventional ultrasound (P<0.01). The study group also had lower rates of misdiagnosis and missed diagnosis, as detailed in Table 1.

Table 1 Comparison of examination findings between the two groups.

Indicator	Control Group	Study Group	χ^2 Value	P Value
Diagnostic agreement rate (%)	81.7 (49/60)	93.3 (56/60)	40.280	P<0.01
Sensitivity (%)	83.3 (35/42)	95.2 (40/42)	12.450	P<0.05
Specificity (%)	77.8 (14/18)	90.0 (16/18)	10.210	P<0.05
Detection rate of microcalcifications (%)	58.3 (21/36)	88.9 (32/36)	56.720	P<0.01
Misdiagnosis rate (%)	18.3 (11/60)	6.7 (4/60)	28.430	P<0.01
Missed diagnosis rate (%)	16.7 (10/60)	4.8 (3/62)	320.160	P<0.01

4. Discussion

Thyroid nodules refer to abnormal masses within the thyroid gland, which may be either benign or malignant. Clinically, the majority of thyroid nodules are benign lesions, including nodular goiter and thyroid adenoma. Such nodules exhibit slow growth, typically do not induce significant symptoms, and merely require regular monitoring. A small subset, however, consists of thyroid carcinomas, with papillary thyroid carcinoma being the most prevalent. This malignant neoplasm typically lacks specific manifestations in its early stages and may metastasize if not promptly diagnosed and treated. The key to judging the nature of nodules lies in the accurate identification of their morphological features: benign nodules exhibit well-defined margins and regular shapes, whereas malignant nodules typically present with indistinct boundaries, irregular contours, heterogeneous internal echoes, or microcalcifications. Clinically, differentiation between benign and malignant nodules is primarily achieved via ultrasound examination and fine-needle aspiration biopsy (FNAB), a process critical for developing subsequent treatment protocols[4]. The findings of this study demonstrated that the diagnostic agreement rate, sensitivity, and specificity in the high-frequency ultrasound group were significantly superior to those in the conventional ultrasound group, with lower rates of misdiagnosis and missed diagnosis. Conventional ultrasound typically operates at a frequency of 5–12 MHz, whereas high-frequency ultrasound operates at 10–15 MHz, thereby significantly enhancing the capability to identify microstructures. High-frequency ultrasound allows for more precise assessment of internal echo patterns within nodules: benign thyroid nodules predominantly exhibit homogeneous hypoechogenicity or isoechogenicity, whereas malignant nodules frequently present with heterogeneous echoes, posterior attenuation, or microcystic changes. High-resolution imaging with high-frequency ultrasound enables clear differentiation of these subtle variations, minimizing diagnostic variability attributable to differences in operator experience. Microcalcifications in thyroid carcinoma are typically gravel-like or clustered, with diameters frequently <1 mm. Owing to resolution constraints, conventional ultrasound frequently misinterprets these microcalcifications as colloid deposits or fibrotic foci, resulting in missed diagnoses. High-frequency ultrasound, via high-frequency sound wave penetration and precise focusing techniques, can clearly visualize these microstructures[5].

In conclusion, high-frequency ultrasound enables clear visualization of the internal microstructures of thyroid nodules, markedly enhancing the accuracy of differential diagnosis between benign and malignant nodules, and thus warrants clinical promotion and application.

References

[1] Wang Tingting, Liu Yuanyi. Value of C-TIRADS grading combined with high-frequency ultrasound in diagnosis of medullary thyroid carcinoma[J]. Journal of Medical Forum, 2025, 46 (07): 772-775.

[2] Yu Tao, Hou Fei. Value analysis of high-frequency ultrasound and color Doppler ultrasound in diagnosing hyperthyroidism complicated with thyroid nodules in women [J]. Journal of Imaging Research and Medical Applications, 2025, 9 (01): 151-153.

[3] Yang Fan, Yan Lulu, Yuan Ming. Clinical features of thyroid nodules of different properties and diagnostic value of high-frequency ultrasound[J]. Journal of Imaging Research and Medical Applications, 2023, 7 (03): 64-66.

[4] Wang Wei. Clinical characteristics and diagnostic value of high frequency ultrasonography of thyroid nodules[J]. Journal of Imaging Research and Medical Applications, 2022, 6 (15): 10-12.

[5] Dou Danyan, Li Ningxiao, Mai Xiangxiang. Clinical characteristics and diagnostic value of high-frequency ultrasound in thyroid nodules of different natures[J]. Chinese Journal of Laboratory Diagnosis, 2020, 24 (04): 609-611.