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The Effectiveness of Two-dimensional Ultrasound and Color Doppler Ultrasound in Diagnosing Benign and Malignant Thyroid Nodules

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Abstract: To explore the effectiveness of two-dimensional ultrasound and color Doppler ultrasound in diagnosing benign and malignant thyroid nodules. The subjects of this study were 193 patients with thyroid nodules admitted to our hospital from January 1, 2019 to January 1, 2023. Provide all patients with two-dimensional ultrasound, color Doppler ultrasound, and a combination of two types of ultrasound examination, and analyze the results of two-dimensional ultrasound, color Doppler ultrasound, and a combination of two types of ultrasound examination for benign and malignant thyroid nodules based on pathological examination results. According to the pathological examination, among the 193 patients with thyroid nodules, 144 were benign nodules and 49 were malignant nodules. The coincidence rate, sensitivity, and specificity of the combined examination of two-dimensional ultrasound and color Doppler ultrasound were higher than those of a single examination of two-dimensional ultrasound and color Doppler ultrasound ($P<0.05$). The detection rates of benign nodules with clear boundaries, solid nodule cysts, and regular morphology are higher than those of malignant nodules using two-dimensional ultrasound and color Doppler ultrasound; the detection rates of low echo and microcalcification in benign nodules using two-dimensional ultrasound and color doppler ultrasound were lower than those of malignant nodules ($P<0.05$). The proportion of benign nodules with type I, II, and III blood flow classification on color Doppler ultrasound was higher than that of malignant nodules, while the proportion of type IV blood flow classification was lower than that of malignant nodules ($P<0.05$). Compared to a single examination using two-dimensional ultrasound and color Doppler ultrasound, the combined examination of the two has higher diagnostic accuracy for benign and malignant thyroid nodules, which is feasible for clinical promotion.

1. Introduction

The thyroid gland is an endocrine organ that can regulate the secretion of thyroid hormones to maintain the balance of calcium and metabolism in the body. In recent years, the incidence rate of thyroid diseases has become higher and higher. In order to effectively prevent thyroid disease and improve the quality of life of patients, it is necessary to screen thyroid diseases as early as possible [1]. Thyroid nodules are one of the most common and high-risk thyroid diseases in clinical practice. They are tissues with altered internal structure and hardness of the thyroid gland. If the nodules are large, they can lead to neck masses, while if they are small, they have no obvious symptoms and are easily overlooked in clinical practice. Although thyroid nodules are mostly benign, if they are malignant, they can induce cancer and endanger the patient's life and safety. Due to the lack of specific manifestations of benign and malignant thyroid nodules, it is difficult to distinguish them. In clinical practice, two-dimensional ultrasound is commonly used for differential diagnosis. Although it can visually present the lesion site, it cannot display the internal blood flow signal of the lesion. With the application of color Doppler ultrasound in clinical practice, it can form color blood flow images and classify the hemodynamics, which is more conducive to clinical differential diagnosis of benign and malignant thyroid nodules [4-5]. This article mainly analyzes the differential diagnosis of benign and malignant thyroid nodules using color Doppler ultrasound combined with two-dimensional ultrasound, and is summarized as follows.

2. Materials and Methods

2.1. General Information

The subjects of this study were 193 patients with thyroid nodules admitted to our hospital from January 1, 2019 to January 1, 2023. This study has been approved by the Medical Ethics Committee of our hospital. Among them, there are 93 males and 100 females, with the oldest and youngest being 68 and 25 years old, respectively, with an average age of (50.22 ± 4.31) years [6].

Inclusion criteria: All are consistent with the diagnostic criteria for thyroid nodules in the "Guidelines for the Diagnosis and Treatment of Thyroid Diseases in China"; confirmed as a thyroid nodule through pathological examination after thyroid surgery; difficulty in swallowing and breathing with varying degrees of complications; both are unilateral and single thyroid nodules; Informed consent for this study.

Exclusion criteria: Liver and kidney dysfunction; Hematological system diseases; Infectious diseases; Mental disorders; Poor compliance; Withdrawal midway; Patients with incomplete clinical data.

2.2. Method

(1) 2D ultrasound examination: The ultrasound instrument is the GE LOGIQ E9 ultrasound diagnostic instrument. During the examination, place the patient in a supine position and observe the patient's thyroid and surrounding blood vessels through multiple sections. Explore the size of the patient's thyroid and record the location, boundaries, and internal echoes of the nodules.

(2) Color Doppler ultrasound examination: The ultrasound instrument is the Philips EPIQ7 ultrasound diagnostic instrument. During the examination, place the patient in a supine position, raise the patient's jaw, and straighten the head to fully expose the anterior cervical area. After adjusting the ultrasound probe to 9-11MHz scan, both sides of the patient's lymph nodes, thyroid area, etc. in transverse, oblique, and longitudinal directions. Observe the ultrasound image performance of the thyroid gland, nodule shape, size, lesion location, posterior echo, calcification, etc. Analyze the internal blood flow signal of the nodule, and perform hemodynamic parameter testing.

(3) Pathological examination: All patients underwent surgery, lesion tissue was collected, fixed with 4% formaldehyde, and sent to the pathology department for biopsy.

2.3. Observation Indicators

(1) Based on the pathological examination, results, we analyze the accuracy, sensitivity, and specificity of two-dimensional ultrasound, color Doppler ultrasound, and a combination of two types of ultrasound in detecting benign and malignant thyroid nodules. The coincidence rate is the number of detected cases/pathological detection results, the sensitivity is the number of true positive cases/(false negative cases+true positive cases), and the specificity is the number of true negative cases/(true negative cases+false positive cases). (2) Evaluate the detection of benign and malignant nodule signs using two-dimensional ultrasound, including clear boundaries, nodule capsule parenchyma, regular morphology, low echogenicity, and microcalcification. (3) Analyze the blood flow signal classification of benign and malignant thyroid nodules using color Doppler ultrasound, based on the classification of internal blood flow morphology proposed by KIM et al., and classify them into four types: I, II, III, and IV. Dotted blood flow signals can be seen within 25% of the surrounding area of the nodule, but no blood flow distribution can be seen inside the nodule. Type I is classified as vascular deficiency type; at least 3 blood flow signals can be seen within a range of more than 25% around the nodule, but no blood flow is observed within the nodule. The peripheral vascular type is type II; A small amount of punctate blood flow signals can be seen within 25% of the area around the nodule, and the internal blood flow of the nodule is mainly curved, spiral, angular, or irregular signals. The central vascular type is type III; blood flow signals can be seen within a range of over 25% around the nodule and inside the nodule, and the mixed vascular type is classified as type IV.

2.4. Statistical Methods

The data was analyzed using SPSS 20.0 software, and the counting data was described in n (%) χ 2 inspection; the measurement data were described in (± s) and subjected to t-test, $P<0.05$, indicating significant differences.

3. Results

3.1. Analysis of Imaging Examination Results

As shown in Tables 1 and 2, pathological examination results show that among 193 patients with thyroid nodules, 144 were benign nodules and 49 were malignant nodules. The coincidence rate, sensitivity, and specificity of the combined examination of two-dimensional ultrasound and color Doppler ultrasound were higher than those of a single examination of two-dimensional ultrasound and color Doppler ultrasound ($P<0.05$).

Table 1. Analysis of Results of Various Inspection Methods [n (%)]

Total pathological examination results by group
Benign Malignant
2D ultrasound benign 136 10 146
Malignant 8 39 47
Color Doppler ultrasound benign 139 10 149
Malignant 5 39 44
Joint examination for benign lesions 141 8 149
Malignant 3 41 44
Total 144 49 193

Table 2. Comparison of diagnostic values of various examination methods in benign and malignant thyroid nodules [n (%)]

Number of inspection methods, coincidence rate, sensitivity, specificity
2D ultrasound 193 90.67 (175/193) 94.44 (136/144) 79.59 (39/49)
Color Doppler ultrasound 193 92.23 (178/193) 96.53 (139/144) 79.59 (39/49)
Joint inspection 193 94.30 (182/193) 97.92 (141/144) 83.67 (41/49)

3.2. Analysis of the Detection of Benign and Malignant Nodules by Two-dimensional Ultrasound and Color Doppler Ultrasound

As shown in Table 3, the detection rates of benign nodules with clear boundaries, solid nodules, and regular morphology on two-dimensional ultrasound and color Doppler ultrasound are higher than those on malignant nodules; the detection rates of low echo and microcalcification in benign nodules using two-dimensional ultrasound and color Doppler ultrasound were lower than those in malignant nodules ($P<0.05$).

Table 3. Analysis of the detection of benign and malignant nodules by two-dimensional ultrasound and color Doppler ultrasound [n (%)]

Symptoms: two-dimensional ultrasound, color Doppler ultrasound
Benign nodules (n=136) Malignant nodules (n=39) χ 2-value P-value benign nodules (n=139) malignant nodules (n=39) χ 2-value P-value
Clear boundary 132 (97.06) 0 (0.00) 154.052<0.001 84 (60.43) 1 (2.56) 40.875<0.001
Nodular cystic parenchyma 128 (94.12) 2 (5.13) 125.650<0.001 107 (76.98) 6 (15.38) 49.840<0.001
Form Rule 132 (97.06) 0 (0.00) 154.052<0.001 98 (70.50) 9 (23.08) 28.569<0.001
Low Echo 12 (88.23) 21 (53.85) 40.151<0.001 68 (48.92) 33 (84.62) 15.808<0.001
Microcalcification 8 (5.88) 31 (79.49) 94.809<0.001 9 (6.47) 27 (69.23) 74.339<0.001

3.3. Analysis of Blood Flow Classification in the Diagnosis of Benign and Malignant Nodules using Color Doppler Ultrasound

As shown in Table 4, the proportion of benign nodules with type I, II, and III blood flow classification by color Doppler ultrasound is higher than that of malignant nodules, while the proportion of type IV blood flow classification is lower than that of malignant nodules ($P<0.05$).

Table 4. Analysis of blood flow classification in the diagnosis of benign and malignant nodules using color Doppler ultrasound [n (%)]

Number of cases of type I, type II, type III, type IV
Benign 139 55 (39.57) 34 (24.46) 33 (23.74) 17 (12.23)
Malignant 39 1 (2.56) 3 (7.69) 3 (7.69) 32 (82.05)
χ 2 values 19.339 5.200 4.861 74.419

P value<0.001 0.022 0.027<0.001

4. Discussion

Thyroid nodules are one or more structurally abnormal masses within the thyroid gland caused by radiation exposure, abnormal iodine intake, or genetic factors. They are more common in women and can cause symptoms such as throat obstruction, neck swelling, excessive sweating, irritability, or neck tightness and suffocation. Statistics show that thyroid nodules are mainly benign, with malignant nodules accounting for only about 5% of the total thyroid nodules. Most benign nodules do not cause subjective discomfort, while malignant nodules can compress the trachea, nerves, and esophagus due to inflammation or excessive nodules as the condition progresses, thereby seriously affecting the patient's quality of life [7]. At present, there are many thyroid patients in China, with an incidence rate of 18.6%, while malignant nodules account for 5% -15% of them. If no timely diagnosis and treatment is carried out, the quality of life of patients may be seriously affected [8]. At present, various clinical methods can be used for early diagnosis of thyroid nodules, such as CT, magnetic resonance imaging, pathological puncture diagnosis, etc. Among them, pathological puncture diagnosis is the gold standard, but it is invasive and not easily accepted by patients. Although CT, magnetic resonance imaging, etc. can reflect the number of nodules, they cannot determine the form of the lesion, and the misdiagnosis and missed diagnosis rates are high [9].

At present, patients with thyroid nodules are often diagnosed by two-dimensional ultrasound and color Doppler ultrasound in clinical practice, that is, by observing the contour and edge of the patient's nodules with determine their characteristics [10]. Two dimensional ultrasound is a widely used imaging examination method in clinical practice. The diagnosis of benign and malignant thyroid nodules by two-dimensional ultrasound can accurately capture the image of the lesion. The diagnosis of benign and malignant thyroid nodules by two-dimensional ultrasound is mainly based on the internal structure and echo of the thyroid nodules, that is, benign nodules are mainly composed of equal echoes, high echoes, and mixed echoes, while malignant nodules are mainly composed of low echoes; benign nodules are less prone to calcification, but if accompanied by calcification, they are relatively thick and have multiple curved edges. Malignant nodules are mainly characterized by microcalcification and accompanied by small punctate sound shadows; Benign nodules have a capsule with clear and smooth edges, while malignant nodules have no capsule and blurred boundaries; benign nodules are limited by the capsule, and the sound halo is swollen and thick. Malignant nodules are not limited by the capsule, and the sound halo is in a state of infiltration and growth, and the image is also messy and irregular. However, two-dimensional ultrasound cannot depict the blood flow signal image, so there is a risk of misdiagnosis and missed diagnosis. Color Doppler ultrasound can make up for the above shortcomings. Color Doppler ultrasound can not only visually obtain clear images of the patient's thyroid interior, but also clearly present the morphology of thyroid tissue, including rich blood flow signals. Color Doppler ultrasound can also quantitatively analyze the area and width of blood flow bundles and track the origin of blood flow. Therefore, compared with two-dimensional ultrasound, its advantages are more obvious. The diagnosis of benign and malignant thyroid nodules by color Doppler ultrasound is often based on the distribution of blood flow and hemodynamic parameters around the thyroid nodules. This means that most benign thyroid nodules do not have rich blood flow signals, so their overall shape is more regular and accompanied by halos, that is, the nodules are surrounded by blood vessels, mainly venous blood flow; malignant nodules are accompanied by abundant blood flow signals inside, which can appear in dots or stripes, often in a disordered state without halos, and even if accompanied by halos, they are incomplete. Generally speaking, if a thyroid nodule with a diameter exceeding 2cm is diagnosed as benign or malignant through color Doppler ultrasound, but for thyroid nodules with a diameter below 1.5cm, relying solely on blood flow distribution cannot determine its benign or malignant nature. Therefore, it is necessary to use two-dimensional

ultrasound combined with color Doppler ultrasound for diagnosis to avoid misdiagnosis and missed diagnosis.
In summary, compared to the single examination of two-dimensional ultrasound and color Doppler ultrasound, the combined examination of the two has higher diagnostic accuracy for benign and malignant thyroid nodules, which is feasible for clinical promotion.

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If any, it should be placed before the reference section without numbering.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The author states that this article has no conflict of interest.

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