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Sonography and Color Doppler in the Evaluation of Cold Thyroid Nodules

Background/Objective: Thyroid nodules are a common finding, especially in our country. In this study, we evaluated the role of conventional ultrasonography (US) and color doppler sonography (CDS) in assessment of cold thyroid nodules.

Materials and Methods: Ninety-seven patients with a cold thyroid nodule were examined by US and CDS before thyroidectomy .On US, the presence of a halo sign, hypoechogenicity or microcalcification was evaluated .The vascular pattern on CDS was classified as follows: Type 1, absence of blood flow; Type 2, perinodular blood flow; Type 3, intranodular blood flow. Sensitivity, specificity, negative predictive value, positive predictive value and accuracy of ultrasound and color doppler findings were evaluated. Ultrasound findings have been compared with postoperative pathological result.

Results: In 38 patients, thyroidal carcinoma was found. Absence of halo sign, presence of microcalcification and hypoechogenicity were predictive of malignancy ($P < 0.001$). Presence of intranodular hypervascularity and perinodular hypervascularity were in favor of malignancy ($P < 0.001$) and benignity ($P < 0.01$), respectively. An avascular pattern could not differentiate between benign and malignant nodules.

Conclusion: US and CDS findings can predict malignant nodules, especially when multiple signs are simultaneously present.

Keywords: thyroid, cold nodule, sonography, color doppler sonography

Introduction

Thyroid nodules are a common finding in the general population, especially in iodine deficiency areas such as our country .In western countries, approximately 5%, and in iodine deficient countries, approximately 25% of the general population have thyroid nodules.[1] Although most of them are benign, 5-10% are malignant (carcinoma).[2] So far, the best single test to discriminate malignant and benign thyroid nodules is fine needle aspiration (FNA),due to its high sensitivity and specificity, but in the case of follicular carcinoma, discrimination from follicular adenoma is difficult.[3]

In this study, we aimed to find differentiating criteria by using noninvasive US and CDS to predict malignancy.

Materials and Methods

The study included 97 patients, with normal thyroid function tests and the presence of a cold thyroid nodule on their nuclear medicine isotope scan. The patients were hospitalized to be operated, either for malignancy or for decompression purposes, and diagnosis was based histological examination of the surgical specimen and was compared to sonographic findings. Radiologist was unaware about other diagnostic results and surgical indication of patient.

The patients were examined before surgery with a GE LOGIC MD 500, 7.5 MHz linear ultrasound probe. During conventional US, we evaluated the nodule for echogenicity (in comparison with the surrounding parenchyma), presence of the hypoecho halo around the nodule (figure 1), and presence of microcalcification, defined as hyperechoic foci less than 2mm and with acoustic shadow.

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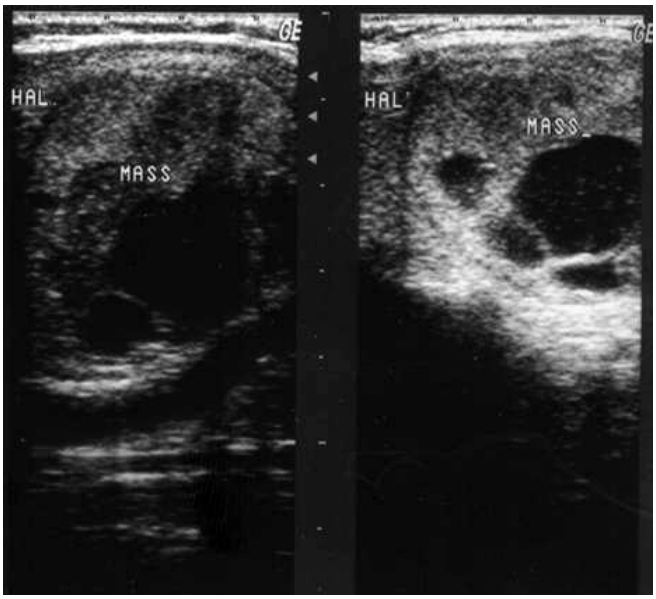


Figure 1: Halo sign

Using CDS, we evaluated nodular vascularity based on three patterns: avascular, perinodular blood flow (figure 2), intranodular blood flow. (Figure 3)

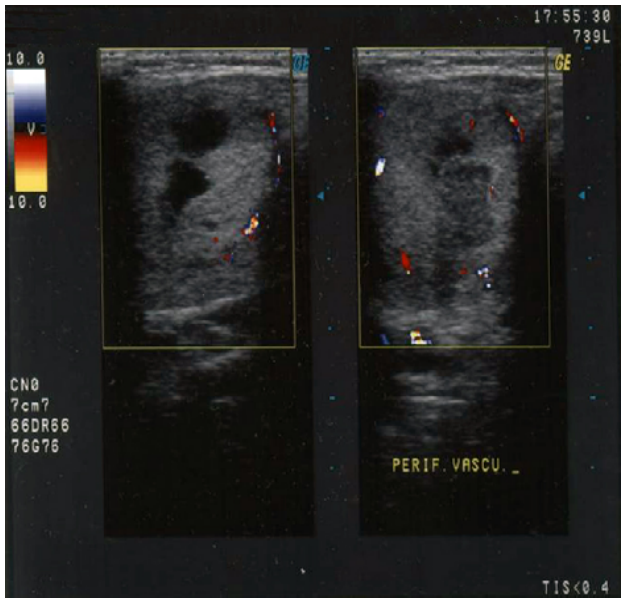
Results

Among these 97 patients, 63 were female and 34 were male. The mean age was 42.6±14 years for females, ranging18-65 years, and 39.5 ±12.6 years for males, ranging 21-62 years. Histological examination demonstrated thyroid carcinoma in 38 patients: 21 papillary carcinomas, 9 follicular carcinomas, 5 medullary carcinomas, 3 undifferentiated carcinomas, and 59 benign thyroid nodules.

On conventional sonography, the absence of the halo sign, presence of microcalcifications, and hypoechogenicity of the nodule were in favor of malignancy.The results were as follows (Table1):

1. Absence of the halo sign was found in 17/59 of benign nodules and 30/38 of malignant nodules ($P < 0.001$).
2. Microcalcification was found in 13/59 of benign nodules and 22/38 of malignant nodules ($P < 0.001$).
3. Hypoechogenicity was found in 18/59 of benign nodules and 27/38 of malignant nodules ($P < 0.001$).

Therefore, in diagnosing malignancy, the absence of halo sign had the most sensitivity and microcalcification had the most specificity. On the other hand, absent halo sign was the most predictive, and absent halo sign plus microcalcification were the most specific criteria (94.8%).



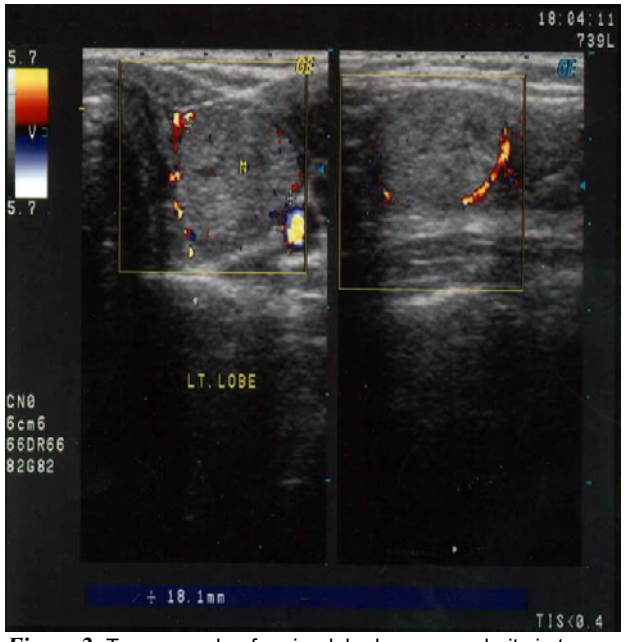


Figure 2: Two example of perinodular hypervascularity in two different patients

Figure 3: A hypoecho nodule with interanodular vascularity

Table 1: Conventional ultrasonographic patterns and histology in thyroid nodules

Echographic pattern	Carcinoma	Benign nodules	Significance	Specificity (%)	Sensitivity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Absent halo sign	30/38	17/59	P<0.001	71.1	78.9	63.8	84
Microcalci-fications	22/38	13/59	P<0.001	77.9	57.8	62.8	74.1
Hypoecho-genicity	27/38	18/59	P<0.001	69.4	71.0	60	78.8

Table 2: Color Doppler Sonography (CDS) and histological pattern in thyroid nodules

CDS	Carcinoma	Benign nodules	Significance	Specificity (%)	Sensitivity (%)	Positive Predictive Value(%)	Negative Predictive Value (%)
Type I	5/38	8/59	P=0.46	86.4	13.1	38.4	60.7
Type II	6/38	31/59	P<0.01	47.4	15.7	16.2	46.6
Type III	27/38	19/59	P<0.001	67.7	71.0	58.6	78.4

On CDS, three flow patterns were considered:
Type 1: avascular
Type 2: perinodular hypervascularity
Type 3: interanodular hypervascularity

For the avascular (type 1) flow pattern, no significant statistical difference was demonstrated between benign and malignant nodules (P = 0.46). (Table2) But Type 2 vascularity was in favor of a benign nodule (31/59 of benign nodules, versus 6/38 of malignant nodules; P < 0.01);thus sensitivity of this type for diagnosis benign nodules is 0.52 and its specificity is 0.84.In this regard, positive predictive value and negative predictive value will be 83.7% and 53.3% ,respectively. Type 3 vascularity was suggestive of malignancy, (9/ 59 of benign nodules, versus 27/38 of malignant nodules, P < 0.001). (Table2)

We also considered combination of conventional ultrasonography and CDS for evaluating thyroid nodules. The indices of various combinations of these methods are shown in table3.

As we see in table 3, the combination of an absent halo sign, presence of microcalcification and type 3 vascularity demonstrated the highest positive predictive value to predict malignancy (88.2%) and highest specificity (96.6%).

Table 3: Combination of conventional ultrasonography and Color Doppler Sonography (CDS) in thyroid nodules

Echographic pattern/ CDS	Carcinoma	Benign nodules	Significance	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Absent halo sign/Type III	24/38	8/59	P <0.001	63.1	86.4	80	78.4
Microcalcifications/Type III	16/38	9/59	P <0.004	42.1	84.7	64	69.4
Hypoechogenicity/Type III	21/38	14/59	P =<0.002	55.2	76.2	60	72.5
Absent halo sign+ Microcalcifications/Type III	15/38	2/59	P <0.001	39.4	96.6	88.2	71.2
Absent halo sign+ Hypoechogenicity/Type III	20/38	5/59	P <0.001	52.6	91.5	80	75
Hypoechogenicity+ Microcalcifications/Type III	14/38	5/59	P =<0.001	36.8	91.5	73.6	69.2

Discussion

In our study, according to the histological examination of surgical specimens, the incidence of malignancy was approximately 38%, which was not far from other studies.[4, 5]

In predicting malignancy with gray scale study, absent halo sign is the best single sign, with a positive predictive value of 64%, negative predictive value of 84%, sensitivity of 78% and specificity of 71% ($P < 0.001$). Microcalcification is more specific (78%) but less sensitive (58%) ($P < 0.001$), and hypoechogenicity has lower specificity (69%) and sensitivity (71%) ($P < 0.001$). The most predictive echo patterns are a combination of these two or three signs; combinations have high specificity, but low sensitivity. These findings are compatible with other studies.[6-9]

On color doppler studies, avascular flow pattern has no significance. The most predictive flow pattern is type 3, with a positive predictive value of 57% and negative predictive value of 78%, 67% specificity and 71% sensitivity ($P < 0.001$). Type 2 flow pattern is in favor of a benign nodule, with a sensitivity of 52% and a specificity of 88% ($P < 0.01$). Subsequently, we may evaluate the value of type 3 flow pattern with each echo pattern and their combination (Table 3). Therefore, to assess the risk of malignancy in a cold thyroid nodule by US, a combination of absent halo sign, microcalcification and intranodular hypervascularity is the most reliable, with a positive predictive value of 88%, negative predictive value of 71%, specificity of 96%, and sensitivity of 39%.

Berni et al noted that US vascular study is a non-invasive, low cost method which is very reliable in differential diagnosis of a cold thyroid nodule (5). On the other hand, the best US modality is power doppler, and US contrast media should only be used for small nodules.[10]

In addition, Bozbora et al reported that detecting arteriovenous shunts detected by CDS was the only parameter having high predictive value for malignancy.[11] Rago et al [4] in a study on 104 patients found that the vascular pattern of nodules is not conclusive in predicting malignancy. As all patients were candidate of surgery, results of this study could only applied to patients that are considered for surgery (Either for malignancy or decompression) and we must be cautious to generalize these results for other cold thyroid nodules without any surgical indications. Further studies based on all cold nodules are needed to evaluate efficacy of these methods in all thyroid nodules.

Finally, the absolute and reliable indicators of malignancy were noted to be invasive growth into surrounding structures, metastases to cervical lymph nodes, or both.[12]

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