Thyroid nodules: Evaluation with power Doppler and duplex Doppler ultrasound

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This study purposes a new classification of thyroid nodules blood flow by power duplex Doppler ultrasound. A total of 177 nodules were studied with B-mode scanning, power Doppler, and spectral analysis. These data were compared with cytological results from ultrasound-guided fine-needle aspiration biopsy. Univariate and multivariate logistic regression analysis were performed. The power Doppler analysis of the nodules produced 5 vascular patterns: I, absence of signal blood flow; II, exclusively perinodular blood flow; III, perinodular > central blood flow; IV, central blood flow > perinodular blood flow; V, exclusively central blood flow. Statistical analysis revealed a significant relationship between these vascular patterns and cytological results. The spectral analysis demonstrated that the resistance index were higher in nodules with malignant versus other cytology ($P < 0.001$). The results indicate that power duplex Doppler facilitates screening of thyroid nodules at high risk for malignancy with elevated sensitivity (92.3%) and specificity (88%). (Otolaryngol Head Neck Surg 2005;132:874-82.)

Thyroid nodules appear in up to 50% of the population older than 50 years of age.¹,² Although only 5% of these thyroid nodules are malignant, it is still necessary to carefully screen benign nodules to determine which should be subjected to more rigorous diagnostic investigation.³

Ultrasonography of the cervical region performed for reasons other than thyroid disease has shown that 13% to 88% of patients have thyroid nodules.²,³ Thyroid B-mode scans show typical nodule features such as the contour, dimensions, echogenicity, presence and type of peripheral halo, and number of nodules in up to 75% of patients; however, this diagnostic mode is not sufficiently specific to establish the nature of the nodule.⁴ Fine-needle aspiration biopsy (FNAB) is considered the most specific preoperative diagnostic method. Despite this, a clinical dilemma can arise when FNAB is not diagnostic (eg, suspicious findings, insufficient material, false positive or nondiagnostic results); this occurs with between 2% to 28% of samples.⁵-⁸

It is known that cellular proliferation is related to increases in vascularity.⁵,⁶ Power Doppler scans performed with high-frequency transducers allow identification of low velocity blood flow in superficial tissues, such as the thyroid gland.¹,²,⁷,⁹ Power duplex Doppler sonography magnifies this view, providing information about nodule vascularization and allowing further investigation of nodules at high risk for malignancy. Recent reports suggest that this method is highly sensitive and specific in differentiating benign from malignant nodules.⁷,⁹

The aim of this study was to demonstrate that duplex power Doppler sonography is useful for screening thyroid nodules with distinguishing higher risk of malignancy.

MATERIALS AND METHODS

One hundred seventy-seven thyroid nodules were studied in 174 patients (159 women and 15 men) at our institution from January 1997 to March 2001. In 3 patients, 2 nodules were analyzed. The patients ranged in age from 11 to 80 years (mean, 50.19 years). The patients had been sent to our department to undergo FNAB after previous examination had revealed thyroid nodules. We included only the nodules for which representative cytological material was available. The Ethics Committee at our institution approved this study, and patients were enrolled after their informed consent had been obtained.

All scans were performed with GE Logic 500 (Milwaukee, WI). A variable high-frequency linear transducer was set for 10 MHz.

Microscopic study of the FNAB specimens demonstrated that 136 (76.84%) of the 177 nodules were benign, 19 (10.73%) had indeterminate cytology, 9 (5.08%) had suspicious cytology, and 13 (7.34%) were malignant.
B-Mode Ultrasonography

Based on the number of nodules visualized, thyroid glands were classified as having a solitary nodule or as being multinodular. The length, width, and depth of each nodule were measured, and nodule features evaluated.

Nodule echogenicity was compared with that of normal adjacent thyroid tissue. Each nodule was classified as being hypoechoic, hyperechoic, isoechoic, anechoic (cysts with no solid components that can contain echogenic foci, particulate fluid, or septa), or mixed (nodules with cystic and solid components).

The halo around the nodules (peripheral halo), when present, is classified by its thickness. A thin halo is ≤ 2 mm and a thick halo, > 2 mm. The halo thickness was included in the nodule measurements.

Calcification, when present, was classified as microcalcification – hyperechoic punctate images, ≤ 2 mm in diameter, with or without posterior shadowing, and no posterior reverberation or coarse calcification is >2 mm in diameter with posterior shadowing.

Power Doppler

Power Doppler analysis of blood flow to the nodules revealed the following vascular patterns: I, absence of signal blood flow; II, exclusively perinodular blood flow; III, perinodular blood flow ≥ central blood flow; IV, marked central blood flow and less significant perinodular blood flow; V, exclusively central blood flow (Fig 1).

Pulsed Doppler

In addition to the qualitative analysis (power Doppler), arterial blood flow to nodules was quantified via spectral analysis. The same equipment settings used for the qualitative analyses were applied, adding a sample volume of 2 mm.

The duplex parameters obtained (pulsatility index [PI] and resistance index [RI]) were based on the formulas: PI = PSV – MDV / Mean Velocity and RI = PSV – MDV / PSV.11

The peripheral and central nodule artery samples were selected by mapping the brightest on color Doppler ones. Criterion for inclusion in the statistical analysis was up to 3 arteries per nodule, based on 2 criteria: (1) spectral morphology, considering the highest PI and RI, and (2) vascular anatomy. For the 3 arteries chosen by the spectral criteria, the mean was calculated for each variable. When both peripheral and central blood flow were found, we selected the 1 peripheral and 2 central arteries with the highest indexes. If we did not find a suitable second central artery, we chose a second peripheral artery as the third vessel.

Ultrasound-guided Fine-needle Aspiration Biopsy (FNAB)

FNAB was performed after the spectral analysis. Examination of the biopsy specimens was in accordance with criteria established by the Papanicolaou Society of Cytology.12

Statistical Analysis

Univariate statistical analysis. The relationship between qualitative variables (number of nodules, echogenicity, halo, margins, calcification, color Doppler study) and the biopsy result was assessed using the chi-square test or likelihood chi-square test.13 Values of \( P < 0.05 \) were considered significant. Single factor analysis of variance was used to evaluate the relationship between continuous variables (nodule size, PI, and RI) and the cytological findings.13

Multivariate analysis. For parameters with \( P < 0.10 \) on the univariate analysis, an adjusted model of multiple logistic regression was used. Thus, a stepwise procedure was used to identify variables that were predictive of malignancy. The same statistical method was used to select variables predictive of malignant or suspicious cytology (combined cytology group).

RESULTS

Univariate Analysis

B-Mode ultrasonography. There was no statistically significant association between the number of nodules and the results of the cytological analysis (\( P = 0.318 \) and \( P = 0.667 \), respectively). Nine (69.2%) of these 13 malignant nodules were found in multinodular glands.

With respect to echogenicity, 69 (38.9%) of the 177 nodules were hypoechoic; 10 (5.6%) were hyperechoic; 20 (11.29%) were isoechoic; 72 (40.6%) were mixed; and 6 (3.3%) were anechoic. Univariate analysis did not reveal a statistically significant relationship between this parameter and the cytological findings (\( P = 0.059 \)). Nevertheless, a higher percentage (16/69, 23.18%) of the malignant or suspicious nodules were hypoechoic nodules. Nine (69.2%) of the 13 malignant nodules were hypoechoic. A peripheral halo was seen around 87 (49%) of the 177 nodules. Of these, only 2 (2.3%) had malignant cytology and 3 (3.45%) had suspicious cytology. Of the 90 nodules without a halo, 11 (12.2%) were classified as malignant and 6 (6.67%) as suspicious (\( P = 0.036 \)). Therefore, the presence of a halo was considered significant evidence of benignity. With respect to halo thickness, a thin halo was considered an important sign of benignity and a thick halo, a sign of malignancy (\( P = 0.029 \)).
Fig 1. Classification system based on vascular patterns observed with power Doppler: I, absence of signal blood flow (A = colloid cyst); II, exclusively perinodular blood flow (B = nodular goiter); III, perinodular blood flow equal to (D = Hürthle neoplasia) or greater than (C = nodular goiter) intranodular blood flow; IV, marked intranodular blood flow and less significant perinodular blood flow (E = papillary carcinoma); V, exclusively intranodular blood flow (F = cystic papillary carcinoma) (G = hypoechoic nodule with regular and well-defined margins and a thick halo from a patient with chronic thyroiditis, papillary carcinoma).
Length, width, and depth measurements revealed that malignant and suspicious nodules were larger than benign and indeterminate nodules ($P = 0.001$). The average width of benign nodules was 1.41 cm versus 3.19 cm for malignant nodules. Calcifications were found in 30 (16.9%) of the 177 nodules. These calcifications were fine in 17 (57%) of the 30 nodules, fine and coarse in 3 (10%), and coarse in 10 (33%). Seven (41.18%) of the 17 nodules containing microcalcifications had malignant cytology; 8 (47.06%), benign cytology; 1 (5.88%) indeterminate cytology; and 1 (5.88%) suspicious cytology. The correlation between fine calcification and malignancy was considered statistically significant ($P = 0.001$).

Eight (61.5%) of the 13 malignant nodules had microcalcifications.

**Power Doppler.** Power Doppler sonography was performed on all 177 nodules to identify vascularization patterns. This revealed that 12 (6.8%) nodules had absence of signal of blood flow (pattern I); 65 (36.7%) had exclusively perinodular blood flow (pattern II); 81 (45.76%) had perinodular blood flow equal to or greater than central flow (pattern III); and 14 (7.9%) had central blood flow greater than perinodular flow (pattern IV); and 5 (2.82%) had exclusively central blood flow (pattern V). Statistical analysis revealed a significant relationship between patterns V and IV with malignancy. Thus, these blood flow patterns were found in 11 (84.6%) of the 13 malignant nodules ($P = 0.001$) (Table 1; Fig 1).

**Pulsed Doppler.** Malignant nodules had a mean PI of 1.53 (SD = 0.63) and a mean RI of 0.74 (SD = 0.12). These values were significantly higher than those associated with the other cytological groups ($P = 0.001$, for both) (Table 2; Fig 2). Twelve nodules that lacked signal blood flow could not be studied by pulsed Doppler.

**Multivariate Analysis**

This analysis included the following parameters with $P < 0.10$ on the univariate analysis: echogenicity, halo, margins, nodule size (cross diameter), calcifications, vascular study by power Doppler, PI, and RI.

**Variables predictive of malignancy.** The pattern on power Doppler and RI were both identified as significant predictors of malignancy. Nodules with central or mainly central vascularization patterns had a risk of malignancy that was 219 times greater than that of nodules with any other vascularization pattern, independent of the RI (Table 3).

The nodules with other vascularization patterns demonstrated a substantial risk for malignancy when the RI > 0.77. For each 0.1 rise in the RI, the risk for malignancy increased fourfold (CI 95%; 1.62; 10.31). Further analysis revealed the sensitivity and specificity of the model were 92.3% and 88%, respectively (Table 3 and Fig 3).

**Variables predictive of both malignant and suspicious cytology.** The vascular pattern, RI, cross diameter (width), and echogenicity were all identified as significant predictors of nodules with malignant or suspicious cytology (combined cytology group).

The risk of finding malignant or suspicious cytology was 15-fold higher for hypoechoic versus nonhypoechoic nodules (CI 95%: 2.5; 92.2); a mainly central (pattern IV) or exclusively central (pattern V) vascular pattern increased this risk 6-fold (CI 95%: 1.73; 23.6).

The risk for malignancy or suspicious cytology increased 2.87 times for each 1.0 cm enlargement in nodule cross diameter (width) (CI 95%: 1.57; 5.28). The risk increased 1.76-fold for each 0.1 rise in RI (CI 95%: 1.03; 3.03).

The sensitivity and specificity of the model were 77.25% and 79.45%, respectively, with a maximum probability value of 0.11. Thus, nodules with cross diameter enlargement, hypoechochogenicity, a mainly central or a central vascular pattern (pattern IV and V), and/or increased RI were at greater risk for malignant or suspicious cytology. Furthermore, hypoechoic nodules >3.0 cm were at increased risk independent of their vascular pattern and RI. And hypoechoic nodules,

<table>
<thead>
<tr>
<th>Flow pattern</th>
<th>Benign</th>
<th>Indeterminate</th>
<th>Suspicious</th>
<th>Malignant</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Perinodular</td>
<td>59</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>67</td>
</tr>
<tr>
<td>Perinodular</td>
<td>64</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>81</td>
</tr>
<tr>
<td>Mainly central</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Central</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>136</td>
<td>19</td>
<td>9</td>
<td>13</td>
<td>177</td>
</tr>
</tbody>
</table>

$P = 0.001$ (likelihood chi-square test).
with any diameter, showing pattern IV or V were high risk independent of their RI. (Table 4).

**DISCUSSION**

Since the advent of high-resolution ultrasonography, the majority of thyroid lesions have been detected, causing a diagnostic dilemma. Although B-Mode sonography is the most sensitive method for diagnosing intrathyroid lesions, this method is often insufficient for characterizing the nature of the lesion (ie, low specificity). Therefore, FNAB has emerged as the default diagnostic test for the preoperative evaluation of intrathyroid lesions. Although FNAB is almost noninvasive, it does have several disadvantages. Thus, identifying a new method to determine which nodules should be studied by this examination is mandatory.

It is well known that tumor growth is associated with increased vascularization. With the technological development and introduction of power Doppler, it is now possible to identify vascular patterns inside superficial tissues. Thus, this new method is potentially useful for identifying thyroid nodules that should undergo FNAB.

<table>
<thead>
<tr>
<th>Biopsy result</th>
<th>n</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Median</th>
<th>Lowest</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign</td>
<td>126</td>
<td>0.63</td>
<td>0.09</td>
<td>0.62</td>
<td>0.43</td>
<td>0.95</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>17</td>
<td>0.57</td>
<td>0.11</td>
<td>0.58</td>
<td>0.38</td>
<td>0.72</td>
</tr>
<tr>
<td>Suspicious</td>
<td>9</td>
<td>0.56</td>
<td>0.11</td>
<td>0.54</td>
<td>0.40</td>
<td>0.70</td>
</tr>
<tr>
<td>Malignant</td>
<td>13</td>
<td>0.74</td>
<td>0.12</td>
<td>0.75</td>
<td>0.48</td>
<td>0.89</td>
</tr>
</tbody>
</table>

*RI*, Resistance index.

P = 0.001 (Analysis of Variance).

**Fig 2.** Results of spectral analysis: A, low-resistance wave morphology (low resistance index (RI)); B, high-resistance wave morphology (high RI).

**Table 3.** Multivariate analysis of malignancy risk related to the vascular pattern and RI with a cutoff probability of 0.04

<table>
<thead>
<tr>
<th>Varied</th>
<th>Evaluated parameter</th>
<th>Standard error</th>
<th>P</th>
<th>“Odds ratio”</th>
<th>Confidence interval 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>−14.023</td>
<td>3.632</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood flow (central and mainly central)</td>
<td>5.392</td>
<td>1.149</td>
<td>0.000</td>
<td>219.710</td>
<td>23.101 999.000</td>
</tr>
<tr>
<td>RI (×10)</td>
<td>1.409</td>
<td>0.472</td>
<td>0.003</td>
<td>4.090</td>
<td>1.622 10.311</td>
</tr>
</tbody>
</table>

*RI*, Resistance index.

Cutoff probability: 0.04; sensitivity: 92.30%, specificity: 88%.
graphic characteristics suspicious for malignancy (eg. examinations. Exceptions include nodules with sono-
incidentalomas”). Many authors have suggested that incidental findings on ultrasound examinations.1,14-16
nodule diameter and considered clinically occult nodules (“in-
FNAB is the best initial approach to palpable and

Fig 3. Graphic representation of a nodule’s risk of malignancy based on the associated vascular pattern and RI, using a cutoff probability of 0.04.

B-Mode Sonography Parameters

Some authors have reported that the risk for malignancy of a solitary thyroid nodule ranges from 10% to 25% and that the risk for nodules associated with a multinodular gland is 1% to 4%.4 However, other reports in the literature challenge the validity of these data. Ross8 and Solbiati et al1 have reported malignant rates for nodules in multinodular glands of 13% and 30%, respectively.

In the present study, we found that 9 (69%) of 13 malignant nodules were in multinodular glands. Thus, our results reinforce the idea that multinodularity does not mean benign disease.1

Hypoechoic and mixed nodules accounted for the majority of nodules, because our study included patients referred to our department for FNAB after screening sonography. Of the 13 malignant nodules identified in this study, 9 (69.23%) were hypoechoic and 4 (30.77%) had mixed echogenicity. These data are consistent with a report in the literature that 70% of malignant nodules are hypoechoic.1

The presence of a halo was considered significant evidence of benignity. Similarly, the absence of halo was statistically significant evidence of a malignancy. Increased halo thickness was another significant indicator of malignancy. These results are in concordance with those in other reports.1,9,14

Ultrasonography can identify nodules in up to 50% of the adult population. Most are smaller than 1.5 cm in diameter and considered clinically occult nodules (“incidentalomas”). Many authors have suggested that FNAB is the best initial approach to palpable and nonpalpable nodules >1.5 cm in diameter that are incidental findings on ultrasound examinations.1,14-16

There is general agreement that nodules <1.5 cm should be followed-up with ultrasound and clinical examinations. Exceptions include nodules with sonographic characteristics suspicious for malignancy (eg, hypoechogenicity, microcalcifications, irregular and partly defined margins, hypervascularized nodules) or those in patients at increased risk of having a malignancy (eg, patients with prior irradiation, multiple endocrine neoplasia, cervical lymphadenopathy).1,14-16

Although increasing nodule diameter is directly related to increasing risk, we thought it advisable to consider additional characteristics (eg, echogenicity, halo, vascularization, presence of microcalcifications) in determining whether a nodule is suspicious. In our opinion, nodules <1.0 cm with suspicious characteristics should be carefully studied and others without suspicious characteristics should only be followed-up. Conversely, nodules ≥ 1.0 cm with benign characteristics on sonography (eg, hyperechogenicity, thin halo, regular and well-defined margins, coarse calcifications) should be followed-up and subjected to biopsy if they show any change in appearance or size.

Microcalcifications were seen in 20 (11.3%) of the 177 nodules. Microcalcifications were present in 8 (61.5%) of 13 malignant nodules. These data are in concordance with reports in the literature and indicate that microcalcifications are a good predictor of malignancy and are present in close to 60% of malignant nodules.17

Power Doppler Parameters

The new equipment allowed us to identify low velocity blood flow in vessels that previously could not be seen. For this reason, we adopted our own classification system for vascular patterns by modifying the initial one proposed by Lagalla et al.6 Thus, our classification consists of the following 5 vascular patterns: pattern I, absence of blood flow; pattern II, exclusively perinodular blood flow; pattern III, perinodular blood flow = central blood flow; pattern IV, central blood flow > perinodular blood flow; and pattern V, exclusively central blood flow. The nodules with a vascular pattern III have a peripheral ring of flowing on color Doppler.

In our study, there was no blood flow to 12 (6.8%) of the 177 nodules, and none of these nodules were malignant. These results agree with a number of published reports1,6,7,9 that indicate an absence of signal blood flow only in benign lesions. However, these data are not consistent with the results of some authors18,19 who observed an absence of signal blood flow in papillary carcinomas. In our opinion, the absence of blood flow in the carcinomas observed in the aforementioned studies could reflect the equipment used (transducer up to 7.5 MHz with lower color Doppler sensitivity) and methods. Other technical conditions (eg, pulse repetition frequency, wall filter, and insonation angle) could also be responsible for these results. It is important to observe during evaluation of superficial lesions with
power Doppler sonography, scanning with minimal probe pressure, because even light compression with the probe can obliterate low-velocity flow.

Perinodular blood flow was seen in 65 (36.7%) of the 177 nodules. Of these, 59 (90.77%) were benign, 4 (6.15%) had indeterminate cytology, and 2 (3.08%) had suspicious cytology. There was no malignant nodule with this vascular pattern. These data are in agreement with the reports by Lagalla et al,6 Solbiati et al,4 Holden,9 and Cerbone et al,7 and demonstrate that exclusively perinodular blood flow strongly suggests benignity.

However, we also noticed that perinodular and intranodular blood flow were found in both benign and malignant nodules. Such findings pose a diagnostic dilemma and represent a source of disagreement among authors regarding the utility of color Doppler in thyroid nodule research. For this reason, we subdivided the type III vascular pattern proposed by Lagalla et al6 into patterns III and IV, and also added pattern V to indicate exclusively central blood flow.

Our results demonstrate that the risk of malignancy increases as intranodular blood flow becomes more dominant. For example, a small number of the nodules with pattern III blood flow (2 of 81 nodules) were malignant, whereas 6 of 14 nodules with pattern IV blood flow and all 5 nodules with pattern V blood flow were malignant. These findings are in concordance with results reported by Holden,9 who found different vascular patterns associated with benign nodules versus carcinomas. Holden identified carcinomas as having more concentrated intranodular blood flow.

Cerbone et al7 also subdivided the type III pattern proposed by Lagalla et al6 when they used power Doppler to distinguish nodules with poor intranodular blood flow and normal vessels from nodules with profuse and chaotic intranodular blood flow and larger-caliber vessels. On comparing observed vascular patterns with histologic data, they found that the sensitivity and specificity of this diagnostic method were 98.1% and 100%, respectively. Cerbone et al7 proposed that the predominantly intranodular blood flow observed in malignant nodules could be explained by the large cellular proliferation in this region. These authors also reported that there was no significant correlation between nodule dimensions and vascularity.

On comparing observed vascular patterns with our cytological findings, we found that most benign nodules had vascular patterns II or III and accounted for 123 (84.25%) of the 146 nodules with these patterns. Although pattern I (absence of blood flow) and pattern II (exclusively perinodular flow) were marked features of benign nodules, pattern III (perinodular blood flow = central blood flow) was seen more often. In addition, the greatest proportion of nodules with indeterminate (9/19; 47.3%) and suspicious (6/9; 66.6%) cytology had vascular pattern III. Malignant nodules mainly had pattern IV (central blood flow > perinodular flow) or V (exclusively central blood flow), accounting for 11 (84.6%) of the 13 malignant nodules.

Power Doppler patterns can be repeated with different equipment, operators, and institutions. Nevertheless, this method depends on many technical settings, such as: Doppler sensitivity, wall filters, signal amplification, pulse repetition frequency, depth of region of interest, and intervening tissue attenuation. Moreover, movements such as breathing and swallowing, as well as the pulsatility of the surrounding arteries, can produce artifacts.9 In this study, the equipment settings used were based on a protocol designed to minimize mistakes and to easily reproduce the data.

With respect to potential study limitations, we know that classification of nodules based on vascular patterns (I to V) is somewhat subjective. However, such classification allowed assembly of a detailed model that conveyed information about the nature of the nodules. Although similar results have been previously reported, they have not been described clearly by any author. In addition, the integration of modern ultrasonography with dedicated computerized systems (software) overcomes one of the major limitations of this method – operator-dependent analysis of the variations in signal intensity. This sort of software should allow quantification and comparison of the blood flow in nodules, to make the study more objective.

### Table 4. Echogenicity, vascular pattern, width, and RI of nodules at high risk for suspicious or malignant cytology

<table>
<thead>
<tr>
<th>Echogenicity</th>
<th>Vascular pattern</th>
<th>Up to 1.0 cm</th>
<th>1.1 – 2.0 cm</th>
<th>2.1 – 3.0 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoechoic</td>
<td>IV/V</td>
<td>Any RI</td>
<td>Any RI</td>
<td>Any RI or vascular pattern</td>
</tr>
<tr>
<td>Hypoechoic</td>
<td>II/III</td>
<td>RI &gt; 0.68</td>
<td>RI &gt; 0.50</td>
<td>Any RI or vascular pattern</td>
</tr>
<tr>
<td>Nonhypoechoic</td>
<td>IV/V</td>
<td>RI &gt; 0.82</td>
<td>RI &gt; 0.65</td>
<td>RI &gt; 0.46</td>
</tr>
<tr>
<td>Nonhypoechoic</td>
<td>II/III</td>
<td>Low risk</td>
<td>RI &gt; 0.96</td>
<td>RI &gt; 0.78</td>
</tr>
</tbody>
</table>

RI, Resistance index.
Waved Pulsed Doppler Parameters

As previously mentioned, it is technically quite difficult to set the insonation angle, and small-caliber vessels may be responsible for the discrepant blood flow velocities observed by other authors for malignant nodules.

It is our opinion that one can use semiquantitative indexes such as RI to reduce the margin of error and improve the accuracy of spectral analysis. Our analysis of semiquantitative indexes in malignant nodules revealed a mean PI of 1.53 (SD = 0.63) and a mean RI of 0.74 (SD = 0.12). Statistical analysis revealed that both mean indexes were significantly higher for malignant nodules than for nodules with other cytology (P = 0.001). We could not find any reference to the PI of thyroid nodules in the literature. However, Holden9 reported a mean RI of 0.76 for carcinomas, 0.66 for adenomas, and 0.57 for colloid nodules. Cerbone et al7 reported similar results and that the RI was >0.75 in 18 (85.7%) of 21 thyroid carcinomas. This result could reflect vascular stenosis and occlusion in thyroid carcinomas, which tend to have low diastolic velocities and high systolic velocities have done high RI and PI.20

Our findings on multivariate analysis imply that the vascular pattern and RI are sufficient and significant predictors of malignancy. The diagnostic sensitivity and specificity of a model that included these variables were 92.3% and 88%, respectively. Thus, nodules associated with vascular pattern IV and V (independent of RI), as well as nodules associated with vascular pattern II or III and an RI >0.77 are at high risk for malignancy and should be studied by FNAB.

If identification of nodules with malignant or suspicious cytology (potentially surgical nodules) is desired, it is mandatory to evaluate nodule cross diameter (width) and echogenicity in addition to the vascular pattern and RI. The diagnostic sensitivity and specificity of a model that included these parameters were 77.25% and 79.45%, respectively. After analyzing the results from this study, we conclude that the following nodules should be submitted to FNAB (Table 4): hypoechoic nodules with a diameter ≥ 3.0 cm, independent of the color and pulsed Doppler findings; hypoechoic nodules with a diameter ranging from 1.0 cm to 2.9 cm and vascular pattern IV or V; hypoechoic nodules with a diameter up to 1.0 cm, vascular pattern II or III, and an RI >0.68 or those with a diameter ranging from 1.1 cm to 2.0 cm, vascular pattern II or III, and an RI >0.50; nonhypoechoic nodules with a diameter up to 1.0 cm, vascular pattern IV or V, and an RI >0.82, those with a diameter ranging from 1.1 cm to 2.0 cm, vascular pattern IV or V, and an RI >0.65, or those with a diameter ranging from 2.1 cm to 3.0 cm, vascular pattern IV or V, and an RI >0.46; nonhypoechoic nodules with a diameter of 2.0 cm, vascular patterns II or III, and an RI >0.96 or those with a diameter of 3.0 cm, vascular patterns II or III, and an RI >0.78.

Comparison of these results to histological findings is a continuing part of our research. Such work should greatly enhance the diagnostic accuracy of ultrasonography, especially with respect to nodules with indeterminate or suspicious cytology.

CONCLUSION

Ultrasoundographic evaluation by means of power Doppler is helpful in the screening of thyroid nodules at high risk for malignancy. Power Doppler and RI have a diagnostic sensitivity and specificity of 92.3% and 88%, respectively, in the detection of malignant nodules. The identification of potentially surgical nodules could be done with echogenicity, cross diameter, duplex power Doppler sonography association, with high sensitivity (77.25%) and specificity (79.45%).

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REFERENCES