The “spoke wheel” sign in thyroid nodules: Synonym of benignity?

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Abstract: Thyroid nodular disease is a highly prevalent condition. Most nodules are asymptomatic and only identifiable on images. We have established a relationship between the particular “spoke wheel” pattern of thyroid masses and a benign histology. A review of our institutional database of thyroid punctured under ultrasound guidance, histologically studied between 2003 and 2011, was performed. Node selection criteria included: mixed /solid, round /oval, surrounded by a halo, with radial structures converging toward a central point, with or without calcifications, and with peripheral vessels along with others oriented toward the center of the thyroid masses. Seventy-nine (2.5%) out of 3,204 punctured masses exhibited this sign. Average size: 28.3 mm. Fifty-eight masses were benign colloid nodules as diagnosed on FNA biopsy. Remaining masses corresponded to Lesion Follicular (4 benign, surgically treated; 7 under follow-up, stable; 10 with no information). Despite being a rare radiologic finding, the “spoke wheel” sign may be another element contributing to ultrasonographic discrimination between benignity and malignancy, especially in large thyroid masses.

Keywords: Benignity, “Spoke wheel” sign, Thyroid masses, Ultrasound.

Resumen: La patología nodular tiroidea es altamente prevalente. La mayoría de los nódulos son asintomáticos y solo identificados en imágenes. Hemos establecido la relación entre una morfología especial del nódulo en “rueda de carreta” e histología benigna. Se realizó una revisión de la base de datos de nódulos puncionados bajo US y estudiados histológicamente entre 2003 y 2011. Criterios de selección: nódulos mixtos/sólidos, redondos/ovales, rodeados por un halo, presentando estructuras convergentes hacia un punto central con o sin calcificaciones y vasos periféricos con otros orientados hacia el centro del nódulo. De 3,204 nódulos puncionados 79 (2,5%) presentaron el signo. Tamaño promedio: 28,3 mm. Cincuenta y ocho resultaron ser nódulos coloideos benignos en PAAF. El resto fueron informados como lesiones foliculares (4 operados benignos, 7 en seguimiento y estables, 10 sin información). Este signo es poco frecuente, pero puede ser un elemento más que colabore en la discriminación ecográfica de benignidad/malignidad, especialmente en nódulos tiroideos de gran tamaño.

Palabras clave: Benignidad, Nódulos tiroideos, Rueda de carreta, Ultrasonido.


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Introduction

Thyroid nodular disease is a highly prevalent condition that increases with age. Most nodules detected in the gland are asymptomatic and only identifiable on images(I,II).

Ultrasound studies identify thyroid lesions of broad morphological spectrum and different sizes, thus posing a dilemma for endocrinologists on how to appropriately select nodules for fine needle aspiration (FNA), avoiding exaggeration in its indication or exclusion of those who do require diagnostic puncture(III,IV).

Over 95% of thyroid masses detected by US studies are benign nodes, and the vast majority of them are colloid nodules(IV,IV). There are multiple sonographic


features as well as classifications of thyroid nodules intended to establish benignity/malignancy criteria in these lesions\(^6\)\(^-\)\(^{14}\). While TIRADS classification (3) mainly considers the sonographic appearance of masses, currently many node puncture indications are primarily based on lesion size.

According to our findings, there is a certain special ultrasonographic morphology of some nodules, usually large ones, that exhibit a “spoke wheel” pattern, usually indicative of benign histology.

The aim of this study is to assess whether this peculiar sonographic pattern could be considered as a predictor of benignity.

Materials and methods

Retrospective study. We performed a review of our institutional database (FileMaker Pro 7.5), which contains the record of thyroid nodules punctured under ultrasound guidance, at our Diagnostic Imaging Unit (Clínica Alemana, Santiago, Chile), and studied histologically by using a clot technique, since 2003 to date. This database includes epidemiologic information, ultrasound features, histological results and surgical data of nodules submitted to thyroidectomy.

Ultrasound study and fine-needle aspiration (FNA) procedures were performed by five experienced radiologists in both thyroid ultrasonography and puncture. We used ATL HDI 5000 and/or Philips iU22 ultrasound machines with 12 to 17 MHz transducers equipped with color Doppler mode. All patients signed an informed consent form before undergoing the procedure.

Images of punctured nodules from January 2003 to March 2011 were reviewed. Those masses exhibiting the following sonographic characteristic features of the “spoke wheel” pattern were selected:

- Mixed or solid
- Round or oval
- Surrounded by a full or partial halo
- Presence of radial structures converging to a central point (Figure 1)
- With or without central calcification (Figure 2)
- Presence of peripheral vessels and others oriented toward the center of the thyroid mass (Figure 3).

Once the selection of nodules meeting these ultrasound criteria was performed, histologic results along with other characteristics registered in the database were thoroughly reviewed. Furthermore, a follow-up of patients with these nodules (monitoring period of 6 months to 8 years) was carried out.

**Figure 1.** Typical ultrasonographic “spoke wheel” pattern with radial structures converging toward the center of the lesion.

**Figure 2.** Thick calcification frequently observed at convergence point of radial structures.

**Figure 3.** Color Doppler image showing peripheral nodular vessels as well as internal branches oriented toward the center, where a thick calcification may be present.
Results
Between January 2003 and March 2011 a total of 3204 nodes punctured under US guidance was recorded in the database.
Sixty-nine nodules showed complete sonographic features typical of the “spoke wheel” pattern, accounting for 2.5% of all punctured nodes. Sixty-seven (85%) of them were found in women, whereas 12 (15%) were detected in men.
These patients had a median age of 45 years (mean 47, range 10-90 years).

Sonographic features (Table I)
According to sonographic features, 7 cases (8.8%) corresponded to multinodular goiter (MNG), and 72 (91.2%) were single lesions of the gland.
The average nodule size was 28.3 mm with a SD of ± 9.6 (range 15-60 mm). Fifty nodules (63%) were clinically palpable.
All nodules were oval- or round-shaped and evidenced peripheral vasculature with some vessels oriented toward its center.
Fifty-seven nodules (72%) had an incomplete halo, while 22 (28%) exhibited a complete and regular halo. Fifty masses (63%) were solid and 29 (37%) of mixed structure.
Seventy-three (92%) nodules were isoechogenic and 28 (35%) showed a thick central calcification.

Histological Study
Fifty-eight (73%) out of the 79 nodules selected for this study were reported in anatomopathology as colloid nodules, and 21 (27%) as follicular lesions. Of the latter, 4 were submitted to surgery, 7 are under ultrasound monitoring for more than two years, and the remaining 10 were not controlled in our Center; consequently, no information on their evolution is available.
All patients underwent surgery (4) and benign final histological results were obtained: 2 follicular adenomas, 1 colloid follicular hyperplasia, and 1 oncocytic follicular lesion.
The seven follicular lesions under ultrasound monitoring at our institution showed no changes in size, and no new FNAs or surgical resolution were required.

Discussion
Although many studies suggest different suspicious sonographic features\(^{[6-15]}\), in day-to-day practice—in compliance with old guidelines—very often diagnostic puncture is indicated only based on nodule size, thus generating an unnecessary increase in FNA-s with benign outcome.
By identifying appropriate ultrasonographic criteria to discriminate benign nodules\(^{[9]}\), patients may be spared the trauma of puncture, thus reducing stress and costs to health services.

The ultrasonographic “spoke wheel” sign refers to a round or oval shaped nodule, surrounded by a partial or complete halo, radial structures converging toward a central point, with or without central calcification, and peripheral vasculature with some vessels projected in radial direction, elements that give it such a characteristic sonographic appearance.
This sign has long been described and used in hepatic ultrasound (focal nodular hyperplasia) as a predictor of benignity.
It is also used by pathologists to describe the macroscopic appearance of old colloid nodules (Figure 4). In these benign nodules hyperplastic areas with cysts around foci of scarring may be observed. The axis and rays are composed of cicatrical fibrous tissue, sometimes with inflammatory infiltrate, old hemorrhage, cholesterol crystals, and dystrophic calcification. This process is the result of degenerative changes caused by accumulation of colloid and hyperplasia with formation of new hair follicles. Distension of follicular walls and blood vessels causes rupture of the follicles, hemorrhage, necrosis, cyst formation, and scarring, frequently with dystrophic calcification. This is not a uniform process, so that successive stages of hyperplasia and degeneration lead to occurrence of nodules, more or less separated by bands of fibrous tissue.
Our study describes this sign for thyroid ultrasound (Figure 5) for the first time and results demonstrate that all evaluable nodules were found to be benign on FNA and/or surgery.
It must be noted that this sign is mainly seen in large bulky nodes (nodule average size of this review: about 3 cm), probably explained by the fact that its pathogenesis is a latent process over time.

The limitation of our study lies in the unavailability of data related to the 10 nodules that were not controlled in our Center, so we lacked the necessary information to establish nodule benignity over time.

Conclusions

Despite being a rare radiologic finding, the “spoke wheel” sign may be another diagnostic element contributing to ultrasonographic discrimination between benignity and malignancy, especially in large thyroid masses, thus reducing the number of unnecessary FNAs.

Bibliography


Figure 4. Macroscopic appearance in anatomopathology of old colloid nodules generating the “spoke wheel” sign.

Figure 5. “Spoke wheel” sign in colloid nodules, medium to large size, characterized by tracts and vessels oriented toward the center of the lesion, often with a thick calcification at this point.
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