

Variable sonographic spectrum of parathyroid adenoma with a novel ultrasound finding: dual concentric echo sign

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Abstract

Aims: To review the detailed gray-scale and Doppler ultrasonography features of histologically proven parathyroid adenomas (PAs) evaluated with high-end ultrasonography devices and to present a novel ultrasonography finding called the dual concentric echo sign in PA with histopathologic correlation which was encountered during detailed analysis. **Material and methods:** Fifty-six PAs with histopathological result were enrolled. The longest dimension, shape, distance to skin surface, internal echo and Doppler US features obtained with high-end US devices were evaluated. **Results:** PAs had variable range of shape including oval, irregular, fusiform, lobulated, crescent-shaped, and nodular configuration. In nine patients the lesions were shown to have cystic components and calcifications were seen in four cases. Dual concentric echo sign was detected in 18% PAs. Histological reevaluation of this subgroup demonstrated significantly increased edema ($p<0.01$), and ectatic vessels ($p=0.02$) in the central part of the lesion compared to the rest of the PAs. **Conclusions:** The results of the study led to the conclusion that PAs have variable gray-scale and Doppler findings. Typical sonographic features like ovoid shape, homogeneously hypoechoic pattern may not be present in all PAs. Dual concentric echo sign which is a novel sonographic pattern may be suggestive of a PA.

Keywords: Parathyroid adenoma, gray-scale ultrasound, Doppler ultrasonography, dual concentric echo sign.

Introduction

Excessive production of parathyroid hormone (PTH) is defined as hyperparathyroidism and classified in three groups; primary, secondary, and tertiary. Primary hyperparathyroidism, originating from autonomous hypersecretion of PTH, usually occurs in the setting of a parathyroid adenoma (PA) in 80% of patients, but can also be seen in parathyroid gland hyperplasia (15–20%) or carcinoma (0.5%) [1,2].

Combined use of ultrasonography (US), PTH evaluation, and fine needle aspiration biopsy have 100% specificity and 90% sensitivity in diagnosing adenomatous disease in parathyroid glands [3]. Over the last decade, minimally invasive parathyroidectomy (MIP) has become the operation of choice for most patients with sporadic primary hyperparathyroidism. Using preoperative imaging as a tool to guide the operation, MIP has many advantages over the traditional four-gland exploration technique [4-6].

A typical PA appears uniformly hypoechoic in US examination. It has dimensions with at least two to three times the size of a normal gland giving a tear-drop appearance [7]. The capsule is usually distinct and hyperechoic relative to parenchyma [8]. On the other hand, larger adenomas may have lobulated configuration; they may contain cystic and/or calcified components. Occasionally, they may display increased internal echogenic-

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ity [9]. Classical hypoechoic, tear-drop shaped appearance, and typical blunt termination of a single vessel into the adenoma parenchyma which gives a “vascular arc” shape in Doppler imaging [10] enable an easy diagnosis in many US examinations. However, not all parathyroid adenomas may follow this rule.

In this study, we reviewed and correlated the preoperative sonoanatomic variations and histopathologic findings of PAs, which were ultrasonographically diagnosed or suspected in our center during the last ten years, and also, defined a novel US sign with histopathological correlation.

Material and methods

Patients:

The clinical, US, and histopathological data of 55 patients with 56 PAs (two PAs in the same patient) which had been ultrasonographically diagnosed or suspected, and later histopathologically proven in our hospital in the last 10 years were retrospectively analyzed. The demographic data, levels of serum calcium, intact PTH and urinary calcium excretion of the patients were retrieved from the digital hospital archive. Intact PTH measurements were performed with Beckman Coulter UniCel DxI 800 system chemiluminescence hormone analyzer (Beckman Coulter, Fullerton, CA, USA). The Institutional Ethics Committee approved this retrospective study and waived the informed consent requirement.

US examinations:

All gray-scale and Doppler US examinations were performed by the same radiologist experienced in this modality for more than 10 years and blinded to the laboratory and pathological results. During US examinations, high-resolution color Doppler US devices (Siemens Sonoline Antares and Siemens Acuson Antares scanners; Mountain View, CA, USA) equipped with multiple (1.5-dimensional) linear-array transducers (VFX9-4 and VFX13-5) were used. The frequency band-widths of these transducers ranged between 4-9 and 5-13 Megahertz (MHz), respectively. Patients with suspicious clinical features of hyperparathyroidism had been routinely examined in supine position with slightly extended neck posture. In addition to the close neighborhood of the thyroid gland, retrotracheal area, suprasternal fossa, cervical regions adjacent to common carotid arteries, and also the upper neck including the submandibular compartment had been scanned for possible ectopic parathyroid lesions. All images were taken and stored using digital software.

Detailed US features of each PA including its location (relative to the thyroid gland), depth of its most superfi-

cial edge from the skin surface, longest diameter (A) and the diameter (B) perpendicular to A in the same plane, shape (in the aforementioned plane), surface regularity, internal echogenicity, echo texture, Doppler sonographic features, in addition to the data regarding the presence of any cystic component or calcification were retrospectively reviewed and analyzed using the digital image and report archive. The **location** of PAs were assumed to be inferior (i.e., originating from the inferior parathyroid glands) when they were demonstrated in the close proximity to the lower poles of the thyroid gland. In accordance with the related literature, the lesions depicted behind the upper half or middle parts of each thyroideal lobe were accepted to have originated from the superior parathyroid glands [11]. Regarding the **shape** of PAs, completely circular lesions were accepted as nodular. On the other hand, ovoid PAs with an A/B ratio less than 5.0 were assumed as oval, while the ones with an A/B ratio equal or greater than 5.0 were considered to have a fusiform shape. Additionally, lobulated and crescent-shaped PAs were named after their special configurations. Any PA with an amorphous appearance other than aforementioned forms was accepted to have an irregular shape. **Surface regularity** of PAs was classified as smooth or irregular. Any adenoma surface with a focal indentation deeper than 0.5 mm was accepted as irregular. The **echo texture** of a PA was accepted as homogeneous, when uniformly fine echoes were demonstrated within the lesion. Lesions with discrete internal echoes other than the dominant texture like septa, cysts, calcification distorting its homogeneity, were classified as heterogeneous. A **cystic component** was defined as any anechoic and well-bordered area with or without posterior acoustic enhancement, while any hyperechogenic focus with or without acoustic shadow was accepted as **calcification**. The internal **echogenicity** of PAs was assessed as hypo-, iso- or hyperechoic in comparison to that of thyroid gland. In some PAs dual concentric echo layers, each covering more than ¼ of the cross-sectional scan area were observed. In these cases, the echogenicity of the larger and dominant layer was selected to represent the echogenicity of the lesion. The cross-sectional color Doppler images of the PAs in the plane of their longest diameter were evaluated qualitatively to assign the **vascularity** of the lesion. In the case of color pixels covering less than approximately 10% of the PA, the lesion was decided to be hypovascular. Lesions with color pixels covering 10-50% or more than 50% of the cross-sectional area were accepted to be moderately or highly vascular, respectively. As described earlier, the demonstration of any vessel enveloping 90 to 270 degrees of the PA was accepted as a positive “vascular arc sign” [3].

Surgical technique:

The diagnosis of primary hyperparathyroidism was based on the presence of elevated serum calcium and PTH levels in the absence of kidney disease. All patients underwent an US and a sestamibi scan as preoperative localization tests. On the basis of the results of these tests, a selective (focused/targeted) parathyroidectomy or conventional unilateral/bilateral exploration was performed [12]. The procedures were carried out using a technique previously described by Miccoli et al [13]. Accordingly, operations were performed under local or general anesthesia, through a 2 to 4-cm transverse neck incision, with or without the use of video assistance. Intraoperative PTH levels were determined as described elsewhere, and a decrease of circulating PTH level by 50%, 20 minutes after excision of the enlarged parathyroid gland(s) was considered indicative of successful parathyroidectomy [14]. Most patients were discharged home the next day of surgery.

Histopathological examinations:

The pathologic materials of 56 PAs were assessed by the same histopathologist experienced in endocrine pathology. The basic criteria to establish adenoma diagnosis included a pushing border with an absence of intralesional fibroadipose tissue, a cell population demarcated from "normal" parathyroid tissue and absence of lobular growth [15]. Cell compositions of each adenomas were categorized as chief cell, oxphilic, and water-clear adenoma. Because some adenomas contained different cell combinations (i.e. chief and oxphilic cell; chief and water-clear cell), they were expressed as a mixed type depending on the most common two cell components. The histopathological findings like the longest diameter of PAs, presence /absence of normal parathyroid tissue around adenomatous tissue were compared to sonographic data of identical lesions. During the preparation of manuscript, the pathological materials of 54 lesions that could be achieved from pathology archive were reevaluated in terms of features such as the presence /absence of ectatic vessels, edema and fibrous bands within the PAs.

Statistical analysis:

The Kolmogorov Smirnov test was used to determine distribution of variables. Normally distributed data were expressed as mean \pm standard deviation (SD), whereas median, minimum-maximum and range values were used for numerical data which did not conform to normal distribution. The analyses between two means were performed with parametric Student's t test and non-parametric Mann-Whitney U test. χ^2 test was used for comparison of ratios. The level of the significance was taken as $p < 0.05$. Statistical analyses were performed with SPSS® for Windows software (version 16.00, Chicago, IL).

Results**Demographic features:**

Eight male and 47 female patients histopathologically diagnosed to have PA constituted the study group (mean age \pm SD, 51.5 ± 13.5). The mean age \pm SD of male and females were 63.3 ± 15.7 and 49.5 ± 12.1 years, respectively. One male patient had two PAs, each located caudal to lower poles of thyroideal lobes. Thus, the total number of PAs reached to 56 for PA-based analyses.

Biochemical results:

The serum calcium levels of 55 patients were found to be between 10.1 and 17.0 mg/dL (median: 11.3, minimum-maximum: 10.1-17, range: 6.9; reference values: 8.6-10.2). Intact serum parathormone levels in 48 patients were found to be between 74 and 2243 pg/mL (median: 123, minimum-maximum: 70-2243, range: 2173; reference values: 15-65). Urinary calcium excretion data was available for 37 patients in the retrospective analysis, and were found to be between 165 and 1385 mg/day (median: 436, minimum-maximum: 165-1385, range: 1220; reference values: 100-300).

Ultrasonographic features:

The longest diameters of PAs ranged from 0.5 to 4.2 cm, having a mean value of 1.89 cm (± 0.9 SD). The distance from the skin surface to the most superficial part of the PAs was 1.4 cm in average (SD: 0.4 cm; range: 0.7-2.7 cm). Other US parameters and the results of the analysis were depicted on Table I. PAs were found to have originated from inferior parathyroid glands in 80% of lesions. In two cases (3.5%) ectopic adenomas were sonographically demonstrated in the right half of suprasternal fossa, where they lay deeply, adjacent to the bifurcation of brachiocephalic artery. One of them was located cranial, while the other was observed caudal to the bifurcation.

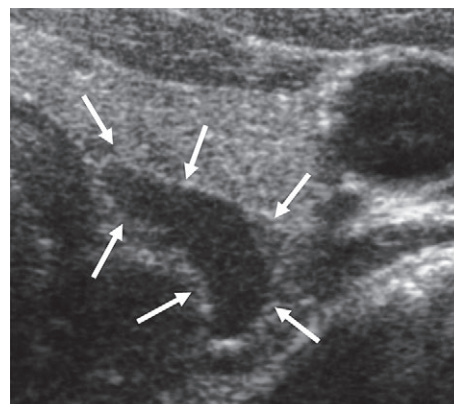


Fig 1. Transverse grey scale US image in a 57 year-old woman is depicted. There is a crescent shaped parathyroid adenoma adjacent to the left inferior half of thyroid gland (arrows).

Table I. Ultrasonographic features of parathyroid adenomas.

Sonographic Parameter	US Finding	Number (%)
Location and glandular origin	Right superior	2 (3.5)
	Left superior	7 (12.5)
	Right inferior	21 (37.5)
	Left inferior	24 (42.8)
	Ectopic	2 (3.5)
Shape	Oval	34 (60.7)
	Irregular	15 (26.7)
	Fusiform	4 (7.1)
	Lobulated	1 (1.7)
	Crescent-shaped	1 (1.7)
	Nodular	1 (1.7)
	Surface regularity	Smooth
	Irregular	11 (20)
Echo texture	Homogeneous	28 (50)
	Heterogeneous	28 (50)
Echogenicity (Dominant)	Hypoechoic	51 (91)
	Isoechoic	4 (7)
	Hyperechoic	1 (2)
Dual-concentric echo sign	Absent	46 (82)
	Present	10 (18)
Cystic component	Absent	47 (84)
	Present	9 (16)
Calcification	Absent	52 (93)
	Present	4 (7)
Vascularization	Hypovascular	4 (7)
	Moderately vascular	42 (75)
	Highly vascular	10 (18)
Vascular arc sign	Absent	40 (71)
	Present	16 (29)

Although approximately 61% of PAs in this series were oval in shape, their configuration varied highly ranging from nodular, fusiform, lobulated or crescent-like forms (fig 1) to a completely irregular outline. In terms of surface regularity, approximately 80% of PAs had a smooth contour. With regard to the internal echo texture, half of the PAs were homogeneous, while the other half exhibited internal components that distorted echo uniformity.

In terms of dominant internal echogenicity relative to that of thyroid gland, the PAs were overwhelmingly hypoechoic (91%). Only one PA had a relatively hyperechoic appearance. In 10 PAs, a unique sonographic appearance of two concentric layers of different echogenicity was noted. The peripheral layer surrounded the central zone. Each of the layers covered more than 25% of the cross-sectional area of PAs. The mentioned dual-concentric echo pattern was in the form of an isoechoic central zone with a peripheral hypoechoic layer in 9 PAs (fig 2), and an isoechoic central part surrounded by a hyperechoic zone in 1 PA.

In 9 PAs (16%), cystic changes were demonstrated in the lesion (fig 3). The PAs with cystic components were

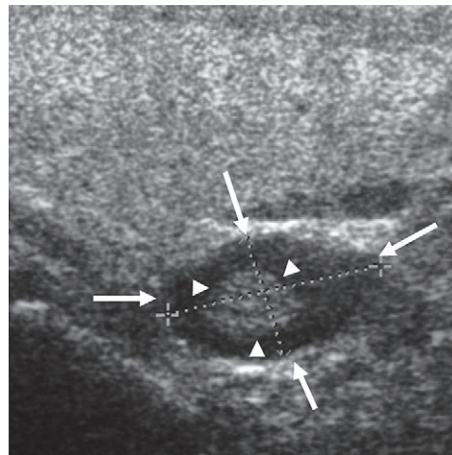


Fig 2. A parathyroid adenoma with dual-concentric echo pattern in a 47 year-old woman is shown in sagittal ultrasound image. Note that contrary to a typical adenoma two distinct echogenic layers are present; isoechoic central zone (arrowheads) and peripheral hypoechoic layer (arrows) which may lead to misinterpretation with a lymph node.

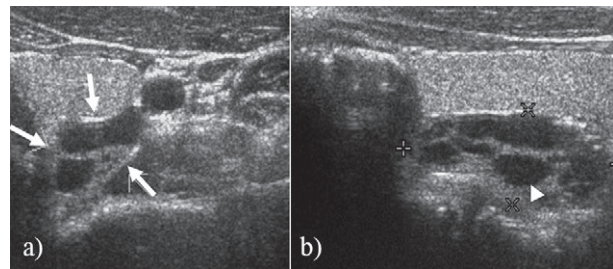


Fig 3. Transverse (a) and sagittal (b) ultrasound images in a 36 year-old woman. A parathyroid adenoma located close to the left lower portion of thyroid gland. Note that adenomatous tissue both comprises solid (arrows) and cystic areas (arrowhead).

significantly larger than the ones without (table II). In 4 PAs, these components were smaller than 5 mm, while the remaining ones had larger cysts measuring up to 9 mm in long diameter. In addition to few punctate calcific foci of millimeter diameter that were demonstrated in 3 PAs, another PA was shown to have coarse calcification (fig 4).

Doppler sonographic evaluation of PAs revealed flow signals in all PAs in the series, demonstrating moderate to high degree of vascularity in 93% of them. Only 4 PAs were hypovascular, and had long diameters ranging from 1.3-2.8 cm, which overlapped the dimensions of remaining lesions. Nor was there any significant difference between hypovascular PAs and others in terms of lesion depth ($p=0.329$). However, highly vascular PAs were significantly more superficially located compared to moderate-hypovascular PAs ($p=0.04$). The “vascular arc” sign

Table II. Comparison of the longest diameters of the PAs with regard to the presence or absence of the most common feature in the series for each US parameter.

Sonographic parameter	Longest diameter (mm) of the PAs with mostly demonstrated feature (mean ± SD) (n)	Longest diameter (mm) of the PAs with other feature(s) (mean ± SD) (n)	p value
Shape	Oval 1.7 ± 0.8 (34)	Others 2.1 ± 0.9 (22)	0.129
Surface regularity	Smooth 1.9 ± 0.9 (45)	Irregular 1.9 ± 0.9 (11)	0.838
Echo texture	Homogeneous 1.6 ± 0.8 (28)	Heterogeneous 2.2 ± 0.9 (28)	0.030†
Echogenicity (dominant)	Hypoechoic: 1.8 ± 0.9 (51)	Others: 2.5 ± 1.0 (5)	0.208
Number of internal echo layers	Single 1.8 ± 0.9 (46)	Dual-concentric 2.3 ± 0.9 (10)	0.139
Cystic component	Cystic component absent 1.6 ± 0.7 (47)	Cystic component present 2.3 ± 0.7 (9)	0.014†
Vascularity	Moderately vascular 1.9 ± 0.9 (42)	Highly vascular* 2.1 ± 0.9 (10)	0.529
Vascular arc	Negative 1.8 ± 0.9 (40)	Positive 2.0 ± 0.9 (16)	0.388

(*) For statistical analysis, only highly vascular PAs were included. (†) Statistically significant difference.

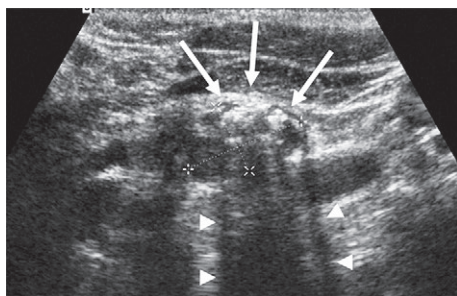


Fig 4. Transverse ultrasound image of a parathyroid adenoma with partially coarse calcification adjacent to the left lower pole of thyroid gland is depicted in a 29 year-old man. Hyper-echoic calcifications (arrows) with strong acoustic shadowing (arrowheads) can be seen.

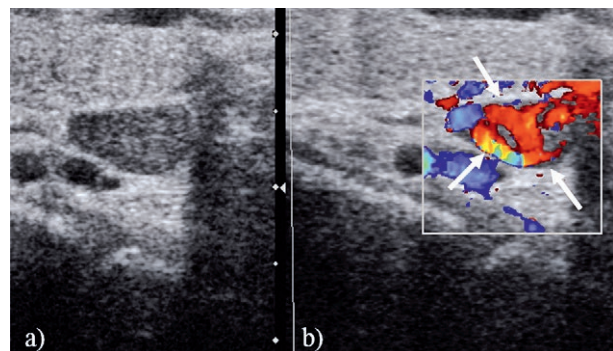


Fig 5. Sagittal grey scale (a) and Doppler ultrasound image (b) of a parathyroid adenoma measuring 1cm in a 26 year-old woman is depicted. Note that an enlarged vessel wraps adenomatous tissue (arrows) giving the typical appearance of “vascular arc”.

was present in 16 (29%) of PAs (fig 5). These PAs did not demonstrate any significant difference in terms of lesion size or depth (p=0.348) relative to those PAs without “vascular arc” sign.

With regard to the different sonographic features of the PAs, mean lesion sizes in different subgroups were compared (tab II). PAs did not demonstrate any significant difference of longest diameter in terms of shape, surface regularity, echogenicity, presence of single or dual concentric echo layers, and degree of vascularity or presence/absence of vascular arc sign. However, heterogeneous PAs and PAs containing cystic components were significantly larger than homogeneous (p=0.03) and completely solid (p=0.01) lesions, respectively. There was no statistically significant relationship between serum calcium, intact parathormone and urinary calcium

excretion levels with PAs showing different sonographic features (table III).

Surgery:

The time interval between the US examination and operation was between 0 and 309 days in the series (70 ±65, mean ±SD). Eighty-one percent of the patients had been operated within 100 days after the US evaluation. All PAs were found surgically in the sites described with preoperative US. The locations of PAs were right superior, 2 (3.5%); left superior, 7 (12.5%); right inferior, 21 (37.5%); left inferior, 24 (42.8%). The remaining two (3.5%) PAs were ectopic and found to be deeply located, adjacent to the bifurcation of brachiocephalic artery in the right half of the suprasternal fossa. The locations of PAs detected with US were in full compliance with surgical approach of adenomatous tissue.

Table III. Statistical comparison of biochemical data with different ultrasonographic features using Mann-Whitney U test.

	Parathyroid hormone levels (p value)	Serum calcium levels (p value)	Urinary calcium excretion levels (p value)
Shape (Oval vs. Others)	0.162	0.301	0.269
Surface regularity (Smooth vs. Irregular)	0.868	0.495	0.775
Echo texture (Homogeneous vs. Heterogeneous)	0.257	0.181	0.328
Echogenicity (Hypoechoic vs. Others)	0.924	0.320	0.845
Number of internal echo layers (Single vs. Dual-concentric)	0.522	0.256	0.955
Cystic component (Absent vs. Present)	0.214	0.091	0.271
Vascularity (Moderately vascular vs. Highly vascular*)	0.250	0.771	0.350
Vascular arc (Negative vs. Positive)	0.529	0.669	0.221

(*) For statistical analysis, only highly vascular PAs were included; vs: *Versus*

Histopathological results:

Fifty-six PAs had a mean value of 1.73 cm (± 0.74 SD) ranging from 0.5 to 3.5 cm in the morphological evaluation. There was good agreement between the lengths of PAs acquired by sonographic and histopathological methods (ICC 0.70; 95% CI values, 0.53-0.81; $p < 0.0001$). In 39 PAs (70%) some normal parathyroid tissue around adenoma had been reported. No significant relationship between the presence of the normal parathyroid tissue around PA and any sonographic parameter could be demonstrated. Predominant cell types were chief cells in 33 PAs, oxyphilic cells in 6 PAs, water-clear cells in 8 PAs, and mixture of cells in 9 PAs.

The histopathological reevaluation of 54 PAs yielded ectatic vessels in 14 (26%), central edema in 12 (22%) and fibrous bands in 7 (13%) of PAs. Blinded to the US observations, this analysis demonstrated significantly higher ratios of ectatic vessels (67% vs. 18%; $p = 0.02$) and central edema (67% vs. 13%; $p < 0.01$) in the ten PAs with dual-concentric echo pattern compared to those without (fig 6). On the other hand, the PAs with the dual pattern did not demonstrate statistically significant dif-

ference in terms of predominant cell type, and presence of internal fibrous bands or normal parathyroid tissue around the lesion.

Discussions

In most cases there are four parathyroid glands located in the neck, but supernumerary and ectopic glands may occur and account for many cases of persistent or recurrent hyperparathyroidism after surgery [16]. Superior parathyroid glands together with the lateral lobes of thyroid gland originate from the 4th branchial pouch and migrate shorter distance compared to the inferior counterparts. On the other hand, the inferior parathyroids, developed from the third branchial pouch, migrate longer distance in embryologic descent. This is why ectopic adenomas originate mostly from inferior parathyroids. Moreno et al reviewed the records of 271 patients operated on for sporadic primary hyperparathyroidism. According to this study the most prevalent location for adenomas was the inferior thyroid pole 26% [17]. Our study partially supports their findings. In our series we detected 80% of the PAs adjacent to the lower poles of thyroid gland. The second mostly encountered location was the left superior location. Regarding the limited number of cases in our series, larger scales of cases are needed to give a more reliable prevalence regarding the locations of PAs.

In typical cases PAs have uniformly hypoechoic appearance relative to the thyroid gland, and appear as well-circumscribed oval lesions. Compared to sestamibi scanning, US has the additional advantage of clearly demonstrating concomitant thyroid nodules which may cause false positive results with the scintigraphic technique. US may also reveal ectopic adenomas within the thyroid tissue, which are also hard to localize on sestamibi scanning [18-19]. The currently reached level of resolution capac-

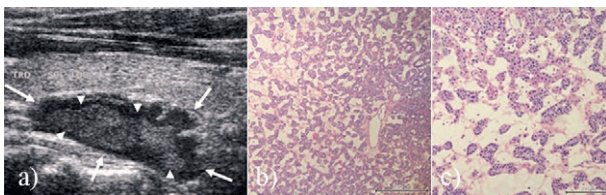


Fig 6. Sagittal ultrasound image (a) of a parathyroid adenoma with dual-concentric echo pattern in a 47 year-old woman. Isoechoic central zone (arrowheads) and peripheral hypoechoic layer (arrows) are seen in the ultrasound image. Low magnification (b) and high magnification view (c) of the same lesion from the central portion are depicted. Patients with this aforementioned novel ultrasound sign demonstrate more edema and ectatic vessels in the central portion with regard to those without this sign.

ity in modern US devices is far beyond those used in previous years; therefore, much more structural and hemodynamic details are obtainable in sonographic examinations today. That is why PAs without hypoechogenic appearance are not rare today, contrary to the older reports [21]. Chandramohan et al analyzed atypical US features of 26 parathyroid lesions. According to their study the ratio of non-hypoechoic PAs reaches up to 27% due to haemorrhage, hyalinisation and fibrosis in adenomatous tissue [22]. In the presented series, 9% of the PAs were hyper- or isoechoic relative to the echogenicity of thyroid gland.

During the growing phase, parathyroid adenomas assume the shape of space between longitudinally located tissues in the neck region which gives their characteristic elongated oval shape. If this process becomes more pronounced, an oval adenoma may become tubular or flat shaped. Due to asymmetric growth, cephalic and/or caudal end may become more circular. Additionally, atypical shapes such as triangular, conical, fusiform or lobulated can emerge in the growth phase of a PA [3]. Atypical shaped PAs with deeply hypoechoic internal echogenicity may be erroneously taken for regional veins in routine cervical scanning. In our series 5 PAs with fusiform or crescent-like shape had such configuration that presented some diagnostic challenge.

Instead of having single echogenicity, approximately 18% of the PAs in our series had dual, concentric echo structure constituted by areas of different echogenicity. The blinded histopathologic reevaluation of the PAs in the series demonstrated central edema and ectatic vessels more often compared to remaining PAs. Besides hemosiderin-laden macrophages and inflammation, edema may be seen in a PA, particularly in larger ones [23]. The sonographic lengths of PAs with dual, concentric echo structure were larger than those without, but the difference was not statistically significant. Although the limited number of cases with dual concentric echo pattern prevents full explanation, central edematous tissue and ectatic vessels may account for this unique US appearance, which had not been reported before, to the best of our knowledge.

Internal echo texture is one of the important diagnostic parameters that facilitate the diagnosis of PAs. Mostly being homogenous, PAs can be differentiated from regional lymph nodes, which are not rare especially in cases of chronic thyroiditis [24]. However, homogeneity of a PA is not a strict rule, especially when the US examination was performed with a high-resolution device. In our series, 50% of the PAs were visualized to display heterogenous texture. Apart from the high resolution technology of recent generation US machines, the dimensions of the PAs affect the sonographic internal appearance. It is known that PAs may develop heterogeneity of internal texture and cystic components, especially when they

grow larger [19]. Microcysts may develop in parathyroid glands, possibly as a result of gradual local degeneration of the gland or retention of colloid secretion [25]. Cystic parathyroid adenomas may occur in approximately 2% of cases, and may be difficult to differentiate from the rare true parathyroid cysts [4]. The percentage of PAs with cystic component was 16% in our series. In accordance with these reports, the heterogenous PAs in our series were significantly larger than the homogeneous ones ($p=0.03$), as were the PAs with cystic elements when compared to those without ($p=0.01$).

Calcification is a rare sonographic finding in a PA [17]. In a recent study, Sidhu et al drew attention to the high positive predictive value of internal calcification in diagnosing parathyroid carcinoma [26]. Studying on adenomas of 15 mm or larger, they found calcified foci in 4 of 8 parathyroid carcinomas, while none of 61 benign lesions had any calcification. In our series, however, none of the operated parathyroid lesions with calcification was proved to be malignant. Therefore, we believe that larger and comparative studies are needed to reveal the real value of this sonographic finding in predicting malignancy of a parathyroid lesion.

Regarding the fact that parathyroid adenomas are almost always hypervascular, color/power Doppler ultrasound is an indispensable tool in diagnosis [19]. There is always a large vessel in close proximity to the PA, usually contributing to the end artery which enters the adenoma from an anterior and superior position [9]. This large vessel creates the vascular arc sign in a typical adenoma [3]. However, this finding is not common in all parathyroid lesions. In our series 4 PAs (7%) were hypovascular, and moreover we were able to detect the "vascular arc" appearance in only 29% of PAs. Contrary to our expectations, neither the hypovascular PAs nor the PAs without vascular arc sign were smaller or deeper in location than others in our series. This result is in favor of the assumption that the degree of vascularity in PAs is significantly influenced by individual characteristics of the lesions in addition to other technical parameters likely to diminish received Doppler signal. On the other hand, the analysis that yielded more superficial location of highly vascular lesions compared to others, underlines the effect of depth in the hypervascularity of PAs.

The retrospective study design and limited number of cases are the major limitations of this study. The ultrasonographic features of dual concentric echo sign could be better assessed if larger numbers of PAs with this aforementioned finding could be enrolled in the study.

Conclusions

Although most of the PAs present with typical features, some of them may exhibit variable sonographic

appearances, dimensions and locations. Typical sonographic features such as ovoid shape, homogeneously hypoechoic pattern and vascular arc sign may not be present in all PAs. Without appropriate clinical guidance, proper knowledge of variations in US appearance, dedicated imaging technique and US devices of optimal quality, they may be easily overlooked. Except for homogeneously hypoechoic pattern and vascular arc sign which is conventionally seen in PAs, atypical features like dual concentric echo sign should alert radiologists for considering PA in differential diagnosis.

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Conflict of interest: none

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