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General Section

HDLive ultrasound images of ovarian dermoid cysts: diagnostic accuracy

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Summary

Objective: To demonstrate that the use of 3D/4D HDLive increases the image quality in the diagnosis of benign cystic ovarian teratomas. *Materials and Methods:* 3D/HDLive ultrasound (US) was used in 31 cases of suspected ovarian cystic teratoma using vaginal 2D US. The following pathognomonic images of mature cystic teratomas were considered for diagnosis: 1) a cystic, unilocular lesion with a densely echogenic tubercle (Rokitansky nodule); 2) a diffuse or partially echogenic mass usually demonstrating sound attenuation; 3) fluid-fluid/fat-fluid levels; 4) dermoid mesh with hyperechogenic calcifications indicating the presence of bone, teeth, or other ectodermally-derived structure; 5) multiple mobile spherical structures (fat globules). *Results:* Dermoids present a wide spectrum of images depending on the predominant tissue type. In the vast majority of cases there are dense echogenic structures that correspond to complex masses of fatty tissue, sebum, hair, epithelial remnants, along with cartilage or bone. If we catalogue all the images together, the pathognomonic of dermoid are: 1) cystic or solid cystic lesions with a Rokitansky nodule, with bone, teeth or cartilage (six cases, 22.2%); 2) a solid mass with or without attenuation that corresponds with pure sebum (five cases, 18.5%); 3) a diffuse mass with fine bands that correspond with hair inside sebum (four cases, 12.9%) and that may form meshes or plugs corresponding with a mixture of fat, sebum, and hair (three cases, 11.5%). *Conclusions:* HDLive U.S. provides some images of exceptional quality that enhance the definition of the structures of these tumors (fat, hair, cartilage, bone, etc.) compared to 2D/3D/4D.

Key words: Benning ovarian cystic teratoma; 2D/3D/4D HDLive.

Introduction

Ovarian teratomas are a group of tumors made up of mature and/or immature tissue derived from embryonic germinal cells following their first meiotic division [1]. They include tumors of different histologic types such as:

1. Mature teratoma or dermoid cysts, the most common, always have tissues from at least two of the three embryonic layers and show the following:
   a) Tissue from the ectodermic layer: skin, brain, neural tissue (always);
   b) Tissue from the mesodermal layer: muscle, fat, cartilage, bone (present in over 90%), and teeth (present in 31%);
   c) Tissue from the endodermic layer: gastrointestinal, bronchial, or thyroid tissue, and adipose tissue (present in 67% to 75% of mature teratomas).
2. Immature teratomas, which are very rare (less than 1%) and with high potential for malignancy.
3. Monodermic teratomas, where a single type of tissue predominates (struma ovarii with thyroid tissue, neuroectodermic tissue in carcinoid tumors, or teratomas of neural tissue, for example).

Although dermoid tumors can be easily diagnosed with ultrasound (US), they at times present image variations that make diagnostic accuracy difficult. The authors report that in their experience, diagnostic uncertainty can be avoided with the use of HDLive US.

Materials and Methods

In a 12-month period *(January - December 2013)*, the authors used 2D/3D/4D vaginal US as well as HDLive US for the evaluation of 31 women with tumors tentatively diagnosed with benign ovarian cystic teratomas. These were consecutive women in which an ovarian teratoma was suspected. All women referred were re-examined with a high-resolution ultrasound machine. The comparison between 2D (orthogonal planes) and HDLive are shown in Figures 1,2,4,6, and 7.

In 27 of these patients (87.1%), the authors confirmed the diagnosis of ovarian cystic teratoma with HDLive US while in the four other patients, other tumors were diagnosed: two endometriomas, one solid-cystic benign tumor, and one ovarian carcinoma, FIGO Stage 1A, all of which were confirmed following surgery.

The ultrasound images were classified based on their cystic, mixed, or solid nature (Table 1). The authors established the following types:

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Table 1. — *Summary of patients characteristics such as age, gravity, and clinical diagnosis, as well as dominant ultrasound image of the tumor.*

	Age	Gravida/Para	Size (cm)	Symptomatology	US image	US dominant image
1	25	G3/P2	4.2 x 4.3	None, pregnancy	Solid with attenuation + bilateral	2
2	23	G1/P1	6.5 x 6.4	None, infertility	Fat balls	Fat balls
3	38	G0/P0	5.1 x 5.2	None, infertility	Solid with attenuation	2
4	35	G1/P0	4.4×3.7	None, pregnancy	Cystic, fluid- serous level, Rokitansky	Mixed (1+ fluid-fluid/ fat-fluid level)
5	52	G2/P2	2.35×1.40	None, menopause	Solid with attenuation and calcium	Mixed (2 + 3)
6	47	G1/P2	2.84	None, menopause	Cystic, mesh, and teeth	Mixed (2+ fluid-fluid/ fat-fluid level+mesh)
7	33	G0/P0	5.57×4.34	None, infertility	Fluid-fluid, Rokitansky, hairs	Mixed (1+ fluid-fluid/ fat-fluid level+mesh)
8	36	G1/P1	3.5×4	None	Solid with attenuation and calcium	Mixed (2 + 3)
9	34	G0/P0	2.15×1.79	None, infertility	Pure cystic with Rokitansky	1
10	19	G0/P0	Bilateral 8.4/10.15 - 6.8/5.8	Tumor	Solid – cystic with Rokitansky	1
11	41	G1/P0	50×42	None, post abortion	Solid with small cystic area	3
12	21	G0/P0	10.9×11.63	None	Solid with attenuation	2
13	52	G0/P0	2.3×1.6	None	Cystic with Rokitansky	1
14	47	G0/pP0	4×3 cm	None, menopause	Solid with cystic area	3
15	43	G2/P2	40×47	bleeding	Solid with a cyst	3
16	39	G3/P0/A1/C2	52×42	None, menopause	Solid with cysts	3
17	39	G1/P1	12×8	Pelvic pain	Solid dense with attenuation	2
18	37	G0/P0	3.7×3.5	Bleeding and pain	Fluid-fluid / fat-fluid level	
19	39	G0/P0	4×4	None	Solid dense, hair	2
20	14	G0/P0	3×4	None	Solid dense, hair	2
21	51	G1/P0/Ao/C1	3×3	None	Cystic with Rokitansky	1
22	18	G0/P0	14×10×10	None	Cystic with Rokitansky	1
23	37	G0/P0	3.5×3.5	None	Solid with attenuation	2
24	35	G1/p1	3×4	Pain	Cystic with Rokitansky	1
25	31	G0/P0	2.2×2.6	None	Non homogeneous	
26	80	G3/P3	8×8.7	None	Non homogeneous	
27	39	G2/P0/C1	3.5×2.8	None, pregnant	Non homogéneous	

1. Cystic most frequent unilocular tumor, with or without a Rokitansky nodule and with or without sonic attenuation.
2. Solid homogeneous and diffuse mass with/without an echogenic area that showed attenuation.
3. Diffuse solid or solid-cystic mass with multiple very fine echogenic bands produced by hair, or other refringent tissues (bone, teeth, or cartilaginous nodules), known as dermoid nodules.

The authors used in addition certain images that are occasionally seen and which are described in the literature as specific of these tumours [2, 3]:

a) The iceberg sign, refringent surface small masses with profound sonic attenuation.
b) The presence of double levels: liquid/liquid, fat/liquid [4].
c) Trabecular images: multiple thin echogenic dots and fine bands caused by hairs, bone, teeth, or other ectodermic structures. Also dermoid mesh was included [4].
d) Dermoid plugs: a wide echogenic area with multiple linear echoes and white points [5].
e) Fat balls floating freely in a great cystic mass.
f) Partial cystic-partial solid tumors, with non-homogeneous inner tissues, also poorly delimited, that we have called non-homogeneous dermoid tumors.

All diagnoses except two were confirmed shortly after ultrasound diagnosis by anatomic pathology following surgery. Tumors seen in two pregnant women were confirmed belatedly by pathology following surgery after the period of lactation.

This study received the approval from the ethical committee of the Hospital Clinico Universitario of Valencia (Spain). Informed consent from all patients participating in this study was obtained for US exam and for the surgery.

Results

Patients age

Because of the embryonic nature of dermoid tumors, the authors have observed them at all ages. Six patients (22.2%) were younger than 25 years of age. Their tumors were diagnosed when they consulted for family planning, infertility, or pregnancy.

Gravity and parity

These are not significant factors, but in any case, 18 patients (66.7%) were nulliparous women.

Tumor size and bilaterality

Only four tumors (14.8%) were larger than ten cm in diameter. This allowed preservation of much ovarian tissue. Two women (7.4%) had bilateral dermoid cysts.

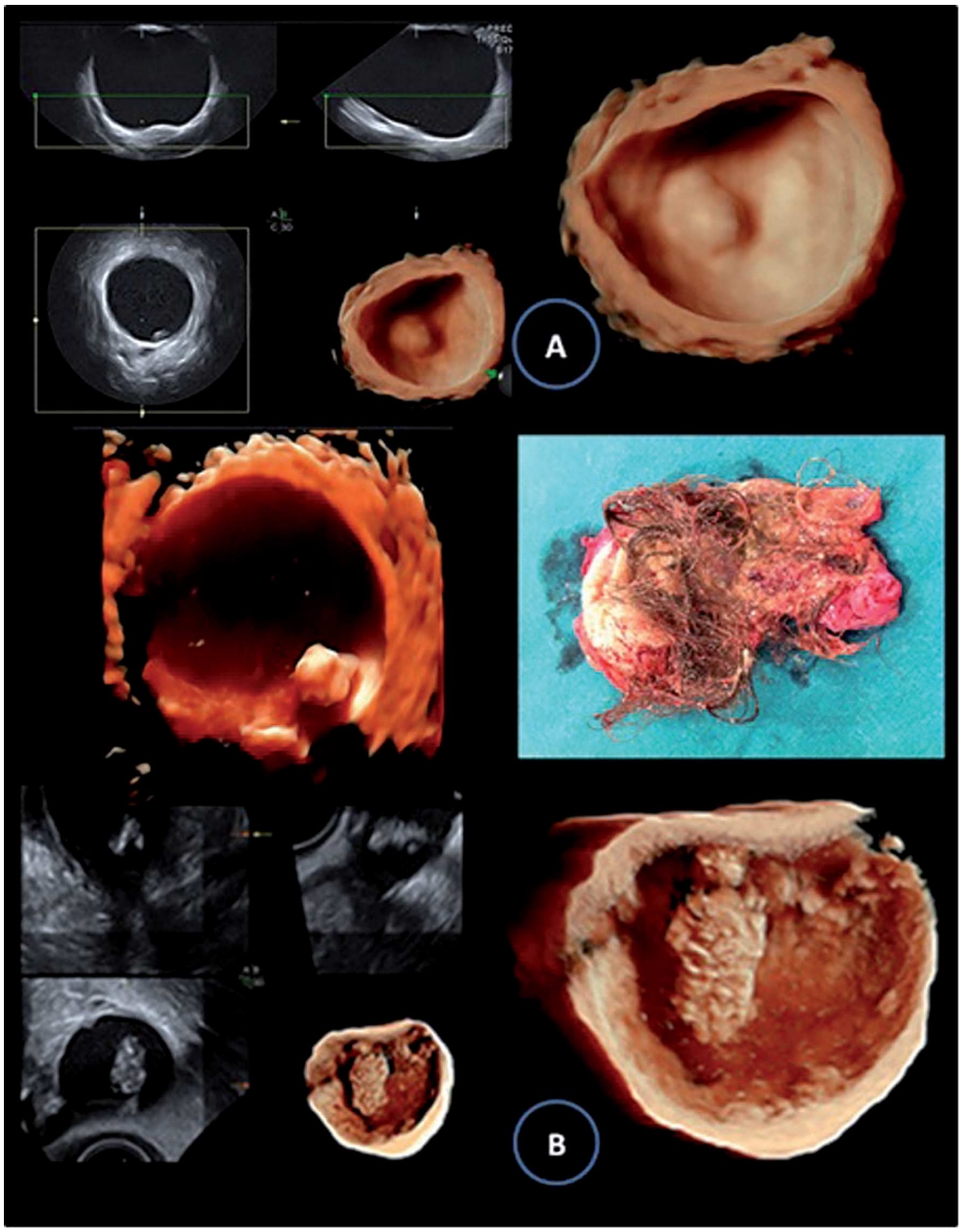

Figure 1. — A: Three orthogonal planes and 3D HDLive image of a cyst with Rokitansky's nodule or dermoid plug (upper left). The nodule can be clearly seen on the upper right side image. The center left shows the image with maximum luminiscence. The light source is entering behind the cyst highlighting in this manner the nodule. The right middle image is the macroscopic surgical sample. B: Pure dermoid cyst that shows Rokitansky's nodule in the shape of a cluster of grapes.

Symptomatology

Because of early diagnosis, their size, and the propensity to grow without involvement of neighboring intra-abdominal organs, dermoid tumors are generally asymptomatic. Only two (7.4%) of the largest tumors (>ten cm in diameter) the authors observed were associated with symptoms (hypogastric pain and menorrhagia), and in these cases the symptoms could be attributed to other concomitant gynecologic pathology (uterine myomata).

Ultrasound appearance with HDLive

Dermoids present a wide spectrum of images depending on the predominant tissue type [3, 5]. In the vast majority of cases there are dense echogenic structures that correspond to complex masses of fatty tissue, sebum, hair, epithelial remnants, along with cartilage or bone.

Dermoids can also present as hyper-echogenic masses with posterior acoustic shadowing. These masses may also reflect focal or diffuse echoes like fine splinters or present double fluid-fluid or fat-fluid layers [2, 3, 5-7]. The present authors have observed a few images that were not pathognomonic of dermoid cysts such as:

1. Cystic, usually unilocular lesions with a tubercle or dense echogenic nodule, known as Rokitansky nodule, which may show acoustic attenuation due to the presence of hair, cartilage, or bone. This nodule is also known as a

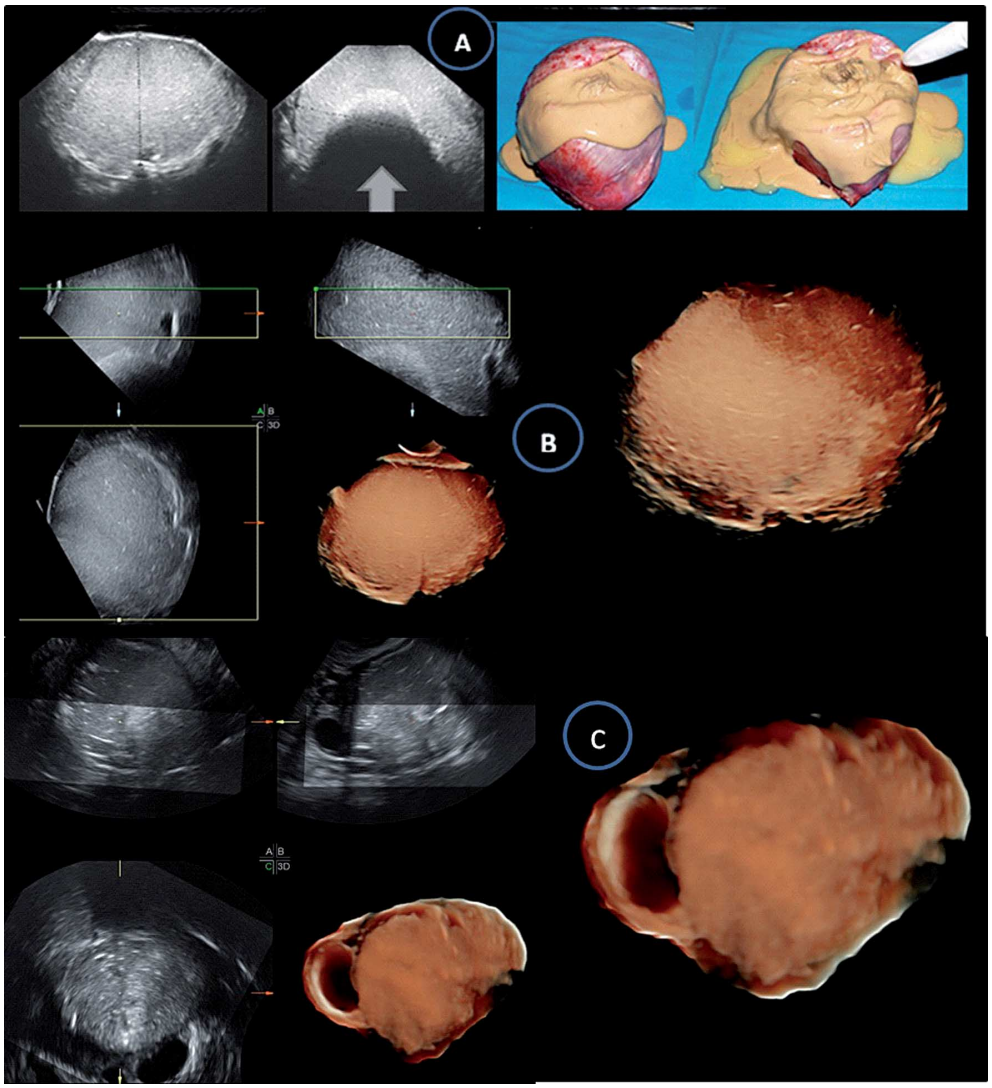

Figure 2. — A: Diffuse echogenic mass with sonic attenuation (white arrow). As can be seen in the surgical sample, the sebaceous material is dense and rich in sebaceous glands, hair, and fat, which are responsible for the sonic attenuation. B: 2D orthogonal planes and 3D HDLive of a dermoid cyst without sonic attenuation that consists of a dense and diffuse echogenic mass. The mass is predominantly sebum. Hair appears as very fine white dots. C: A dermoid that consists totally of sebum. The teratomas depicted in B and C were delimited by the Amagic cut system.

dermoid plug and represents a protuberance of the internal wall of the tumor where hair and other solid elements originate (Figures 1A and 1B).

2. Diffuse echogenic mass, usually with a small zone of sonic attenuation (not always present), that is basically produced by a large accumulation of sebaceous material (Figure 2).
3. Diffuse echogenic mass with numerous very fine and elongated bands of greater echogenicity caused by hair [8] (Figure 3).

The present authors consider the following ultrasonographic signs to be specific and pathognomonic of dermoid tumors:

1. Pure cystic lesions with bones, teeth, or cartilaginous nodules (generally called bones or dermoid plugs [9]. In these cases the papillae appear as protuberances with an acoustic shadow projecting into the cyst cavity. Hair, teeth, and bones typically arise from these nodules. (Figures 1 and later Figure 5).
2. The iceberg sign. It is very similar to the Asound attenuation phenomenon previously described. It is a mass with an amorphous, poorly defined echogenic focus in the near field that causes a posterior shadow and thus obscures the posterior portion of the lesion along with any structures behind it. The echogenic focus appears as a solid mass, but it is actually a cyst that contains a mixture of fatty liquid (i.e., sebum), matted hair, and cellular debris. The multiple tissue interfaces are responsible for the characteristic acoustic shadow. The fat mixed with the hair strands is echogenic and often attenuates the ultrasound beam. The reflective echo pattern is caused by the multiple tissue interfaces of the hair and sebum within the cystic mass. The acoustic shadow may totally obscure the back of the mass, hence, the term used for describing this image, Atip of the iceberg sign [10].
3. The fluid-fluid/fat-fluid levels. This type of layering within a cystic ovarian tumor strongly suggests a cystic

Figure 3. — Multicystic ovarian dermoid tumor seen with HDLive maximum luminescense. The use of HDLive allows us to visualize multiple thin echogenic dots and fine bands caused by hairs.

teratoma and is therefore considered pathognomonic of this tumor [11]. Pure sebum inside the cyst may be hypoechoic or anechoic. Fluid-fluid levels or fat-fluid interface result from sebum floating above an aqueous surface, which appears more echogenic than the sebum layer. There is a constant horizontal fluid level inside the mass that can change with the patient's position (Figure 4).

4. The dermoid mesh [4]. A dermoid mesh with hyperechogenic calcifications indicates the presence of bone, teeth, or other ectodermal structure. These images are usually seen in a predominantly cystic medium. Hyperechoic solid mural components and hair-fluid levels represent multiple echogenic linear interfaces floating inside a cyst. All these interfaces represent hair fibers (Figure 4).
5. Dermoid plugs. These are in a vast hyperechogenic area with multiple bright linear echoes and spots [12]. (Figure 5.
6. Multiple mobile spherical structures (fat balls) of slightly increased echogenicity floating free in a large cystic mass is one of the rarest patterns observed in dermoid tumors (Figure 6). In all cases some degree of mobility was observed with the application of abdominal pressure. In rare cases, a single ball that measures between four and seven cm can be observed [2, 13-26].
7. The non-homogeneous group. These are poorly defined cystic tumors with solid areas, always homogeneous, although poorly delimited, can be seen in their interior. These solid internal areas represent sebum. The combined use of transvaginal 2D and HDLive is required for diagnosis since both allow us to show clearly that the solid content consists of sebum and fat. Although the present authors have labeled it non-homogeneous, the nature of the solid areas, with or without whitish spikes, is pathognomonic.

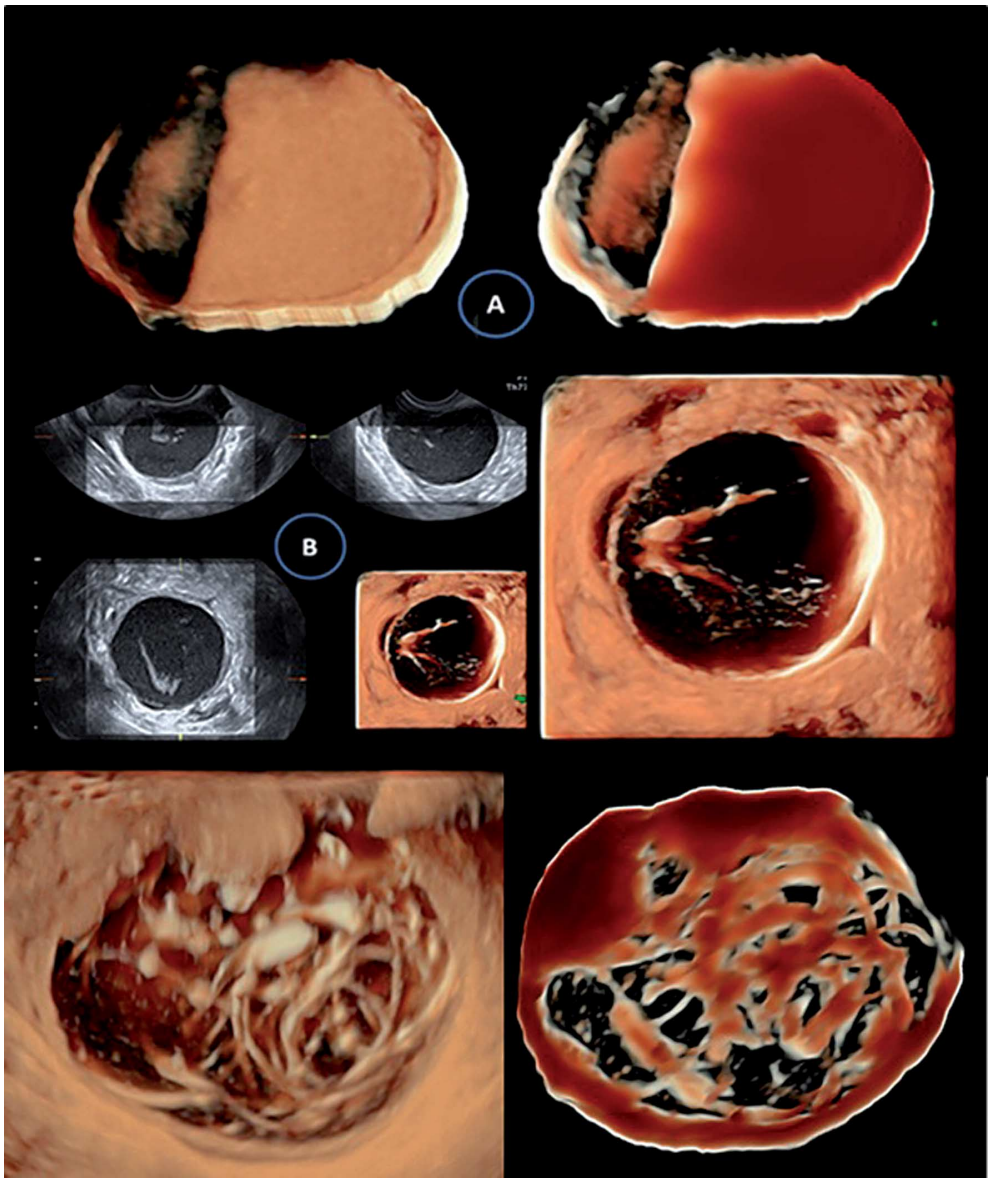

Figure 4. — A: Fluid-fluid/fat-fluid level. HDLive and maximum luminescence. B: Dermoid lesion in the form of a net (dermoid mesh, below). The fibrous tracts expand like a spider web. At the base of the fibers a small, more dense zone can be seen where cartilage, bone, or teeth are localized (center). Multiple small echoes in the form of white dots or small lines float within the cyst. They represent hair (center).

The images that the authors saw most frequently were Rokitansky nodule in a cyst in six cases (cases 4, 9, 13, 21, 22, and 24), five cases (number 1 was bilateral) of diffuse solid mass with an area of attenuation (cases 1, 3, 8, and 12), four cases of diffuse solid mass with echogenic bands (cases 11, 14, 15, and 16), three cases of dermoid mesh (cases 6, 19, and 20), and three non-homogeneous cases (25, 26, and 27).

The present authors have seen isolated cases of pure unilocular or multilocular tumors (case 10, which was bilateral), of solid-cystic mass with calcification (teeth, bone, or cartilage)(case 5). Case 18 was a cyst with double liquid-liquid or fat-liquid levels and case 2 was a tumor with multiple balls.

Cases with dermoid plug and with the iceberg sign are very rare. The authors did not observe any with these findings among their cases. In five of the present cases there was a combination of images. In case 4 the authors saw a cystic area with a nodule of Rokitansky along with fluid-fluid/fat-fluid levels. Case 5 combined solid cystic area with calcium and acoustic attenuation. In case 6 there was a combination of double levels, solid-cystic mass with attenuation, and dermoid mesh. Case 7 had a combination of fluid-fluid/fat-fluid levels, a Rokitansky nodule, and a mesh. Case 8 combined a solid-cystic mass with a Rokitansky nodule and calcium.

Since several of the ultrasound images described are very similar (i.e., iceberg sign y echogenic mass with attenuation, or dermoid mesh with dermoid plug), if we catalogue them together, we can conclude that ultrasound images pathognomonic of dermoid are:

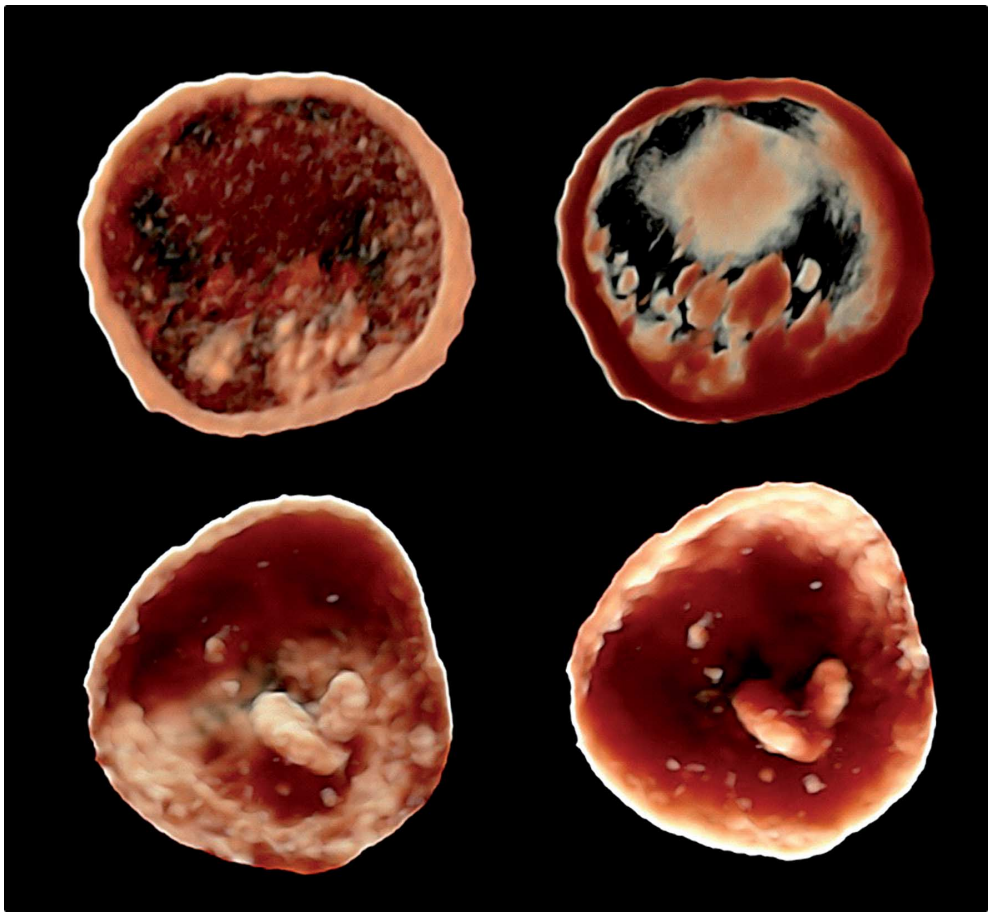

Figure 5. — Multiple small echogenic linear interfaces (mesh) are seen in the upper images. In the lower images two Aplugs can be seen inside the cyst. The small linear dots are hair and fibroid tissue.

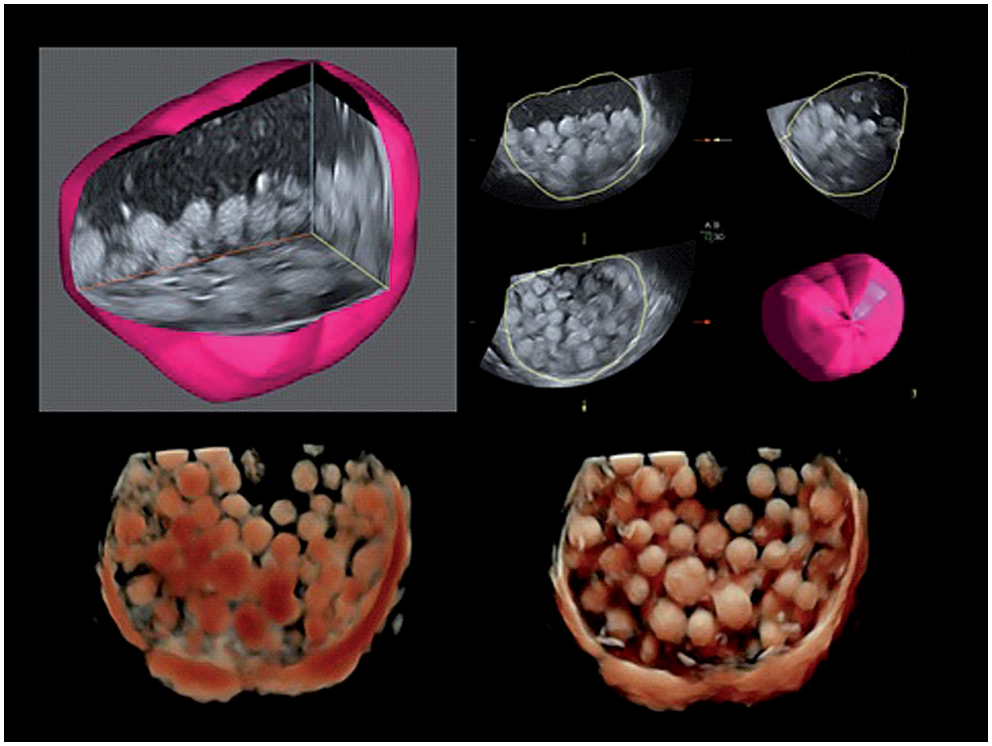

Figure 6. — Fat balls seen in 2D shell mode and HDLive with and without maximal luminescence.

1. Cystic or solid cystic lesions with a Rokitansky nodule, with bone, teeth or cartilage (six cases, 22.2%)
2. The solid mass with or without attenuation that corresponds with pure sebum (five cases, 18.5%)
3. A diffuse mass with fine bands that correspond with hair inside sebum (four cases, 12.9%) and that may form meshes or plugs corresponding with a mixture of fat, sebum, and hair (three cases, 11.5%).

The sum of these last 12 cases (46.1%) of solid material add up to the most frequent US images observed in dermoid tumors. The authors therefore have available pathognomonic ultrasound images that enable them to accurately diagnose ovarian dermoid tumors in almost 100% of cases.

Discussion

It is evident that using HDLive improves the quality of images when compared with those obtained by imaging identical cases with 3D/4D [27]. Several publications regarding imaging in normal and pathological pregnancies, in folliculogenesis, and in gynecology agree on this point [27].

The present is the first report about the degree of improvement in diagnostic accuracy that can be achieved by using HDLive for the evaluation of a specific type of tumor, ovarian dermoid, which may reveal with 2D several complex images that compromise diagnostic accuracy. Of the 31 cases referred with a diagnosis of dermoid diagnosed by 2D transvaginal sonography, the authors agreed with the diagnosis in 27 cases (87%) with the use of HDLive, subsequently confirmed by pathologic evaluation of surgical specimens.

Certain US images like Rokitansky papilla, fluid-fluid/fat-fluid layers, and diffuse echogenic masses with or without sonic attenuation are evidently pathognomonic of benign teratomas. Because of the extreme rarity of other equally pathognomonic signs such as balls of fat, generate even greater interest when observed [14, 18, 28, 29]. The present authors show the first 3D/4D and HDLive images reported in the literature of these Aballs of fat.

The pathogenesis of dermoid ball formation is unknown. Several theories have been postulated:

a) Predominance of large secretory and absorptive rather than exfoliative surfaces lining the cysts would favor absorption of most of the contents into the general circulation, leaving the remaining material to solidify and mould into balls.
b) Each globule is formed by the aggregation of sebaceous matter around a tiny focus of debris, squamous cells, or a fine hair shaft while moving around in the cystic cavity.
c) The spherules are modeled as discrete masses rather than as amorphous masses because of the difference in physical and thermal properties of the material being deposited around each nidus. Floating balls require space to be remodeled.
d) This type of growth could be related to an unusual pattern of estrogen and progesterone receptor expression in the cystic teratoma [15].

No one has yet defined a method to test these theories [16, 17, 18]. These Aballs are described in classical German, English, and French literature and have been ascribed the interesting names that the present authors list in their original language [14]: Boules de graisse, Butterkugeln, Caviar-like bodies, Dermokugeln, epithelial balls, Erbsenartige Körper, fatty concretions, Fettkugeln, floating balls, inclusions, lipid globules, pill-like bodies, rounded balls, sebum balls, solid concretions, and spherules.

The first descriptions were microscopic [19] to be followed sometime later by radiologic descriptions using CT and MRI, and lastly, ultrasound description [8, 12, 14], report of three cases [15-18, 20-24], followed by five cases [25] and other reports [26]. Labeled as fat balls the microscopic findings were desquamative keratin, fibrin, hemosiderin, and sebaceous debris with skin squamous cells, fine hair shafts, and only a small amount of fat component. Some spherules had a two- to three-mm thick outer sebaceous shell [14].

As a differential diagnosis the authors can only postulate the possibility of lesser pelvis echinococcal infection, an exceptional event that takes place with daughter vesicles [18, 23, 26]. Dermoids may show hyperechogenic globules floating in a hypoechogenic liquid. The echinococcal cysts or vesicles are hypoechogenic [30, 31].

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