Ultrasonography: The Main Diagnostic Tool in Subfertile Women

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ABSTRACT

The diagnostic assisted reproductive technology (ART) workup includes ultrasonography, hysteroscopy, hysterosalpingography, magnetic resonance imaging (MRI) and laparoscopy where appropriate. Ultrasound represents the mainly used imaging modality for assessing the female genital tract. Recent developments, i.e. the introduction in the daily praxis of hydrosoneography, elastography and the use of contrast media, enhanced by the application of three-dimensional (3D) and four-dimensional (4D) software produce images of high resolution. All these offer the possibility of multiplanar approach and create fast techniques that result in specific and detailed reports. The comparably short period of training for the medical doctors could transform the ultrasonography in the leading diagnostic tool even in nonexperienced hands. It is noteworthy, that in suspicion of malignancy, patients should be referred to more experienced teams.

Keywords: Three-dimensional ultrasound, Subfertility, Diagnosis.

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INTRODUCTION

The term subfertility includes the failed achievement of gestation after 1 year of unprotected sexual intercourse. In last decade, the number of pairs that request assisted reproductive technology (ART) methods augmented considerably. It has been calculated that around 2% of the born children in the Western world belong to the in vitro fertilization (IVF) group.¹⁻³ The increase in age of the women that desire to become pregnant could represent the main reason. The long period of infertility, the increased number of cycles, the male factor, the ovarian pathology, the anatomical uterine defects and the tubal obstruction interpret also in the subfertile etiology.^{1,4,5}

The diagnostic ART workup includes ultrasound scan, hysteroscopy (evaluation of the endometrium and the endomyometrial junction), hysterosalpingography (evaluation of tubal patency), magnetic resonance imaging (MRI) and laparoscopy (estimation of the pelvis and adnexa).⁶

Hysteroscopy offers the possibility to investigate directly the anatomical defects of uterine cavity and the precise

diagnosis of the existence of polyp, hyperplasia and submucous myoma. Advantage of the method is the possible direct intervention, treatment of the lesion and biopsy performance. Disadvantage of the method is the anesthetic issuing and the cost. The usage of the minimal diameter hysteroscopic instruments, which provoke minimal discomfort, made the method more easily to apply.^{4,7} There is an ongoing debate, if hysteroscopy should be included as routine in the standard workup before IVF cycles.^{4,8,9} Some researchers suggest that the correction of the lesion, if it exists, the dilatation of the cervical canal during introduction of the instrument and/or a series of immune reactions that are released after endometrium relative damage represent some of the reasons that hysteroscopy increases the percentage of success of IVF cycles.⁹⁻¹¹

Hysterosalpingography is the most widely used method in the diagnostic protocol concerning subfertility.^{12,13} This method provides the possibility to examine the patency of the tubes, their orientation in the pelvis and to clarify the possible existence of adhesions that could affect externally their mobility. On the other hand, it offers the possibility indirectly to evaluate the anatomical structure of the endometrial cavity. Disadvantage of the method consists the radiation issuing, increased feeling of pain reported by the women, cost as well as the necessity to program the method by making an appointment. The relative disadvantage of the method is the elevated number of positive false results as compared to hysteroscopy because of increased sensitivity but decreased specificity observed.

MRI, characterized as a second level diagnostic study, offers the possibility to investigate the anatomical structure of the uterus, to evaluate the ovarian lesions, if they exist and to examine the patency of the tubes. Increased sensitivity and specificity is observed concerning the diagnosis of deep nodes of endometriosis, especially the smaller one and/or localized in retroperitoneal space. MRI represents a really specific method, but the elevated cost as well as the absence of the direct availability limits significantly its daily use.^{14,15}

Laparoscopy may participate as a diagnostic tool in the workup of IVF protocols. It provides directly the possibility of examination of the whole pelvis and the anatomical-included structures. Simultaneously, it is possible one to intervene and to correct the possible observed lesions. Additionally, it enters considerably in the diagnosis and the treatment of the deep nodes of endometriosis. Despite its

advantages, this method remains an interventional, highly costly method, not familiar in women that demands anesthesia issuing.^{5,16}

Ultrasound approach of female genital tract constitutes a method simple, repeatable, real-time monitoring without radiation, painless, cost-effective and familiar to gynecologists as well as to women. In the past few years, occurred a dramatic improvement in the technological profile of ultrasound scan, regarding the technical clinical applications as well as the knowledge and experience of the medical doctors applying these.

Ultrasonography enters in the daily clinical practice for the examination of the uterus, adnexa and anatomic structures of the pelvis (transvaginal). Its usefulness has been extended in the exploration of the gynecological case into the abdominal investigation (transabdominal), into the functional profile of the bladder (translabial), and into the examination of microscopic lesions identified in the pelvis as deep endometriotic lesions and cervical lacerations (transrectal). Individual developing techniques as hydrososonography (infusion of saline in the endometrial cavity) and use of means, such as SonoVue and EX-Em foam eject the attribution of diagnostic process.

During ART protocols, ultrasound scan enters daily into the follow-up of the controlled ovarian stimulation, the estimation of follicular maturity at the time of human chorionic gonadotropin. It is really important to avoid the appearance of OHSS. In addition, ovum sampling is realized under ultrasound.

Many variables interfere in the achievement of successful clinical pregnancy. We believe and we will try to prove through the presentation of gynecological subfertile cases investigated in our department that the enhanced ultrasound scan by the application of the three-dimensional (3D) and four-dimensional (4D) software, hydrososonography and issuing of contrast agents constitutes the main diagnostic tool in the daily clinical practice that could guide (permits or excludes) further surgical treatment, if necessary, overlapping henceforth the other diagnostic methods.

ENDOMETRIUM

Successful implantation is strongly correlated to normal anatomical pattern of endometrium as well as to endometrial receptivity during a short window phase, where the endometrium erases the implantation of the blastocyst. Initially, endometrial receptivity was defined based on histological criteria. This procedure demanded D and C, anesthetic issuing, increased cost and increased worry of the women for consequent provocation of endometrial

adhesions and subsequently abortions. The diagnostic ultrasound examination, as it is performed in our days, leads to clear identification, delimitation and description of the normal and/or abnormal endometrium. Targeted studies have been conducted concerning the normal endometrial cavity, meaning endometrial receptivity (model of vascularity) and anatomical model of endometrium (congenital anomalies, polyps and submucous myomas).¹⁷⁻¹⁹

Normal Endometrial Pattern

In order to approach the pathology of endometrial cavity, it is required to present the physiological endometrium during 3D and 4D ultrasound examination in the different parts of the normal menstrual cycle (Fig. 1A). In premenopausal woman, the triple layer endometrium is delimited in early follicular phase. Progress of the menstrual cycle, provokes more hyperechogenic layers and more hypoechogenic uniform interior space. In the luteal phase of the cycle, endometrium is appeared as thick hyperechogenic region in the centrum of the body of the uterus. During 4D ultrasound, we can clearly see the horns of a normal endometrial cavity submerging into the adjacent myometrium.

In the postmenopausal woman, the normal endometrium appears as a hyperechogenic line that uniformly delineates the body of the uterus (Fig. 1B).

Ultrasound examination of endometrial cavity is performed during 5th to 10th day of the menstrual cycle. In suspicion of congenital anomalies, submucous myoma and polyp it should be realized during the second part of the cycle.²⁰ The introduction of 3D- and 4D-enhanced applications of hydrososonography in the daily clinical praxis remove these restrictions via the smooth enlargement of the endometrial lips that it provokes.

Congenital Anomalies

The observation of alterations in the normal described endometrial pattern is not a rare condition in daily clinical praxis. Anatomical disturbances, resulting from abnormal development of Mullerian ducts, consist a reason of failed achievement of pregnancy as well as early and/or late abortion.²⁰ Frequently, in our department we observed arcuatus morphology of endometrial cavity in different degrees. The latter, does not seem to affect seriously the achievement of pregnancy but shows a remarkable frequency in subfertile women. In addition, we identified cases of bicornuate uterus, didelphus, septate and uterus that show disturbed development of the horns (Figs 2A to S).

Fig. 1A: 3D and 4D appearance of normal endometrium during follicular phase (a, b and c), periovulatory (d, e and f) and during luteal phase of the menstrual cycle (g, h and i)

BODY OF THE UTERUS

Structural Disturbances

Recurrently, we detect and describe lesions concerning the anatomical structure of endometrium and/or myometrium in subfertile women. Polyps and submucous myomas originating from endometrium and adenomyosis and intramural myomas originating from myometrium are the most frequently observed. In some cases, masses, of not specified origination (endometrium or myometrium) affect the body of the uterus and the endometrial cavity causing significant diagnostic and clinical complications in the applied IVF protocols. In regard to their size, localization and extension they can influence the anatomical pattern of normal endometrium and therefore, impact the successful achievement and/or continuing of the pregnancy.²¹

The appearance of lesions that affect the classical architectonical structure of endometrium and, therefore, the successful implantation of the fertilized egg is not a rare condition. These lesions originate from endometrium, they remain in the cavity or they may extend in the adjacent myometrium. They may present as hyper- or hypoechogenic masses during two-dimensional (2D) as well as 3D and 4D

Fig. 1B: 3D appearance of endometrial cavity in postmenopausal women

ultrasound examination usually with a centrally located feeding vessel (pedicle artery). These lesions are commonly combined with clinical symptoms of menometrorrhagia (Figs 3A to I).

Adenomyosis consists of groups of hyperplastic bundles of smooth muscles that surround ectopic implantations of the endometrium. It can be seen as the diffused pattern of

Figs 2A to S: (A and B) triple-layer endometrium during the follicular phase of the menstrual cycle; smooth hyperechogenic region was detected in the middle of the cavity; via 4D application, endometrium was isolated and its arcuatus morphology became obvious, (C and D) endometrium during the luteal phase of the cycle; 4D software revealed its bicornual morphology, (E and F) bicornual endometrial morphology; empty pregnancy sac in the left horn, (G and H) abnormal appearance of thick hyperechogenic endometrium during the luteal phase of the cycle in 3D images; 4D software showed hypoplastic right horn, (I to L) investigation of endometrium in different levels during 3D examination resulted in failure of appearance of both horns; during 4D application, appearance of unicornuate uterus, (M to P) hyperechogenic endometrium during the luteal phase of the cycle and abnormally thickened anterior uterine wall in 3D application; via 4D software, didelphys uterus and intramural myoma were revealed, (Q to S) in 3D images, it was observed hyperechogenic endometrium as well as a hyperechogenic region in the cervix; via 4D software, septate uterus consisting of two endometrial cavities and two discrete cervixes was observed; The one endometrial cavity was hypoplastic, communicating to the greater one

the disease, occupying the whole body of the uterus or as the localized pattern creating the adenomyomas. By blocking the normal contractile behavior of the myometrium it interferes in the causes of subfertility.^{22,23}

The application of the 3D ultrasound examination results in the clear presentation of disorganized smooth muscle bundles of the myometrium (Fig. 4A). The combination of ultrasound and clinical data increases significantly the accuracy of the method.

Adenomyosis is highly correlated to the coexistence of myomas. Identification of well-described masses in the uterine wall usually with circular-surrounded circulation indicates the diagnosis of myomas (Fig. 4B). The latter, in correlation to their localization (submucous, intramural, subserous) and/or their size (>5 cm) could affect negatively the outcome of the IVF program. Application of 3D/4D software permits the clear description of the myomas, the exact identification of their position and predominantly their relationship to the endometrial cavity.

Figs 3A to I: (A) 3D presentation of hypogenic lesion that fulfill the endometrial cavity, (B) 4D presentation of possible polyp that destroys the anterior endometrial lip, (C) 3D appearance of hyperechogenic mass in the endometrium, (D and E) via Doppler, centrally located vessel was clearly observed in 4D images, (F) hydrosonography enhanced by 3D software revealed undoubtedly the polyp that originated from the anterior endometrial lip, (G and H) hyperechogenic smooth disturbance of the anterior endometrial lip; (I) hydrosonography enhanced by 3D software revealed two polypoid lesions; 4D real-time application cancelled the possibility of existence of polyps and the final report included the diagnosis 'normal endometrium'

Recently the elastography gains part of the diagnostic workup of uterine disturbances.²⁴ This ultrasound method calculates the percentage of elastic profile of the myometrium that could be increased in cases of myomas and decreased in cases of adenomyosis. The results are presented via three basic colors; blue for the hard tissue, red for the smooth and green for the in-between (Fig. 4C).

Despite the significant help that 3D and 4D hydrosonography offers to the clinician, there are some gray zone cases (described in the follow image; Figs 5A to I) that still remain obscure without standardized ultrasonographic criteria. In these cases, the clinician should refer to experts, in order to avoid a possible underlining malignancy.

ADNEXAL MODEL

Ovulation Induction

The follow-up of ovulation induction is taken partly through ultrasound measurement of the 3Ds of the stimulated follicle in each ovary separately. Applying the 3D ultrasound

technology, the measurement is realized automatically by taking a single volume of each ovary. A variety of colors marks the various stimulated follicles (Fig. 6). The software calculates simultaneously the 3Ds of each marked follicle as well as its volume.

Ovarian Pathology

In the past few years, a revolution occurred in the diagnostic efficacy of transvaginal ultrasound concerning the ovarian lesions. Logistic regression models, like international ovarian tumor analysis (IOTA), orientate diagnosis with high accuracy, concerning the benign or malignant nature of the lesion.²⁵⁻²⁷ The extension of ultrasound in the 3D and the 4D enhances the diagnostic faculty. This extended ultrasonography requires relatively low-grade familiarization of the clinical doctors with technological parameters. On the other hand, it offers clear and readable images decreasing considerably the rate of necessity of expert ultrasonographers.

Fig. 4A: Presentation of 3D and 4D images; (a and b) disorganization of the ultrasound appearance of smooth myometrial muscles implies the underline pathophysiology of adenomyosis, (c and d) lesion of mixed echogenicity, observed in the posterior uterine wall, could be attributed to the existence of malignancy; identification of minimal vascularity pattern cancels the probability of malignancy and introduces the possibility of underline adenomyosis in the differential diagnosis, (e and f) 4D appearance of thickened endometrial cavity; the woman underwent hysteroscopic excision of polyp 6 months ago; hydrosonegography enhanced by 4D software revealed protrusion of myometrium in the endometrial that could be attributed to iatrogenic cause of adenomyosis

Fig. 4B: (a) 3D presentation of an intramural myoma that it seems to occupy the whole uterine wall, (b) working on 3D images, endometrial cavity was revealed, (c) 4D application showed the whole endometrial cavity in close relationship to the intramural myoma, (d and e) similar case of an intramural posterior myoma; its position was clearly seen via 4D application

Fig. 4C: Predominance of the blue color was observed in the region occupied by the intramural myoma; while prevalence of the red color was saw in the nearby region of uterine wall, probably affected by adenomyosis

Figs 5A to I: 3D and 4D ultrasound examination. Case I: Woman, 28-year-old, primary infertility; lesion of mixed echogenicity (A), highly vascularized (B) localized on the anterior uterine wall probably affecting the endometrium (C); enhance hydrosonography and 3D/4D application failed to distend the endometrial lips (D and E); the histological report by two investigators was completely different, one suggesting that it is a stromal endometrial sarcoma of low malignancy, while the other one supported that this lesion is a cellular leiomyoma, Case II: Woman, 39-year-old, secondary infertility; similar images obtained during equal methodology; (F) lesion of mixed echogenicity; (G) highly vascularized; (H and I) enhance hydrosonography and 3D/4D application failed to distend the endometrial lips histological report recorded the presence of placenta and trophoblastic tissue without any sign of malignancy

Endometriosis

It represents a pathological procedure that enters considerably (20-48%) in the subfertile pathophysiology.²⁸ The majority of the endometriotic lesions (88%) are identified in the ovary. The decision of their surgical excision is crucial. It has been shown that the percentage of ovarian failure after surgical intervention is not negligible.²⁹

Transvaginal ultrasound constitutes an accurate method (sensitivity and specificity around 98%) for the diagnosis of endometriomas.³⁰⁻³³ Hard and soft markers enhance the diagnostic capacity as well as the safe follow-up of the disease.³⁴⁻³⁶

Endometriosis, in 3D images, may appear as unilocular cyst, with thick septum, ground glass echogenicity and sparse wall vascularity (Fig. 7A).

Hyperechogenic foci in the cyst wall are not so infrequent but also not always innocuous (Fig. 7B). Patel et al (1999)³⁷ suggested that unilocular cysts, of low

echogenicity with hyperechogenic areas in their walls show a 63-fold increased possibility of malignancy and demand more detailed and careful examination. Identification of papillary projections, transforming the regular wall of endometriotic cysts to irregular, implies the possibility of covered malignancy.^{38,39}

Ovarian endometriosis during transvaginal sonography may also look like bilocular cysts of double echogenicity, where an invisible septum orientates two discrete foci (Fig. 7C).

Unilocular cysts of low echogenicity could imply the diagnosis of endometriosis but also multilocular cysts with thick septum with/without ground glass appearance which could also be endometriotic masses (Fig. 7D).

The presence of adhesions to the pelvis may indirectly indicate the existence of underlining pathophysiology of endometriosis. These could be identified directly during transvaginal examination as fine, hyperechogenic strains

Fig. 6: Presentation and calculation simultaneously of the stimulated follicles during ovulation induction

Fig. 7A: Typical images of endometrioma during 3D ultrasound procedure; it appears as a unilocular cyst with regular cyst wall, ground glass echogenicity and low-grade vascularity

Fig. 7B: Endometrioma showing irregular cyst wall during 2D ultrasound examination. (a) in 3D images, hyperechogenic papillary projections are obvious, (b) the absence of these features in the e plane during niche mode application, (c to e) proved the nonsolid nature of the projections, indicating the presence of normal blood clots on the cyst wall

Fig. 7C: Two different cases of double echogenicity endometriomas

or indirectly through the observation of a nailed uterus that does not follow the movements of the probe and/or ear sign of the uterus. In addition, the observation of kissing ovaries supports the diagnosis of the existence of adhesions (Fig. 7E).

Furthermore, through transvaginal ultrasound, the existence of deep nodes of endometriosis is investigated.

These are mainly hypogenic structures with irregular borders that remain stable despite the movements of the probe. The uterosacral ligament is the driver point to explore the rectovaginal space, where deep nodes are usually situated. The whole examination is based on the reaction of the patient. The symptom of pain of various degrees indicates the possible existence of deep node.⁴⁰

Fig. 7D: 'Atypical' endometriomas during 3D ultrasound; (a) unilocular cyst of low level echogenicity, (b) bilocular of ground glass echogenicity mass, (c) bilocular lesion of ground glass and low level echogenicity and (d) bilocular lesion, containing an endometrioma and a hemorrhagic corpus luteum

Fig. 7E: Indirect signs that imply the underlying presence of adhesions, (a) flattened endometrial cavity flexed to lower level appearing as being under a strong downward pull, (b) and (c) joined strongly ovaries (kissing ovaries)

Figs 8A to D: (A and B) Unilocular cyst, originated from the right ovary, which shows mixed echogenicity, regular cyst wall and circular pattern of vascularity; (C and D) hemorrhagic ovarian lesion that shows similar pattern in both 3D and 4D images

Transrectal ultrasound obtains more clear images of deep small endometriotic implants including rectum and parametrium in the examination. It seems that this option of ultrasound examination shows increased sensitivity and specificity as compared to MRI findings, avoiding the rectum peristalsis and its produced bias notably in the sigmoid and ileocecal junction areas.^{41,42}

Application in the daily praxis of 3D software and especially niche mode and TUI, offers the possibility to describe in greater detail the extent of the endometriotic implant in the rectovaginal septum and the relationship with the rectosigmoid junction or ureter.⁴³

Hemorrhagic Cysts

Ovarian lesions characterized by mixed echogenicity predominantly in both 2D and 3D ultrasound method. Low echogenicity may also be observed. High vascularity pattern may be appeared surrounding the cyst (ring of the foyer). Regarding the diagnostic accuracy, the real-time ultrasonography (2D and 4D) seems to be superior as compared to 3D static image (Figs 8A to D). The main diagnostic point of these masses is the combination of firstly the appearance of movements of the internal contents of the cyst that follow the smooth movements of the probe and secondary the absence of any feeling of pain of the examined patient.

Teratomas and Dermoid Cysts

They represent the 15 to 20% of germ cell tumors, apparent more frequently in young women. In the majority of the

cases, they are characterized by mixed echogenicity while the observation of a clear image of Rokitansky node is not a rare condition. In some cases they show a uniformly dotted morphology, provoking problems in the differential diagnosis from endometriosis. The accurate characterization of a mass as endometriotic or teratoma is crucial because the two entities demand differentiated therapeutic approach. The absence of vascularity, the diffuse borders of the mass without a specific surrounded cyst wall consist ultrasonographic remarks that help the investigator to discriminate the teratoma from an endometriotic cyst. Additionally, the absence of acousting streaming and/or movements of the internal contents following the movements of the probe in combination to the absence of any reaction from the patients are supporting findings of the diagnosis of teratomas (Figs 9A to D). The size of the lesion >5 cm recommends surgical excision because they are not responsive to hormonal therapy and their biologic behavior leads to increase of the dimensions of the mass complicating the achievement of pregnancy that consist the main target of the woman in the ART protocols.^{30,44}

Serous Cystadenomas

Unilocular ovarian cysts, presenting ultrasonographic characteristics that support the benign nature of the lesion are not rare in premenopausal women (Figs 10A to E). An unresponsive pattern of the cyst, meaning without alteration and/or increase in size, after 6 months hormonal therapy indicates the nonfunctional nature of the mass and leads

Figs 9A to D: 3D images presenting in: (A and B) A teratoma of mixed echogenicity and minimal vascularity, observed in the outer margin of the cyst; (C) a dermoid cyst of low diffused dotted echogenicity easily dispersed to endometriotic lesion; (D) mature cystic teratoma without specific borders and clear appearance of centrally located Rokitansky node

Figs 10A to E: 3D images obtained during ultrasonographic examination of a patient, 31 years old, asymptomatic reporting primary infertility. (A) Shows a unilocular cyst, anechoic with regular cyst wall, (B) the TUI software confirmed the regularity of the cyst wall and the absence of any internal content, (C, D and E) the ground plan of the lesion in three different axes is shown

Figs 11A to F: (A) 3D and 4D images presenting a case of hydrosalpinx, where a sausage-like structure with irregular cyst wall is observed, (B) an incomplete septum appears with high clarity, (C) four cases of abscess; these lesions may appear as a multilocular cyst of low echogenicity, thick irregular septum (>3 mm), papillary projections and irregular cyst wall, (D) unilocular cyst showing low echogenicity and extremely thick wall, (E) multilocular solid mass with regular thick septum (>3 mm) and low echogenicity, (F) finally as a solid structure with extremely high vascularization pattern

obligatory to its surgical excision. Very often, it results to the histological diagnosis of ovarian serous cystadenoma.

Infections

It is really often to diagnose hydrosalpinx in young women. It appears as a sausage-like structure with irregular cyst wall and obvious incomplete septum in 3D and 4D ultrasound (Figs 11A to F). Especially, the 4D-real-time investigation of the lesion leads to the achievement of real-time images

of the tubular (burgeoning-swollen) tube as well as the internal septum. The severe inflammatory process (abscess) may be more 'impressive' regarding the clinical situation and the ultrasonographic findings. It can be marked by high fever, abdominal sensitivity and/or pain during gynecological examination in combination with complex ultrasound pictures of ovarian lesions (mixed echogenicity, solid parts, irregular cyst wall and excessive vascularization pattern; Figs 11A to F). All these symptoms and signs that

indicate the inflammation subside progressively by the issuing of antibiotic therapy.

FUNCTIONAL PROFILE OF THE TUBES

Ultrasound method using contrast agents represents a restively new tool in the diagnostic process concerning the evaluation of the patency of the tubes as well as the confirmation of the various anatomical defects observed by 3D and 4D software.⁴⁵⁻⁴⁷

In our department, 26 subfertile women underwent ultrasound examination by issuing of a contrast agent. Detailed personal history was obtained; reports of previous

exams were recorded; gold standard was the report of the hysterosalpingography. Ultrasound (3D, 4D) was performed and it was repeated with a contrast agent. At the end of the whole procedure (mean duration 15 minutes, ultrasound with contrast agent <2 minutes) women were asked to fill in a visual analog scale, the feeling of 'pain' during the ultrasound examination and the feeling of 'pain' during hysterosalpingography.

No significant difference was observed comparing the ultrasonographic results to hysterosalpingography reports regarding the pattern of tubal patency (Fig. 12A).

Fig. 12A: (a) woman 37 years old, primary infertility; ultrasound report: Impossible appearance of the lower part of the body of the uterus, patent tubes; hysterosalpingography report: Irregular borders and not obvious lower part of the uterus, patent tubes, (b) woman 35 years old, primary infertility; ultrasound report: Normal anatomical pattern of the uterus, nonpatent tube on the left; hysterosalpingography report: patent right tube. Besides, the application of the 3D and 4D software allowed us through the shading of the structure of the whole tube, the evaluation of their morphology, the regularity or the irregularity of their sequence, their cool mobility or in the contrary their fixation because of the underline adhesions (Fig. 12B). All these details, easily and directly obtained during this way of ultrasound examination could not be observed during 2D ultrasound methods

Fig. 12B: Woman, 38 years old, secondary infertility; (a) normal presentation of the body of the uterus and the cervix; complete shading of the tube on the left; probably barrier on the right tube, (b) rotation of the image along the Z axis permits the shading of the whole right tube. The final report included: patent both tubes. Woman, 39 years old, secondary infertility, (c) normal triple-layer endometrium in 3D image, (d) not clearly defined right horn during 4D ultrasound examination, (e) ultrasound report after contrast agent issuing: Incomplete shading of both tubes, presenting a beaded-like path, indicating obstruction of the contrast agent passage because of underline adhesions; hysterosalpingography report: Fixed tubes without diffusion of liquid in the retroperitoneal space

Fig. 12C: Woman, 36 years old, primary infertility, (a) incomplete shading of the endometrial cavity during issuing of contrast agent and ultrasound examination, (b) 3D clear appearance of endometrial polyp, (c) woman 37 years old, secondary infertility; arcuatus appearance of the uterus, possible intramural myoma nearby the right horn, patent struggle tubes showing beaded-like path

Besides, the application of the 3D and 4D software allowed us through the shading of the structure of the whole tube, the evaluation of their morphology, the regularity or the irregularity of their sequence, their cool mobility or in the contrary their fixation because of the underline adhesions (Fig. 12B). All these details, easily and directly obtained during this way of ultrasound examination could not be observed during 2D ultrasound methods.

Finally, the passage of the contrast agent through the body of the uterus may reveal possible structural defects concerning the body of the uterus, such as polyps or myomas (Fig. 12C).

A statistically significant difference was observed concerning the differentiation of the feeling of pain comparing the recorded subjective impression of the patients (Fig. 13).

Applying the graphic patterns of the patients to (%) percentage, we have established that the feeling of pain was limited to a mere 18% during ultrasound examination, while

it surged considerably to 79% during hysterosalpingography. Thus, in the absence of pain as well as the avoidance of radiation exposure of the patients, the use of contrast agent in subfertile patients in enhancing the diagnostical efficiency of the specialized ultrasound method, seems to have certain advantages compared to the widely used hysterosalpingography.

CONCLUSION

Based on our experience, we strongly suggest that the introduction in the daily clinical praxis of the enhanced ultrasound method, meaning 3D and 4D ultrasonography, transforms the ultrasound in the main diagnostic tool even in inexperienced hands. It allows directly to evaluate and to diagnose through quite clear images possible anatomical defects of the female genital tract. Simultaneously, it provides the possibility to investigate the functional profile of the tubes and their relationship to the nearby structures in the pelvis without pain and without radiation. The latter was impossible in the conventional ultrasound examination. This method demands only a short period of training for the doctors in order to become familiar to the technical points and availability.

It is noteworthy to underline that damages that could imply the possibility of malignancy should be referred to more experienced doctors whose specialty is focused on ultrasound examination.

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Fig. 13: 3D mesh plot presentation of the feeling of pain recorded by the women during ultrasound and hysterosalpingography examination. Significantly, lower disturbance has been observed during ultrasound examination as compared to hysterosalpingography

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