Three-Dimensional Ultrasound for Routine Check-Up in In Vitro Fertilization Patients

Erden Radončić, Biserka Funduk-Kurjak

Modern Medical Center, Zagreb, Croatia

Aim. To determine whether three-dimensional ultrasound (3D US) improves diagnosis in patients undergoing in vitro fertilization (IVF).

Methods. Three-dimensional and power Doppler ultrasound were used in examination of 267 patients undergoing IVF on their first visit, during ovulation induction and aspiration of the oocytes. Patients with suspected uterine anomalies and/or abnormalities of the endometrium (N = 108) were treated by operative hysteroscopy. On the day of oocyte collection, multiplanar imaging and 3D reconstruction demonstrated cumulus greater than 15 mm. Cumulus assessment in side the ovarian follicles was correlated to the number of mature oocytes. Power Doppler examination was performed when superposing vessels did not allow the puncture needle to be introduced correctly.

Results. The diagnosis was correct in all cases of endometrial polyp, submucous myoma, arcuate uteri, and septate uteri, as confirmed by an office hysteroscopy. Intracanine synechiae was correctly diagnosed preoperatively in one out of the four cases. The mean (±SD) number of follicles >18 mm was 8.2 ± 5.8, and the total number of follicles in all three planes was 6.4 ± 5.1. The ratio cumulus/retrieved oocytes, cumulus/fertilized oocytes, and cumulus/mature oocytes was 6.2 ± 4.2, 5.4 ± 2.8, and 5.9 ± 2.6, respectively.

Conclusion. 3D US improved recognition of the uterine anatomy, characterization of the surface features, and morphologic and functional evaluation of the anatomical structures of the inner reproductive organs, thus avoiding the need of invasive diagnostic procedures. Puncturing procedures, such as oocyte collection, can be more precisely performed.

Key words: Doppler ultrasonography, color; fertilization in vitro; hysteroscopy; oocytes; ovulation in duction; test-tube fertilization

The assessment of the overall structural details of the inner reproductive organs with conventional two-dimensional ultrasonography is often difficult and time consuming. Since the introduction of three-dimensional (3D) ultrasonography in clinical practice, particularly in gynecology and obstetrics, the detailed and accurate examination of female pelvis has become feasible (1-4). Preliminary clinical reports indicate that this newly developed technique could be suitable for evaluating complex structures and applicable in a routine check-up. Recently, several investigators reported advantages of 3D ultrasound imaging over 2D ultrasonography in evaluating infertility patients undergoing in vitro fertilization (IVF) procedures. Diagnostic capabilities of 3D ultrasound simplify the diagnostic algorithms in evaluation of infertile couples and allow for advanced invasive procedures (5-8).

The aim of this study was to evaluate a routine use of 3D ultrasonography in infertile patients for various infertility diagnostics and treatment procedures.

Patients and Methods

Between January 1999 and March 2000, 267 patients undergoing infertility treatment in our Center were evaluated by 3D ultrasound. The study was focused on the patients under 40 years of age undergoing IVF and intracytoplasmic sperm injection (ICSI) treatment, with serum concentration of follicular stimulating hormone (FSH) in early follicular phase up to 10 IU/L.

All patients underwent color Doppler ultrasound examination for assessment of the uterine and ovarian morphology and cervical status in the mid-luteal phase of the spontaneous cycle.

An office hysteroscopy was performed routinely in all the patients with suspected uterine abnormalities (N = 108) at least two months before starting with ovulation drugs ad min-
is traction. All the hysteroscopic procedures were documented by video tape recordings. Prior to ovulation in duction, a standard regime of the gonadotrophin-releasing hormone agonist (GnRHa), Buserelin (Suprefact, Hoechst Marion Rusel, Frankfurt, Germany), was administered cs. at daily doses of 500 μg, start ing in the mid-luteal phase of the cycle. After the confirmation of pituitary down-regulation (E2<50 pg/mL, endometrial thickness <5mm, and no ovarian cyst >2 cm), ovarian stimulation with human menopausal gonadotrophin (hMG, Pergonal, Serono, Ger many) in step-down age-dependent starting doses was commenced. All patients un der went serial ultrasound examinations to assess follicular growth until at least three follicles with a mean di ameter of 18 mm were seen. At this stage, 10,000 IU of human chorionic gonadotrophin (hCG, Profasi, Serono, Ger many) were used to trig ger the final maturation of oocytes.

A transvaginal ultrasound scanning was performed in all cases by use of an elec tronic 7.5 MHz transducer with 3D facility (Kretz Combison 530D Voluson, Kretztechnik Medison, Zipf, Aus tria). Live 3D and niche mode were used di ning applied, when clear uter i ne anatomy could not be obtained by multiplanar imaging. After an accurate longitudinal view of the uterus and/or adnexa was obtained, 3D scanning and reconstruction of three perpendicular planes was performed. The exact visualization of the follicles with cumulus oophor us was performed. Only these follicles were as pi rated in the first step. After the aspiration had been completed, an embryologist identified and separated these oocytes from those in which cumulus was not visualized. Live 3D ap pli ca tion was used for a precise introduction of the aspiration needle in order to avoid mechanical damage of the cumulus. Movements of the probe were minimized, and fast or mid-volume ac quisition settings were activated.

Oocytes were collected with a 3D transvaginal ultrasound-directed follicular aspiration. Up to 3 high-quality embryos were transferred 48-72 hours after the ovocyte collection. At that time, progesterone vaginal suppositories (300 mg for 14 days) were prescribed. Pregnancy was defined as the expected time of pe riod.

All the patients consented to participate in the study and were in formed that the procedure can be delayed due to ap pli ca tion of the new tech nique.

Results

A total of 267 patients (mean age 32.4 and mean duration of infertility 3.7 years) were analyzed. Male factor and tubal disease were the most common causes of infertility, respectively (Table 1).

During the first check-up, a uterine abnormality was suspected in 108 women (40.4%) and an office hysteroscopy con firmed the finding. The results of hysteroscopy are shown in Table 2. The most common abnormality was septate uterus (87.9%), correctly diagnosed in all cases. Arcuate uterus was suspected in only one case and the finding was proved by hysteroscopy. Three submucous leiomyomas and five endometrial polyps were correctly diagnosed by 3D ultrasound, and treated by operative hysteroscopy. Interestingly, 3 patients with intruterine synechia were not correctly diagnosed preoperatively.

The characteristics of stimulated cycles are shown in Table 3. Mature oocytes were obtained in most cases with visible cumulus. The fertilization rate was 5.4±2.6 oocytes per cycle and the mean number of transferred embryos was 2.8±1.8.

In 11 pa tients (4.1%), a live 3D was performed to avoid a tortuous hydrosalpinx surrounding the stimulated ovaries, and in 4 of these cases (1.4%) a 3D reconstruction of the superposing vessels was performed during the follicular aspiration procedure. The oocyte retrieval was not successful in only one case due to severe postinflammatory changes of the adnexa.

Discussion

Three-dimensional ultrasonography, which generally provides a clearer and more comprehensive view of complex intra-abdominal/pelvic structures than conventional ultrasonography does, has the potential to facilitate the routine management of infertility patients. After a short training period, three-dimensional assessment of a defined region of interest requires less time than a two-dimensional examination. There are several advantages of three-dimensional imaging over two-dimensional imaging to be clearly pointed out: (i) the ability to have multiplanar views of anatomy or pathologic features; (ii) the images can be

### Table 1. Characteristics of the infertility patients enrolled in the study

<table>
<thead>
<tr>
<th>Cause of infertility</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male factor</td>
<td>122 (45.7)</td>
</tr>
<tr>
<td>Tubal disease</td>
<td>87 (32.6)</td>
</tr>
<tr>
<td>Endometriosis</td>
<td>34 (12.7)</td>
</tr>
<tr>
<td>Unexplained</td>
<td>24 (9.0)</td>
</tr>
<tr>
<td>Uterine abnormalities</td>
<td>108 (40.4)</td>
</tr>
<tr>
<td>Total</td>
<td>267 (100.0)</td>
</tr>
</tbody>
</table>

### Table 2. The comparison of preoperative 3D ultrasound (US) and intraoperative hysteroscopy of diagnosed abnormalities

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Preoperative 3D US</th>
<th>Hysteroscopy No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endometrial polyph</td>
<td>5 (4.8)</td>
<td>5 (100.0)</td>
</tr>
<tr>
<td>Intrauterine synechia</td>
<td>1 (0.9)</td>
<td>4 (25.0)</td>
</tr>
<tr>
<td>Submucous myoma</td>
<td>3 (2.8)</td>
<td>3 (100.0)</td>
</tr>
<tr>
<td>Arcuate uteri</td>
<td>1 (0.9)</td>
<td>1 (100.0)</td>
</tr>
<tr>
<td>Septate uterus</td>
<td>95 (90.4)</td>
<td>95 (100.0)</td>
</tr>
<tr>
<td>Total</td>
<td>105 (100.0)</td>
<td>108 (100.0)</td>
</tr>
</tbody>
</table>

* Sensitivity of 3D US.

### Table 3. Characteristics of ovarian response in the study patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of stimulation (days)</td>
<td>11.2 (7.5-16.7)</td>
</tr>
<tr>
<td>Number of hMG ampules</td>
<td>32.2 (21.5-48.3)</td>
</tr>
<tr>
<td>Total number of the follicles &gt;18 mm</td>
<td>8.2 (5.8-17.8)</td>
</tr>
<tr>
<td>Total number of follicles with cumulus oophor us</td>
<td>6.4 (5.1-12.3)</td>
</tr>
<tr>
<td>Cumuli/retrieved oocytes</td>
<td>6.2 (4.2-14.5)</td>
</tr>
<tr>
<td>Cumuli/fertilized oocytes</td>
<td>5.4 (2.8-10.3)</td>
</tr>
<tr>
<td>Cumuli/mature oocytes</td>
<td>5.9 (2.6-10.8)</td>
</tr>
<tr>
<td>Number of transferred embryos</td>
<td>2.8 (1.8-4.3)</td>
</tr>
</tbody>
</table>
viewed later from the angles not seen initially in the presence of a patient; (iii) the automatic multiplanar analysis allows visualization from the coronal view of the examined structures (9-11). This is especially important in the assessment of the coronal plane of the uterus/endometrium, which is impossible to perform on 2D machines even for the most skilled examiner (9).

In the past, the so-called minor uterine abnormality was not thought to have a significant influence on woman’s reproductive potential. Recently published articles (12) concluded that even subtle anomalies of the uterine cavity could be a serious additional factor in combination with other known causes of infertility. Thus, a precise, cost-effective, and minimally invasive diagnostics is very helpful in anoma lies and their safe and easy treatment in a one-day surgery manner (13).

Several authors concluded that uterine anomalies are associated with complications in pregnancy and lower rate of embryo implantation (14). However, there is no consensus whether all detected anomalies should be corrected or should our treatment be directed at those who have already experienced pregnancy wastage. How these minor uterine abnormalities affect the implantation rate is still disputable, although some published data suggest that surgical treatment has a beneficial influence in majority of the cases (15,16).

In 12 out of 42 patients with Müllerian anomalies undergoing IVF procedures, Raga et al (17) found an excellent correlation between three-dimensional ultrasound findings and hysterosalpingography findings. In 91.6% of the cases, the external uterine configuration observed by laparoscopy was also correctly diagnosed. They advocated this technique as reliable in an office setting for diagnosing and classifying Müllerian anomalies (17). Similarly, Wu et al (18) demonstrated all congenital uterine abnormalities with a 100% sensitivity and specificity. Moreover, in their series, a septate uterus was diagnosed in 11 of 12 such cases (92%), and bicornuate uterus in 3 patients with that anomaly. These two abnormalities are commonly confused with both hysterosalpingography and/or conventional sonography, but not with 3D US (9).

The main advantage of 3D ultrasound over other diagnostic modalities is that all the relevant information about uterine morphology is obtained quickly and safely in a non-invasive way. Our data support that the three-dimensional approach is safe, non-invasive, and accurate, and should be the first method in detecting all the suspected uterine abnormalities routine practice. The important exception is the suspected intrauterine synechiae, known to be very difficult to visualize without an invasive procedure. In our series, despite a high specificity in cases of major uterine anomalies (Table 2), the diagnosis in 3 ultrasonically unsuspected cases of intrauterine synechiae was made by office hysteroscopy.

Multiplanar analysis of the stimulated ovaries proves the diagnosis of the interuterine synechiae, and allows visualization from the coronal view of the examined structures (9-11). This is especially important in the assessment of the coronal plane of the uterus/endometrium, which is impossible to perform on 2D machines even for the most skilled examiner (9).

In the past, the so-called minor uterine abnormality was not thought to have a significant influence on woman’s reproductive potential. Recently published articles (12) concluded that even subtle anomalies of the uterine cavity could be a serious additional factor in combination with other known causes of infertility. Thus, a precise, cost-effective, and minimally invasive diagnostics is very helpful in anoma lies and their safe and easy treatment in a one-day surgery manner (13).

Several authors concluded that uterine anomalies are associated with complications in pregnancy and lower rate of embryo implantation (14). However, there is no consensus whether all detected anomalies should be corrected or should our treatment be directed at those who have already experienced pregnancy wastage. How these minor uterine abnormalities affect the implantation rate is still disputable, although some published data suggest that surgical treatment has a beneficial influence in majority of the cases (15,16).

In 12 out of 42 patients with Müllerian anomalies undergoing IVF procedures, Raga et al (17) found an excellent correlation between three-dimensional ultrasound findings and hysterosalpingography findings. In 91.6% of the cases, the external uterine configuration observed by laparoscopy was also correctly diagnosed. They advocated this technique as reliable in an office setting for diagnosing and classifying Müllerian anomalies (17). Similarly, Wu et al (18) demonstrated all congenital uterine abnormalities with a 100% sensitivity and specificity. Moreover, in their series, a septate uterus was diagnosed in 11 of 12 such cases (92%), and bicornuate uterus in 3 patients with that anomaly. These two abnormalities are commonly confused with both hysterosalpingography and/or conventional sonography, but not with 3D US (9).

The main advantage of 3D ultrasound over other diagnostic modalities is that all the relevant information about uterine morphology is obtained quickly and safely in a non-invasive way. Our data support that the three-dimensional approach is safe, non-invasive, and accurate, and should be the first method in detecting all the suspected uterine abnormalities routine practice. The important exception is the suspected intrauterine synechiae, known to be very difficult to visualize without an invasive procedure. In our series, despite a high specificity in cases of major uterine anomalies (Table 2), the diagnosis in 3 ultrasonically unsuspected cases of intrauterine synechiae was made by office hysteroscopy.

Multiplanar analysis of the stimulated ovaries proves the diagnosis of the interuterine synechiae, and allows visualization from the coronal view of the examined structures (9-11). This is especially important in the assessment of the coronal plane of the uterus/endometrium, which is impossible to perform on 2D machines even for the most skilled examiner (9).

In the past, the so-called minor uterine abnormality was not thought to have a significant influence on woman’s reproductive potential. Recently published articles (12) concluded that even subtle anomalies of the uterine cavity could be a serious additional factor in combination with other known causes of infertility. Thus, a precise, cost-effective, and minimally invasive diagnostics is very helpful in anoma lies and their safe and easy treatment in a one-day surgery manner (13).

Several authors concluded that uterine anomalies are associated with complications in pregnancy and lower rate of embryo implantation (14). However, there is no consensus whether all detected anomalies should be corrected or should our treatment be directed at those who have already experienced pregnancy wastage. How these minor uterine abnormalities affect the implantation rate is still disputable, although some published data suggest that surgical treatment has a beneficial influence in majority of the cases (15,16).

In 12 out of 42 patients with Müllerian anomalies undergoing IVF procedures, Raga et al (17) found an excellent correlation between three-dimensional ultrasound findings and hysterosalpingography findings. In 91.6% of the cases, the external uterine configuration observed by laparoscopy was also correctly diagnosed. They advocated this technique as reliable in an office setting for diagnosing and classifying Müllerian anomalies (17). Similarly, Wu et al (18) demonstrated all congenital uterine abnormalities with a 100% sensitivity and specificity. Moreover, in their series, a septate uterus was diagnosed in 11 of 12 such cases (92%), and bicornuate uterus in 3 patients with that anomaly. These two abnormalities are commonly confused with both hysterosalpingography and/or conventional sonography, but not with 3D US (9).

The main advantage of 3D ultrasound over other diagnostic modalities is that all the relevant information about uterine morphology is obtained quickly and safely in a non-invasive way. Our data support that the three-dimensional approach is safe, non-invasive, and accurate, and should be the first method in detecting all the suspected uterine abnormalities routine practice. The important exception is the suspected intrauterine synechiae, known to be very difficult to visualize without an invasive procedure. In our series, despite a high specificity in cases of major uterine anomalies (Table 2), the diagnosis in 3 ultrasonically unsuspected cases of intrauterine synechiae was made by office hysteroscopy.

Multiplanar analysis of the stimulated ovaries proves the diagnosis of the interuterine synechiae, and allows visualization from the coronal view of the examined structures (9-11). This is especially important in the assessment of the coronal plane of the uterus/endometrium, which is impossible to perform on 2D machines even for the most skilled examiner (9).

In the past, the so-called minor uterine abnormality was not thought to have a significant influence on woman’s reproductive potential. Recently published articles (12) concluded that even subtle anomalies of the uterine cavity could be a serious additional factor in combination with other known causes of infertility. Thus, a precise, cost-effective, and minimally invasive diagnostics is very helpful in anoma lies and their safe and easy treatment in a one-day surgery manner (13).

Several authors concluded that uterine anomalies are associated with complications in pregnancy and lower rate of embryo implantation (14). However, there is no consensus whether all detected anomalies should be corrected or should our treatment be directed at those who have already experienced pregnancy wastage. How these minor uterine abnormalities affect the implantation rate is still disputable, although some published data suggest that surgical treatment has a beneficial influence in majority of the cases (15,16).

In 12 out of 42 patients with Müllerian anomalies undergoing IVF procedures, Raga et al (17) found an excellent correlation between three-dimensional ultrasound findings and hysterosalpingography findings. In 91.6% of the cases, the external uterine configuration observed by laparoscopy was also correctly diagnosed. They advocated this technique as reliable in an office setting for diagnosing and classifying Müllerian anomalies (17). Similarly, Wu et al (18) demonstrated all congenital uterine abnormalities with a 100% sensitivity and specificity. Moreover, in their series, a septate uterus was diagnosed in 11 of 12 such cases (92%), and bicornuate uterus in 3 patients with that anomaly. These two abnormalities are commonly confused with both hysterosalpingography and/or conventional sonography, but not with 3D US (9).

The main advantage of 3D ultrasound over other diagnostic modalities is that all the relevant information about uterine morphology is obtained quickly and safely in a non-invasive way. Our data support that the three-dimensional approach is safe, non-invasive, and accurate, and should be the first method in detecting all the suspected uterine abnormalities routine practice. The important exception is the suspected intrauterine synechiae, known to be very difficult to visualize without an invasive procedure. In our series, despite a high specificity in cases of major uterine anomalies (Table 2), the diagnosis in 3 ultrasonically unsuspected cases of intrauterine synechiae was made by office hysteroscopy.
tic uterine follicle), live 3D mode is a very helpful and easy-to-perform method.

In our experience, 3D Doppler visualization of the superposing vessels was of great help during risky aspiration procedures of the ovaries, which are dislocated along or even behind the uterus. Using B-mode of standard equipment, the vessels (usually branches of the uterine artery) seemed superimposed and did not allow safe aspiration. However, reconstruction of the vessels by 3D Angio mode allowed more accurate spacious positioning and aspiration of the follicles. Angio mode allowed more accurate spacious positioning and aspiration of the follicles.

In conclusion, 3D ultrasonography can become a standard routine check-up of infertility patients allowing improved visualization of the uterine anatomy, characterization of the surface features, and precise depiction of the ovaries during stimulation cycles. The ability to examine the myometrium and endometrium at the same time increases diagnostic accuracy. It can enhance and facilitate the morphologic and functional evaluation of the pelvic structures, thus avoiding the need of invasive procedures. Various puncturing procedures can be performed more precisely with the built-in application of live 3D mode, and it is likely that this technique will be accepted as the gold standard.

References


Received: April 13, 2000
Accepted: May 22, 2000

Correspondence to:
Erden Radončić
Moderni medicinski centar, Zagreb
U. kralja Zvonimira 26
10000 Zagreb, Croatia
moderini-medicinski-centar@zg.tel.hr

Radončić et al: 3D Ultrasound in IVF Patients
Croat Med J 2000;41:262-265

265