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Three-dimensional power Doppler imaging in the assessment of Fallopian tube patency

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ABSTRACT

Objective *The aim of the study was to evaluate the feasibility of three-dimensional power Doppler imaging (3D-PDI) in the assessment of the patency of the Fallopian tubes during hysterosalpingo-contrast sonography (HyCoSy).*

Methods *Women attending the fertility clinic were offered a Fallopian tubal patency test as part of the initial investigation. Hysterosalpingo-contrast sonography using contrast medium Echovist was performed on 67 women. Findings on the two-dimensional (2D) gray-scale scanning and three-dimensional power Doppler imaging were compared. The first technique visualizes positive contrast in the Fallopian tube; the second demonstrates flow of medium through the tube.*

Results *Contrast medium Echovist produced prominent signals on the 3D-PDI image. Free spill from the fimbrial end of the Fallopian tubes was demonstrated in 114 (91%) tubes using the 3D-PDI technique and in 58 (46%) of tubes using conventional HyCoSy. The mean duration of the imaging procedure was less with 3D-PDI, but the operator time which included postprocedure analysis of the stored information was similar. A significantly lower volume of contrast medium (5.9 ± 0.6 mL) was used for 3D-PDI in comparison with that (11.2 ± 1.9 mL) used for conventional 2D HyCoSy.*

Conclusion *Color coded 3D-PDI with surface rendering allowed visualization of the flow of contrast through the entire tubal length and free spill of contrast was clearly identified in the majority of cases. The 3D-PDI method appeared to have advantages over the conventional HyCoSy technique, especially in terms of visualization of spill from the distal end of the tube, which was achieved twice as often with the 3D technique. Although the design of the investigation did not allow the side effects of the two techniques to be compared, the shorter duration of the imaging and lower volume of the contrast medium used suggested that the 3D-PDI technique might have a better side-effect profile. The 3D-PDI technique allowed better storage of the information for re-analysis and archiving than conventional HyCoSy.*

INTRODUCTION

Tubal disorders are thought to be responsible for up to 30% of female infertility[1]. X-ray hysterosalpingography (HSG) and laparoscopy and dye are still the most widely used methods of assessing the patency of the Fallopian tubes. Recently, various ultrasonographic contrast media have been developed for tubal visualization and have been used in the diagnosis of tubal patency or blockage[2]. Any ultrasound based technique that uses fluid as a contrast agent in the evaluation of tubal patency is called hysterosalpingo-contrast-sonography (HyCoSy).

Echo positive contrast agents have mainly been used for visualization of the flow in the Fallopian tubes and the medium that has been investigated most widely is Echovist (Shering AG, Germany), which is a suspension of galactose microparticles in aqueous galactose solution. HyCoSy can be performed as an outpatient procedure and can be incorporated into the initial scan (pivotal scan) used to investigate subfertile patients[3–6]. The aim of HyCoSy therefore is to visualize both tubal ostia and to demonstrate the flow of ultrasound contrast medium in the Fallopian tubes.

However, a number of difficulties are encountered with the standard two-dimensional (2D) gray-scale HyCoSy technique. First, the Fallopian tube cannot be seen completely in any scanning plane and visualization of the entire tube happens only on rare occasions. Furthermore, spill of the echo positive medium from the fimbrial end of the tube is difficult to distinguish from bowel surrounding the Fallopian tube, which is of similar echogenicity.

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Consequently, only the proximal parts of the tubes then can be visualized with certainty. Third, even for an experienced sonographer, the learning curve for the HyCoSy procedure is considerable in view of the requirement to quickly manipulate the transvaginal probe in order to visualize the different parts of the tube. The whole HyCoSy procedure with visualization of both tubes has to be completed in 10 min because the homogenous milky-white suspension of Echovist loses its echogenic properties if the procedure lasts longer.

The purpose was to evaluate a modification of the HyCoSy technique by the use of other ultrasound methods, namely three-dimensional scanning and power Doppler imaging (3D-PDI) and to determine if this could overcome the problems inherent in the standard HyCoSy procedure[7].

MATERIALS AND METHODS

Sixty-seven women were attending a fertility clinic with primary infertility and required an assessment of tubal patency. The conventional 2D HyCoSy procedure is the standard method in our unit for clinical evaluation of tubal patency according to the unit's clinical protocols. The patients were counselled as to the HyCoSy procedure and a full explanation was given about an additional 3D-PDI procedure; informed consent was obtained from all patients. In all patients, the pelvic organs were examined systematically by transvaginal ultrasound, with the women in the dorsal lithotomy position. The ultrasound machine used was a Kretz Combison 530D Voluson (Kretztechnik-Medison, Zipf, Austria) with an integrated 3D imaging evaluation software package (Kretztechnik-Medison). All scans were performed by the same operator. The patients with obvious pathology of Fallopian tube (hydrosalpinges, previous surgery on the tube, etc.) were excluded from the investigation.

After evaluation of the uterus and ovaries by 2D ultrasound and color Doppler imaging, the preparations for HyCoSy were made as described elsewhere[8]. Initially, 5–10 mL of sterile saline was injected into the uterine cavity, to determine if there were any intracavitary abnormalities. The tubal assessment with a galactose microbubble positive contrast agent (Echovist-200, Schering AG, Berlin, Germany) followed immediately and gray-scale imaging of the tubes was performed[8]. Following this, the 3D-PDI was carried out. The tip of the transvaginal transducer was directed firstly to the right parametrium to visualize the tissues between the uterus and ovary. The 3D volume box was placed over this region, the power Doppler mode was then switched on and the Echovist injection was commenced; 3–5 s later the 3D-PDI volume was acquired over a period of 30–40 s. The transducer, which was kept still during this process, automatically captured the volume. Once the image volume was obtained, three mutually perpendicular image planes could be seen on the screen (Figure 1). Acquired 3D volumes were stored on a removable 540Mb hard disk cartridge (Nomai, Electronique d2, France) for later review. The analysis of stored volumes was performed after the procedure.

The way the procedure was carried out did not allow a comparison of side effects between the two techniques. However, the volume of the contrast medium used was measured for each method. In addition, the time for the imaging part of the each technique from beginning of infection to optimal visualization of each Fallopian tube was recorded.

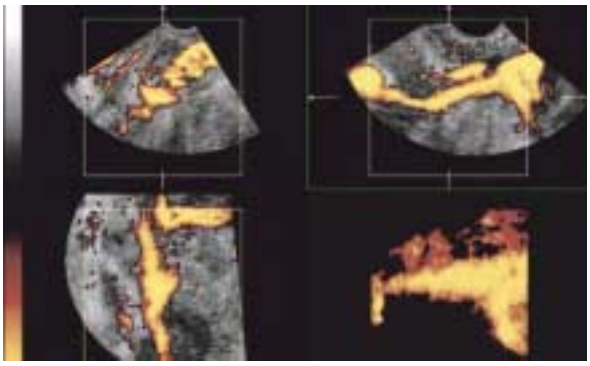

Figure 1 Three-dimensional ultrasound screen. Within the scanned volume, three matched and dynamically linked orthogonal sector planes are displayed simultaneously. The Fallopian tube's entire length, particularly the ampullar part, and free spill, are visualized. The color rendering allows further detailed assessment of the Fallopian tube.

RESULTS

All 67 women tolerated HyCoSy well and the number of side effects was similar to that normally encountered with this procedure. The side effects are summarized in Table 1.

The galactose microbubble contrast agent, Echovist, created prominent signals on PDI that were stronger, more uniform and brighter than signals from the blood vessels. Color coded 3D-PDI with surface rendering allowed visualization of the entire tube length, from the uterine cavity up to the ampullary end, and the free spill of contrast was clearly identified in the majority of the cases (Table 2; Figure 2). Because none of the included women had undergone an operation on the tubes, it was assumed that there were 134 Fallopian tubes to be investigated. In nine of these tubes, proximal filling was not identified by either technique. Because 2D conventional HyCoSy is accepted in our unit for the routine investigation of tubal patency, the results were interpreted as nine patients having a unilateral blocked Fallopian tube. Of the remaining 125

Table 1 The side effects which occured due to HyCoSy in the 67 patients examined

Side effect	*Number and percentage*
Mild pain as during menstruation	49 (73%)
Moderate or severe pain	5 (7.5%)
Nausea	6 (9%)
Vomiting	2 (3%)
Diarrhea	2 (3%)
Outbreak of sweat	2 (3%)
Hypotension	1 (1.5%)
Vaso-vagal reaction	3 (4.5%)

Table 2 Comparison of visualization between conventional 2D and 3D-PDI HyCoSy procedures

Type of HyCoSy	*Proximal part of the **right** tube**	*Distal end of the **right** tube*	*Proximal part of the **left** tube**	*Distal end of the **left** tube*
Conventional 2D ($n = 67$)	64 (95.5%)	32 (48%)	61 (91%)	26 (39%)
3D-PDI ($n = 67$)	64 (95.5%)	60 (89%)	61 (91%)	54 (80%)

*Proximal part and distal end of the Fallopian tubes were not visualized using both methods in the same patients on three occasions on the right side and on six occasions on the left side.

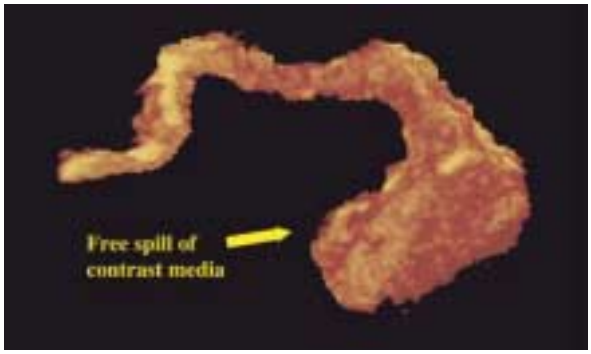

Figure 2 The color rendering of the Fallopian tube. This visualizes the entire tubal length and free spill of contrast agent at the end of tube.

Fallopian tubes, free spill from the distal end of the tube was demonstrated in 46% (58/125) with conventional HyCoSy and in 91% (114/125) with 3D-PDI.

The time spent for both procedures is summarized in Table 3. There was a significant difference in the duration of the practical procedure (i.e. injection of contrast medium and scanning). The time spent with 3D-PDI was between 5 and 7 min (5.6 ± 0.3 min), compared to approximately 10 min (10.1 ± 1.8 min) using conventional HyCoSy. However, the overall time required for the operator was similar due to the postprocedure analysis of the stored 3D-PDI information.

During the 3D-PDI volume acquisition, only 4–6 mL (5.9 ± 0.6 mL) of contrast medium Echovist was injected, while during conventional examination the volume injected was between 9 and 15 mL (11.2 ± 1.9 mL).

DISCUSSION

This investigation did not compare in terms of accuracy either the HyCoSy technique or 3D-PDI with any other method because conventional HyCoSy has previously been shown to compare well with X-ray hysterosalpingography and laparoscopy and dye in large series[9–12].

In order to assess the feasibility and potential effectiveness of 3D-PDI, we decided to perform this after conventional HyCoSy as the latter technique is routinely used in our department. We accept that ideally the study should have been carried out using both techniques as the first procedure in a randomized way. However, we do not believe that the sequence of 2D imaging followed by 3D-PDI affected the validity of our results. Although both techniques are based on the injection of a positive contrast agent (Echovist) through the cervix, they are fundamentally different in the acquisition and method of display of the ultrasound echoes and therefore are independent of each other.

Any remaining contrast medium, which still presents in the tube after conventional HyCoSy, could not affect the 3D-PDI technique because the latter method detects only flow. In order to obtain the power Doppler signals, the contrast medium has to be injected continuously with the purpose of maintaining flow during the volume acquisition irrespective of whether Fallopian tube contains or does not contain contrast medium.

Knowledge of the tubal position does not affect the time spent on 3D-PDI. During 3D information acquisition, a large volume box is placed over the adnexa from uterus to the ovary on the right and left sides consecutively. The placement of the box is standard and would not be affected by knowledge of results of a previous procedure. After placement of this volume box, the time spent is only that required for the transducer to sweep across this volume and for the observer to store the information obtained. Conventional HyCoSy is more dependent on ultrasonographer's scanning skills while 3D-PDI technique is more dependent on the ultrasound machine's settings.

Because 3D-PDI was always performed after the

Table 3 The time in minutes spent during conventional HyCoSy and with 3D-PDI (mean ± SD (range))

Time	*Conventional HyCoSy*	*3D-PDI*
Discussion with patient, explanation of the procedure	9.3 ± 2.1 (6–14)	9.3 ± 2.1 (6–14)
Catheterization, preparation of Echovist	8.1 ± 1.7 (6–15)	8.1 ± 1.7 (6–15)
Injection and scanning with/without a volume acquisition	10.1 ± 1.8 (7–12)	5.6 ± 0.3 (5–7)
Analysis of stored information	None	5.9 ± 0.9 (3–8)
Producing the report	~5 min	~5 min

conventional HyCoSy, we could not compare the side effects of the two techniques but, in view of the shorter examination time and lesser volume of the contrast agent used, these are likely to be less with the 3D technique. The side effects we encountered were similar to those published in other studies[13–15].

We believe that the technique of 3D-PDI may become an important means of diagnosing tubal patency. The conventional HyCoSy technique was introduced in the 1990s as an alternative to X-ray hysterosalpingography[16]. The advantage of HyCoSy was that it did not use ionizing radiation, had relatively few side effects, and could be performed by the infertility team as part of the initial investigation. Combined with initial sonographic examination of the 'pivotal' scan, it was believed that it could reduce the necessity for laparoscopy, and accelerate the whole investigation process. HyCoSy has not become widely popular because of certain problems, mainly concerning the performance and interpretation of the test. The tortuosity of the Fallopian tube means that it can only be visualized on conventional transvaginal sonography in segments. Frequently, only the proximal part of the tube can be seen. Furthermore, spill from the fimbrial end is frequently difficult to visualize, because the positive contrast agent is difficult to distinguish from the white echoes of the surrounding bowel. Therefore, there is frequently some doubt as to whether spill has occured and, if so, whether it is free or loculated. We believe that the new technique retains the advantages of the HyCoSy technique and, at the same time, overcomes the disadvantages. Because it is the flow of the contrast that is visualized with 3D-PDI, the tube can be identified as a color stream and the flow of contrast from the fimbrial end can be easily seen against the surrounding bowel. Most importantly, by using 3D surface rendering, the whole of the tube can be demonstrated from the uterine cavity to the fimbrial end. Three-dimensional imaging has other advantages. The volume, which includes the Fallopian tube, can be stored and analyzed later, thus cutting down the examination time for the patient. Furthermore, because the whole tube is visualized, less contrast agent is required compared to conventional HyCoSy when, because of difficulty in visualization, an excessive amount of contrast is frequently injected to achieve a diagnosis.

Of great importance was our finding that visualization of the terminal part of the tube and spill of the contrast medium into the peritoneal cavity was achieved significantly more frequently with 3D-PDI than with conventional HyCoSy.

Another major advantage is that 3D-PDI allows documentation and storage of volume information of the pelvic organs and Fallopian tubes for later review and analysis, which is complicated for conventional HyCoSy unless the whole examination is recorded on video tape, which is basically difficult on an everyday basis. To reassess the tape is time consuming, whereas digital assessment of stored ultrasound volume is reasonably fast in experienced hands.

Because this was a pilot investigation, we believe that improved results will accrue with experience. As a result, we believe this novel technique will find a place in the early investigation of the subfertile woman. We believe that the results of this observational study justify a large-scale, randomized study to compare the 3D-PDI method with laparoscopy and X-ray hysterosalpingography.

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