Saline infusion contrast intrauterine sonographic assessment of the endometrium with high-frequency, real-time miniature transducer in normal menstrual cycle: a preliminary report

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Normal endometrial texture was visualized using saline infusion contrast intrauterine sonography with a specially developed 20 MHz flexible catheter-based high-resolution, real-time miniature (2.4 mm outer diameter) ultrasound transducer in primary infertile women (n = 15) with a normal menstrual cycle. All the women had <2 years infertility duration and were studied in proliferative, and early or mid-secretory phases. Before intrauterine sonography, transvaginal sonographic assessment of the endometrium was conducted. The overall image clarity was subjectively compared between intrauterine and transvaginal sonography. Most endometrial textures in both proliferative and secretory phases were viewed more easily with intrauterine rather than transvaginal sonography, and this was especially true with an intrauterine saline infusion technique. Moreover, it was possible to obtain finer image quality of very small endometrial interfacial and internal textures with intrauterine sonography. However, the depth of penetration of the ultrasound beam is only ~2 cm, therefore examination of larger pathological endometrial lesions is markedly limited because of the shallow scanning range of the high-frequency transducer. Intrauterine sonography may be a valuable tool in imaging endometrial texture in normal menstrual cycle, and possibly in infertility practice, complementing and not replacing transvaginal sonography.

Key words: endometrium/high-frequency, real-time miniature transducer/normal menstrual cycle/saline infusion contrast intrauterine sonography/transvaginal sonography

Introduction

As a consequence of improvements in ultrasound technology and with the advent of transvaginal sonography, visualization and appreciation of normal endometrium allow menstrual cyclic changes to be assessed especially in infertile women (Doherty et al., 1993). Moreover, the technique of saline contrast hysterosonography makes evaluation of the endometrial interface with abnormal lesions possible (Cullinan et al., 1995). However, Li et al. (1992) suggested that it is unlikely that sonographic measurement of endometrial thickness can replace histological examination of the endometrium in the evaluation of the luteal phase. Grunfeld et al. (1991) reported that transvaginal sonography demonstrates a sensitivity of 100%, and a specificity of 62% for the detection of histologically normal endometrial development.

With recent advances in miniaturization of the ultrasound transducer, Goldberg et al. (1991) showed the feasibility of passing flexible catheter-based high-resolution real-time ultrasound transducers into the endometrial canal and Fallopian tube to examine uterine abnormalities. Potential obstetric and gynaecological applications of intrauterine sonography for systematic examination of the developmental stages of the early embryo or detection of gross embryonic malformations have also been reported (Fujiwaki et al., 1995; Kikuchi et al., 1995, 1996; Tsuda et al., 1996; Hata, 1996; Hata et al., 1996, 1997a,b, 1998; Senoh et al., 1999).

The objective of the current study was to determine whether saline infusion contrast intrauterine sonography with high-frequency, real-time miniature transducer is useful for the evaluation of cyclic changes of the endometrial interface and texture during a normal menstrual cycle.

Materials and methods

Fifteen women with idiopathic infertility of <2 years duration and a normal menstrual cycle were studied with a specially developed flexible catheter-based, high-resolution, real-time miniature (2.4 mm in outer diameter) ultrasonography transducer [20 MHz (Aloka AMP-PN20-08L®; Aloka, Tokyo, Japan)]. In each patient, serum oestradiol and progesterone concentrations were within normal limits, and neither endometrial nor uterine disorders were recognized. The depth of penetration of the ultrasound beam was ~2 cm. This ultrasonic catheter was connected to an ultrasound device (Aloka SSD-550®; Aloka). A motor in the main imaging device (Aloka ASU-100®; Aloka) rotated the metal drive shaft at 900 r.p.m., resulting in a 360° real-time grey-scale image orientated perpendicularly to the long axis of the ultrasonic catheter. The study was approved by the local ethical committee of Kagawa Medical University, and standardized informed consent was obtained from each patient.

First, each patient was prepared and draped in the usual sterile fashion in the dorsolithotomy position. Before each intrauterine sonography procedure, an evaluation of the endometrium was performed by transvaginal sonography (7.5 MHz Mochida MEU-1581®; Mochida, Tokyo, Japan) with a sterile probe cover. A sterile speculum was inserted into the vagina. The ultrasonic catheter was introduced gently through the cervix and into the endometrial cavity until it could not be advanced any further. Once within the endometrial cavity, the catheter tip was advanced or withdrawn slightly until the endometrial texture was visualized. Next, after removal of the intrauterine ultrasound catheter, 1–2 ml of sterile saline solution was
injected into the endometrial cavity with a catheter for artificial insemination, to compare sonographic images with and without saline in either the transvaginal or intrauterine sonographic technique. Then transvaginal sonography and intrauterine sonography were again sequentially performed. Endometrial biopsy was performed after ultrasound examinations, using a metal curette placed high in the uterine cavity (biopsy curette, CM-5283®; Atom, Tokyo, Japan). The endometrial sample was dated by an independent senior pathologist who was blinded to any clinical information concerning the study group. The criteria of Noyes et al. (1950) were used for endometrial dating. Each procedure was done in proliferative, and early or mid-secretory phase of the menstrual cycle in each patient. Ovulation was confirmed using ultrasound and basal body temperature in all patients. After all procedures, prophylactic antibiotics were administered in all patients. The subjective assessment of overall image clarity was compared between transvaginal and intrauterine sonography. Hor-

Figure 1. Endometrium in proliferative phase (follicular day 10). Transvaginal (a) and intrauterine sonograms (b) before intrauterine saline infusion; transvaginal (c) and intrauterine sonograms (d) after intrauterine saline infusion. Endometrium basalis (arrow heads); endometrium functionalis (*); L, lumen; M, myometrium; S, serosa; C, catheter.

Figure 2. Endometrium in secretory phase (luteal day +4). Transvaginal (a) and intrauterine sonograms (b) before intrauterine saline infusion; transvaginal (c) and intrauterine sonograms (d) after intrauterine saline infusion. Endometrium basalis (arrow heads); endometrium functionalis (*); L, lumen; M, myometrium; C, catheter.
Endometrium in secretory phase (luteal day 15).
Intrauterine (a) and transvaginal sonograms (b). A small vesicle (V) is clearly depicted only by means of intrauterine sonography. Endometrium basalis (arrow heads); endometrium functionalis (*); L, lumen; M, myometrium; S, serosa; C, catheter.

monal measurements such as oestradiol and progesterone were also performed at each examination in each patient.

Results

Neither cervical dilatation nor anaesthesia was required, and the probe could be easily introduced through the cervix into the endometrial cavity in all patients. No notable complications (e.g. bleeding, perforation, etc.) were encountered.

Most endometrial textures in both proliferative and secretory phases were easier to view with intrauterine rather than transvaginal sonography, and this was especially true with an intrauterine saline infusion technique. Moreover, it was possible to obtain finer image quality of very small endometrial interfacial and internal textures with intrauterine sonography than with transvaginal sonography. In proliferative phase (10.7 ± 1.4 days) (oestradiol, 130.9 ± 41.8 pg/ml; progesterone, 0.61 ± 0.19 ng/ml), endometrium appeared as a leaflet pattern with hypo-echoic functionalis surrounded by minimal hyperechoic basalis and echogenic endometrial interface by transvaginal sonography (Figure 1a); intrauterine sonography showed anterior and posterior endometrial layers with different echogenicity that demonstrated the smooth interface of the endometrium (Figure 1b). After intrauterine saline infusion, the smooth interface of the lumen was visualized with both transvaginal and intrauterine images, but intrauterine sonography depicted it more clearly and finely than transvaginal sonography (Figure 1c,d). In secretory phase (18.9 ± 1.2 days) (oestradiol, 142.1 ± 34.7 pg/ml; progesterone, 14.33 ± 8.27 ng/ml), the endometrial layer appeared as a totally hyperechoic pattern using transvaginal sonography, and the interface of the endometrium could not be distinguished by transvaginal sonography because echogenicity of both anterior and posterior wall endometrium was the same (Figure 2a). Intrauterine sonography characterized anterior and posterior endometrial layers as different echogenic patterns with slightly irregular interface of the endometrium (Figure 2b). Under 1–2 ml of intrauterine saline infusion, the irregular endometrial interface was more evident than before infusion by intrauterine sonography (Figure 2c), but not by transvaginal sonography (Figure 2d). A few small vesicles in the endometrial layer were clearly visualized in secretory phase by means of intrauterine sonography in six patients (40%) (Figure 3a), but not visualized using transvaginal sonography (Figure 3b). In this study, endometrial dating was closely related to menstrual dating in all examinations.

Discussion

Where transvaginal sonography has been used in infertility practice, characteristic sonographic patterns of endometrial cyclic changes have been classified in spontaneous normal cycles (Doherty et al., 1993), and hormonal therapeutic effects have been assessed by the evaluation of endometrial patterns and the measurement of endometrial thickness (Khalifa et al., 1992). Moreover, the intrauterine saline infusion technique under transvaginal sonographic examination was shown to enhance visualization of the endometrial texture, and it revealed pathological lesions on the endometrial interface (Cullinan et al., 1995). Saline contrast hysterosonographic assessment of endometrial abnormality is as accurate and well tolerated as hysteroscopy (Widrich et al., 1996; Ayida et al., 1997). However, the resolution obtained with a 6 or 7.5 MHz transvaginal ultrasound transducer is not adequate to depict endometrial texture and superficial cyclic changes. In the current study, the sonographic frequency used was 20 MHz and it was possible to visualize very fine endometrial interface structures. However, the depth of penetration of the ultrasound beam is only ~2 cm, which might be sufficient to evaluate fine superficial cyclic changes of endometrium, but examination of larger pathological endometrial lesions is markedly limited because of the shallow scanning range of the high-frequency transducer. Therefore, intrauterine sonography with high-frequency transducer (20 MHz) might be suitable for visualization of normal endometrial interface texture or very small pathological disorders of the endometrium [e.g. endometrial polyp, endometrial carcinoma with or without early invasion of the myometrium (Senoh et al., 1999a)] in infertile patients.

In this study, the contrast enhancement effect of intrauterine saline infusion was more marked under intrauterine than transvaginal sonographic examination. In transvaginal hystero-
sonography, a hysterosalpingography catheter with balloon is sometimes needed for preventing regurgitation of saline solution through the cervical canal because a clear image of the endometrial interface cannot be obtained without the proper amount of intrauterine saline pooling (Cullinan et al., 1995). In intrauterine sonography, however, only a scanty amount of saline pooling (1–2 ml) in the uterine cavity in secretory phase is required to enable a clear depiction of the endometrial interface and to reveal different endometrial textures between proliferative and secretory phases.

The small vesicular echo-free spaces were visualized by intrauterine sonography in one of nine women examined in the early secretory phase, and in five of six patients in the mid-secretory phase. It is well known that secretion in the endometrial glands increases after ovulation and production reaches a maximum in the mid-secretory phase. The small vesicles recognized in the secretory phase might be considered as the pooling of secretion from the endometrial glands. These results suggest that intrauterine sonography might be more suitable than transvaginal sonography for visualization of the endometrial cyclic changes, especially using the saline infusion technique.

With respect to limitations associated with intrauterine sonography, it is an invasive diagnostic procedure requiring sterile conditions, although we and previous authors (Goldberg et al., 1991; Fujiwaki et al., 1995; Kikuchi et al., 1995; Hata, 1996; Hata et al., 1996, 1997a, b, 1998; Kikuchi et al., 1996; Tsuda et al., 1996; Senoh et al., 1999a, b) encountered no immediate complication. Moreover, the images obtained with this method are cross-sectional (i.e. perpendicular to the long axis of the uterus), so the evaluation of the fundus is theoretically difficult (Kikuchi et al., 1995). Another limitation of the high-frequency transducer is the lack of penetration depth, which produces a poor quality of images in the area next to the transducer. Moreover, there is the difficulty in the interpretation of images obtained using the high-frequency probe, and particular training may be necessary.

In conclusion, intrauterine sonography provides additional information in the visualization of anatomical structures of the endometrium. These results suggest that intrauterine sonography may be a valuable tool in imaging the endometrium, complementary but not replacing transvaginal sonography in infertility practice.

References


Received on April 20, 1999; accepted on July 12, 1999