Two-dimensional and three-dimensional imaging of uterus and fallopian tubes in female infertility

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Noninvasive imaging techniques play an important role in the female infertility diagnostic algorithm. In this review article, a description of the diagnostic performance and potential clinical value of both computerized tomographic virtual hysterosalpingography (CT-VHGS) and magnetic-resonance virtual hysterosalpingography (MR-VHSG) is made, describing for both techniques, to guarantee the best possible diagnostic outcome, patient preparation and normal and principal pathologic findings. Both noninvasive diagnostic imaging modalities improve the diagnostic confidence in identification of the specific cause of female infertility. These procedures are well tolerated and can be performed without tenaculum and sedation. The combined analysis of all the imaging data offers the gynecologist a wide information spectrum, enabling a better therapeutic decision. CT-VHSG and MR-VHSG are consistent diagnostic imaging modalities for the evaluation of the female reproductive system, with an excellent diagnostic performance compared with traditional diagnostic exams and allowing a comprehensive assessment of the female reproductive system. (Fertil Steril® 2016;■:■–■. ©2016 by American Society for Reproductive Medicine.)

Key Words: Virtual hysterosalpingography, virtual studies, magnetic resonance imaging, computerized tomography, cervix, uterus, fallopian tubes

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During the past two decades, the diagnostic algorithms of patients with infertility have implicated the use of conventional X-ray hysterosalpingography (HSG) (1–5). However, this technique provides suboptimal information given its two-dimensional (2D) and luminographic nature. In addition, it has a low spatial resolution and involves an invasive technique that exposes the patient to moderate radiation doses, with a typical effective dose of 1.2–3.1 mSv, although higher values of 8 mSv have been reported (6). It is beneficial to use a noninvasive imaging modality that warrants a more precise diagnosis with less radiation dose. Currently, two imaging modalities can accomplish these requirements: virtual HSG performed with the use of computerized tomography (CT-VHSG) and with the use of magnetic resonance imaging (MR-VHSG). Although the cost of HSG is less than CT-VHSG or MR-VHSG, these minimal invasive imaging modalities allow a complete evaluation of the gynecologic system (cervix, uterus, and fallopian tubes) in a single examination (7–13). They require state-of-the-art technology to achieve insightful information that allows a comprehensive assessment of the female reproductive organs.

In this review, we focus on CT-VHGS and MR-VHSG, describing techniques to guarantee the best possible diagnostic outcome, patient preparation, and normal and pathologic findings.

PATIENT PREPARATION BEFORE THE STUDY

To avoid the interruption of any possible pregnancy, the studies have to be performed between the 6th and 11th days of the menstrual cycle. It is also mandatory that patients abstain from sexual intercourse after the interruption of menstrual bleeding until 48 hours after the procedure. In cases

Received February 2, 2016; revised April 12, 2016; accepted April 13, 2016.
P.C. reports personal fees from General Electric Healthcare, outside the submitted work. C.C. has nothing to disclose. J.V. has nothing to disclose. J.C. has nothing to disclose. M.B. has nothing to disclose. S.P. has nothing to disclose.
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Fertility and Sterility® Vol. ■, No. ■, ■ 2016 0015-0282/$36.00

http://dx.doi.org/10.1016/j.fertnstert.2016.04.016

of persistent bleeding, infection or pregnancy, the study can not be performed. No antibiotic prophylaxis is required owing to the noninvasive approach of both techniques; in contrast to HSG, no cervical puncture or clamping is necessary.

TECHNICAL PARAMETERS

CT-VHSG uses multidetector computerized tomography (MDCT) that obtains volumetric acquisitions in a few seconds. It needs to be performed with $\geq$64-detector-row CT scanners because of a fast acquisition time of $<$5 seconds as well as high spatial, temporal, and contrast resolutions. New high-coverage MDCT scanners of 320 and 512 rows can perform the study in only 1 second, allowing a dynamic real-time diagnostic study, showing the contrast passing though the ampullary region of the tube to the peritoneal cavity (14). Lower scanning times enable a better assessment of the fallopian tubes, because they are opacified and lose contrast fast. For that reason, scanners with fewer than 64 detectors rows are not suitable.

Radiation dose saving techniques have to be applied to get the lowest possible radiation dose to the patient. The tube output and current have to be adapted according to the patient's body mass index, with the use of other tools such as automatic tube current modulation or tube output modulation. Iterative reconstruction techniques can also be used, contributing further reductions in radiation exposure by improving image quality (15, 16).

MR-VHSG requires high-field 3-T MR imaging scanners and the implementation of three-dimensional (3D) volumetric time-resolved MR sequences, such as TRICKS (time-resolved imaging of contrast kinetics) technology which provides cervical, uterine, and fallopian tube imaging with excellent spatial and temporal resolutions. With these data sets, different uterine and tubal opacification phases can be obtained after image acquisition. The combination of morphologic T1-and T2-weighted images and a 3D volume scan improve myometrial and ovarian visualization (Table 1) (17).

The entire CT-VHSG examination, including the patient's preparation, takes 15–20 minutes, and the MR-VHSG procedure takes 30–40 minutes. Although images acquired with CT and MR must be reconstructed with the use of different post-processing tools, results are available to the ordering physician after the examinations are finished.

PATIENT'S PREPARATION DURING THE EXAMINATION

Once the patient is in the scanner room, she is placed on the CT/MR table in gynecologic position and a plastic vaginal speculum is inserted. The perineum and the external cervical orifice are cleansed with povidone-iodine solution. For the majority of CT-VHSG procedures, a 15-mL mix of iodininated contrast and saline solution (70% dilution) is used to distend the cervix, uterus, and fallopian tubes. In patients with history of allergy, gadolinium can be an alternative at a dilution of 40%. For MR-VHSG, a 20-mL mix of 1 mL gadolinium, 29 mL iodinated contrast, and 70 mL saline solution is used.

Any of these mixtures are instilled through a plastic cannula that is placed at the external cervical orifice with the use of a power injector or manually. Injection with the use of a power injector at a slow rate of 0.3 mL/s enables a constant speed and pressure, which lessens the discomfort during the procedure and warrants an optimal uterine distention and tubal opacification (18).

METHODS OF POST-PROCESSING AND ANALYSIS

In CT-VHSG examinations, axial CT images can be visualized with the use of classic 3D imaging or 3D post-processed images without image quality loss (19, 20) owing to the isotropic concept that permits the analysis of images in any plane or view from the original axial raw data images. Each post-processing tool gives different and valuable information for a final precise diagnosis (21, 22). This novel examination not only provides valuable information about the gynecologic apparatus but also evaluates the entire pelvic structures, allowing a complete diagnosis.

Multiplanar reconstructions performed in different planes with the use of a soft tissue window allow the evaluation of the cervix, uterus, fallopian tubes, and pelvic structures. This is the best type of reconstruction to perform measurements of any lesion.

In MR-VHSG studies, morphologic T1-and T2-weighted images allow the evaluation of the cervix, uterine wall and morphology, the presence of tubal dilation, and the identification of normal follicles or pathologic ovarian findings (23, 24).

In both techniques, maximum intensity projection (MIP) images show all the gynecologic system with detail, particularly the fallopian tubes, in normal as well as pathologic scenarios. Occasionally, the fallopian tubes in axial CT images are hard to follow, and MIP reconstructions help to shorten the diagnostic time. However, this post-processing technique is not very useful for the detection of intrauterine lesions, because some of them can be undetectable and might require other reprocessing methods.

CT and MR 3D volume rendering reconstructions provide 3D views of the gynecologic system, enabling the identification of many types of lesions, such as stenosis, synechiae, polyps, myomas, and hydrosalpinx, among others.

Virtual endoscopy (VE) views permit confirmation of suspected lesions visualized with other post-processing modalities, providing a complete endoluminal vision of the cervix, uterus, and fallopian tubes in a noninvasive fashion (25). The view angles can be conducted from the cervix or from the fundus according to the physician's convenience.

The combined analysis of all the imaging data offers the gynecologist comprehensive information, aimed at facilitating the therapeutic decision (Supplemental Figs. 1–7 are available online at www.fertstert.org).

COMPLICATIONS

Owing to the minimal invasive nature of both procedures, the rate of complications is low. The most frequent complication is the intravasation of contrast to the venous plexus, which is observed in 3% of patients (Supplemental Fig. 2).