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Original Article

The imaging characteristics of magnetic resonance hysterosalpingography in infertile women

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Abstract: Objective: We aimed to analyze the imaging characteristics of magnetic resonance hysterosalpingography (MR-HSG) in infertile women. Methods: A total of 20 infertile women admitted to our hospital from October 2018 to December 2019 were selected as the subjects of study for retrospective analysis. The MR-HSG examination was performed in all patients to analyze the examination results and imaging characteristics. Results: (1) The completion rate of MR-HSG examination was 100.00% in the 20 patients, of which those with primary infertility accounted for 65.00% and those with secondary infertility accounted for 35.00%. (2) Among the 20 infertile patients, 30.00% had unobstructed fallopian tubes, 40.00% had partial fallopian tube obstruction, 20.00% had full fallopian tube obstruction and 10.00% had hydrosalpinx. (3) Among the 14 patients with abnormal fallopian tubes, 14.29% had bilateral fallopian tube obstruction, 35.71% had partial fallopian tube obstruction on both sides, 7.14% had fallopian tubes that were unobstructed on one side and obstructed on the other side, 21.43% had fallopian tubes that were unobstructed on one side and partially obstructed on the other side, 7.14% had fallopian tubes partially obstructed on one side and obstructed on the other side, and 14.29% had hydrosalpinx. (4) Among the 7 patients with an abnormal uterus, 15.00% had adenomyosis, 5.00% had metropolypus, and 15.00% had hysteromyoma. In the patients with hysteromyoma, there was 1 case of submucous myoma and 2 cases of intramural myoma. (5) Among the 8 patients with abnormal ovaries, 20.00% had polycystic ovaries (PCO), 5.00% had teratoma, and 15.00% had endometriosis. In the patients with endometriosis, there was 1 case of superficial ovarian endometriosis, 1 case of endometrial cysts of the ovary (ECO) and 1 case of deep infiltrating endometriosis (DIE). Among the 20 infertile patients, 30.00% had normal fallopian tubes + uterus + ovaries, 20.00% had abnormal fallopian tubes + uterus + ovaries, 35.00%/40.00%/70.00% had abnormal uterus/ovary/fallopian tubes and 30.00% had abnormal fallopian tubes + uterus. Conclusion: Through MR-HSG examination, the infertility caused by pelvic factors can be identified clearly, and the tubal patency can be determined accurately to assist the clinical diagnosis of infertility and lay a good foundation for the early treatment of infertility.

Keywords: Infertility, fallopian tube, enhanced magnetic resonance imaging, characteristics

Introduction

At present, the clinical definition of infertility is that the women who have regular sex without contraceptives fail to get pregnant for one year [1]. According to Boubour J et al. [2], the incidence of infertility is about 15% in women of gestational age. Fallopian tube factors are thought to be the most common cause of infertility. Besides, infertility is also influenced by uterine factors, cervical factors and ovulation failure, *etc.* What's more, Bergman D et al. [3] found that female infertility may also be caused by long-term poor mental and psychological states as well as immune dysfunction.

Imageological methods are widely applied to the clinical diagnosis of infertility and imageological examination is of significant value in determining the pathogenesis of infertility. The imageological methods commonly used in clinical practice include pelvic magnetic resonance imaging (MRI), hysterosalpingography (HSG), hysterosalpingocontrast sonography (HyCoSy) and pelvic ultrasonic examination [4]. The proper selection of imageological methods depends on the specific site to be examined. Many scholars believe that the application of multi-modal imageological methods to the diagnosis of infertility could provide the most comprehensive evaluation [5, 6]. MR-HSG is a widely used

method in clinic to evaluate the fallopian tubal patency in recent years. MR-HSG examination can clearly show the specific location and shape of the fallopian tube and directly determine the abnormal situation of infertility, which will provide useful information for the clinical diagnosis of infertility [7].

In this study, 20 infertile women admitted to our hospital from October 2018 to December 2019 were selected as the subjects to explore the value of MR-HSG in the diagnosis of infertility, thus provide more useful methods for the clinical diagnosis of infertility.

Materials and methods

Materials

A total of 20 infertile women admitted to our hospital from October 2018 to December 2019 were selected as the subjects of the study. They were aged 23-35 years old, with an average age of (29.86±5.12) years, and the duration of infertility was 1-3 years, with the average duration of (1.52±1.03) years (**Table 1**). (1) Inclusion criteria: The duration of infertility was at least one year; the patients age was between 20 and 40 years old; the patients had not received other tests of tubal patency in the past 6 months; the patients and their mates were examined and were found to have normal semen in the male and normal menstruation in the female. The patients signed an Informed Consent Form. This study was approved by the Hospital Ethics Committee. (2) Exclusion criteria: This study excluded patients during their menstrual period; those with unexplained metrorrhagia; those with reproductive tract inflammation; those with a history of abortion or uterine curettage in the past 1 month; those with contraindications of MR examination; and those who were allergic to the contrast medium.

Methods

All the 20 infertile patients received the MR-HSG examination by the same physician, with SIEMENS MAGNETOM Skyra 3.0T used as magnetic resonance scanner and MEDRAD Spectris Solaris EP as high pressure injector. The body surface coil and body coil were used for examination, with the patients kept in a head first-supine position.

Scanning solutions: LocalizerT2 Haste sag, T2 tse tra p2 384, T1 tse tra p2 384, Dwi b1000 tra p2, T2 tse cor p2 320, T1 vibe fs tra p4 bh, ___+C___, T1 vibe fs tra p4 bh_10 (high time resolution), T1 vibe fs tra 384 (high spatial resolution).

Scanning technical parameters: Dynamic dosing sequence T1 vibe fs tra p4 bh_10 (high time resolution): TR/TE: 4.08/1.35 ms, FOV: 300 mm, Voxel size: 1.3*1.3*1.2, Slice thickness: 1.2 mm, FA: 9.5, TA: 12 s. 16 ml mixture of Magnevist (Bayer) and iodixanol (320 mg/ml) at the proportion of 1:100 was used as the contrast medium, which was prepared half an hour before the examination and stored at the room temperature of about 20°C, and then injected with the high pressure injector at the speed of 0.3 ml/s.

Image evaluation: All MR-HSG images were evaluated by two senior physicians who would reach a consensus about any inconsistent results through consultation.

Observation targets

(1) Evaluation of tubal patency [8]: The tubal patency included 4 grades, with the details described as follows. ① Hydrosalpinx: Hydrops were observed in fallopian tube. ② Fallopian tube obstruction: The pressure was high during the injection and the image development was merely observed in partial fallopian tube and uterine cavity. The contrast medium did not spill from the fimbria. ③ Partial fallopian tube obstruction: The pressure existed continuously during the injection. The fallopian tube was relatively rigid, showing a coiled and tortuous shape in the distal end, and appeared beaded and slightly dilated. The contrast media were observed in fimbria, but only in small amounts. ④ Unobstructed fallopian tube: There was no pressure during the injection. Bilateral fallopian tubes were displayed clearly and the shape was very normal. A large amount of contrast media were observed in fimbria. (2) Abnormal manifestations related to infertility outside the fallopian tube: The MR-HSG image was taken as the basis to observe the occurrence of hysteromyoma, adenomyosis, uterine malformation, endometrial polyps, intrauterine adhesions, endometriosis, PCO, ovarian atrophy and ovarian tumors, etc. (3) Evaluation of infertile factors: MR-HSG image was used to evaluate the

Table 1. General data analysis of 20 cases of infertility ($\bar{x} \pm s$)/[n (%)]

General data		Range/case	Average value/ratio
Age (years)		23~35	29.86±5.12
Infertility time (years)		1~3	1.52±1.03
Cause of the disease	Oviduct obstruction	7	35.00
	Abnormality of ovarian function	4	20.00
	Endometriosis	3	15.00
	Uterus and cervix factors	2	10.00
	Immune factors	2	10.00
	Others	2	10.00

Table 2. Tubal patency of the 20 infertile patients based on MR-HSG examination (case, %)

Tubal patency	Number of patients	Proportion of patients
Unobstructed fallopian tube	6	30.00
Partial fallopian tube obstruction	8	40.00
Fallopian tube obstruction	4	20.00
Hydrosalpinx	2	10.00

infertile factors of patients. (4) MR-HSG image characteristics: The characteristic imaging manifestations of MR-HSG examination were analyzed in patients.

Statistical analysis

SPSS 22.0 was used for statistical analysis. The enumeration data were represented by [n (%)]; the results between groups were compared through X^2 test; and the multi-point comparison within the groups was performed through ANVOA and F test. $P<0.05$ meant that the difference had statistical significance.

Results

Completion status of MR-HSG examination

All the 20 patients completed the MR-HSG examination successfully and the completion rate of MR-HSG examination was 100.00%. In the 20 infertile patients, there were 13 cases of primary infertility, accounting for 65.00%, and 7 cases of secondary infertility, accounting for 35.00%.

Evaluation of tubal patency

Among the 20 infertile patients who underwent MR-HSG examination, 30.00% had unobstructed fallopian tubes, 40.00% had partial fallopian tube obstruction, 20.00% had fallopian tube obstruction, and 10.00% had hydrosalpinx (**Table 1**).

Evaluation of abnormal fallopian tube

Among the 14 patients diagnosed with abnormal fallopian tubes by MR-HSG examination, 14.29% had bilateral fallopian tube obstruction, 35.71% had partial fallopian tube obstruction on both sides, 7.14% had unobstructed fallopian tubes on one side and obstructed on the other side, 21.43% had unobstructed fallopian tubes on one side and partially obstructed on the other side, 7.14% had fallopian tubes partially obstructed on one side and obstructed on the other side, and 14.29% had hydrosalpinx (**Table 2**).

Evaluation of abnormal uterus

Among the 7 patients diagnosed with abnormal uterus by MR-HSG examination, there were 3 (15.00%) cases of adenomyosis, 1 (5.00%) case of metropolypus, and 3 (15.00%) cases of hysteromyoma. Besides, among the 3 patients with hysteromyoma, there was 1 case of submucous myoma and 2 cases of intramural myoma.

Evaluation of abnormal ovaries

Among the 8 patients diagnosed with abnormal ovaries by MR-HSG examination, there were 4 (20.00%) cases of PCO, 1 (5.00%) case of teratoma, and 3 (15.00%) cases of endometriosis. Besides, among the 3 patients with endometriosis, there was 1 case of superficial ovarian endometriosis, 1 case of ECO, and 1 case of DIE (**Table 3**).

Evaluation of infertile factors

Among the 20 infertile patients, 30.00% had normal fallopian tube + uterus + ovary, 20.00% had abnormal fallopian tube + uterus + ovary,

Table 3. Evaluation on specific abnormalities of the 14 infertile patients with abnormal fallopian tubes (case, %)

Specific manifestation of abnormal fallopian tube	Number of patients	Proportion of patients
Bilateral fallopian tube obstruction	2	14.29
Partial fallopian tube obstruction on both sides	5	35.71
Fallopian tube unobstructed on one side and obstructed on the other side	1	7.14
Fallopian tube unobstructed on one side and partially obstructed on the other side	3	21.43
Fallopian tube partially obstructed on one side and obstructed on the other side	1	7.14
Hydrosalpinx	2	14.29

Table 4. Evaluation of infertile factors in the 20 infertile patients (case, %)

Infertile factor	Number of patients	Proportion of patients
Normal fallopian tube + uterus + ovary	6	30.00
Abnormal uterus only	7	35.00
Abnormal ovary only	8	40.00
Abnormal fallopian tube only	14	70.00
Abnormal uterus + ovary	5	25.00
Abnormal fallopian tube + uterus	6	30.00
Abnormal fallopian tube + uterus + ovary	4	20.00

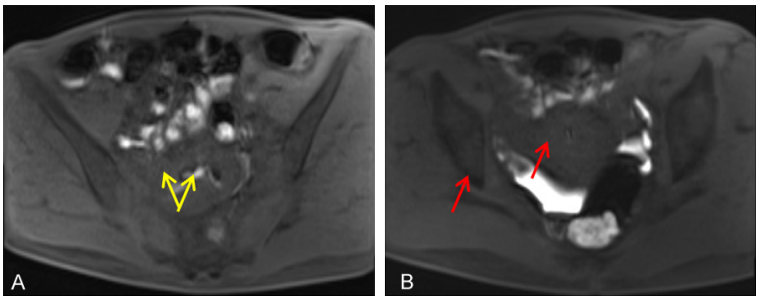

Figure 1. Patient condition in case 1: female, 40 years old, she gave birth to her first baby in 2002. She has prepared for pregnancy for 2 years up to now and it has been 7 days since her last menstrual period. MR-HSG showed that bilateral oviducts were unobstructed. A. Bilateral oviduct development (yellow arrows); B. Delayed scanning revealed contrast media diffusion in bilateral ovaries and lacunae of uterus and rectum (red arrows).

35.00%/40.00%/70.00% had abnormal uterus/ovary/fallopian tubes, and 30.00% had abnormal fallopian tube + uterus (**Table 4**).

Analysis on imaging characteristics in typical cases

In this paper, the imaging characteristics of MR-HSG of 6 patients were listed in detail, and the images and descriptions are shown in **Figures 1-6**.

Discussion

With the continuous increase of the prevalence rate of infertility, assisted reproductive technology is also gradually increasing, so most infertility patients will be treated effectively at the early stage to restore their fertility if the causes of infertility can be determined accurately [1]. In the past, ultrasonic examination or HSG was used to determine the fertility function by checking the origins of infertility, thus providing guidance for therapeutic treatment [9].

Clinically, it is believed that fallopian tube dysfunction is the main cause of infertility. X-hysterosalpingography (X-HSG) is an important method to determine the tubal patency. However, Petit C et al. [10] indicated that the sensitivity of this method was only 65% and the specificity was only 83%. The deficiency of X-HSG is mainly due to the difficulty of examination in patients with reproductive organ exposure to ionizing radiation [11]. In addition, the ultrasonic salpingography has also been used widely. The contrast media were infused into the fallopian tube for ultrasonic examination, which is rapid and simple with higher tolerance, and the examination can be performed synergistically in the uterus and ovaries. Furthermore, it has been verified in clinical practice that this method has higher specificity and sensitivity, but poor repeatability. To some extent, the

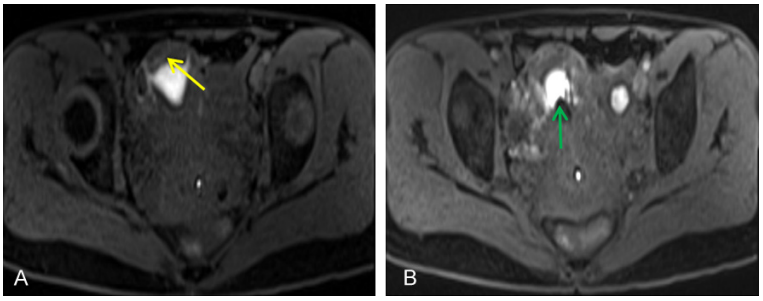

Figure 2. Patient condition in case 2: female, 33 years old, she gave birth to two children by natural birth and removed the IUD in 2016. It has been 5 days since her last menstrual period. MR-HSG showed that unilateral oviduct was opened (the right fallopian tube was partially obstructed, and the left fallopian tube was obstructed). A. Bilateral tubal interstitium development (yellow arrow); B. The diffusion of contrast media around the right ovary was not uniform in delayed scanning; No contrast diffusion was observed around the left ovary; At the same level, the left chocolate cyst of ovary is highly signaled (green arrow).

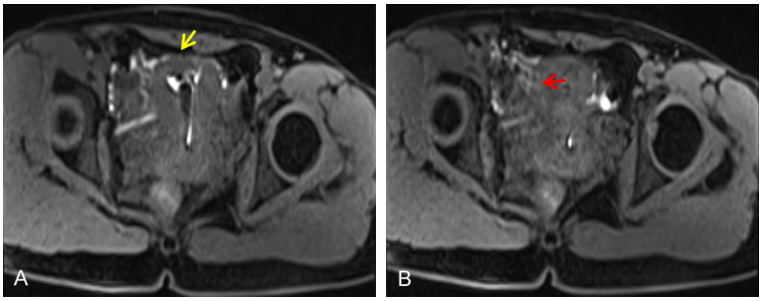

Figure 3. Patient condition in case 3: female, 24 years old, she has been married for 2 years without deliberate contraception. It has been 5 days since her last menstrual period. MR-HSG shows that unilateral oviduct was opened (left fallopian tube was unobstructed and the right fallopian tube was obstructed). A. Left oviduct development and right oviduct without development (yellow arrow); B. Contrast media diffusion was observed around the left ovary in delayed scanning (red arrow); No clear contrast media diffusion was observed around the right ovary.

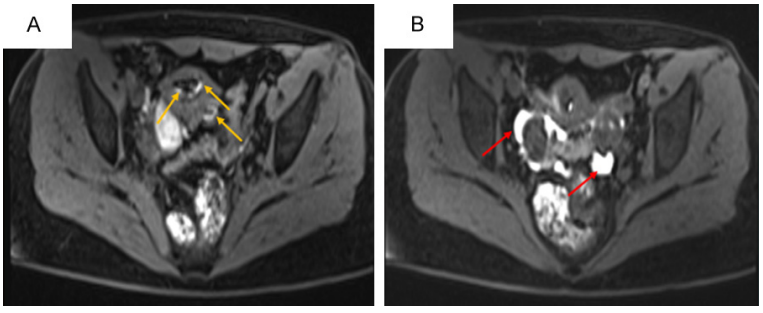

Figure 4. Patient condition in case 4: female, 30 years old, she has been married for 2 years without pregnancy. It has been 5 days since her last menstrual period. MR-HSG showed that bilateral oviducts were opened. A. Bilateral tubal interstitium development (yellow arrows indicate bilateral tubal interstitium and left tubal ampulla); B. The diffusion of contrast media around the right ovary was not uniform in delayed scanning. No contrast diffusion was observed around the left ovary (red arrows).

accuracy of examination results is related to the operation technique of physicians, so the technical level of the physicians is highly required [12, 13]. Compared with the previous two methods, MRI has more advantages. Except for the non-ionizing characteristic, there is no direct requirement on the operation technique of the physicians [14]. It is believed that MRI has the highest accuracy among all imageological methods, and has a higher practical rate and an outstanding application value in the diagnosis of gynecological lesions, such as endometriosis [15]. In recent years, many studies have emphasized the evaluation of the application value of MR-HSG in respect of tubal patency, and found that tubal patency could be demonstrated by infusing the contrast media into the uterine cavity through T1 weighted dynamic enhancement sequence [16]. Jagannathan D et al. [9] studied and compared the evaluation values of HSG and MR-HSG in respect of tubal patency and found that MR-HSG had a more outstanding evaluation value. Kaproth-Joslin K et al. [17] compared the values of HSG and MR-HSG in the diagnosis of infertility and proposed that MR-HSG may become the most useful method to diagnose infertility in the future because it could be used to examine and evaluate the ovary, uterus, pelvis and fallopian tube without gonadal exposure to ionizing radiation. Zafarani F et al. [18] and Devine K et al. [19] pointed out the deficiencies of MR-HSG, including taking a long time, having a high price and lack of MRI equipment in some hospitals, *etc*. However, the advan-

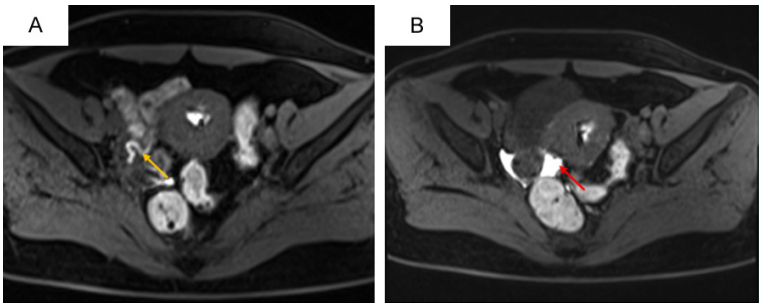

Figure 5. Patient condition of case 5: female, 29 years old, she has been married for 2 years without pregnancy. MR-HSG showed that the right oviduct was opened. A. Right tubal ampulla development (yellow arrow); B. The contrast media was diffused evenly around the right ovary in delayed scanning (red arrow); No contrast diffusion was observed around the left ovary.

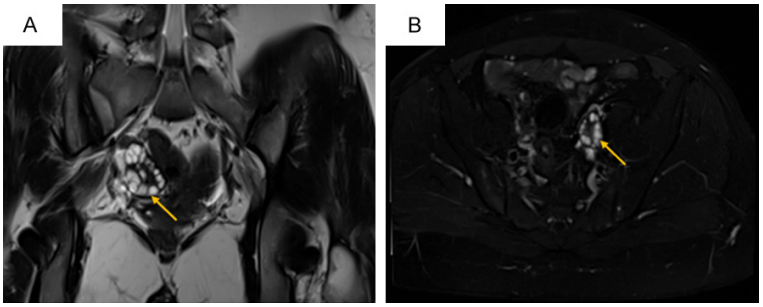

Figure 6. Patient condition in case 6: female, 30 years old, she has been married for 2 years without pregnancy. She had experienced amenorrhea, hair thinning, and elevated testosterone. MR plain scanning showed polycystic ovarian syndrome. A, B. Small sacs of similar size were observed under the bilateral ovarian capsule in a wheel-like arrangement (yellow arrows), with more than 10 small sacs (diameter less than 1 cm).

tages of MR-HSG are more prominent than the disadvantages. Therefore, it is believed that with the progress of society and the enhancement of technology, these disadvantages will be gradually resolved, and the application value of MR-HSG will become more outstanding.

In this study, 3.0T MR-HSG was used for MR-HSG examination. With the main characteristic of visualization, it displayed the shape of the fallopian tube more clearly [20]. 3.0T MRI provided relatively satisfactory signal-to-noise ratio and contrast-to-noise ratio, which was conducive to enhancing the spatial resolution and temporal resolution during the examination. Meanwhile, the time of image acquisition was reduced significantly by this method and the contrast media achieved a better contrast effect after application [14]. In addition, the use of contrast media with high viscosity in examination could control the absorption of the fallopian tube, promote the fallopian tube to generate more protons within a certain area, so as to increase the signal-to-noise ratio [15]. Among the 20 infertile women who underwent MR-HSG examination, 30.00% had unobstructed fallopian tubes, 40.00% had partial fallopian tube obstruction, 20.00% had fallopian tube obstruction, and 10.00% had hydrosalpinx. It was found by further analyzing the 14 patients with abnormal fallopian tubes that 14.29% had bilateral fallopian tube obstruction, those with partial fallopian tube obstruction on both sides accounted for 35.71%, while 7.14% had unobstructed fallopian tubes on one side and obstructed on the other side, 21.43% had unobstructed fallopian tubes on one side and partially obstructed on the other side, 7.14% had fallopian tube partially obstructed on one side and obstructed on the other side, and 14.29% had hydrosalpinx. Besides, it was found by examination that in the 20 patients, 7 patients had an abnormal uterus and 8 patients had abnormal ovaries. It was found by analyzing infertile factors that 30.00% had normal fallopian tube + uterus + ovary, 20.00% had abnormal fallopian tube + uterus + ovary, 35.00%/40.00%/70.00% had abnormal uterus/ovary/fallopian tube, and 30.00% had abnormal fallopian tube + uterus. It can be learned from above analysis that the application of MR-HSG in the diagnosis of infertility can clearly reveal the specific causes of infertility and guide the determination of influencing factors of infertility, thus providing guidance for the formulation of specific therapeutic schedule in clinical practice.

Through the MR-HSG examination, the following precautions are summarized. The speed of infusing contrast media should be controlled properly and the pain degree and reactive state of patients should be observed and recorded

during the infusion of contrast media so as to reasonably adjust the infusion rate. In order to divert the attention of patients, alleviate their unhealthy emotions and reduce the occurrence risk of proximal fallopian tube spasm, it was necessary to communicate with patients continuously during the infusion of contrast media. The infusion of contrast media at a constant speed could prevent the proximal fallopian tube spasm that could be also reduced by keeping the contrast media at room temperature. The proximal situation of the fallopian tube could be displayed more clearly by infusing the contrast media slowly at first and then faster gradually. The application of spasmolytics before intubation could prevent fallopian tube spasm, which could control the contraction of fallopian tube, thus greatly reducing the artifact caused by intestinal tract movement [21].

In conclusion, the application of MR-HSG examination to infertile patients could determine the specific causes of infertility, which is conductive to taking reasonable therapeutic measures in clinical practice, and has a good application value. However, due to the few subjects included in this study, the results were biased to some extent, and the analysis of the results was not comprehensive enough. In addition, the specific application mechanism of MR-HSG in the treatment of infertility has not been studied.

Therefore, an intensive study with larger samples in more aspects should be emphasized and conducted in the future to obtain more scientific and representative conclusions, so as to provide better guidance for the selection of diagnostic methods for infertile patients.

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Disclosure of conflict of interest

None.

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References

[1] McGain F, Moore G and Black J. Steam sterilisation's energy and water footprint. Aust Health Rev 2017; 41: 26-32.

[2] Boubour J, Jenson K, Richter H, Yarbrough J, Oden ZM and Schuler DA. A shipping container-based sterile processing unit for low resources settings. PLoS One 2016; 11: e0149624.

[3] Bergman D, Goldenberg A and Jacob SE. Update on providing re-essure-ance to the nickel-allergic patient considering hysteroscopic sterilization. J Minim Invasive Gynecol 2016; 23: 1012-1023.

[4] Long B, Long D and Koyfman A. Emergency medicine evaluation of community-acquired pneumonia: history, examination, imaging and laboratory assessment, and risk scores. J Emerg Med 2017; 53: 642-652.

[5] Thorborg K, Reiman MP, Weir A, Kemp JL, Serner A, Mosler AB and Hölmich P. Clinical examination, diagnostic imaging, and testing of athletes with groin pain: an evidence-based approach to effective management. J Orthop Sports Phys Ther 2018; 48: 239-249.

[6] Benabbas R, Hanna M, Shah J and Sinert R. Diagnostic accuracy of history, physical examination, laboratory tests, and point-of-care ultrasound for pediatric acute appendicitis in the emergency department: a systematic review and meta-analysis. Acad Emerg Med 2017; 24: 523-551.

[7] Volondat M, Fontas E, Delotte J, Fatfouta I, Chevallier P and Chassang M. Magnetic resonance hysterosalpingography in diagnostic work-up of female infertility-comparison with conventional hysterosalpingography: a randomised study. Eur Radiol 2019; 29: 501-508.

[8] Luciano DE, Exacoustos C and Luciano AA. Contrast ultrasonography for tubal patency. J Minim Invasive Gynecol 2014; 21: 994-998.

[9] Jagannathan D and Hithaya F. Conventional and magnetic resonance hysterosalpingography in assessing tubal patency-A comparative study. Indian J Radiol Imaging 2019; 29: 163-167.

[10] Petit C, Vernet T, Verpillat P, Rubod C, Cosson M and Giraudet G. Radiological assessment of the placement of essure® in order to reduce hysterosalpingography: pelvic X-ray versus combined pelvic X-ray and ultrasound. J Gynecol Obstet Hum Reprod 2017; 46: 623-628.

[11] Xu A, Zhang D, Wang M and Long J. The analysis of factors influencing the success of diagnosing salpingemphraxis by x-ray hysterosalpingography. Eur Rev Med Pharmacol Sci 2016; 20: 2764-2768.

[12] Lefringhouse JR, Neward E, Ueland FR, Baldwin LA, Miller RW, DeSimone CP, Kryscio RJ, van Nagell JR and Pavlik EJ. Probability of fallopian tube and ovarian detection with transvaginal ultrasonography in normal women. Womens Health (Lond) 2016; 12: 303-311.

[13] Raban O, Zilber H, Hadar E, Efrat Z, Krissi H, Wiznitzer A, Meizner I and Bardin R. Isolated fallopian tube torsion: a unique ultrasound identity or a serial copycat? J Ultrasound Med 2018; 37: 2387-2393.

[14] De Felice C, Rech F, Marini A, Stagnitti A, Valente F, Cipolla V, Borgogni G and Meggiorini M. Magnetic resonance hysterosalpingography in the evaluation of tubal patency in infertile women: an observational study. Clin Exp Obstet Gynecol 2012; 39: 83-88.

[15] Ma L, Wu G, Wang Y, Zhang Y, Wang J, Li L and Zhou W. Fallopian tubal patency diagnosed by magnetic resonance hysterosalpingography. J Reprod Med 2012; 57: 435-440.

[16] Akhatov A, Ryzhkin S and Mikhaylov M. The experience of using magnetic resonance imaging of the uterus and its appendages as an alternative to X-ray hysterosalpingography. Vestn Rentgenol Radiol 2016; 97: 269-273.

[17] Kaproth-Joslin K and Dogra V. Imaging of female infertility: a pictorial guide to the hysterosalpingography, ultrasonography, and magnetic resonance imaging findings of the congenital and acquired causes of female infertility. Radiol Clin North Am 2013; 51: 967-981.

[18] Zafarani F, Ahmadi F and Shahrzad G. Hysterosalpingography in the assessment of congenital cervical anomalies. Int J Fertil Steril 2017; 11: 71-78.

[19] Devine K, McCluskey T, Henne M, Armstrong A, Venkatesan AM and DeCherney A. Is magnetic resonance imaging sufficient to diagnose rudimentary uterine horn? A case report and review of the literature. J Minim Invasive Gynecol 2013; 20: 533-536.

[20] Cipolla V, Guerrieri D, Pietrangeli D, Santucci D, Argirò R and de Felice C. Role of 3.0 Tesla magnetic resonance hysterosalpingography in the diagnostic work-up of female infertility. Acta Radiol 2016; 57: 1132-1139.

[21] Takeyama K, Ishikawa R, Nakayama K and Suzuki T. Intraperitoneal residual contrast agent from hysterosalpingography detected following cesarean section. Tokai J Exp Clin Med 2014; 39: 69-71.