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SPECIAL SECTION: ENDOMETRIOSIS

Hysterosalpingography in endometriosis: performance and interpretation

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Abstract

Endometriosis is often seen and sometimes initially diagnosed on hysterosalpingography (HSG), an imaging exam routinely performed on patients with infertility. Here we discuss the role of HSG in the evaluation of patients with infertility with a focus on patients with endometriosis. The HSG technique, including patient preparation as well as potential risks and complications, is detailed. Imaging findings in patients with endometriosis are illustrated and a template for exam reporting is presented. Common imaging pitfalls are described with examples.

Keywords Female pelvic imaging · Gynecology · Infertility · Mullerian anomalies · Adenomyosis · Fallopian tube · Pelvic adhesions · Peritubal adhesions · Tubal occlusion

Introduction

Endometriosis is defined as the growth of endometrial tissue outside the endometrial cavity [1]. Approximately 10% of women of reproductive age have endometriosis [2, 3]. However, there is a reported incidence of up to 50% in patients with infertility [4]. Pathologically, three forms of endometriosis are described—superficial peritoneal, ovarian, and deeply infiltrating [1, 5]. With superficial involvement, endometriotic implants are present on the surface of the pelvic peritoneum [6]. In ovarian endometriosis, ovarian pseudocysts are lined by endometrioid mucosa, hence called "endometriomas" [6]. Deep infiltrating endometriosis is defined as the presence of invasive tissue that infiltrates greater than 5 mm into the peritoneal surface or into the wall of adjacent pelvic organs [1, 5, 6].

Hysterosalpingography (HSG) is the fluoroscopic evaluation of the uterine cavity, fallopian tubes, and adjacent peritoneal cavity following injection of contrast media through the cervical canal [7]. It evaluates the fallopian tubes, the uterine contour, and indirectly the adjacent pelvic peritoneum in patients undergoing evaluation for infertility. HSG findings are sometimes the first indication of underlying endometriosis as infertility is one of the sequelae of this disease. Thus, radiologists performing and interpreting HSG should be familiar with the findings associated with endometriosis.

This review describes the technical aspects of HSG performance including issues related to patient preparation and safety screening. Interpretation of HSG images is then discussed including a description of expected findings. A reporting template for HSG in patients with suspected endometriosis is presented.

Technique

Safety screening and patient consent

A brief medical history is taken from the patient to include the duration of symptoms, if any, history of previous pelvic infections or surgery, obstetric history, contraceptive use, date of last menstrual period (LMP), and previous contrast reactions (Table 1). Informed consent is obtained after a discussion between the patient and the health care provider about the possibility of pelvic discomfort, vaginal bleeding, infection, contrast reaction, and the potential for irradiation

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Table 1 Patient safety evaluation before hysterosalpingography

Contraindication	Pertinent medical history	Corrective action
Pregnancy	Sexually active without contraception and on day 12 or beyond of menstrual cycle	Reschedule procedure to day 6–11 of menstrual cycle and advise patient to use contraception until then
Acute reaction to iodinated contrast	Categorize index reaction as mild, moderate, or severe*	If severe, the procedure is contraindicated; for mild reaction, premedication and other precautionary measures are required^
Active pelvic infection	Symptomatic or undergoing treatment	Reschedule procedure until asymptomatic and after completion of therapy
Active uterine bleeding	Usually day 1–5 of menstrual cycle	Reschedule to day 6–11 of menstrual cycle

*Categorization of contrast reactions by severity and recommended premedication protocols can be found in the ACR Committee on Drug and Contrast Media

ACR manual on contrast media, Version 10.3, American College of Radiology 2018

https://www.acr.org/~/media/ACR/Documents/PDF/QualitySafety/Resources/Contrast-Manual/Contrast_Media.pdf

^See text for description of premedication regimen and other precautionary measures

of an unsuspected pregnancy. Patients with indwelling fallopian tube micro-inserts or intrauterine devices are counseled regarding the risk of implant dislodgement, potentially requiring a separate procedure for replacement.

HSGs should ideally be performed on day 6 through 11 of the menstrual cycle to avoid peak menses and radiating a pregnancy. Neither serum nor urine pregnancy tests reliably exclude pregnancy during the first 3 weeks following the LMP and are therefore not routinely required [8]. Thus, in the timeframe of the exam, screening pregnancy tests add cost and delay that can be avoided by careful history and counseling. The most common indication for HSG is in patients undergoing fertility evaluation and, in this group, reported LMPs are typically accurate. If the patient states that she is past ovulation and sexually active, making a pregnancy a possibility, we reschedule the exam and counsel the patient on the correct timing and preparations for the return visit. Patients who cannot provide a reliable LMP and those who have just had an atypically light menses that could represent implantation bleeding of an early pregnancy are also asked to reschedule.

Potential risks and complications

Infection

Routine antibiotics are not required prior to the procedure. The risk of infection following HSG is low, with reported rates ranging from 0.3 to 3.4% [9–11]. Antibiotics should be administered if contained pools of contrast (e.g., dilated tubes without spill or spilled contrast within locules) are noted at the end of the exam.

These findings are associated with an increased risk of post-procedural infection [9, 12]. Doxycycline 100 mg orally, twice daily for 5 days is a commonly used regimen in this patient cohort [12] which can be prescribed by the radiologist or the referring physician.

Patient discomfort

While discomfort can occur during HSG, typically due to uterine distension, analgesia is not routinely administered. Pain associated with the procedure is typically mild and self-limited. Peritoneal irritation can also lead to discomfort [13]

Table 2 Hysterosalpingography findings in endometriosis

Pathology	Imaging finding
1. Hydrosalpinx	1. Dilated fallopian tube
2. Fallopian tube occlusion	2. Partial contrast filling but lack of spill from tube
3. Peritubal adhesions	3. Loculated contrast spill or pooling collections of spilled contrast
4. Deep infiltrative endometriosis	4. Pooled contrast in the deep pelvis. Fallopian tube courses posteriorly from the uterus to the midline cul-de-sac
5. Uterine adenomyosis	5. Abnormal uterine cavity contour with extrusion of contrast into the myometrium
Associated with endometriosis	Focal—can mimic necrotic fibroid
Endometrial tissue infiltrates into the myometrium	Diffuse

but this discomfort can be minimized with a slow contrast injection and the use of iso-osmolar contrast agents [14]. If cramping does occur following the procedure, we advise patients to use over-the-counter non-steroidal anti-inflammatory medications.

Severe pain following HSG is extremely rare and could indicate a complication such as an infection. In such cases, we advise patients to seek medical attention from their physician.

Contrast allergy

Iodinated contrast is injected into the uterine cavity and the fallopian tubes into the peritoneal cavity during a HSG. Nonionic, water-soluble contrast is preferred, as the risk of allergic reaction is less than that with ionic contrast [15]. The amount of contrast injected varies between patients but is typically around 10 to 30 mls. As some of this contrast is metabolized intravascularly, there is a small amount of systemic absorption of contrast.

In patients with a history of mild contrast allergy, premedication is administered with a steroid and antihistamine (oral prednisone 50 mg at 13, 7 and 1 h prior to contrast administration; oral, IM or IV diphenhydramine 50 mg 1 h prior to contrast administration) [15]. History of moderate contrast allergy is a relative contraindication to HSG [16]. In these patients, HSG is performed, only if alternative methods for the assessment of tubal patency are unsuitable or unsafe. Premedication and intraprocedural vital sign monitoring is necessary and the exam is performed in a setting where immediate resuscitation expertise is available. In patients with a history of severe contrast allergy, HSG is contraindicated.

Radiation

Radiation dose conferred by an HSG is below that of annual background radiation and below the 50 mGy consensus threshold for negligible risk [17, 18]. HSG is performed in real-time using fluoroscopy during which selected spot radiographs are acquired. The average dose to the female gonads

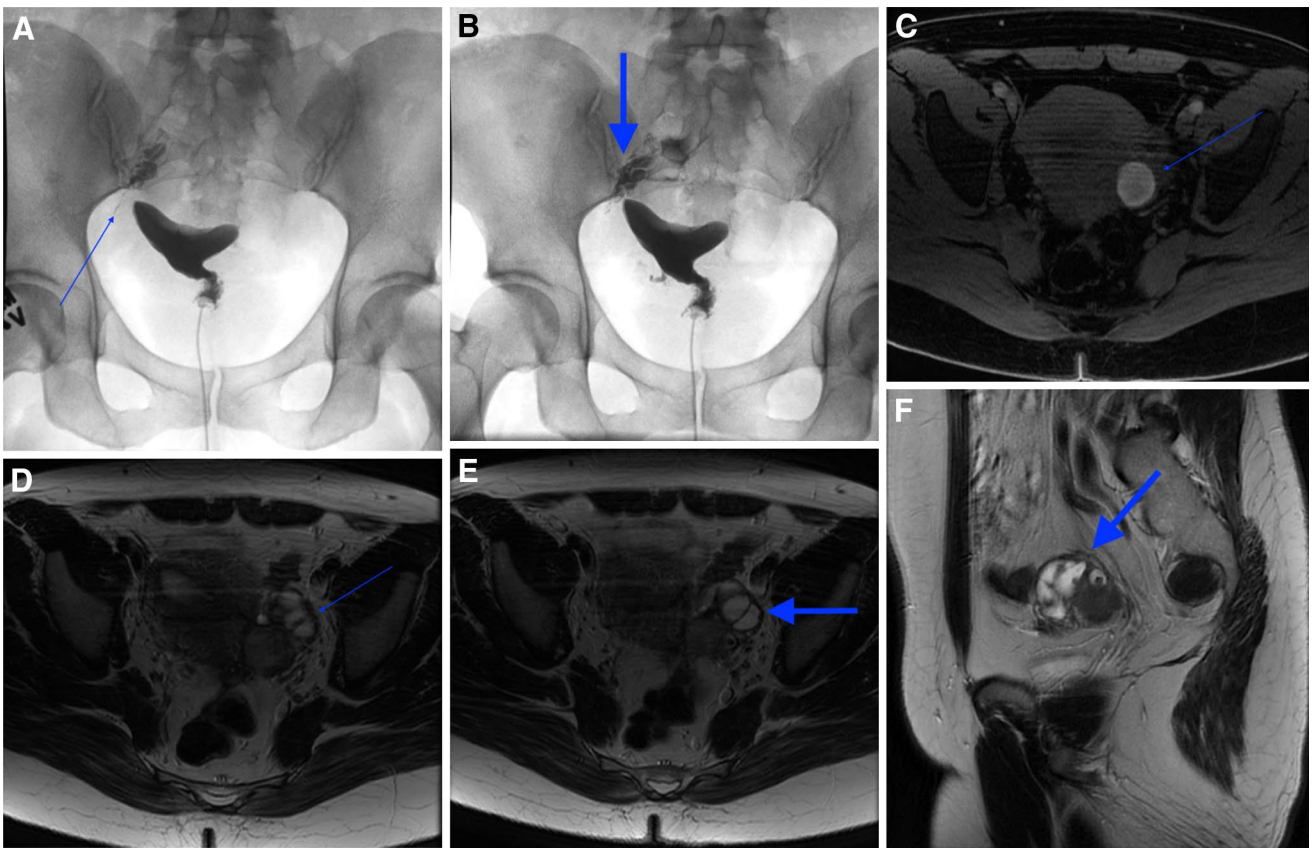

Fig. 1 Abnormal fallopian tube. 36-year-old female with infertility. HSG images demonstrate a normal right fallopian tube (**a**, arrow) with free spill of contrast (**b**, arrow). The left fallopian tube does not opacify which could represent either occlusion or spasm. Axial T1-weighted images with fat saturation (**c**) and axial T2-weighted (**d**) MR images demonstrate a left ovarian endometrioma (arrow). Axial (**e**) and sagittal (**f**) T2-weighted images demonstrate a left hydrosalpinx (thick arrow)

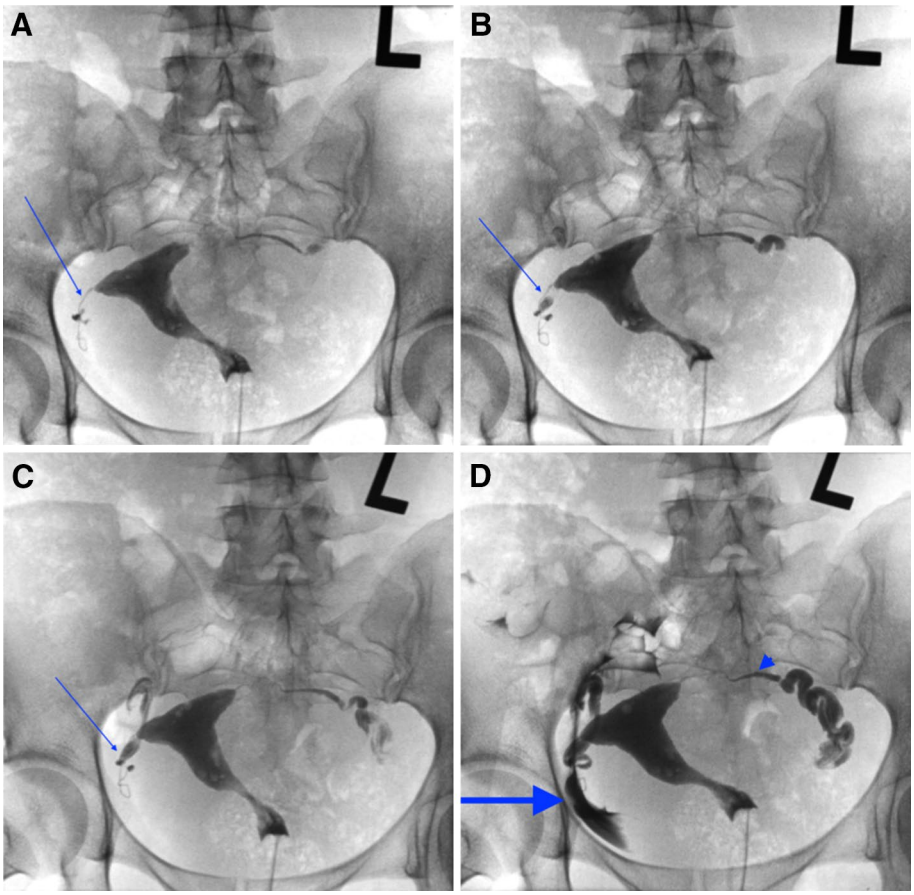

Fig. 2 Hydrosalpinx. 31-year-old female with a history of endometriosis. HSG images (**a**–**d**) demonstrate a normal right fallopian tube (thin arrow) with free spill (thick arrow) and a dilated left fallopian tube (arrowhead). At laparoscopy, bilateral ovarian endometriomas, a normal right fallopian tube, and a markedly swollen left fallopian tube with adherent blood clots were noted. Endometriosis was seen on the pelvic side walls

is estimated at 2.7 mGy with an effective dose of 1.2 mSv [19]. This compares to an effective dose from annual background radiation of 3.1 mSv and from screening mammography of 0.4 mSv [20].

Procedure

Catheter placement

The patient is placed in the dorsal lithotomy position. A bimanual examination is performed to assess uterine body flexion, cervical location, and size of the vaginal canal [13]. A speculum is placed in the vagina to visualize the cervix. The cervix is cleaned with antiseptic soap (or saline in the case of allergy). A blunt dilator may be gently placed in the cervical canal for a couple of minutes.

Using long forceps, a 5-F flexible balloon-tipped catheter is placed into the endocervical canal. Once positioned, the catheter is secured in place by inflating the balloon with approximately 1.5 cc of sterile water. If the catheter cannot be placed in the endocervical canal, it should be placed into the endometrial cavity, and the balloon is gently inflated and then retracted until it is secure. After catheter placement, the speculum is removed to allow optimal visualization of the cervical canal and lower uterine segment. The patient is then placed supine on the table for fluoroscopy.

Image acquisition

In order to optimize image quality and reduce radiation dose, attention to correct fluoroscopic technique is necessary. To decrease background scatter, the distance from the beam source to the target organs is reduced and the images are coned. The following images are typically obtained:

- Scout, prior to contrast injection.
- Early filling anteroposterior (AP) view of the uterus.
- Antero-lateral oblique view of one tube demonstrating spill.
- Antero-lateral oblique view of the other tube demonstrating spill.
- En face, AP view of the uterus. To achieve this, the clinician gently pulls down the catheter to lay the uterine cavity out in the imaging plane.

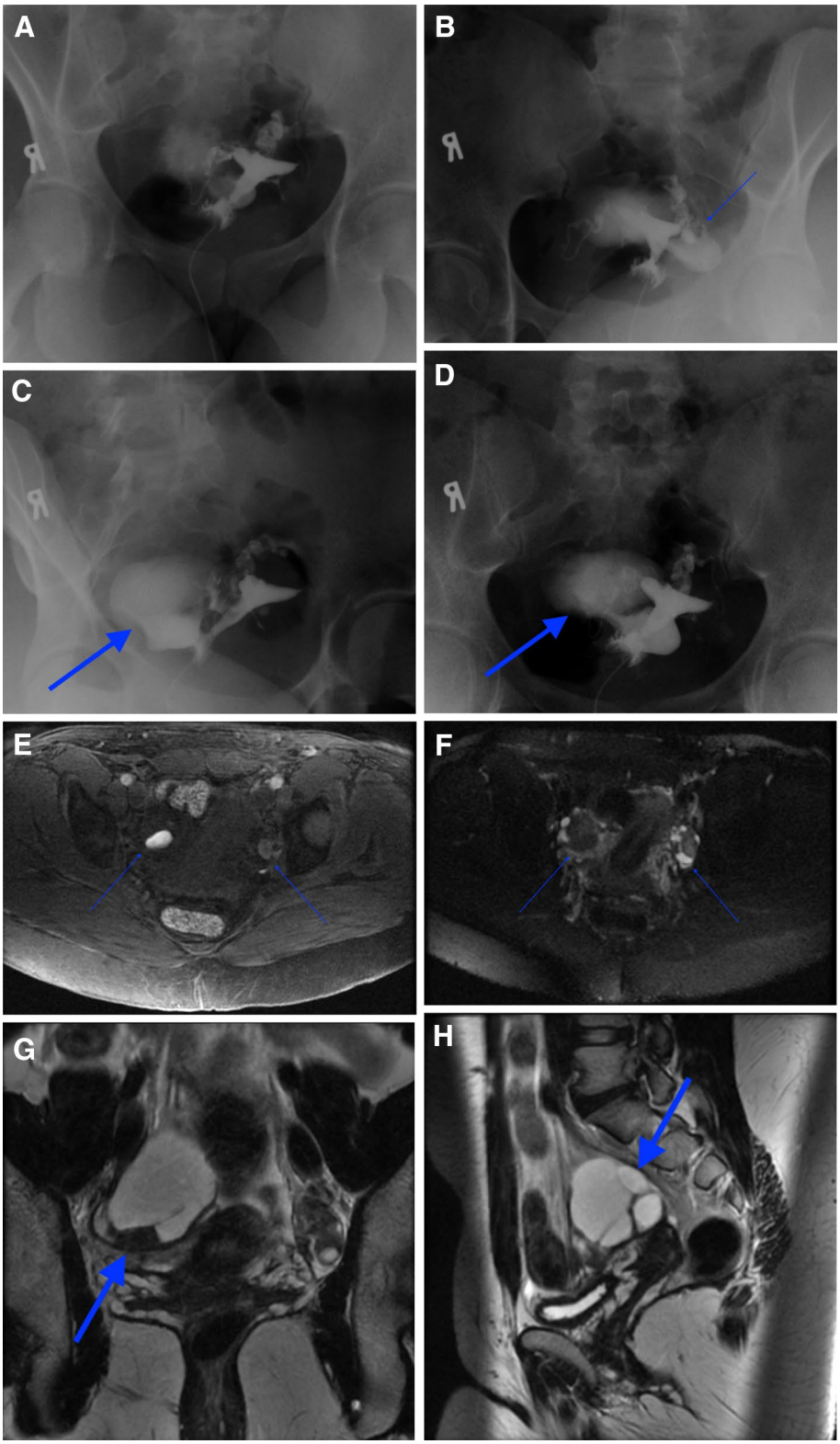

Fig. 3 Loculated contrast spill. 29-year-old female with a history of infertility. HSG images (**a**–**d**) demonstrate free spill into the peritoneum on the left side (arrow) but loculated spill on the right side (thick arrow) indicating peritubal adhesions. Axial T1-weighted images with fat saturation (**e**) and axial T2-weighted images with fat saturation (**f**) from a pelvic MR performed three months later demonstrate bilateral ovarian endometriomas (arrows). Coronal and sagittal T2-weighted (**g** and **h**) images demonstrate a right hydrosalpinx and loculated peritubal fluid (thick arrow)

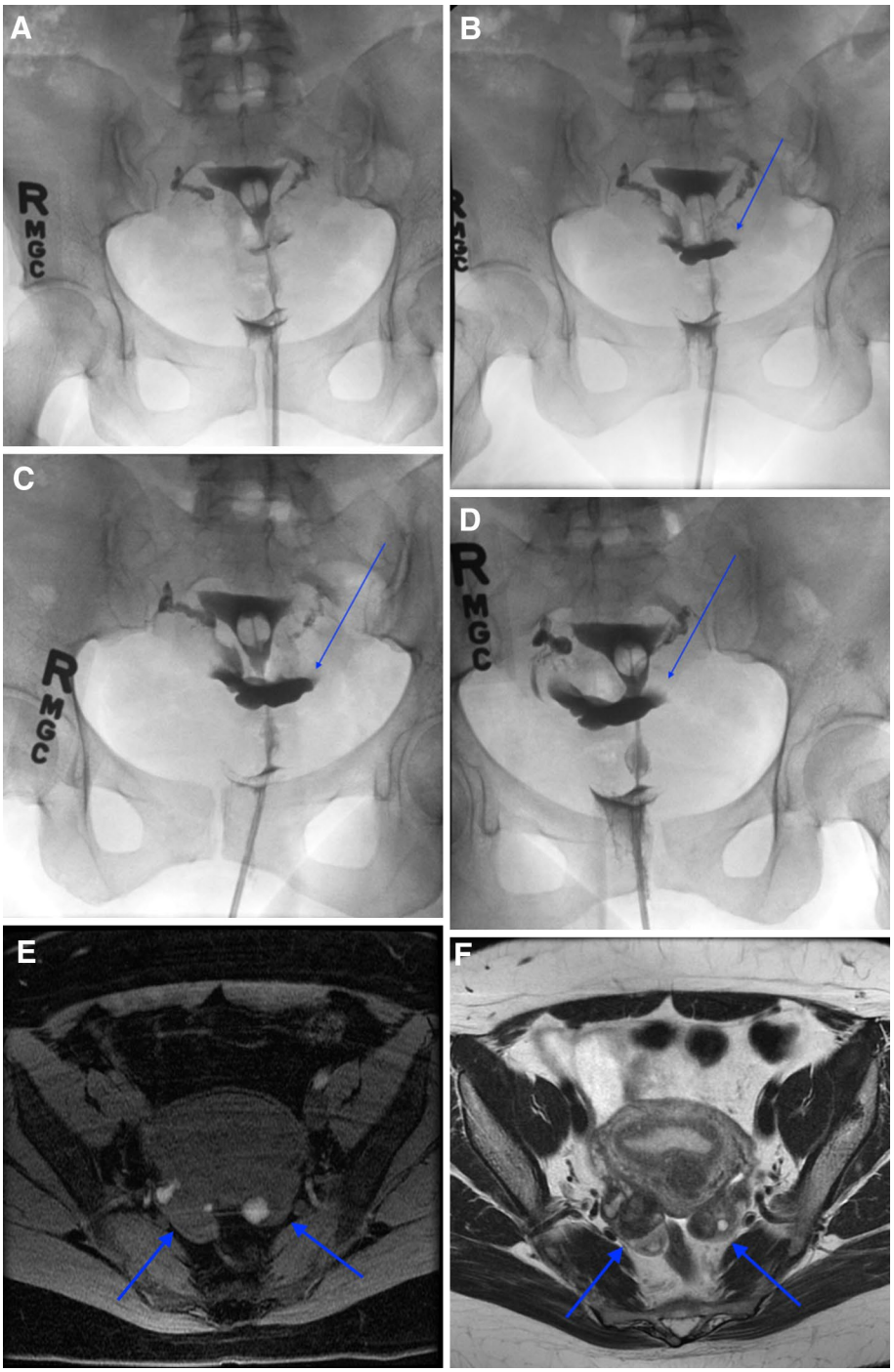

Fig. 4 Deep infiltrative endometriosis. 38-year-old female with history of infertility and known endometriosis. HSG images (**a**–**d**) demonstrate spill of contrast into the peritoneum which is loculated in the deep posterior pelvis (arrow). The fimbrial ends of both fallopian tubes and the fluid are midline in the cul-de-sac, a finding associated with deep infiltrative endometriosis. Axial T1 with fat saturation (**e**) and axial T2-weighted (**f**) MR images demonstrate bilateral endometriomas (thick arrow). Both ovaries are correspondingly in the midline cul-de-sac

Interpretation (Table 2)

Fallopian tubes

Each fallopian tube can be divided into three segments. The interstitial or cornual segment is the short segment that traverses the muscular wall of the uterus [7]. The isthmic segment is narrow and extends between the interstitial and ampullary segments. It is the longest of the three segments. The ampullary segment is the widest, adjacent to the ovary.

Tubal obstruction

Partial filling of the fallopian tube with contrast with no contrast spill into the peritoneal cavity indicates obstruction. The ampulla is a common site of tubal obstruction in patients with pelvic adhesions [16]. Obstruction at the

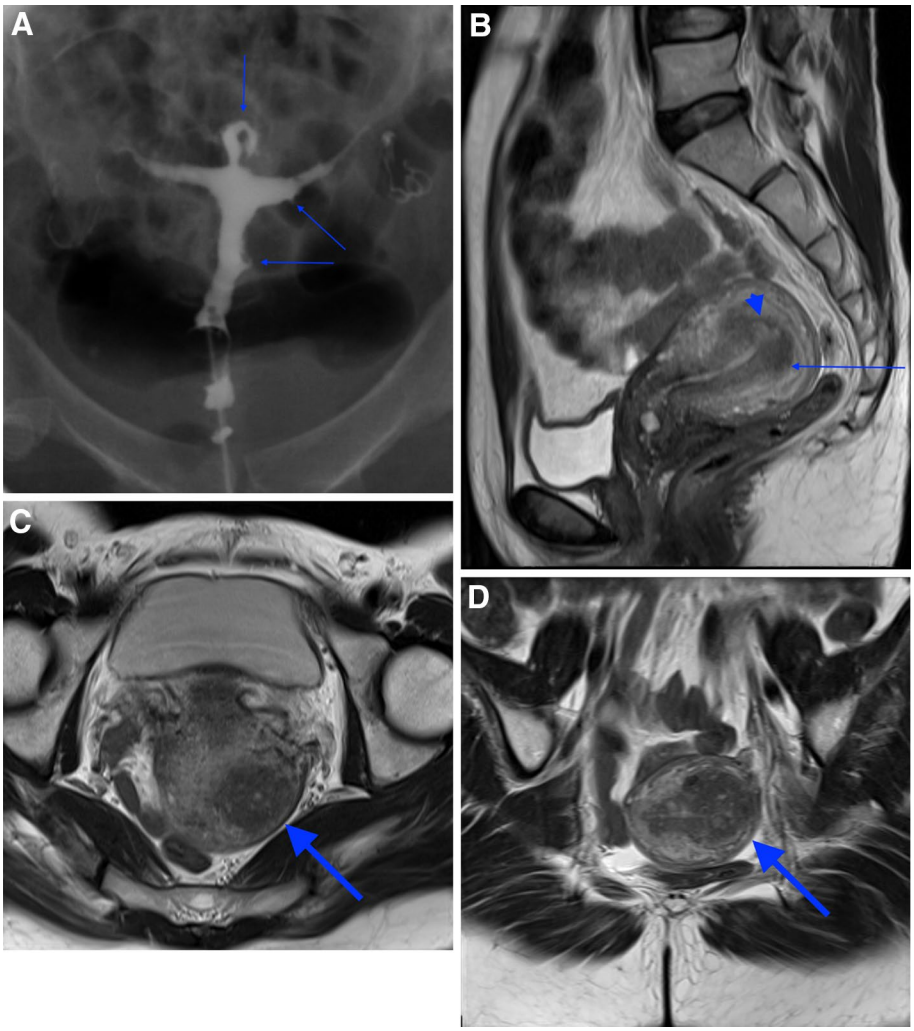

Fig. 5 Uterine adenomyosis and tubal occlusion. 38-year-old female. History of three spontaneous abortions. HSG (**a**) demonstrates an abnormal uterine lumen, with an irregular contour and multiple outpouchings in the lower uterine segment, adjacent to the left uterine horn and extending superiorly from the fundus (arrows). Appearance of the uterine cavity indicates adenomyosis. The caliber of both fallopian tubes are normal, although free spill was not seen from either fallopian tube. Sagittal T2-weighted MR image (**b**) demonstrates thickening of the junctional zone (arrow) and hyperintense endometrial glands into the fundal myometrium consistent with adenomyosis (arrowhead). Axial T2 (**c**) and coronal T2 (**d**) weighted MR images demonstrate an adenomyoma (thick arrow)

isthmus can be seen following surgical procedures such as salpingectomy or tubal ligation. Tubal obstruction is seen most commonly in pelvic inflammatory disease [21] but is also seen in endometriosis [22].

Hydrosalpinx

Hydrosalpinx is defined as fluid-filled dilatation of the fallopian tube [23] (Figs. 1 and 2). On HSG, the finding is contrast opacification of a dilated fallopian tube, an abrupt cut-off and no free spill of contrast into the peritoneal cavity. Hydrosalpinx is commonly due to peritubal adhesions, a sequela of endometriosis [24].

Loculated contrast after spill

Spill of contrast from the fallopian tube is normally free flowing. However, peritubal adhesions prevent free flow of contrast material after spillage. Loculations around the ampullary segment of the fallopian tube indicates peritubal adhesions (Fig. 3). On HSG, loculation is seen as pooling of contrast material.

Fallopian tube location

A common location for solid invasive endometriosis is the rectouterine pouch. Consequently, in patients with deep infiltrative endometriosis, the ovaries are often located midline, posterior to the uterus in the cul-de-sac. This is due to adhesions between the adjacent peritoneal surfaces and has been described as “kissing ovaries” on cross-sectional imaging. The correlative finding on HSG are fallopian tubes that drape posterior to the uterus with the fimbrial ends in the midline and loculated contrast spill into the cul-de-sac. This finding may indicate deep infiltrative endometriosis [25] (Fig. 4).

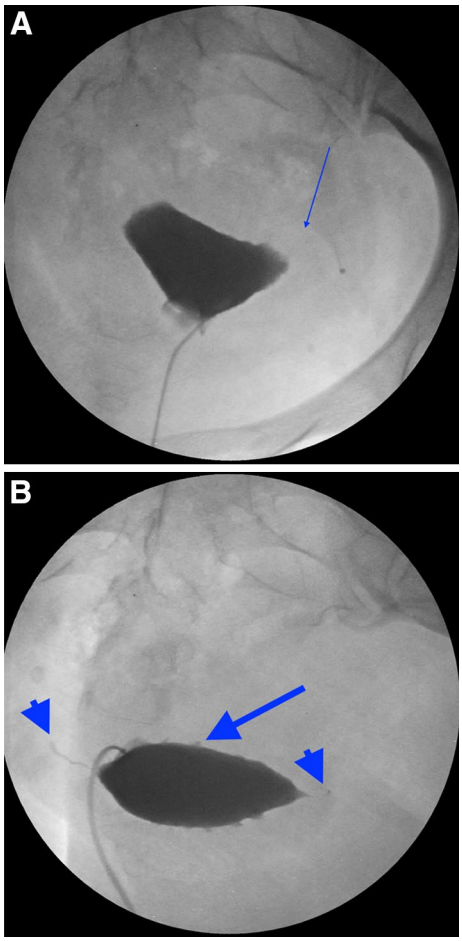

Fig. 6 Bilateral tubal occlusion and adenomyosis. 34-year-old female with a history of infertility. Anteroposterior (**a**) image from HSG following instillation of contrast shows an enlarged cavity and partial filling of the left fallopian tube (thin arrow). Oblique image (**b**) demonstrates an irregular uterine lumen with multiple outpouchings suggestive of adenomyosis (thick arrow) and partial filling of both fallopian tubes (arrowheads)

Uterus

Adenomyosis

Adenomyosis is characterized by the presence of ectopic endometrium within the myometrium [26]. There is an association between endometriosis and adenomyosis with a reported prevalence of adenomyosis of up to 91% in patients with endometriosis [27]. Adenomyosis on HSG is seen as multiple saccular contrast collections that extend beyond the expected endometrial margin into the myometrium (Figs. 5 and 6). The endometrial cavity itself is sometimes enlarged. Patients with suspected adenomyosis are referred for MRI for accurate diagnosis [28].

Mullerian anomalies

Patients with Mullerian duct anomalies with obstruction of antegrade menstruation have an increased risk of endometriosis [1, 29–31] (Fig. 7). This includes females with a unicornuate uterus with a non-communicating rudimentary horn or uterus didelphys with a transverse vaginal septum [32]. HSG can identify a uterine cavity with a single horn indicating a unicornuate or didelphys uterus. A vertical intracavitary septum would indicate a bicornuate or septate uterus. Definitive characterization of these abnormalities requires visualization of the external uterine contour. Consequently, when HSG indicates a Mullerian anomaly, the patient is referred for further imaging with either pelvic MRI or ultrasound with three-dimensional reconstruction [16].

Uterine synechiae

Uterine synechiae or adhesions are often seen in patients undergoing evaluation for infertility when synechiae can cause uterine outflow obstruction. The associated retrograde menstruation is a risk factor for endometriosis [1, 33–35]. On HSG, synechiae are usually seen as an unusually small uterine cavity with an abnormal contour (Fig. 8).

Exam reporting (Table 3)

HSG exam reporting should include a description of the tube and the nature of the contrast spill into the peritoneal cavity. Uterine cavity abnormalities should be noted and referred for further evaluation.

The fallopian tube caliber and patency should be described. If the tube is patent, the contrast spill should be described as free or loculated. If the course of the fallopian tube and the location of loculated spill in the cul-de-sac suggest deep infiltrative endometriosis, this should be noted.

The contour of the uterine cavity should be described. Findings indicating adenomyosis or a Mullerian fusion anomaly should be noted and characterized further with a pelvic MRI. Any intracavitary filling defects should be noted and referred for evaluation with sonohysterography or hysteroscopy.

Pitfalls in performance and interpretation

Cornual spasm

The cornual segment of the fallopian tube is encased by uterine smooth muscle. Muscle spasm can lead to transient tubal occlusion, thus leading to non-opacification of a patent

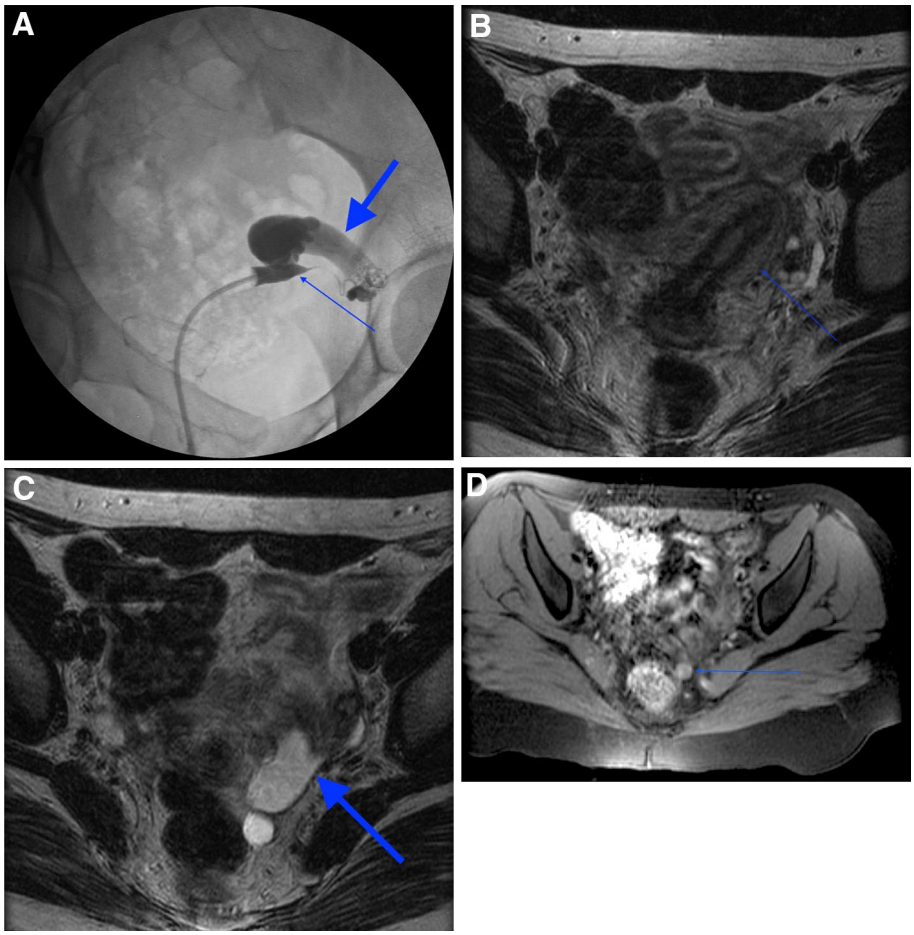

Fig. 7 Uterine anomaly and hydrosalpinx. 29-year-old female with a history of infertility. HSG (**a**) image demonstrates a single, left-sided uterine cavity (arrow) and a dilated left fallopian tube indicating a hydrosalpinx (thick arrow). Axial T2-weighted MR images (**b**, **c**) illustrates a unicornuate uterus (thin arrow) and a left-sided hydrosalpinx (thick arrow). Axial T1-weighted image with fat saturation (**d**) demonstrates a T1 hyperintense nodule in the pelvis (arrow) corresponding to an endometrial implant

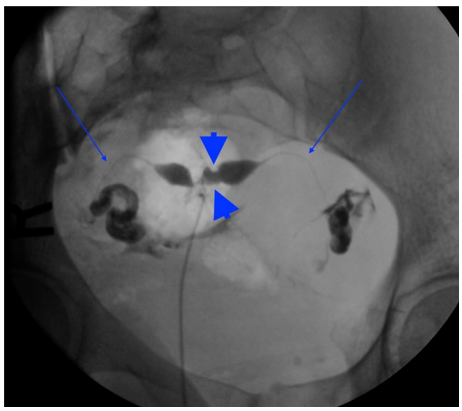

Fig. 8 Uterine synechiae. 33-year-old female with a history of infertility. HSG image demonstrates a small uterine cavity with multiple irregular filling defects compatible with scarring and adhesions (arrowheads). There are normal fallopian tubes bilaterally (arrows) which demonstrated free spill

tube (Fig. 9). Occlusion from muscle spasm is reversible but can last for over 15 min.

In our practice, if we suspect cornual spasm, we pause the study for several minutes to allow the spasm to resolve. If the spasm does not resolve, and imaging evaluation of the tube is clinically necessary, the patient is rescheduled. Repeat examination of such patients usually shows a normal fallopian tube indicating cornual spasm on the original exam. Often, repeat exam is not necessary as illustration of a single normal fallopian tube is sufficient for the patient to progress onto the next steps in the evaluation of infertility.

Tubal occlusion from other causes

Infection from pelvic inflammatory disease, appendicitis, and diverticulitis as well as endometriosis are the most common causes for pelvic adhesions. Less common causes include congenital uterine anomalies, pelvic masses, and other rare causes of inflammation, such as tuberculosis or xanthogranulomatous salpingitis [36]. The ampulla is a common site of obstruction (Fig. 10). Obstruction at the isthmus is seen following salpingectomy and tubal ligation.

Active menses

Active menses is a relative not absolute contraindication [16]. In our practice, we perform HSGs on day 6 through 11 from the LMP to avoid both pregnancy and intrauterine

Table 3 Reporting checklist for hysterosalpingography in patients with suspected endometriosis

Fallopian tubes	If the tube is patent, describe the spilled contrast:	Uterine contour
Caliber: Normal/abnormal/unknown*	Does the contrast spill freely (normal) or loculate around the tube (suggesting peritubal adhesion)?	Saccular contrast extrusion suggests adenomyosis—Refer for pelvic MRI
Patency: Yes/no/unknown*	Do the tubes course with the fimbrial ends located midline behind the uterus with pooling of the spilled fluid in the cul-de-sac indicating adhesions of deep infiltrative endometriosis?	Mullerian anomaly—Refer for pelvic MRI or 3-D pelvic ultrasound
		Filling defects suggesting adhesions—Refer for sonohysterography or hysteroscopy

*Lack of any tubal opacification may indicate myometrial spasm at the cornua rather than tubal abnormality. In such cases, the fallopian tube has not been evaluated by the exam

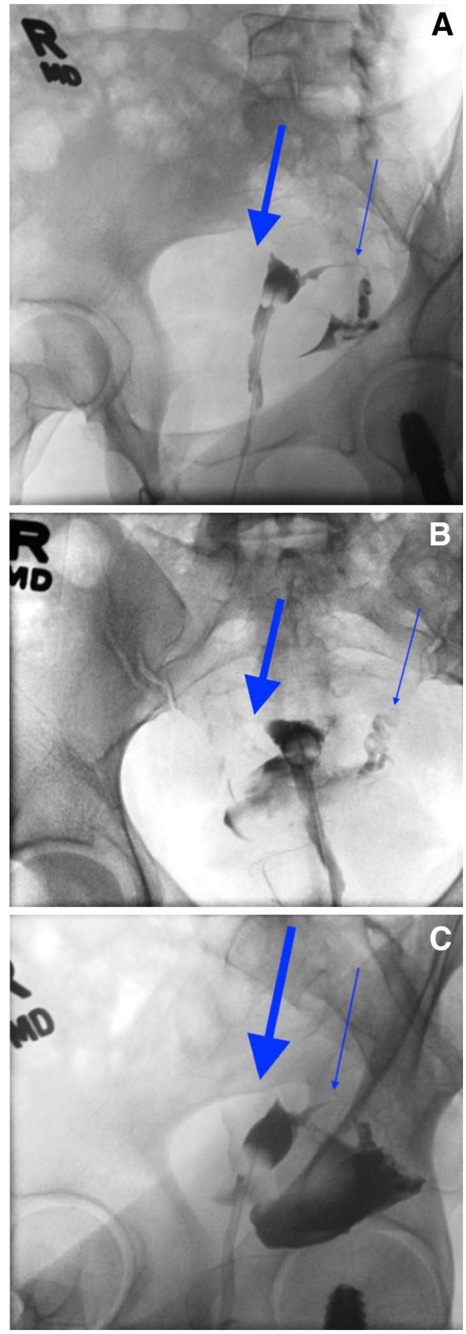

Fig. 9 Cornual spasm. 30-year-old female with a history of infertility. HSG image with a balloon-tipped catheter in the uterine cavity demonstrates a normal left fallopian tube (thin arrow) with free spill. The right fallopian tube does not demonstrate any filling, most likely due to spasm (thick arrows) and cannot be evaluated

blood clots. The presence of active menses can cause filling defects in the uterine cavity leading to erroneous diagnoses of focal endometrial or myometrial lesions. Moreover, it occasionally precludes evaluation of the tubes. Intrauterine blood clots can occlude the passage of contrast into the

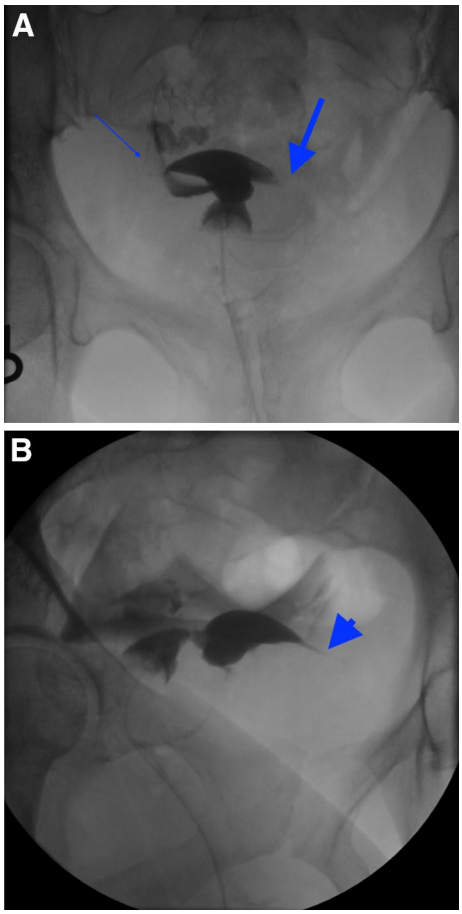

Fig. 10 Unilateral tubal occlusion. 48-year-old female with a history of infertility. Anteroposterior image from a HSG (**a**) shows no opacification of the left fallopian tube (thick arrow) and a normal right fallopian tube (thin arrow). Oblique, magnified image (**b**) demonstrates peritoneal spill from the right side and partial opacification of the left fallopian tube (arrowhead) indicating tubal occlusion

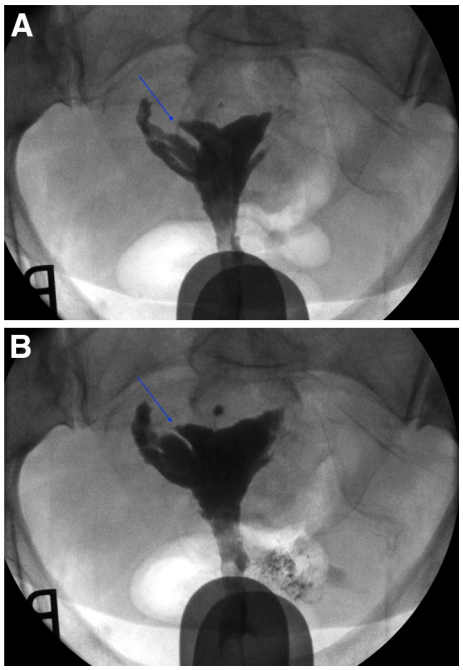

Fig. 11 Active menses with clots in the uterine cavity. 40-year-old female with a history of secondary infertility. HSG images demonstrate filling defects (arrows) during the early filling stage (**a**), which persist on later images (**b**), consistent with intrauterine blood clots. As there is no contrast opacification of the fallopian tubes, they cannot be evaluated

fallopian tubes (Figure 11). Patients who present before day 6 but a few days past peak menses can usually be evaluated.

Fibroids

Large fibroids can distort the uterine cavity, in some cases mimicking uterine anomalies and in others precluding complete evaluation of the fallopian tubes (Fig. 12). If uterine cavity distortion from fibroids is suspected, we refer the patient for further imaging with pelvic ultrasound or MRI. The latter is preferred if the HSG indicates an enlarged uterus that would require large field-of-view imaging.

Adnexal mass

Large pelvic masses can distort the course or obstruct the fallopian tubes, mimicking peritubal adhesions or deep infiltrative endometriosis (Fig. 13). This should be suspected if fallopian tube appears displaced or is not following a normal course. If an underlying pelvic mass is suspected, we refer the patient for further imaging with pelvic ultrasound or MRI. The latter is preferred if the HSG indicates a mass greater than 5 cm that would require large field-of-view imaging.

Intravasation

On HSG, the early appearance of venous or lymphatic intravasation is of multiple thin-beaded channels surrounding the uterine cavity [37]. These channels can occasionally be mistaken for tubal filling. In order to avoid this pitfall, we avoid excessive pressure during contrast injection as well as inadvertent placement of the cannula into the myometrium (Fig. 14).

Conclusion

Endometriosis is often seen and sometimes initially diagnosed on HSG, an imaging exam routinely performed on patients with infertility. HSG findings suggesting endometriosis include hydrosalpinx, tubal occlusion, peritubal, and deep pelvic adhesions and adenomyosis. Findings indicating

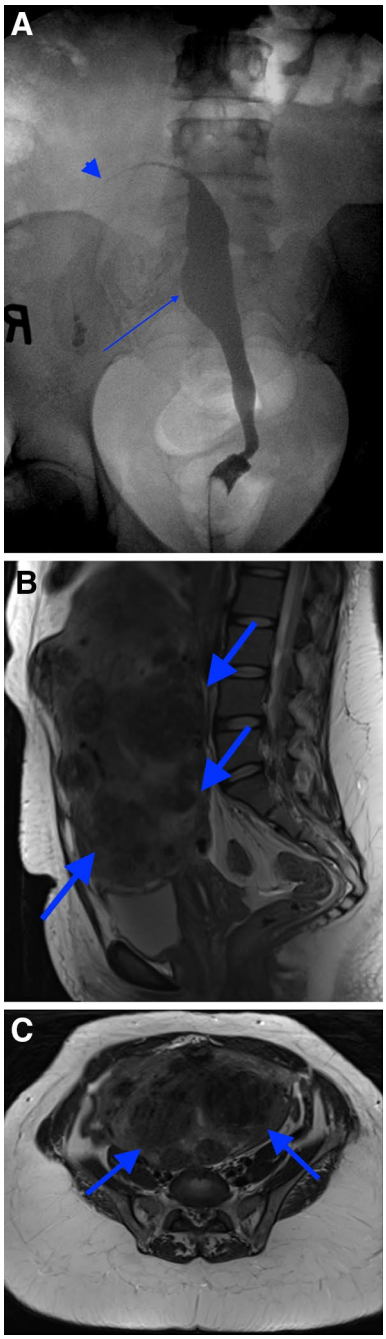

Fig. 12 Uterine fibroids. 40-year-old female with a history of infertility. HSG image (**a**) demonstrates a markedly enlarged uterine cavity with distorted contour (arrow). There is partial opacification of the right fallopian tube (arrowhead) with intraperitoneal spill demonstrated on later spot images. There was no opacification of the left fallopian tube, which was thought to be due to mass effect on the tubal os by the distorted uterine geometry. Sagittal (**b**) and axial (**c**) T2-weighted images from an MRI pelvis in the same patient confirms the presence of an enlarged uterus with multiple fibroids (thick arrows)

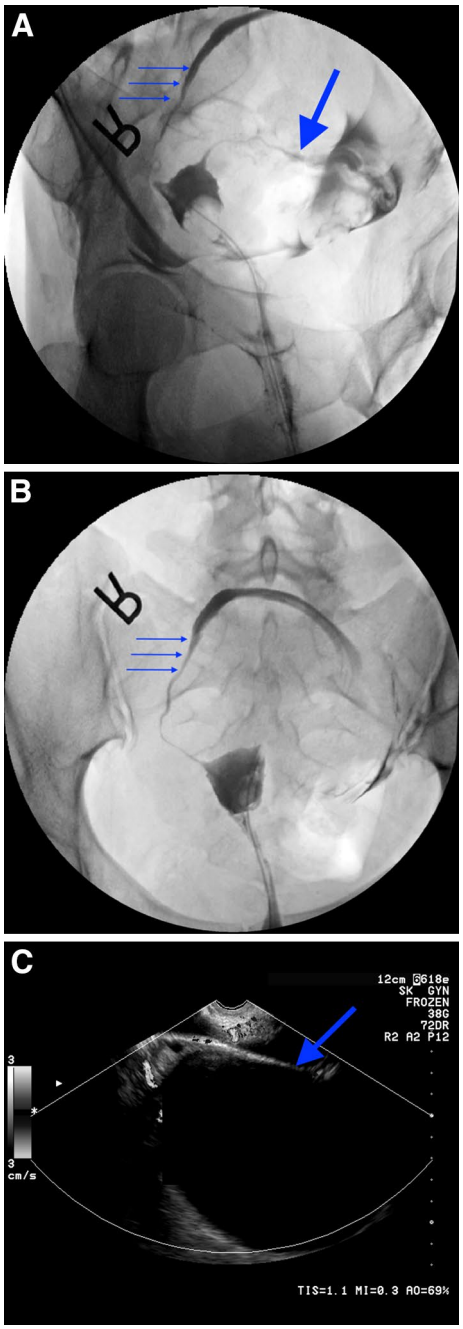

Fig. 13 Adnexal mass. 31-year-old female with a history of infertility. Images obtained following instillation of contrast demonstrate a patent left fallopian tube (**a**) with intraperitoneal spill. The right fallopian tube (**a** and **b**) is opacified but has an abnormal course (arrows). Pelvic ultrasound indicates the presence of a 10-cm cystic right adnexal mass (**c**) separated from the urinary bladder which accounts for the displaced fallopian tube. The mass was surgically excised and confirmed to represent an ovarian serous cystadenoma

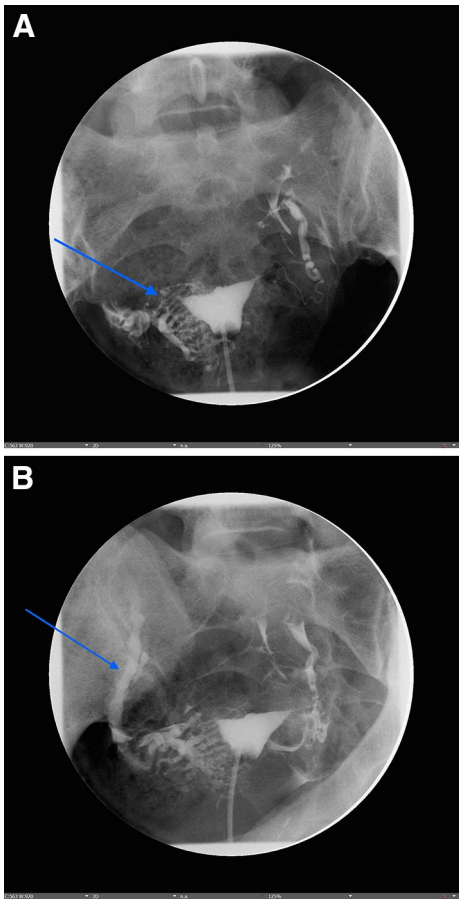

Fig. 14 Venous intravasation. 34-year-old female with a history of infertility. HSG images demonstrate opacification of multiple thin-beaded channels surrounding the uterine cavity (**a**, arrow) as well as opacification of the right gonadal vein (**b**, arrow), with appearances being consistent with venous intravasation

a Mullerian anomaly or uterine synechiae would indicate a patient at higher risk of endometriosis. A diagnosis of endometriosis suspected on HSG should be confirmed with MRI or surgery.

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Compliance with ethical standards

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References

1. Bulun SE. Endometriosis. N Engl J Med 2009;360:268-279
2. Soliman AM, Surrey E, Bonafede M, Nelson JK, Castelli-Haley J. Real-World Evaluation of Direct and Indirect Economic Burden Among Endometriosis Patients in the United States. Adv Ther 2018;35:408-423
3. Shafrir AL, Farland LV, Shah DK, et al. Risk for and consequences of endometriosis: A critical epidemiologic review. Best Pract Res Clin Obstet Gynaecol 2018;51:1-15
4. Eskenazi B, Warner ML. Epidemiology of endometriosis. Obstet Gynecol Clin North Am 1997;24:235-258
5. Koninckx PR, Martin DC. Deep endometriosis: a consequence of infiltration or retraction or possibly adenomyosis externa? Fertil Steril 1992;58:924-928
6. Schneider C, Oehmke F, Tinneberg HR, Krombach GA. MRI technique for the preoperative evaluation of deep infiltrating endometriosis: current status and protocol recommendation. Clin Radiol 2016;71:179-194
7. Simpson WL, Jr., Beitia LG, Mester J. Hysterosalpingography: a reemerging study. Radiographics 2006;26:419-431
8. McPherson RA PM. Henry's clinical diagnosis and management by laboratory methods. 22nd ed. Philadelphia: Elsevier Saunders, 2011
9. Pittaway DE, Winfield AC, Maxson W, Daniell J, Herbert C, Wentz AC. Prevention of acute pelvic inflammatory disease after hysterosalpingography: efficacy of doxycycline prophylaxis. Am J Obstet Gynecol 1983;147:623-626
10. Stumpf PG, March CM. Febrile morbidity following hysterosalpingography: identification of risk factors and recommendations for prophylaxis. Fertil Steril 1980;33:487-492
11. Moller BR, Allen J, Toft B, Hansen KB, Taylor-Robinson D. Pelvic inflammatory disease after hysterosalpingography associated with Chlamydia trachomatis and Mycoplasma hominis. Br J Obstet Gynaecol 1984;91:1181-1187
12. ACOG Practice Bulletin No. 195: Prevention of Infection After Gynecologic Procedures. Obstet Gynecol 2018;131:e172-e189
13. Yoder IC, Hall DA. Hysterosalpingography in the 1990s. AJR Am J Roentgenol 1991;157:675-683
14. Chalazonitis A, Tzovara I, Laspas F, Porfyridis P, Ptohis N, Tsimitselis G. Hysterosalpingography: technique and applications. Curr Probl Diagn Radiol 2009;38:199-205
15. ACR Manual on Contrast Media. Vol Version 10.32018.
16. Lee SI KA. Hysterosalpingography. *UpToDate*. Waltham, MA: Wolters Kluwer; 2019.
17. Medicine AAoPi. A primer on low-level ionizing radiation and its biological effects. 1986;AAPM Report No. 18.
18. Medical Radiation Exposure of Pregnant and Potentially Pregnant Women *NRCP Report No. 54*1977.
19. Perisinakis K, Damilakis J, Grammatikakis J, Theocharopoulos N, Gourtsoyiannis N. Radiogenic risks from hysterosalpingography. Eur Radiol 2003;13:1522-1528
20. Radiation Dose in X-Ray and CT Exams. Accessed date: 2019 August 6th Available from: http://www.radiologyinfo.org/en/info.cfm?pg=safety-xray.
21. Sadow CA, Sahni VA. Imaging female infertility. Abdom Imaging 2014;39:92-107
22. Schankath AC, Fasching N, Urech-Ruh C, Hohl MK, Kubik-Huch RA. Hysterosalpingography in the workup of female infertility: indications, technique and diagnostic findings. Insights Imaging 2012;3:475-483
23. Rezvani M, Shaaban AM. Fallopian tube disease in the nonpregnant patient. Radiographics 2011;31:527-548
24. Kim MY, Rha SE, Oh SN, et al. MR Imaging findings of hydrosalpinx: a comprehensive review. Radiographics 2009;29:495-507

25. Ghezzi F, Raio L, Cromi A, et al. "Kissing ovaries": a sonographic sign of moderate to severe endometriosis. Fertil Steril 2005;83:143-147
26. Takeuchi M, Matsuzaki K. Adenomyosis: usual and unusual imaging manifestations, pitfalls, and problem-solving MR imaging techniques. Radiographics 2011;31:99-115
27. Bazot M, Bharwani N, Huchon C, et al. European society of urogenital radiology (ESUR) guidelines: MR imaging of pelvic endometriosis. Eur Radiol 2017;27:2765-2775
28. Champaneria R, Abedin P, Daniels J, Balogun M, Khan KS. Ultrasound scan and magnetic resonance imaging for the diagnosis of adenomyosis: systematic review comparing test accuracy. Acta Obstet Gynecol Scand 2010;89:1374-1384
29. Bennett GL, Slywotzky CM, Cantera M, Hecht EM. Unusual manifestations and complications of endometriosis–spectrum of imaging findings: pictorial review. AJR Am J Roentgenol 2010;194:WS34-46.
30. Rock JA, Zacur HA, Dlugi AM, Jones HW, Jr., TeLinde RW. Pregnancy success following surgical correction of imperforate hymen and complete transverse vaginal septum. Obstet Gynecol 1982;59:448-451
31. Ugur M, Turan C, Mungan T, et al. Endometriosis in association with mullerian anomalies. Gynecol Obstet Invest 1995;40:261-264
32. Siegelman ES, Oliver ER. MR imaging of endometriosis: ten imaging pearls. Radiographics 2012;32:1675-1691
33. de Ziegler D, Borghese B, Chapron C. Endometriosis and infertility: pathophysiology and management. Lancet 2010;376:730-738
34. Giudice LC. Clinical practice. Endometriosis. N Engl J Med 2010;362:2389-2398
35. Burney RO, Giudice LC. Pathogenesis and pathophysiology of endometriosis. Fertil Steril 2012;98:511-519
36. Thurmond AS. Imaging of female infertility. Radiol Clin North Am 2003;41:757-767, vi
37. Ledbetter KA, Shetty M, Myers DT. Hysterosalpingography: an imaging Atlas with cross-sectional correlation. Abdom Imaging 2015;40:1721-1732