Role of Hysterosalpingography (HSG) and Sono-HSG

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7.1 Introduction

Hysterosalpingography (HSG) has become an important initial investigation in patients who present with infertility or other endometrial/tubal problems. This chapter predominantly deals with HSG as the initial screening procedure for an intrauterine adhesion or Asherman's workup with emphasis on procedural details and image interpretation. It also briefly addresses the ultrasound extension of HSG–sono-HSG and its advantages over HSG.

7.2 Hysterosalpingography (HSG)

This is the radiographic imaging of uterine cavity, fallopian tubes, peritoneal cavity, and cervical canal, during intracavitary injection of contrast media under fluoroscopic visualization. Though the procedure is in practice for more than 100 years now, HSG is now increasingly being performed [1]. This is likely to be due to increase in the number of patients presenting with the problem of infertility as well as the recent advances in the field of reproductive medicine. Hysterosalpingography is considered an initial screening procedure for an infertility workup, and despite the development of other diagnostic tools including MRI, hysteroscopy, and laparoscopy, HSG remains the main examination for the study of the fallopian tubes [2].

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In general, ultrasound is considered to be more effective for endometrial imaging: MRI for myometrial imaging and HSG for tubal imaging. In infertility workup, HSG has been reported to have high sensitivity but low specificity, particularly in the evaluation of endometrial abnormalities [3]. The technical quality of HSG and the image interpretation skills play an important role in the performance of HSG in these patients [4]. The concerns about the technical and interpretation lapses in HSG were highlighted in a questionnaire-based study [5]. The study included 50 radiologists and 50 gynecologists, irrespective of their practice settings and years of experience. The study revealed few serious lapses in the procedure and interpretation of HSG which can account for the inferior diagnostic performance and can certainly be improved with awareness, education, and training.

Hysteroscopy is the gold standard of methods for diagnosis of intrauterine adhesions, against which all others must be compared. Hysterosalpingography (HSG) is a useful screening outpatient radiological procedure for diagnosis and has 75% sensitivity, 95% specificity, 50% positive predictive value (PPV), and 98% negative predictive value (NPV). Considerable interobserver variability in the interpretation of HSGs has been reported, depending on the type of pathology being assessed. Women with possible comorbidity such as pelvic and tubal diseases may need a laparoscopic assessment.

For greatest accuracy, it is important to perform HSG without a speculum in the vagina and, if a balloon catheter is used, to deflate the balloon before ending the examination to ensure that the entire cavity has been adequately visualized. Mild-to-moderate intrauterine adhesions generally yield irregular filling defects in a lacunar pattern and may be identified in any region of the uterine cavity.

When adhesions are severe, it may be impossible to visualize the endometrial cavity altogether. The fluoroscopic exposure (radiation exposure) associated with a normal HSG is approximately 63 s (range 17–404 s) when the test is normal and 100 s (range 28–172 s) when abnormal.

Mild-to-moderate cramping pain is commonly associated with HSG and can be minimized by treatment with nonsteroidal anti-inflammatory agents beginning approximately 1 h before the procedure. Pelvic infections, vagal reactions, intravasation of contrast, and iodine-induced allergic reactions are uncommon but potentially serious complications of HSG.

7.3 Patient Selection

7.3.1 Indications and Contraindications

Apart from the IUA workup, HSG may be advised for a wide range of clinical indications. Based on the clinical settings, appropriate patient selection is important for performing the HSG. The other clinical indications and contraindications for HSG are mentioned in Fig. 7.1 [6].

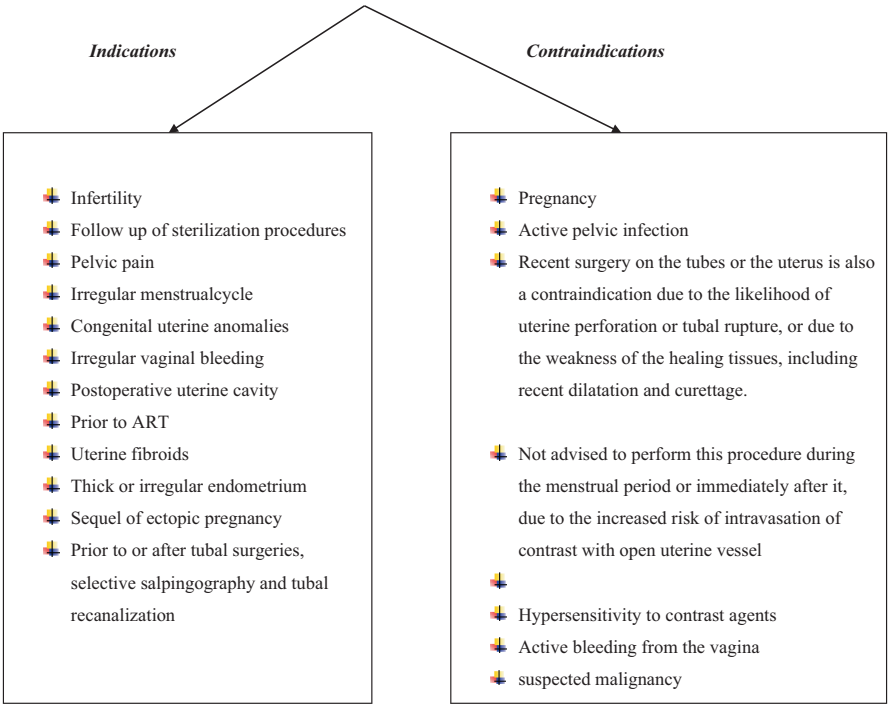

Fig. 7.1 Patient selection

7.3.2 Preparation

- As pregnancy is the absolute contraindication, 10-day rule should be followed.
- HSG should be scheduled during the follicular phase of the menstrual cycle, after menstrual flow has ceased but before the patient has ovulated, usually between 7th and 10th days of menstrual cycle. HSG before the 7th day may increase the chances of contrast intravasation into the fragile veins and therefore adversely affect the image interpretation.
- The patient should be instructed to abstain from sexual intercourse from the time menstrual bleeding ends until the day of the study to avoid a potential pregnancy.
- If the patient has irregular menstrual cycles or there is a possibility of pregnancy, serum beta HCG level should be evaluated.
- HSG should not be performed when ongoing pelvic infection or active vaginal bleeding is present.
- Patients with cervical stenosis may pose difficulty due to difficulty in cervical cannulation and may be initially treated.
- History of allergy or idiosyncratic reaction to iodinated contrast media is a relative contraindication and may require premedication with diphenhydramine, steroids, and/or other medications.

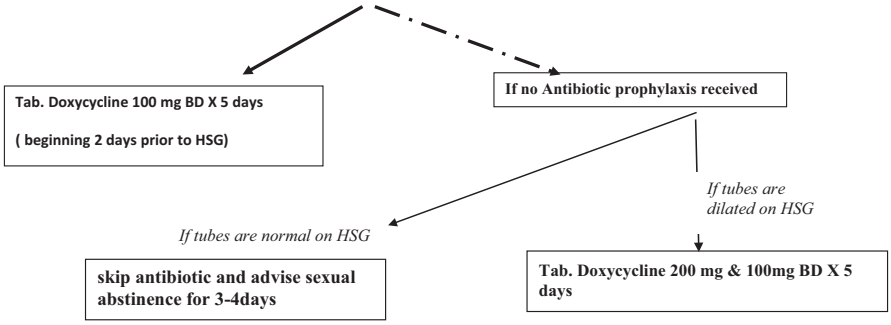

Fig. 7.2 Antibiotic prophylaxis for HSG

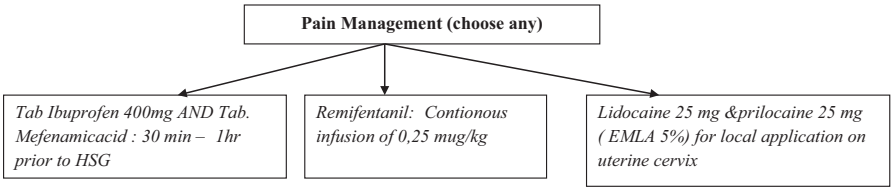

Fig. 7.3 Pain management (choose any)

- Though pre-procedural antibiotics are not advised in all the patients, it should be considered in patients with a history of pelvic inflammatory disease or with cardiac lesions.
- A practical recommendation for the use of antibiotics is stated in Fig. 7.2 [7]. Antibiotics may also be advised in patients after hydrosalpinx is diagnosed on HSG.
- Pre-procedural analgesia is important to ensure painless patient experience and to avoid the vasovagal response during the procedure. The clinical practice often varies across different institutions. List of different drug combinations is stated in Fig. 7.3 [8, 9].

7.3.3 Procedural Technique

The patient is asked to empty her bladder and then lie supine on the fluoroscopy table in the lithotomy position.

The perineum is prepared with povidone-iodine solution and draped with sterile towels.

A speculum is inserted into the vagina. The cervix is localized and cleansed with povidone-iodine solution.

Metal or plastic Leech Wilkinson HSG cannula is used depending upon the institute's practice (Fig. 7.4).

During traditional HSG, a vulsellum or tenaculum is placed on the anterior cervical lip of the external cervical os for traction. It is placed at 12 o'clock position as cervical vascularity is greatest at 3 o'clock and 9 o'clock positions, and therefore avoided. There are many catheter systems including rigid systems or flexible catheters with and without a balloon system [7]. Patients with a patulous or incompetent cervix are best examined with the 5F balloon systems or an 8-French pediatric Foley catheter. The balloon should be filled with fluid to avoid artifact. Balloon catheters usually do not require tenaculum placement for cervical traction.

The cannula is placed just beyond the internal os. Several modifications in technique may be required. External compression over the pubic symphysis is likely to bring the cervix into view in patients with posterior location of cervix (Fig. 7.5).

Valsalva maneuver is useful to improve cervical visualization particularly in multiparous or grand multiparous patients.

Fig. 7.4 Leech Wilkinson cannula

Fig. 7.5 Instruments required for HSG (Sims speculum, anterior vaginal wall retractor, uterine sound, vulsellum, Allis forceps, HSG cannula)

7.4 Radiological Contrast Used in HSG

The choice of contrast material for HSG is often debated as few authors support the use of an oil-soluble contrast medium, as this is likely to provide greater contrast and image sharpness and better evaluate peri-tubal adhesions [10].

An increase in pregnancy rates in infertile patients after HSG with oil-soluble medium has been suggested [11] whereas another study [12] shows no statistical difference between the use of oil- and water-soluble contrast agents.

A recent multicenter [13], randomized trial in 27 hospitals in the Netherlands randomly assigned the patients with infertility into oil-based contrast or water-based contrast groups. A total of 220 of 554 women in the oil-based group (39.7%) and 161 of 554 women in the water-based group (29.1%) conceived (rate ratio 1.37; 95% confidence interval [CI] 1.16 to 1.61; $P < 0.001$), and 214 of 552 women in the oil-based group (38.8%) and 155 of 552 women in the water-based group (28.1%) had live births (rate ratio 1.38; 95% CI 1.17 to 1.64; $P < 0.001$). Rates of pregnancy and live births were significantly higher among women who underwent HSG with oil-based contrast as compared to women who had HSG with water-based contrast in this study.

- *Still, water-soluble contrast medium is preferred at most institutions due to absence of any serious secondary effects like peritoneal inflammatory or granulomatous reaction and because it eliminates the risk of pulmonary and retinal oil emboli during the inadvertent venous in extravasation of contrast medium during the procedure.*

7.5 Complications

- Bleeding and infection are the most common complications of HSG. The patient should be made aware about the possibility of light spotting after the procedure, usually lasting less than 24 h.
- Mild fever or foul-smelling vaginal discharge over the 2–4-day period following the procedure may be secondary to infection.
- Patients may experience cramping when the catheter balloon is inflated in the endocervical canal or when the uterus is overdistended with contrast material or with tubal obstruction. This cramping is generally minor and transient and is well tolerated by the majority of patients.
- Risk of reaction to contrast material is very low with the use of low-osmolar nonionic contrast agents.
- Perforation of the uterus or fallopian tubes is extremely unlikely with the use of optimal technique.
- Appropriate timing of the examination and a negative pregnancy test should minimize the possible chances of irradiation of an unsuspected pregnancy.

7.6 Image Acquisition

Plain radiograph of the pelvis is obtained with the catheter in place before contrast material is instilled with the side marker in place. Water-soluble iodinated contrast (ionic or nonionic) is slowly injected under fluoroscopy guidance.

7.6.1 Standard Set of Images (Fig. 7.6a–d) Include

FIRST IMAGE obtained during early filling of the uterus to evaluate for any focal/linear filling defect due to polyp/mass lesion or adhesion in the endometrial cavity. Small subtle filling defects are best seen at this stage.

SECOND IMAGE is obtained with the uterus fully distended to evaluate the uterine contour. The fallopian tubes are also optimally opacified and delineated in this image for course and caliber.

THIRD IMAGE is expected to delineate the free or loculated intraperitoneal spillage of the contrast to assess tubal patency.

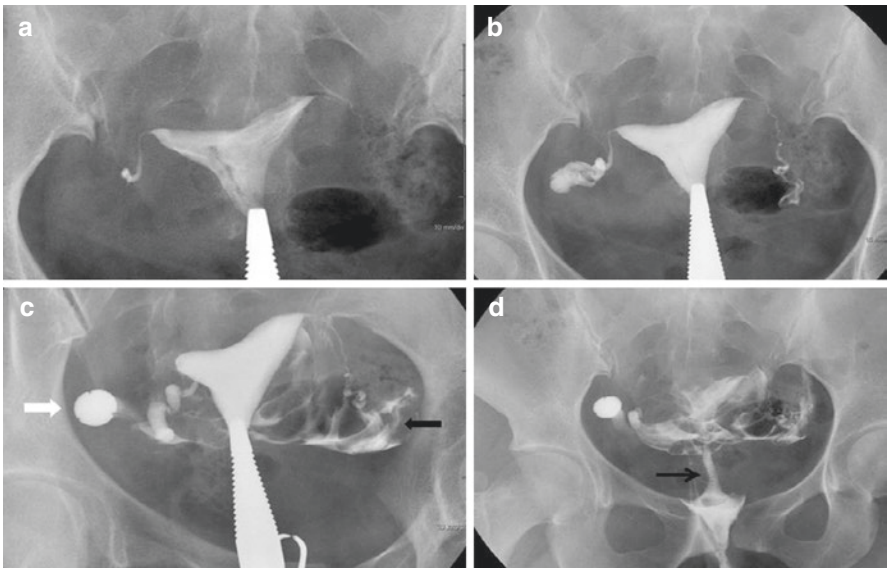

Fig. 7.6 (**a**–**d**) Standard set of images to be acquired during HSG. (**a**) Shows early endometrial filling to look for small lesions, (**b**) endometrial cavity for uterine shape and contour, (**c**) white arrow showing right-sided hydrosalpinx without spillage and black arrow showing normal spillage, (**d**) post-cannula removal film for evaluation of uterine cervix (thin black arrow). Slow and steady contrast injection is necessary to ensure image acquisition in different phases

FOURTH IMAGE is acquired soon after the removal of metal or plastic cannula to delineate the endocervical canal for focal filling defects. It is important to ensure that the contrast injection rate is slow and uniform to ensure acquisition of images in different phases. Additional images including pelvic inlet views, oblique views, or delayed spot views may be acquired in selective cases depending upon the findings.

Just before removing the cannula, "pull-release" maneuver may be performed to assess the degree of pelvic peritoneal adhesions. Apart from this, extravasated contrast is likely to track along the external uterine fundal surface following the maneuver, which provides vital clues in the evaluation of uterine mullerian anomaly.

7.6.2 Equipment Specifications

HSG must always be performed with fluoroscopic equipment meeting all applicable federal, state, and local radiation standards [6]. The equipment should provide diagnostic fluoroscopic image quality and recording capability. The equipment should be capable of producing kilovoltage greater than 100 kVp. Fluoroscopy equipment with the ability to hold the last image is necessary. Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications. The equipment and medications should be monitored for inventory and drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be appropriate for the range of ages and sizes in the patient population.

7.7 Radiation Dosage and Safety

As the HSG involves use of ionizing radiation, patient selection is an important step and diagnostic algorithms should be carefully followed. Nationally developed guidelines, such as the ACR's Appropriateness Criteria, should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure. If justified, HSG should be done with the minimum radiation exposure necessary to provide sufficient anatomic detail for diagnosis of normal or abnormal findings. Adherence to the appropriate practice parameters will maximize the diagnostic benefit of HSG and ensure optimal patient safety. Risk-benefit analysis should be performed for each case.

Radiation hygiene is an important component of HSG procedure and ALARA [as low as reasonably achievable] principles should be followed. Accordingly, due care must be taken to minimize the radiation dose without compromising the quality. To achieve this objective use of digital fluoroscopy is better for HSG, as there is precise control over the radiation dose. Intermittent fluoroscopy should be performed during the procedure. With mean fluoroscopy time of 0.3 min, the average gonad dose is approximately 270 cGy and the effective dose is 1.2 mSv [14].

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for radiation safety in the workplace by keeping radiation exposure to patients, staff, and society as a whole, "as low as reasonably achievable" (ALARA). Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. Otherwise, appropriate manual techniques should be used.

Additional information regarding patient radiation safety is available at the Image Wisely websites [15]. "Image Wisely" is a joint initiative of the American College of Radiology, Radiological Society of North America, American Society of Radiological Technologists, and American Association of Physicists in Medicine. These global awareness campaigns provide free educational materials for all the patients, technologists, referring clinicians, medical physicists, and radiologists. Radiation exposures should be measured and regular auditing should be performed by a qualified medical physicist in accordance with the applicable technical standards and guidelines [16].

7.8 Normal Appearances and Imaging Pitfalls in HSG

On HSG, the uterus should be seen as an inverted triangle with well-defined, smooth contours (Fig. 7.7a). Anteverted or retroverted uterine position may have significant impact on the appearance of normal uterus. Similarly, the rotation of uterus along the long axis may not show the profile views of the uterine cornu. The anteroinferior traction on the uterine cervix is likely to straighten the uterus and minimize the impact of position or rotation of the uterus. The uterus should be evaluated for abnormal filling defects due to focal lesion in the endometrial cavity or for the altered shape and position secondary to uterine mullerian anomaly or due to presence of space-occupying lesion in the endometrial cavity, myometrium, or pelvis.

It is important to be cautious of linear filling defects along the long axis of uterus in the early filling defects due to mucosal folds and it should not be assumed to be pathological (Fig. 7.7b).

Care should be taken to flush the catheter thoroughly with contrast material to avoid injecting air bubbles. Air bubbles manifest as well-circumscribed rounded filling defects in the nondependent portion of the uterus (Fig. 7.7c). They are often mobile and transient and should always be differentiated from fixed filling defects. Cesarean section scars may be seen as focal outpouching or irregularity at the typical location in the lower uterine segment in the region of the isthmus.

The cervical canal is opacified during HSG and shows varied appearance depending upon the parity of the patient. The cervical canal is usually narrower at external and internal os and wider in the midportion. The walls may be smooth or serrated with longitudinal ridges. Prominent serrated appearance (plicae palmatae) is often more prominently seen in nulliparous females (Fig. 7.7d).

Venous or lymphatic intravasation may occur during HSG, which may interfere with optimal image interpretation. Though it may occur in healthy patients, few predisposing factors include recent uterine surgery or instrumentation, increased

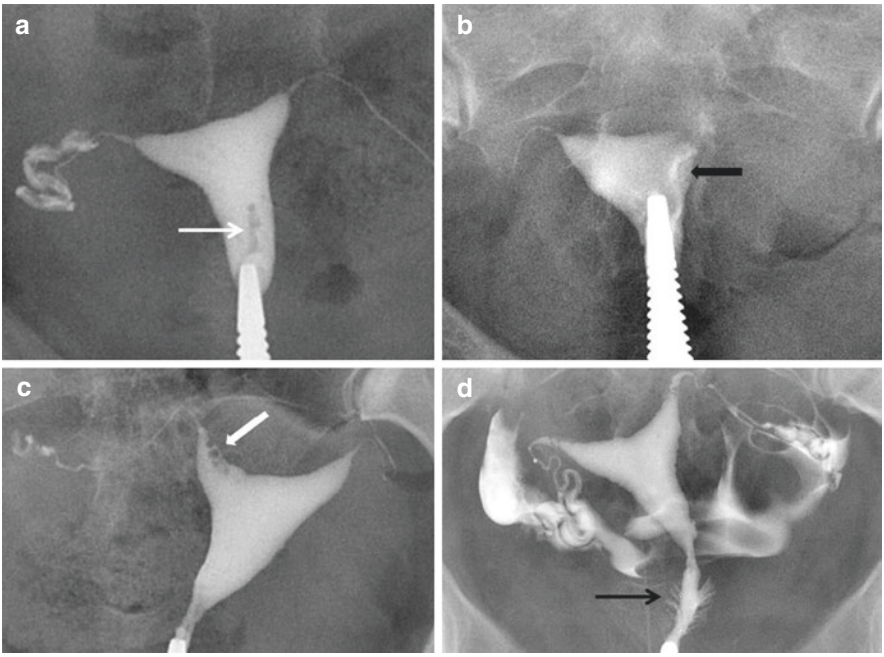

Fig. 7.7 (**a**–**d**) Normal appearance and pitfalls. Uterus should be seen as an inverted triangle with well-defined, smooth contour on HSG (**a**). Dislodged mucous plug is at times seen as linear filling defect (white thin arrow). Linear filling defects may be seen along the long axis of uterus in the early filling defects due to mucosal folds (**b**, black thick arrow). Air bubbles may be seen as well-circumscribed rounded filling defects (**c**, white thick arrow). Prominent serrated appearance (plicae palmatae) is often seen in nulliparous females (**d**, black thin arrow)

intrauterine pressure because of tubal obstruction, or excessive pressure during the injection. The radiographic appearance of early intravasation is characterized by filling of multiple thin tortuous beaded channels with vertical or oblique course with or without delineation of the ovarian vein (Fig. 7.8).

The normal appearances of fallopian tubes on HSG should be clearly understood. The fallopian tubes measure approximately 10 cm and are seen as linear tubular structures on both sides which show varied appearances and caliber in different parts (Fig. 7.9a). From medial to lateral ends, the medial most part is the interstitial or cornual segment, which extends from the uterine cavity through the uterine muscle and continues into the isthmic segment. The interstitial and isthmic segments are often divided by a thin linear filling defect on HSG. The isthmus is the narrow muscular portion adjacent to the uterus, which is seen as linear/curvilinear thin structure. The isthmus gradually continues as the ampullary segment which is wider and longer middle part of the tube. Characteristically, this part shows longitudinal linear filling defects due to presence of prominent mucosal folds (Fig. 7.9b). Ampulla terminates into infundibular segment laterally which is a funnel-shaped segment next to the fimbrial end. The infundibulum segment and

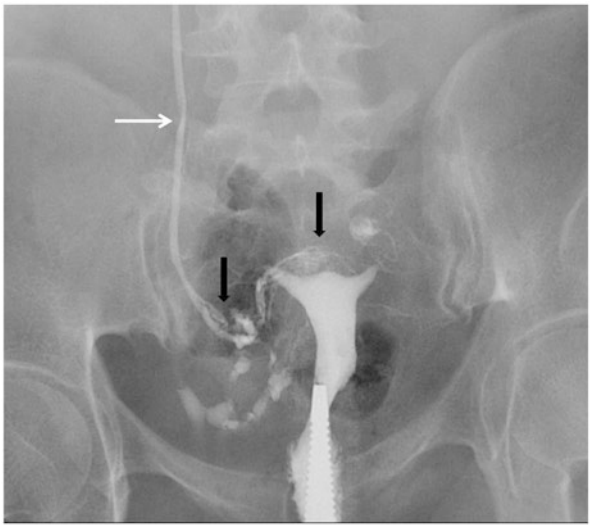

Fig. 7.8 HSG image showing early intravasation into myometrial and para-tubal veins (black arrows). Venous intravasation may also lead to opacification and delineation of the ovarian veins (white arrow)

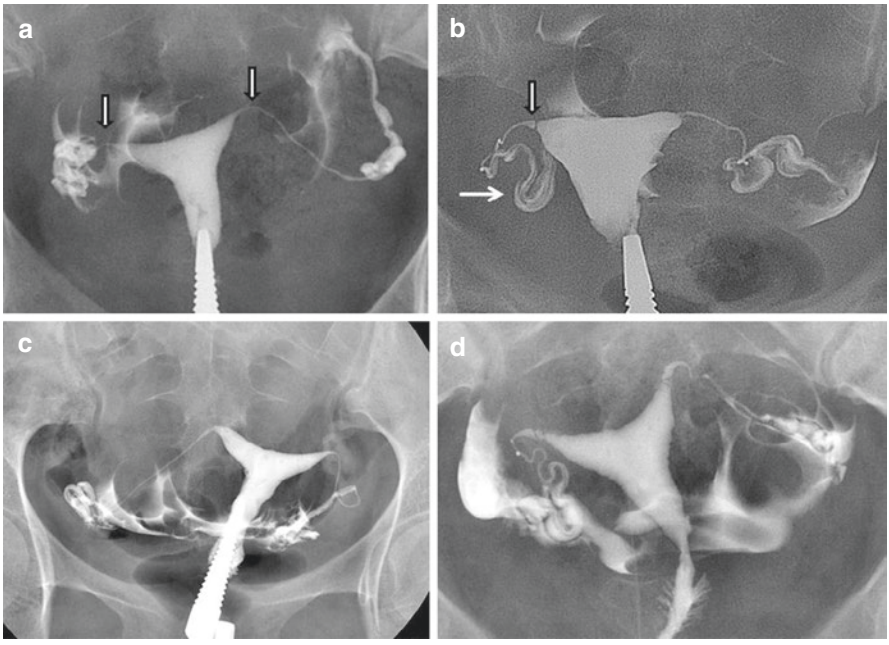

Fig. 7.9 HSG image showing different parts of fallopian tubes on each side (vertical arrows; **a**). The interstitial and isthmic segments are often divided by a thin linear filling defect on HSG at the uterine cornu (vertical arrow; **b**). The isthmus is the narrow muscular portion adjacent to uterus, which is seen as linear/curvilinear thin structure. The isthmus gradually continues as the ampullary segment which is wider and longer middle part of the tube. Characteristically, this part shows longitudinal linear filling defects due to the presence of normal mucosal folds (horizontal arrow, **b**). Free spillage of contrast during HSG should always delineate the peritoneal folds including the region of pouch of Douglas (**c**, **d**)

the fimbrial ends are not seen separately and are only seen as focal flaring of the lateral end of the tube.

The injected contrast during the HSG is expected to show normal spillage into the peritoneal cavity. The spillage of contrast into the peritoneal cavity should be carefully evaluated to decide if it is free spillage of localized spillage. Free spillage should always delineate the peritoneal folds including the region of pouch of Douglas (Fig. 7.9c, d).

7.9 Role of HSG

7.9.1 Presence of Abnormal Endometrial Filling Defects (Fig. 7.10)

Presence of intracavitary filling defect often suggests presence of intra-endometrial lesion.

- **SYNECHIAE** are intrauterine adhesions that result from scarring secondary to the endometrial trauma of curettage procedure or due to endometrial infections.

Early adhesions—Linear or curvilinear filling defects in the endometrial cavity (Fig. 7.11a).

Extensive adhesions—The cavity may show gradually progressive mucosal surface irregularity, altered shape, reduction in the volume, and poor distension of the endometrial cavity (Fig. 7.11b, c).

Endometrial polyps are focal polypoidal areas of hypertrophied endometrium and are seen as well-defined filling defects, more conspicuously during the early filling stage (Fig. 7.12). Small polyps may be obscured in the late distended phase of injection when contrast material completely fills the uterine cavity. Small endometrial polyp and submucosal myoma may not be distinguishable on HSG and would require transvaginal ultrasound examination.

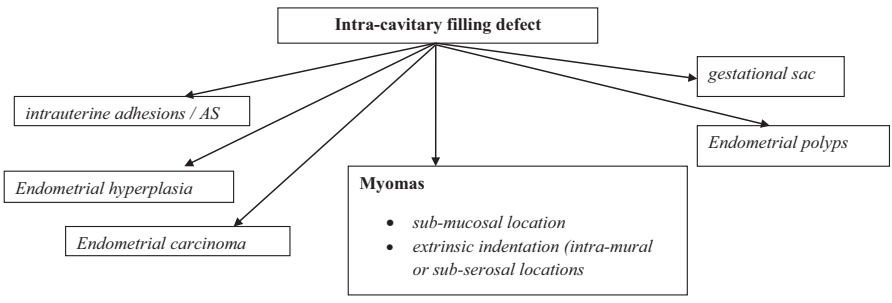

Fig. 7.10 Intracavitary filling defect

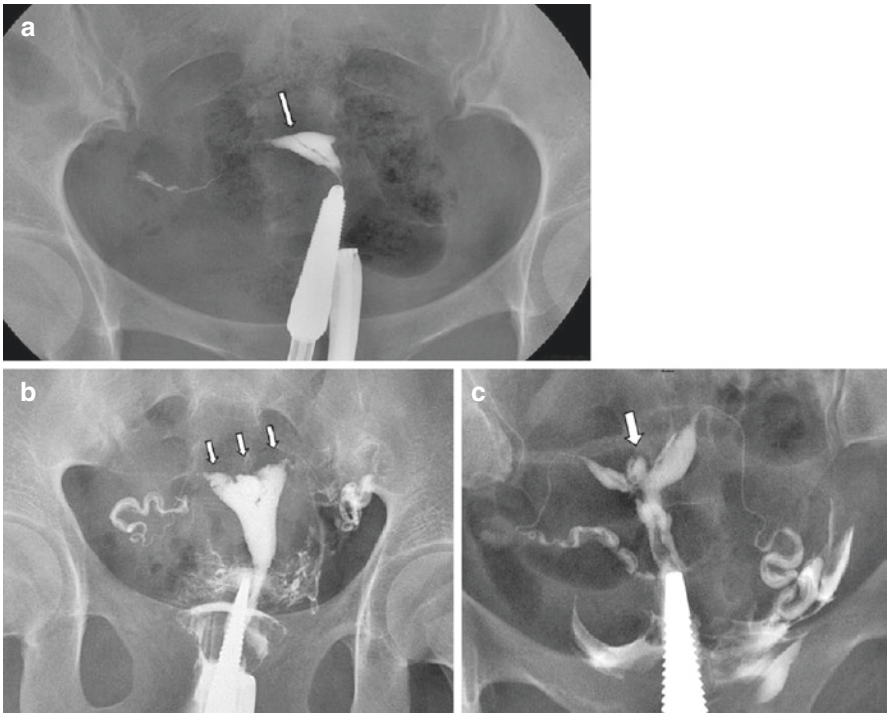

Fig. 7.11 (**a**) HSG image showing the presence of linear filling defect in the endometrial cavity extending up to fundal surface which suggested early endometrial adhesions. (**b**, **c**) Radiographic acquisition in the early filling phase is necessary to detect early changes as illustrated here. With extensive adhesions as in Asherman's syndrome, the cavity may show gradually progressive mucosal surface irregularity, altered shape, reduction in the volume, and poor distension of the endometrial cavity. The endometrial adhesive process may or may not be associated with disease in the fallopian tubes

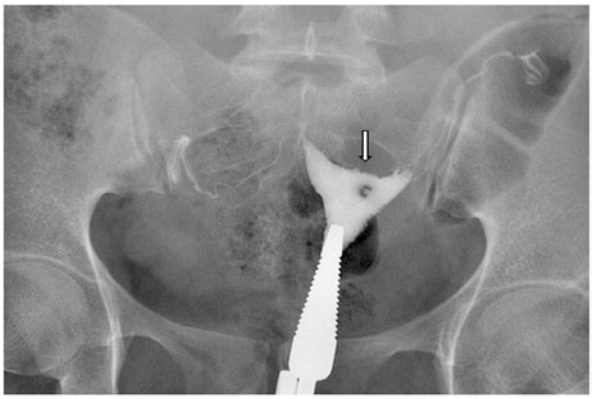

Fig. 7.12 HSG image showing a rounded filling defect in the endometrial cavity secondary to focal endometrial polyp (arrow). Mild surface irregularity is also noted in the endometrial cavity

7.9.2 Altered Uterine Shape and Contour

A detailed evaluation of the uterine shape and contour is an integral component of HSG as it provides vital clues about uterine mullerian anomaly or presence of pelvic space-occupying lesion. The uterine margins should be carefully evaluated with particular emphasis on the fundal region. The shape of the uterus and the status of external fundal surface are important morphological parameters for diagnosis and typing of the uterine mullerian anomaly [17, 18]. Tubular laterally located [banana-shaped] endometrial cavity with presence of single ipsilateral tube is usually seen in unicornuate uterus. Complete or partial duplication of the endometrial cavity is nicely delineated on HSG to diagnose uterine didelphys, bicornuate uterus, or septate/subseptate uterus on HSG. Use of pull-release maneuver is likely to provide important information about the external fundal surface for precise interpretation. The septate/subseptate uterus is likely to have shallow indentation (<10 mm) along the external uterine surface as compared to deep indentation in patients with bicornuate uterus. This important parameter is however better delineated on ultrasound or MRI. Additional morphological parameters which may be evaluated on HSG include intercornual angle and distance. Intercornual angle less than 75° suggests septate uterus while intercornual angle more than 105° suggests bicornuate uterus. Angles measuring 75°–105° are indeterminate in this differentiation. Intercornual distance more than 4 cm usually suggests bicornuate uterus. Presence of broad-based indentation over the fundus with flattening of the external surface with partial duplication of the endometrial cavity is suggestive of arcuate uterus.

Depending upon the size and location, uterine leiomyomas may be seen as either focal filling defect (submucosal location) or extrinsic indentation (intramural or subserosal locations) with or without deformity of the uterine shape (Fig. 7.13).

Sono-HSG is a better imaging option for effective diagnosis, characterization, and exact localization of the uterine intra-endometrial or submucosal lesions.

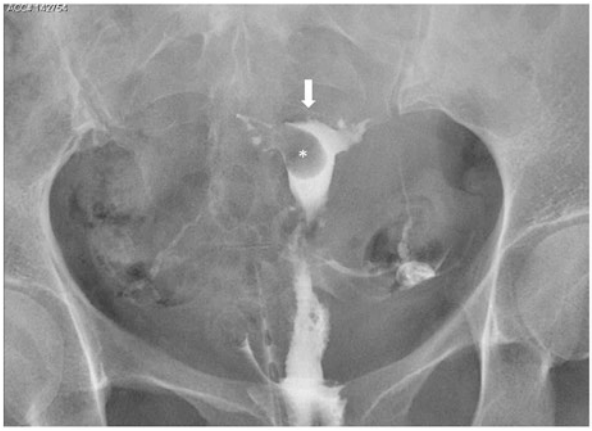

Fig. 7.13 HSG image showing large filling defect (marked as *) in the right pericornual location of uterus [arrow] with non-opacification of the right fallopian tube. Uterine leiomyomas may be seen as either focal filling defect (submucosal location) or extrinsic indentation (intramural or subserosal locations)

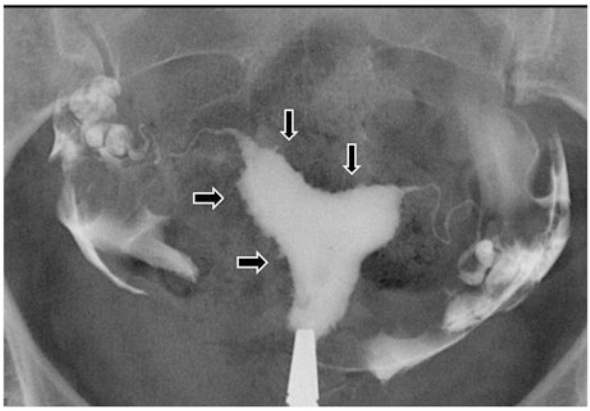

Fig. 7.14 HSG image showing the presence of multiple small diverticula (arrows) along the endometrial cavity extending into the inner myometrium, which is suggestive of uterine adenomyosis. Preserved uterine shape and volume points against the possibility of endometritis or adhesions. Bilateral tubes are patent with preserved course and caliber

Though MRI is the gold standard for imaging diagnosis of adenomyosis, they may be suspected on HSG with the presence of multiple small diverticula extending into the inner myometrium (Fig. 7.14). Inadvertent HSG performed during the ongoing pregnancy may show gestational sac as a focal rounded filling defect on HSG and should be confirmed with prompt ultrasound examination in suspected cases. The procedure should be immediately abandoned and dose calculations performed to decide the continuation or termination of pregnancy.

7.10 Role of HSG in Tubal and Peritoneal Evaluation

Tubal abnormalities seen at HSG may be due to either spasm or secondary to luminal occlusion or infection. The cornual portion of fallopian tube is encased by the smooth muscle of the uterus. If there is spasm of the muscle during HSG, one or both tubes may not fill beyond the corneal portion of the tube. Tubal spasm cannot be distinguished from tubal occlusion on the basis of imaging signs. Administration of spasmolytic agent like glucagon may result in uterine muscle relaxation and help to differentiate tubal spasm from true occlusion [19].

Evaluation of tubal patency is one of the prime objectives of HSG in infertility workup.

Tubal occlusion is seen as abrupt cutoff of intraluminal contrast with non-opacification of distal fallopian tube, which may be unilateral or bilateral and may involve any portion of the tube. If the occlusion is in the ampullary portion, the tube may dilate and form hydrosalpinx. The dilated tubal segments may be focal or

segmental. PID is the most common cause of tubal occlusion leading to infertility. While looking for tubal patency, it is important to assess that the peritoneal spillage is free and the extravasated contrast has unimpeded access to pelvic peritoneal folds and is seen to delineate the region of POD. Mere extravasation of injected contrast into the peritoneal cavity does not establish tubal normalcy. This may also happen with localized peritoneal spillage in patients with peri-tubal adhesions in the region of fimbria and should be differentiated from free spillage.

Apart from tubal patency, evaluation of tubal mucosa is an important component of tubal evaluation in HSG. Infective or inflammatory processes are likely to cause mucosal abnormality in the ampullary region with consequent formation of hydrosalpinx. The normal linear mucosal fold pattern on HSG may be replaced by cobblestone appearance. Salpingitis isthmica nodosa (SIN) is associated with infertility or pelvic inflammatory disease (PID) including tuberculosis, which is an important cause in India. SIN appears as small outpouchings or diverticula from the isthmic portion of the fallopian tube and can affect one or both tubes. Beaded appearance of fallopian tubes is often suggestive of tubercular etiology.

Apart from the tubal opacification and luminal caliber, the course of fallopian tubes should also be carefully evaluated as it provides vital clues about the status of peri-tubal peritoneum. Vertical convoluted course of fallopian tubes, clubbed lateral tubal ends, and peri-tubal halo are important determinants of peri-tubal adhesions (Fig. 7.18a–d). Contrary to popular belief, HSG does provide vital clues about the presence or absence of peri-tubal adhesions. Vertical convoluted course of fallopian tubes with peri-tubal "halo," intraperitoneal loculation, ampullary dilatation, "clubbed" distal tubal ends, fixed latero-deviation of uterus, and immobile tubes are suggested to be important determinants of peri-tubal adhesions [20, 21]. Despite its high specificity in the assessment of tubal patency, the HSG diagnosis of peri-tubal adhesions was not reported to be reliable [22]. As of today, pelvic peritoneal adhesions can be most reliably diagnosed with CT and MRI [23]. Apart from this, the course of fallopian tubes on HSG provides useful indirect clues to suspect pelvic pathologies which may be further confirmed on ultrasound or MRI.

HSG may be advised for documentation of the tubal occlusion following tubal ligation, which is seen as an abrupt termination of the tube at the surgical site or mild bulbous expansion of the tube with cutoff. New irreversible occlusion device called Essure (Conceptus, San Carlos, Calif) was introduced for minimally invasive tubal occlusion. The soft, flexible microinsert is placed hysteroscopically into each fallopian tube, which induces scar tissue formation and consequent tubal occlusion [24]. HSG may also be performed to demonstrate tubal patency without extravasation of contrast material after reversal of a ligation procedure.

Tubal polyps are rare and represent ectopic endometrial tissue located in the interstitial portion of the tube. Tubal polyps may be seen as unilateral or bilateral smooth, rounded filling defects without concomitant dilatation or tubal occlusion and are less than 1 cm in diameter. Women with tubal polyps are asymptomatic, and the association of these polyps with infertility has not been established [25].

HSG evaluation of fallopian tubes should extend beyond peritoneal spillage and tubal patency. It is important to carefully evaluate the tubal mucosal pattern, course, and caliber of the tube on each side. The peritoneal spillage should be carefully evaluated to differentiate between free and loculated spillage. Careful inspection and schematic image interpretation of HSG films may offer valuable information about the status of peritoneal cavity apart from the endometrial and tubal information in patients with infertility.

7.10.1 Therapeutic Procedures During HSG

Selective salpingography is a fluoroscopy-guided transcervical selective cannulation of the fallopian tubes, which is useful in the differentiation of cornual block and tubal spasm. The procedure offers finer tubal evaluation in terms of luminal and mucosal details and intraluminal pathology and helps to resolve discrepancy between HSG and laparoscopy. Fallopian tube recanalization (FTR) is a safe treatment option in patients with infertility from proximal tubal obstruction. The procedure involves transcervical selective cannulation of fallopian tubes to recanalize the tubal obstruction in proximal tubes. This is reported to have high technical success rate (71–92%), low complication rate, and increased chances of pregnancy (approximately 30%) and should be preferred before attempting more expensive and resource-intensive procedures. The combination of selective salpingography with fallopian tube recanalization has improved the overall management of infertility caused by tubal obstruction [26, 27].

Proximal tubal occlusion (PTO) occurs in 10–25% of women with tubal disease and is mainly due to salpingitis isthmica nodosa (SIN), chronic salpingitis, intratubal endometriosis, amorphous material (due to menstrual debris), or spasm [28]. Luminal occlusion due to menstrual debris is the primary cause in a significant number of patients with PTO. The occlusion is usually not associated with mural inflammation or peri-tubal disease. Selective salpingography and fallopian tube recanalization are therefore likely to be more effective in this group of patients with PTO. A meta-analysis has suggested that selective salpingography and transcervical cannulation under fluoroscopic guidance are effective at establishing patency in appropriately selected patients and are less invasive and costly than the surgical alternatives [29].

7.10.2 Reporting Format for Hysterosalpingography

HSG report should essentially include detailed description of the procedure including instrumentation, medications, fluoroscopy time, and radiation dosage. The status of uterus, fallopian tubes on each side, and peri-tubal adhesions should be mentioned. A standard reporting format is illustrated in Table 7.1.

Table 7.1 Standard reporting format

Procedure Medication Fluoroscopy time Radiation dose	Hysterosalpingography was performed using a metal cannula. The cervical cannulation was uneventful. The pre-procedural medication used for the procedure included oral administration of Meftal Spas 500 mg. No intra-procedural medication was administered. Pre- and post-procedural antibiotics were advised. The total fluoroscopy time is 1.01 min. The radiation dosage during the study is 192 cGy/cm cm
Endometrial cavity	Uterus is in midline location and the endometrial cavity appears normal in shape and volume with normal margins. No evidence of any definite filling defect or marginal irregularity. Mild peri-cornual venous intravasation on the left side (on later spots only) appears nonspecific
Uterine cornu	The uterine cornu appears normal on both sides
Right tube	The right fallopian tube shows normal course. There is generalized dilation of the right tube, more pronounced in the distal aspect. The ampullary mucosal folds are not visualized on right side. There is no peritoneal spillage on the right side
Left tube	The left fallopian tube shows normal course and caliber. The normal ampullary mucosal folds are visualized on the left side. There is free peritoneal spillage on the left side
Endocervical canal	The endocervical region does not reveal any definite abnormality
Pull-release	*The pull-release maneuver does not reveal any definite abnormality*
Miscellaneous	*The bones under view do not reveal any definite abnormality*

7.10.3 Sono-Hysterosalpingography (Sono-HSG)

Ultrasound-guided sono-HSG or saline infusion salpingography (SIS) in conjunction with transvaginal ultrasound is a safe, effective, and convenient diagnostic procedure for the evaluation of female genital tract. It is a suitable alternative to conventional HSG, avoiding the risks of ionizing radiation and the need to inject an iodinated contrast. It provides similar diagnostic results, perhaps with improved sensitivity and specificity for endometrial lesions [30, 31].

Sono-HSG is the preferred mode of imaging for uterine abnormalities for both primary and secondary infertility, and for evaluation of endometrium in the perimenopausal and postmenopausal age group. Common indications are irregular menstrual bleeding, recurrent miscarriage, and to check for the patency of fallopian tubes or for a baseline scan before planning IVF procedures. Endometrial polyps, intracavitary fibroids, uterine adhesions, or synechiae uterine septae are well demonstrated. Absolute contraindication of the procedure is pregnancy or suspected pregnancy. Relative contraindications are pelvic infections or unexplained pelvic tenderness.

7.10.4 Technique

- The procedure is usually performed between days 4 and 11 of the menstrual cycle.
- For perimenopausal and postmenopausal bleeding, it is performed on any day of the cycle to evaluate the cause of abnormal bleeding.

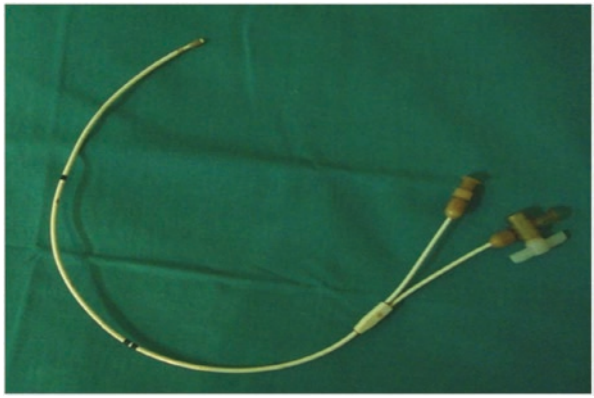

Fig. 7.15 Photograph showing a plastic cannula used for sono-HSG

Pain relief with nonsteroidal anti-inflammatory tablets (NSAID) is offered the previous night and another 2 h prior to the procedure to prevent cramping pain during catheter insertion.

Preliminary pelvic scan is performed first, both transabdominal and transvaginal to evaluate the uterus, adnexa, ovaries, and adjacent pelvic structures. The urinary bladder is emptied again just before the procedure, written informed consent is taken, and patient is placed in lithotomy position. Transvaginal probe is prepared along with the catheter guide [32]. A speculum is placed and a small thin (usually 8 or 12 French) catheter (Fig. 7.15) is inserted gently into the uterine cavity through the cervical os, through which normal saline is injected via a syringe. A sagittal view of the uterus and endometrium is focused and an initial amount of 2 mL is injected to check placement. The tip of the catheter is then inflated to retain placement. Further 20 mL or more (20–40 mL) of agitated normal saline is injected. Agitated saline produces air bubbles and improves visualization of the fallopian tubes. On real-time scan fluid is seen to distend the endometrial cavity and appears hypoechoic with a clear demarcation of the separated endometrial stripe. Endometrial lesions like polyps are then well delineated with the improved contrast between the hypoechoic fluid and hyperechoic endometrial lining. Thin endometrial adhesions are well recognized and may even be lysed by the saline. Further the probe is focused on the cornu of uterus in the transverse plane and agitated saline is pushed, to check patency, which is depicted by the stream of air and fluid bubbles exiting the cornu into the pelvic cavity. The procedure is repeated to check the patency of contralateral fallopian tube. The endometrial cavity is scanned thoroughly in both longitudinal and transverse directions. Images are annotated and saved for documentation, if required.

7.10.5 Precautions and Complications

Pregnancy test must be done to exclude pregnancy.

Before injecting the saline into the uterine cavity, the air must be cleared from the syringe by flushing a stream of saline.

Normal saline used is prewarmed or brough to room temperature, and not used cold straight from refrigerator.

Saline backflow is prevented by inflating the catheter balloon to occlude the internal cervical os. Slight pelvic discomfort during catheter insertion is usually transient and subsides in a few hours.

Routine tablet of NSAID ibuprofen is advised 1–2 h before the procedure, to relax the muscles and for pain relief.

Any post-procedural bleeding is usually related to the underlying pathophysiology and the patient is advised to bring a pad for the same. Very rarely, in less than 1% of cases there may be excessive bleeding, pain, or infection, which is treated accordingly. Antibiotics may be prescribed prophylactically, if there is a history of preceding infection.

7.10.6 Image Interpretation

Normal endometrium with sono-HSG expands symmetrically with saline instillation and appears smooth with almost similar thickness measurements on both the sides (Fig. 7.16).

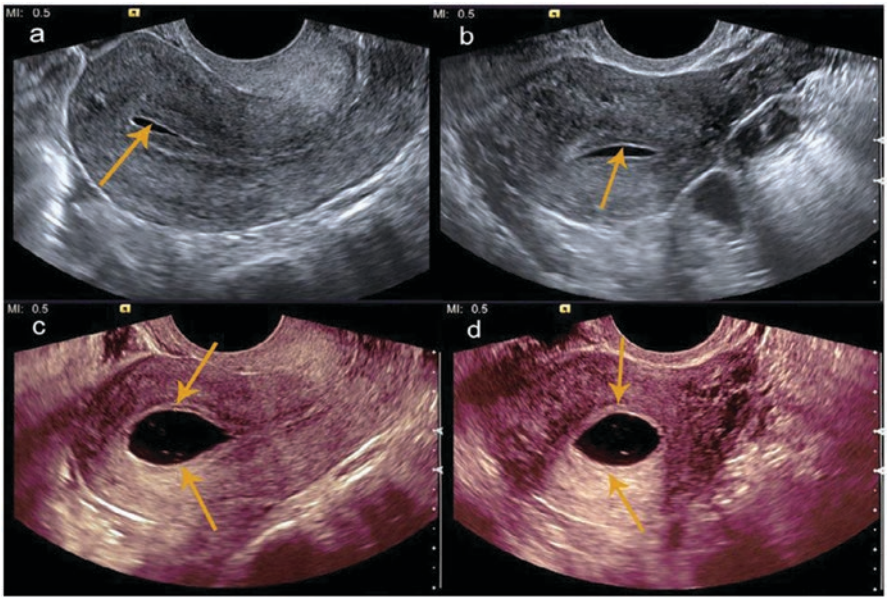

Fig. 7.16 Longitudinal (**a**, **c**) and transverse (**b**, **d**) transvaginal saline infusion sono-HSG images. Images (**a**, **b**) with minimal (5 mL) saline infusion and images (**c**, **d**) with further (20 mL) saline infusion showing well-expanded endometrial cavity (arrows) with normal smooth, symmetrical outline on both sides (acknowledgements: Dr. Shradha Chaudhary, Dept. of Gynecology, Medanta Medicity, Gurugram, Delhi NCR)

Endometrial adhesions may appear as thin or thick echogenic bands across the endometrial cavity and are well distended against the background of hypoechoic saline. The distension of the endometrial cavity may also be compromised with severe adhesions in patients with Asherman's disease (Fig. 7.17).

Endometrial polyps and submucosal fibroids are well delineated with a layer of saline, polyps generally being isoechoic to the endometrium and mucosal fibroids being hypoechoic as compared to endometrium (Figs. 7.18a, b and 7.19). Submucosal fibroids are usually broad based as compared to endometrial polyps and show distal shadowing.

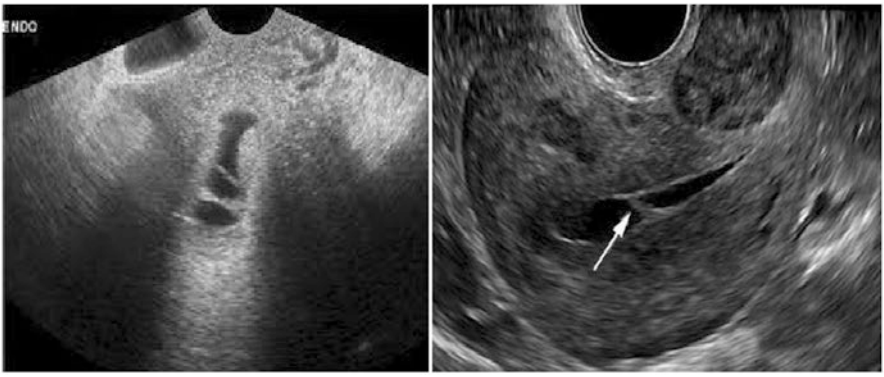

Fig. 7.17 Adhesions characteristically appear as "bridging bands" of tissue that distort the cavity. Filmy adhesions are described as thin, undulating membranes

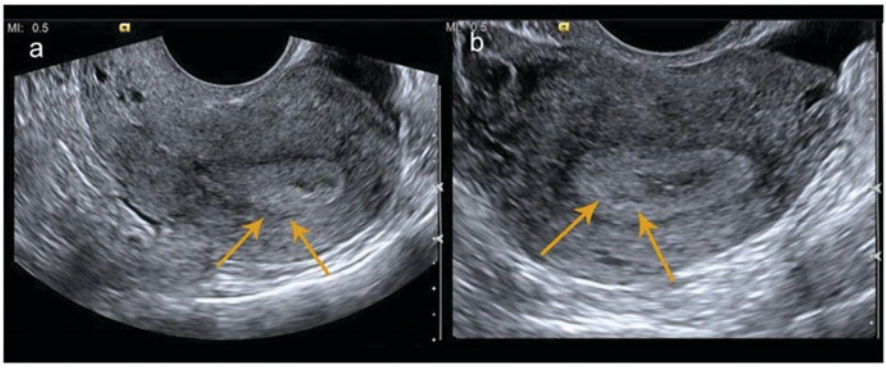

Fig. 7.18 (**a**, **b**) Longitudinal (**a**) and transverse (**b**) transvaginal sono-HSG images. Infusion of minimal (5 mL) saline infusion showing slightly demarcated hyperechoic area (arrows) in the endometrial cavity which was confirmed on hysteroscopy to be a sessile endometrial polyp. The patient clinically presented with primary infertility and intermenstrual spotting. Only minimal saline could be injected due to pain. Poor distension of the endometrial cavity also suggested endometrial adhesions in this patient (acknowledgements: Dr. Shradha Chaudhary, Dept. of Gynecology, Medanta Medicity, Gurugram, Delhi NCR)

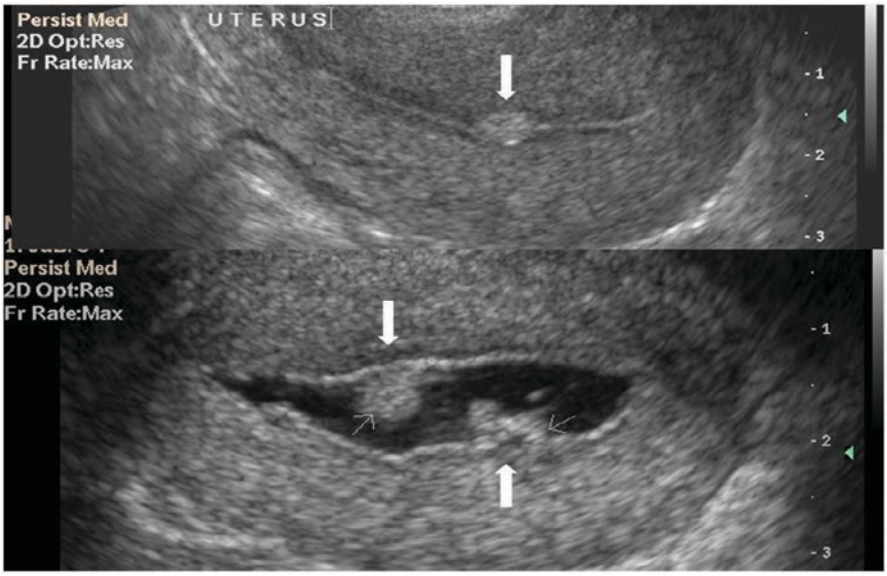

Fig. 7.19 Sono-HSG longitudinal images show focal echogenic thickening seen on transvaginal ultrasound image [arrow in upper panel]. Sono-HSG image (done in the same sitting) showing multiple focal endometrial polyps (arrows in lower panel). Optimal distension of the endometrial cavity ruled out endometrial adhesions in this patient

Diffuse endometrial pathologies such as endometrial hyperplasia may show irregularly thickened endometrial lining (Fig. 7.20a, b). Endometrial carcinoma may present as a focal or diffuse abnormality (Fig. 7.21). There is small but real risk of malignant cell dissemination in patients with endometrial carcinoma who undergo SIS. Adenomyosis may reveal loss of endometrial myometrial interface along with tiny sub-endometrial anechoic cysts [33].

7.11 Hysterosalpingo-Contrast Sonography (HyCoSy)

A further extension of SIS is HyCoSy [34] using a contrast, either SonoVue or a mixture of air and saline to test for tubal patency. With the scan focused in the transverse plane at the level of cornu, further 20 mL of agitated normal saline is injected and the spill of the contents from the cornual regions into the pelvis is then observed. There is scintillating effect noted due to the flow of echogenic air and saline from the distal end of fallopian tube into the pelvis. The spill is very transient, lasting for 5–10 s; hence the probe positioning must be appropriate to be able to observe the same and record it.

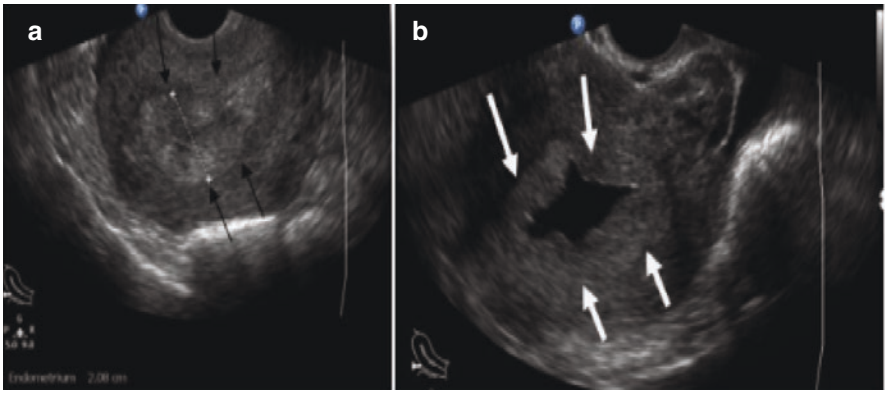

Fig. 7.20 (**a**) Shows TVS image of thickened endometrium. (**b**) Shows SIS image of endometrial hyperplasia

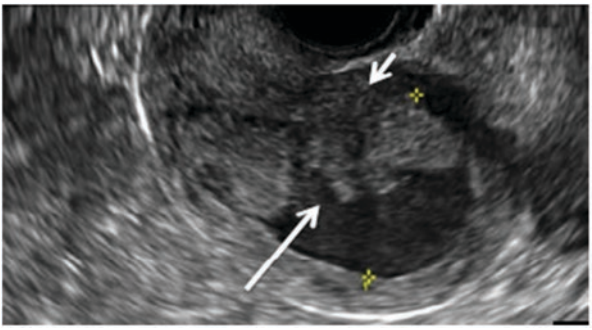

Fig. 7.21 Endometrial carcinoma may present as an irregular focal or diffuse

7.11.1 Advantages Over Conventional HSG

There are definite advantages of sono-HSG in terms of patient safety comfort and convenience to the patient.

The main advantage of sono-HSG is that it can be employed as an integrated procedure along with routine transvaginal ultrasound to evaluate the patency of fallopian tubes and other structural abnormalities, by using a single ultrasound-guided and radiation-free procedure. Use of a continuous saline air device may produce technically better image quality in sono-HSG procedures.

7.11.2 MRI and MR-HSG

Due to excellent soft-tissue resolution, MRI is accepted as the gold standard in the evaluation of the female pelvis. In terms of uterine assessment, MRI is particularly

useful in the evaluation of uterine myometrium. Routine MRI offers limited information about the status of fallopian tubes and cannot evaluate tubal patency. Dynamic MR-HSG combines the advantages of HSG and MRI in a single study and allows the assessment of the uterus, patency of fallopian tubes, and extrauterine pelvic structures in a "one-stop" investigation [35]. Clinically available MR angiographic sequence (3D time-resolved imaging of contrast kinetics [TRICKS]) is reported to have high accuracy in the evaluation of tubal patency using dilute 1:100 gadodiamide and saline [36]. The technique offers adequate spatial resolution for visualization of fallopian tube contrast spillage, with superior temporal resolution of approximately 2 s per phase. This temporal resolution allows documentation of progressive spillage from left and right tubes and allows discrimination of contrast spill from the separate tubes.

7.11.3 CT-HSG

MDCT-virtual HSG is described as an additional imaging investigation that combines the advantages of HSG and MDCT imaging in female patients with infertility [37]. MDCT has high spatial resolution, which provides excellent delineation of the tubal lumen and patency when combined with HSG. MDCT-virtual HSG uses plastic cannula for instillation of the contrast medium through the cervix using the power injector. This helps to ensure a steady low pressure of instillation, and the administration of a diluted water-soluble contrast medium. MDCT-virtual HSG is therefore less painful, more comfortable, and more easily tolerated by patients than conventional HSG.

Moreover, the high spatial resolution and range of post-processing algorithms available in MDCT imaging allow precise characterization of elevated or polypoidal lesions of different sizes which is otherwise not possible without hysteroscopy. Virtual endoscopic navigation allows visualization of the inner tubal lumen. Volume rendering method provides excellent definition of the tubes and tubal pathology.

The use of 128-row MDCT allows the study to be completed in only 4 s, capturing the images in real time while the contrast is still in the tubal lumen. MDCT-virtual HSG is accurate in the diagnosis of uterine and ovarian infertility causes, while less accurate in the diagnosis of tubal causes. The sensitivity for detection of uterine and fallopian tube abnormality on MDCT-VHSG was reported to be 100% and 100%, respectively, while the specificity was reported to be 100% and 85.71%, respectively [38].

The procedure is, however, still not popular due to concerns about the effects of radiation at hysterosalpingography and pelvic MDCT [39, 40].

7.12 Clinical Recommendations

The diagnostic accuracy of HSG has been compared with that of laparoscopy and dye in a systematic review of 20 studies that distinguished between tubal obstruction and peri-tubal adhesions [22]. However, only three studies involved judgment

of laparoscopy without knowledge of HSG results. Meta-analysis based on these three studies gave pooled estimates of sensitivity and specificity for HSG as a test for tubal obstruction of 0.65 (95% CI 0.50–0.78) and 0.83 (95% CI 0.77–0.88), respectively. HSG could be used as a screening test for couples with no history of pelvic infection, and if abnormal, confirmatory laparoscopy would follow [41, 42].

Considerable inter-observer variability in the interpretation of HSGs has been reported, depending on the type of pathology being assessed. Women with possible comorbidity such as pelvic and tubal diseases may need a laparoscopic assessment.

It is estimated that tubal damage accounts for 14% of fertility problems, one which suggests that when HSG suggests the presence of tubal obstruction this will be confirmed by laparoscopy in only 38% of women. Thus, HSG is a not a reliable indicator of tubal occlusion. However, when HSG suggests that the tubes are patent, this will be confirmed at laparoscopy in 94% of women, and so HSG is a reliable indicator of tubal patency [43].

Key Points

1. Hysterosalpingography (HSG) is a useful screening outpatient radiological procedure for diagnosis and has 75% sensitivity, 95% specificity, 50% positive predictive value (PPV), and 98% negative predictive value (NPV).
2. HSG is an important screening modality for evaluation of the endometrial cavity which often requires further evaluation with ultrasound, sono-HSG, or hysteroscopy.
3. HSG and sono-HSG remain important investigations in a wide range of clinical conditions including endometrial adhesions in Asherman's syndrome.
4. Intrauterine filling defects are seen in intrauterine adhesions, endometrial polyps, myomas, endometrial hyperplasia, and endometrial carcinoma.
5. Due attention to the procedural details and optimal image interpretation is certainly the key to derive the benefits of HSG and sono-HSG in these patients.

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