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REVIEW

Current update on status of saline infusion sonohysterosalpingography

Shruti Kumar[1] · Pankaj Nepal[2] · Sabarish Narayanasamy[3] · Ashish Khandelwal[4] · Joshua Sapire[2] · Vijayanadh Ojili[5]

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Abstract

The purpose of this article is to elucidate the current role of saline infusion sonohysterosalpingography (SIS) in evaluation of various uterine pathologies. SIS improves visualization of the endometrium and pathologies related to endometrial cavity, as well as it can simultaneously assess tubal patency. SIS provides high-resolution images, and three-dimensional (3D) reformatted images provide excellent orientation for radiologists as well as the clinicians about the underlying pathologies. This article will discuss imaging technique, indications, pearls, and pitfalls in imaging, diverse disease pathologies, and ultimately compare performance of SIS among other different imaging modalities. SIS as an adjunct imaging modality results in a greater diagnostic yield for diverse uterine pathologies.

Keywords Saline infusion sonohysterosalpingography · Sonohysterography · Uterus · Imaging

Introduction

Saline infusion sonohysterosalpingography (SIS), also known as saline infusion sonohysterography is an adjunct imaging modality that can be used for imaging various endometrial and endocervical canal pathologies. SIS is best utilized to detect and evaluate endometrial lesions and differentiate them from myometrial origin. Accuracy of SIS is comparable to hysteroscopy in the assessment of endometrial lesions [1]. In addition, SIS can simultaneously assess tubal patency with comparable accuracy when compared to hysterosalpingogram (HSG) [2, 3]. The technique involves placing a catheter in the uterine cavity and injecting sterile saline to distend the endometrial cavity, with concurrent pelvic imaging using transvaginal or transabdominal sonography.

SIS is performed in a few centers across the globe; therefore, the radiologist, clinicians, as well as trainees are not well versed with the imaging technique as well as imaging findings. In this article, we will discuss the indications and contraindications, patient preparation, imaging techniques, and procedural steps in SIS. We will then demonstrate various examples of common as well as uncommon uterine abnormalities on SIS, technical difficulties, diagnostic challenges, imaging artifacts, and procedural complications. Comparative performance of SIS with other imaging modalities such as transabdominal and transvaginal sonography

✉ Pankaj Nepal
Pankaj-123@live.com

Shruti Kumar
Shrutikumar2506@gmail.com

Sabarish Narayanasamy
nsabarish86@gmail.com

Ashish Khandelwal
Khandelwal.ashish@mayo.edu

Joshua Sapire
sappynyc@yahoo.com

Vijayanadh Ojili
Ojili@uthscsa.edu

[1] Department of Radiology, University of Arkansas for Medical Sciences, Little Rock, AR 72205, USA

[2] Department of Radiology, St. Vincent's Medical Center, Bridgeport, CT 06606, USA

[3] Department of Radiology, University of Iowa, Iowa City, IA 52242, USA

[4] Department of Radiology, Mayo Clinic Rochester, Rochester, MN 55901, USA

[5] Department of Radiology, University of Texas Health San Antonio, San Antonio, TX 78229, USA

(TVS), hysterosalpingogram (HSG), hysteroscopy, and Magnetic Resonance Imaging (MRI) is discussed in detail at the end.

Indications and contraindications

Most common indication for SIS is abnormal uterine bleeding (AUB). AUB is a common gynecological condition that warrants a complete evaluation especially in the perimenopausal and post-menopausal age group, as the endometrial cancer accounts for 10–15% of such cases [1]. Hysteroscopy-guided endometrial biopsy remains the reference standard for diagnosing AUB. Preliminary investigation is usually performed with non-invasive technique like TVS. The usefulness of TVS in screening of endometrial pathologies is, however, limited [1]. SIS ensures adequate distention of the endometrial cavity with saline during ultrasound and enables single-layer evaluation of the endometrial lining, thus providing better differentiation of focal versus diffuse lesions. This allows targeted sampling of the focal pathologies with better diagnostic yield. Second most common indication for SIS is infertility. Female factor infertility accounts for 37% of total cases, while combined female and male factors account for another 35% [4]. TVS is the primary imaging modality for initial evaluation of female infertility. HSG is performed to evaluate the uterine cavity and tubal patency. SIS is a modality that combines the features of a TVS as well as HSG and can concurrently visualize the uterine cavity, tubal patency, as well as other adnexal pathologies.

Other indications for SIS include recurrent abortions, monitoring after tamoxifen therapy, suboptimal visualization of endometrial stripe TVS (secondary to severe uterine angulation or pathology), preoperative assessment of uterine myomas, suspected uterine synechiae, confirmation of suspected endometrial pathologies detected on ultrasound, and congenital uterine anomalies [5, 6]. SIS is contraindicated in pregnancy and in patients with active pelvic infection or unexplained pelvic tenderness. Presence of an intrauterine contraceptive device is another contraindication [7].

Imaging technique

The procedure should be scheduled in the early proliferative phase between the 5th and 10th day of the menstrual cycle, when the endometrial lining is thinnest [5]. This ensures not mistaking a normally thickened bulky endometrium of the secretory phase for an underlying endometrial polyp or mass [8]. The timing also ensures that a fertilized ovum is not dislodged during saline flushing in the secretory phase. The procedure is also avoided during the first four days of the menstrual cycle due to residual blood clots in the endometrial cavity that may obscure or be confused for a pathology. This liberty of reliable scheduling may not be available in patients with irregular menstrual cycles, and it is best to rule out a possible pregnancy prior to the procedure. Post-menopausal women with AUB can undergo the procedure at any time of their cycle. Patients on hormone replacement therapy should be scheduled at the end of the progesterone phase [9].

The importance of pre-procedural baseline ultrasound imaging cannot be emphasized enough. It can help in the initial screening of pathologies such as hydrosalpinx; in the absence of prior imaging, it may be confused with injected fluid during SIS (Fig. 1). The causes of uterine or adnexal

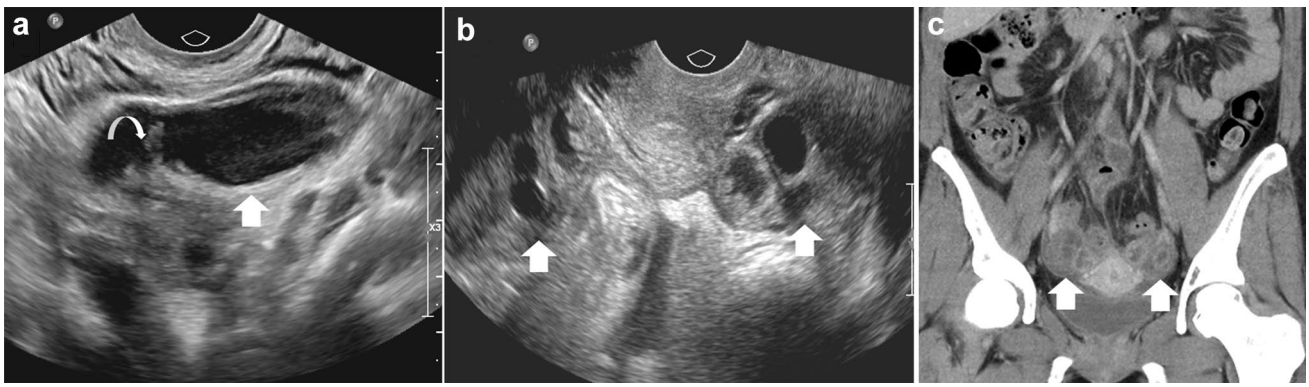

Fig. 1 Importance of pre-procedural ultrasound imaging. **a** Pre-procedural transabdominal ultrasound shows a well-defined fluid containing tubular structure in the left adnexa. This was further interrogated with transvaginal ultrasound which confirms the dilated fallopian tube (arrow) with thickened folds (curved arrow). In the absence of pre-procedure imaging it is difficult to differentiate hydrosalpinx from infused saline during SIS. **b** Transvaginal ultrasound image in a 32-year-old female referred for SIS due to infertility showing enlarged bilateral enlarged (arrows). **c** Post-contrast coronal CT image of the lower abdomen and pelvis on same patient showing enlarged bilateral adnexa (arrows) and fat stranding suggesting diagnosis of acute pelvic inflammatory disease (PID). Acute PID is contraindication for SIS procedure

tenderness can be evaluated with pre-procedural imaging ensuring appropriate usage of antibiotics in selected patients [9]. Pre-procedural baseline imaging can screen active pelvic inflammatory disease which remains an absolute contraindication for performing SIS. Pre-procedural imaging can be used to assess the size and position of the uterus and orientation of the cervix for better positioning of the catheter during SIS [9].

Prophylactic antibiotics are administered to patients with a history of pelvic inflammatory disease and prophylaxis of systemic bacterial endocarditis. Routine prophylaxis in the infertile population is debatable and not practiced at our institution. We use oral analgesics routinely 30 min prior to the procedure unless contraindicated. Use of analgesic is to minimize pain or discomfort and better tolerated by our patient population. Use of analgesics varies across the globe. Informed consent is obtained from the patient. The procedural steps involve patient positioning in the lithotomy position, hips flexed and abducted with feet in stirrups, and buttocks extending beyond the table edge. An antiseptic solution is applied to the vaginal introitus, and a speculum is inserted after cleaning the area. After the external os is reached and localized, it is cleaned with Povidone-iodine solution. A 5–7 F Catheter is inserted through the cervical os into the uterine cavity (Fig. 2). The catheter as well as the balloon is flushed with saline prior to insertion as inadvertent injection of air during the procedure results in shadowing artifacts, obscuring the area of interest. The tip of the uterine fundus should be avoided being touched as it may provoke a vasovagal response. The catheter balloon is inflated with 1–2 ml of saline. The speculum is then removed. A transvaginal ultrasound probe is then inserted alongside the catheter. Warm sterile saline is injected through the prefilled syringe attached to the catheter. The initial infusion rate should not exceed 5 mL/min and can be adjusted based on the patient's response and comfort level. A total of 10–20 mL of fluid is injected over 3–10 min. Slow injection is recommended to avoid a vasovagal reaction. The total amount of saline injected into the endometrial cavity will vary depending on the uterine distension and patient tolerance. Typically, TVS is performed in the coronal and sagittal planes. Sonographic volumes can be obtained for 3D reconstruction. The lower uterine segment and cervix is imaged, while the balloon is being deflated and removed. A normal uterine cavity should expand symmetrically after saline injection. The normal endometrial lining is smooth and symmetric.

Problems and pitfalls in diagnosis

The prerequisite for adequate endometrial visualization on SIS is optimal distention of the endometrial cavity with anechoic saline. Various patient-related, as well as technique-related challenges, may be encountered while performing SIS. Inability to obtain cervical access is the most common cause of discontinuation of the procedure [9]. This can be ensured by adequate patient positioning and appropriate speculum selection as per the vaginal

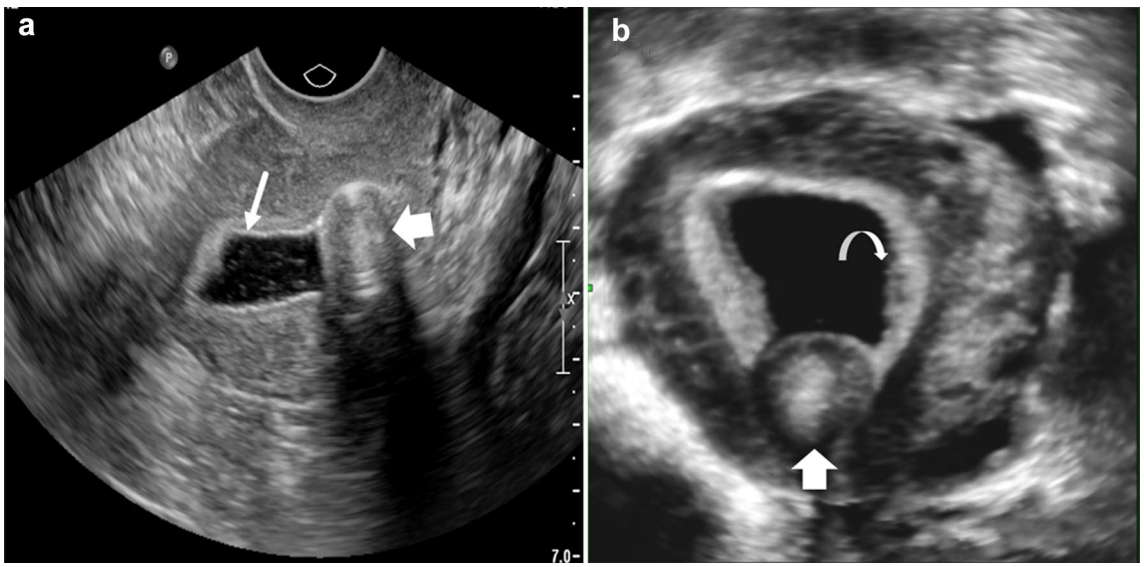

Fig. 2 Images demonstrating the technique for SIS. **a** Instillation of the saline into the endometrial cavity with the tip of balloon catheter just passing through the internal os (thick arrow). The endometrial lining (thin arrow) is distinctly visualized on preface of surrounding saline. **b** Reformatted high-resolution coronal image of the uterus shows details of the endometrium (curved arrow) and the adjacent myometrium. Such high definition of the endo-myometrial junction cannot be achieved from other imaging modalities, indicating superiority of SIS to evaluate endometrial and intracavitary pathologies

size. In patients with variable cervical orientation, the speculum is maneuvered along the known location of the external os. The patient is then asked to bear down to realign the cervix, or gentle pressure may be applied to the perineal body [9]. Variable cervical angulation can also be tackled by applying traction on the cervix using a tenaculum [8]. Advancement of the catheter beyond a cervical stenosis can be achieved using cervical dilators or the use of guide wires.

Air trapped within the endometrial cavity may lead to dirty shadowing and obscure the pathology under consideration. Hence it is important to flush air out of the syringe before injecting it into the endometrial cavity. There may be mechanical interference with visualization because of blood clots within the endometrial cavity, especially in women with irregular menstrual cycles where the scheduling of the procedure may not be well-timed. A blood clot may mimic an endometrial polyp or other focal endometrial lesions. Usually, blood clots are dislodged by brisk saline injection, seen on cine imaging. Absence of flow on color Doppler imaging may also be helpful in differentiating blood clots from endometrial masses. It is essential to adequately inflate the balloon in order to prevent the catheter from being dislodged. Saline backflow may be prevented by gently retracting the catheter and making a seal around the internal os [9]. At the same time, over-distension of the balloon must be avoided as it may obscure the pathology under consideration.

Uterine pathologies

Utility of the SIS in evaluation of various endometrial and sub-endometrial pathologies are discussed disease specific as follows:

Endometrial polyp

Endometrial polyp is a benign localized proliferation of endometrial stroma and glands that project beyond the surface into the endometrial cavity. Its prevalence is between 16 and 34%, varying for population characteristics and diagnostic methods used [10]. It is an important cause for AUB in both pre-and post-menopausal women. Polyps and diffuse endometrial hyperplasia may co-exist [11]. The risk of malignant transformation in an endometrial polyp is rare, with reported prevalence of less than 5% [12].

On ultrasound, they appear as homogeneously echogenic polypoid lesions that may undergo cystic changes as a result of necrosis, hemorrhage, and infarction [5, 13]. On TVS, both diffuse endometrial hyperplasia and endometrial polyp may appear as non-specifically thickened echogenic endometrium. SIS allows the separation of the collapsed endometrial walls by flushing of anechoic saline within the endometrial cavity that outlines the lesions and allows for better characterization of different endometrial pathologies (Figs. 3, 4). Endometrial polyp has an identifiable stalk in most cases with a single feeding vessel within it [14]. Echogenic lesions with smooth outline, without irregularity of the endometrium on SIS images can also differentiate it from

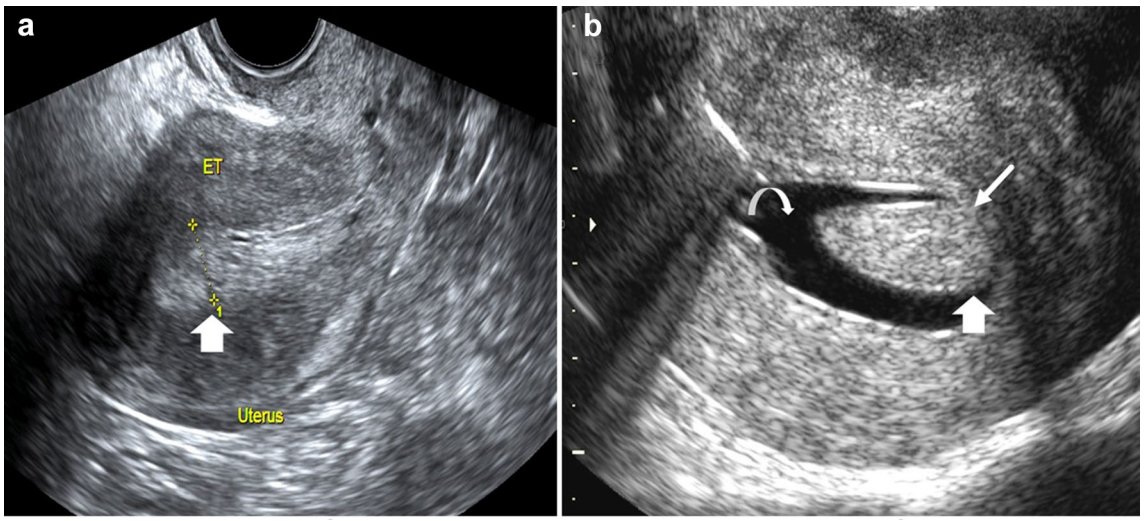

Fig. 3 37-year-old female with persistent excessive vaginal bleeding. **a** Transvaginal ultrasound shows diffusely thickened endometrium (arrow, measured by calipers). **b** Sagittal SIS image shows a well-defined, homogenously echogenic endometrial polyp (thick arrow) surrounded by the saline. Note the preserved endometrial-myometrial junction (thin arrow) with acute angle to the endometrium. No endometrial irregularity to suggest malignancy in this benign polyp treated with polypectomy

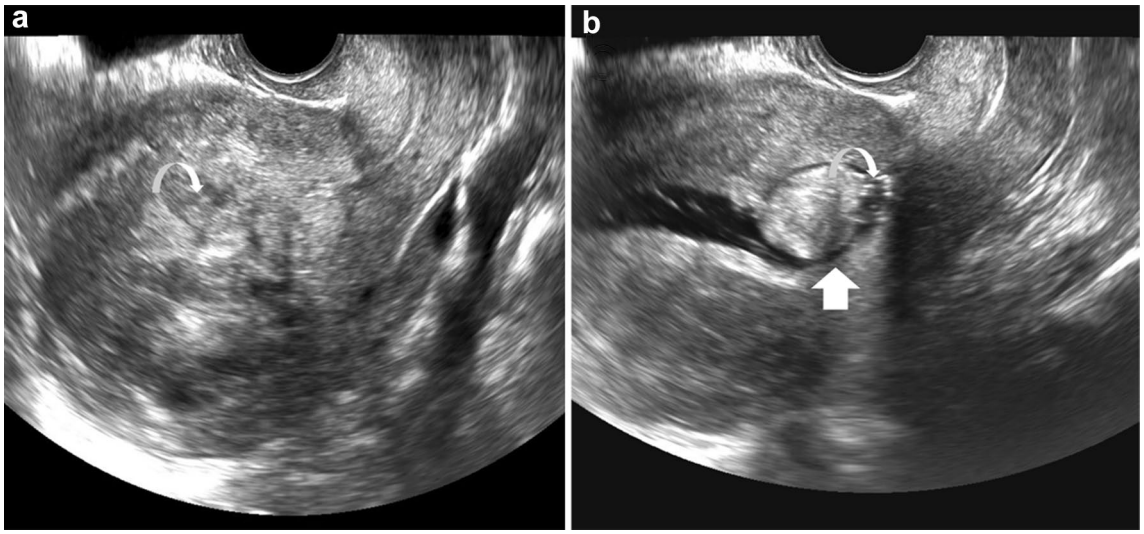

Fig. 4 **a** 47-year-old perimenopausal women with AUB evaluated with transvaginal ultrasound shows irregular area (curved arrow) within the endometrial cavity. **b** Sagittal SIS image shows a well-defined pedunculated polyp (arrow) arising from lower endometrial cavity. Note the thin stalk (curved arrow) attaching the polyp to the adjacent endometrium

malignancy. All endometrial polyps need to be surgically resected as imaging cannot differentiate between benign and malignant polyps [7].

Submucosal fibroid

Uterine fibroids are benign tumors of smooth muscle cells and fibrous tissue that are classified as per their location within the uterus: submucosal, intramural, and subserosal. They are often asymptomatic and found incidentally on imaging; however, symptomatic fibroids are the most common cause of hysterectomy [15, 16]. Symptomatic fibroids can present with AUB, pelvic pain or pressure symptoms, infertility, and recurrent pregnancy loss. Submucosal fibroids are more likely to be associated with AUB, and approximately 10% are present as post-menopausal bleeding [5, 6].

On imaging, fibroids appear as broad-based, rounded hypoechoic lesions in contrast to endometrial polyps that appear hyperechoic with respect to the myometrium. SIS may help in differentiating fibroids from endometrial polyps. In fibroids, the endometrial-myometrial interface is lost and the lesion has an obtuse angle with respect to the endometrium (Fig. 5). In contrast, endometrial polyps have an intact endometrial-myometrial interface with an acute angle of the lesion to the endometrium [7]. A single feeding artery, although found in only less than half of the cases, remains a pathognomonic imaging finding for endometrial polyps [5,

Fig. 5 Submucosal fibroid in a 41-year-old female evaluated with SIS. **a** Sagittal view of transvaginal sonogram reported as heterogeneous myometrial lesion (arrow) with ill-defined margins and possible submucosal extension. **b** SIS image shows a well-defined hypoechoic submucosal mass with loss of endometrial-myometrial interface(curved arrow). **c** 3D SIS image of the same patients shows a submucosal fibroid in relation to the endometrial lining (labeled image)

14, 17], while uterine fibroids have a branching vascular pattern [13]. Typically, fibroids demonstrate refractive posterior shadowing on ultrasound [13].

Fibroids may appear heterogeneous in echotexture, with some showing calcification or cystic changes. Both hormone-based medical and surgical treatment options are available for fibroids. Fibroids are managed conservatively in most cases, but submucosal fibroids that present with AUB may be resected. SIS can be useful in ascertaining the location and number of fibroids, such as differentiating submucosal from intramural fibroids. It can also determine the volume of projection of the lesion into the endometrial cavity [13]. Greater than 50% of the projected circumference into the endometrial cavity requires hysteroscopic removal, while less than 50% projection can be removed via the open or laparoscopic methods [6]. In patients with multiple uterine fibroids, the endometrium may be obscured or distorted on pelvic ultrasound. It cannot be presumed that the fibroids are the cause of bleeding when the endometrium is obscured and warrant further evaluation with SIS.

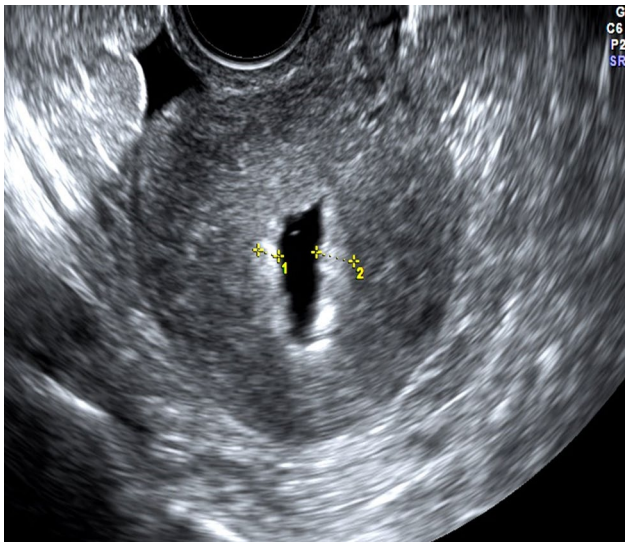

Fig. 6 Accurate measurement of endometrial thickness. SIS image shows single-layer evaluation of the endometrial lining with accurate measurement of the endometrial thickness (measured with calipers)

Endometrial hyperplasia

Endometrial hyperplasia is defined as an abnormal proliferation of endometrial glands and stroma, that is diffuse as opposed to focal proliferation seen in endometrial polyps. It is classified into three main types- simple hyperplasia, complex hyperplasia, and atypical hyperplasia based on the presence and degree of atypia. In women without AUB, the prevalence of simple and complex hyperplasia is 0.5–5%, while that of atypical hyperplasia and endometrial cancer is less than 1%, whereas this risk is higher in women with AUB [18].

On SIS, endometrial hyperplasia is usually seen as diffuse homogeneous endometrial thickening (Fig. 6). The endometrial thickening can be heterogeneous with cystic degeneration, asymmetrical thickening may mimic focal lesions like polyps, fibroids, or carcinoma. Cyclic progesterone therapy or hysterectomy are the major treatment options for endometrial hyperplasia without or with atypia, respectively [19].

Endometrial carcinoma

Endometrial carcinoma is the most common gynaecological malignancy in the United States [13]. Most commonly it affects post-menopausal women and comprises 10% cases of post-menopausal bleeding [13]. Major risk factors are related to unopposed estrogen, such as, early menarche, nulliparity, late menopause, obesity, polycystic ovary syndrome (PCOS), and metabolic syndrome.

On ultrasound, endometrial cancer usually presents as focal endometrial thickening, polypoid mass, or diffuse heterogeneous endometrial thickening with disruption of the endometrial-myometrial interface. Early endometrial cancer may not be differentiated from endometrial hyperplasia based on imaging alone, and histopathology is essential to confirm the diagnosis. Distortion of the endometrial-myometrial interface, heterogeneous echotexture, irregular margins of the endometrium, and complex fluid in the endometrial cavity point toward a malignant pathology [6, 13]. In contrast, a well-defined endometrial-myometrial interface, homogeneous echotexture, regular endometrial margins, and cystic changes point toward a benign pathology. Endometrial carcinoma may fill and obstruct the uterine cavity precluding adequate distention on SIS [20]. The major surgical treatment option is total abdominal hysterectomy and bilateral salpingo-oophorectomy. Radiation and chemotherapy may also be used in selected cases [21].

Adenomyosis

Adenomyosis is a benign uterine pathology characterized by the presence of ectopic endometrial glands and stroma in the myometrium with subsequent smooth muscle hypertrophy [22]. It can be asymptomatic or present with symptoms of AUB, pelvic pain, or dysmenorrhea [23]. On sonography, adenomyosis presents as globular uterine enlargement, heterogeneous myometrial echotexture, with asymmetrical myometrial wall thickening, myometrial cysts, echogenic linear striations, enlarged junctional complex, and tracking of fluid from the endometrial cavity to the myometrial cracks [23, 24]. TVS is often the first imaging modality used, but may not provide a specific diagnosis. MRI features are more specific when compared to ultrasound. SIS also overcomes

disadvantages of TVS and enables accurate localization of the sub-endometrial cystic changes. More importantly, saline instillation in the uterine cavity in SIS enables better visualization of the endometrium which can otherwise be obscured by the underlying adenomyosis. Hysterectomy is the definitive treatment for adenomyosis. Other non-surgical options include hormonal therapy, endometrial ablative therapy, and uterine artery embolization [25].

Uterine synechiae/adhesions

Uterine synechiae is one of the important causes for infertility and recurrent abortions. It is difficult to visualize the adhesions on routine TVS and the endometrium often appears normal [26, 27]. SIS enables the separation of the uterine walls and provides improved visualization of the echogenic bands. Uterine synechiae appear as irregular echogenic bands traversing across the endometrial canal with distortion of the cavity (Fig. 7). Adhesions are best seen on real-time cine imaging as thin echogenic bands traversing the uterine cavity. In advanced stages, it is difficult to distend the endometrium adequately with saline. Poor distention of the endometrial cavity is indicative of underlying pathology. Endometrial adhesions or synechiae from prior procedures/uterine instrumentation, or infections may tether the endometrial mucosa together, limiting the distention of the cavity. Hysteroscopic guided adhesiolysis is the mainstay of treatment. Intrauterine device may be inserted to prevent re-adhesion [26, 27].

Tamoxifen therapy

Tamoxifen is used in treatment of breast cancer due to its anti-estrogenic effects on the breast. Due to its estrogenic properties on the endometrium, there is an increased incidence of endometrial pathologies like cysts, polyps, hyperplasia, and malignancy. The most common finding on imaging is endometrial hyperplasia with cystic changes [6]. SIS is a useful diagnostic tool for monitoring endometrial pathologies secondary to tamoxifen therapy. It is superior in specificity as compared to TVS scan in evaluating endometrial pathologies in asymptomatic post-menopausal women with breast cancer receiving tamoxifen [28].

Congenital uterine anomalies

SIS may be performed to better characterize congenital uterine anomalies such as septate or bicornuate uterus (Figs. 8, 9). Distention of the uterine cavity with saline allows for accurate visualization of the septum, its thickness, and type (complete versus partial, fibrotic versus myometrial). It can also differentiate septate versus a bicornuate uterus. SIS can also be used in post-operative assessment for adequate repair of the congenital uterine anomalies.

Complications of the procedure

SIS is minimally invasive, relatively safe procedure, and is well-tolerated by patients, with very few reported

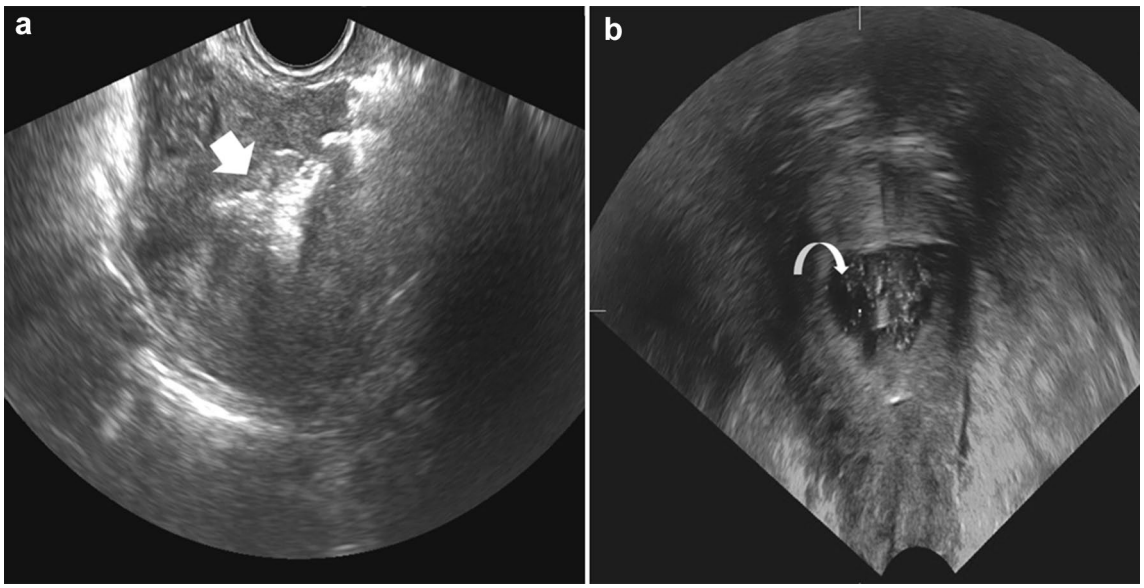

Fig. 7 Evaluation of infertility in a 35-year-old female with remote history of pelvic inflammatory disease. **a** Transvaginal sonogram image shows irregular echogenic areas with distortion of the endometrial cavity (arrow). **b** SIS image shows multiple echogenic strands suggesting a mixture of internal synechiae and agitated saline (curved arrow). Incomplete distention of the endometrial cavity should raise possibility of synechiae, although uterine masses, especially malignancy, also can do so

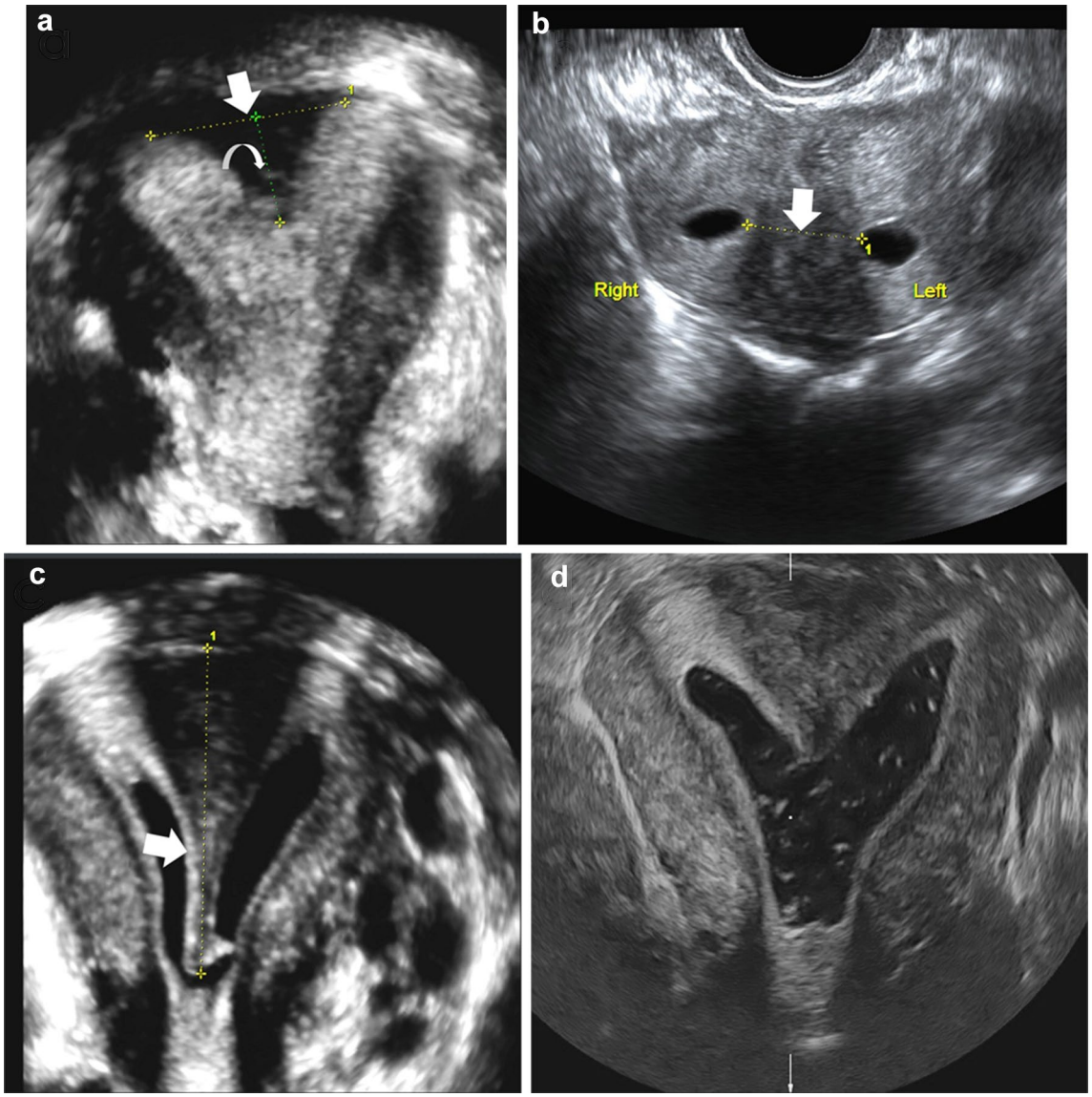

Fig. 8 Evaluation of congenital uterine anomalies. 25-year-old female with septate uterus: **a** Sagittal, transvaginal sonogram showing measurement of the myometrial septum (curved arrow) and inter-cornual distance (arrow) in septate uterus. **b** SIS was performed for better evaluation. Axial SIS image shows the exact thickness of myometrial septum (arrow). **c** Coronal SIS image shows the exact length of the myometrial septum measured from the level of uterine fundus (calipers and arrow). **d** SIS imaging performed in same patient demonstrates adequate resection of the septum

complications. In a prospective study by Dessole et al., complications were described in approximately 8.8% of 1153 patients who underwent SIS [29]. Pelvic pain and vasovagal symptoms were the most common side effects followed by nausea and fever. Post-procedure infection was reported in less than 0.2% of the patients [29] (Fig. 10).

Comparison of SIS with other modalities

TVS versus SIS

Although TVS is the mainstay in evaluation of uterus and adnexa, its usefulness is limited in evaluation of small intracavitary endometrial lesions and in differentiation between focal versus diffuse endometrial lesions.

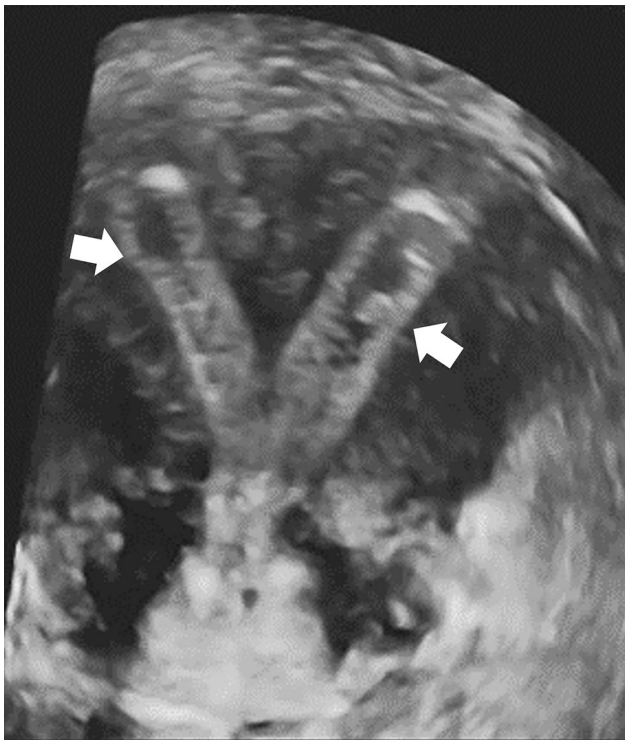

Fig. 9 22-year-old female with bicornuate uterus. Coronal SIS image shows accurate visualization of the two horns (arrows) of the bicornuate unicollis uterus

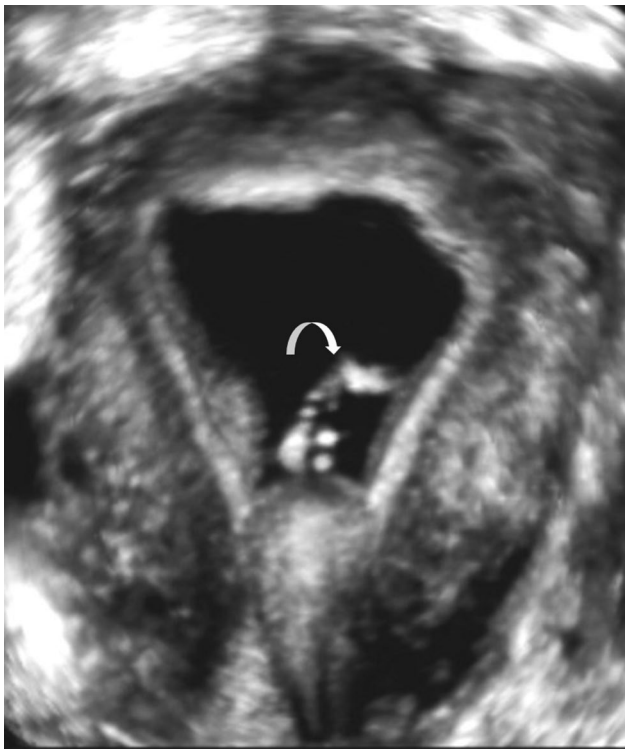

Fig. 10 Complication of the SIS masquerading as pitfall in diagnosis. Mechanical shearing of the endometrium seen during the procedure (curved arrow)

Endometrial distortions due to uterine mass such as fibroids or adenomyosis, and different phases of the menstrual cycle also pose challenges in precise diagnoses. On TVS and high-resolution transabdominal ultrasound, the endometrial thickness is an arbitrary visualization of a longitudinal stripe of the endometrium. This may be challenging in cases of endometrial distortion resulting from fibroids or abnormal uterine angulation. Sometimes, the normal endometrial lining may be misinterpreted as endometrial hyperplasia on TVS due to double-layered evaluation. SIS is superior for imaging of both focal and diffuse endometrial lesions as it permits single-layer evaluation of endometrial lining, unlike TVS which is limited by evaluation of the double-layered thickness of the endometrium [1].

Multiple studies have shown that SIS is a better tool than TVS for the assessment of endometrial lesions. [30–34]. In a study by Kamel et al., SIS had a superior diagnostic accuracy (93.3%) when compared to TVS (68.8%) in detection of endometrial polyps. [30]. In another study by Jacques et al., accurate diagnosis of polyps was reported in 34% and 91.3% patients with TVS and SIS respectively [32]. Aslam et al. noted higher sensitivity and specificity of SIS as compared to TVS in evaluating endometrial abnormalities in women with AUB [1]. The greatest difference was seen in cases of submucosal myomas wherein sensitivity and specificity of SIS was close to 100% as opposed to TVS (61.55%) [1]. Becker et al. in a prospective study compared combined TVS and SIS with TVS alone in evaluating uterine lesions. They reported superior sensitivity (90%) for focal endometrial lesions using TVS and SIS, as compared to 70% for TVS alone [35]. Hence, the single-layer evaluation of SIS permits superior detection of small intracavitary focal lesions which may be missed on TVS, and also enables accurate detection of the location of submucosal versus intramural myomas.

HSG versus SIS

Evaluation for infertility requires testing for tubal factors and assessment of fallopian tube patency. Currently, HSG is the standard screening modality of choice for testing of tubal patency, whereas laparoscopy with chromopertubation is the reference standard test for tubal assessment in infertility [36]. SIS is a safe and efficacious alternative technique that may be used for assessing tubal factors of infertility. Tubal patency is assessed by instillation of sterile fluid into the fallopian tubes via the uterine cavity, often followed by injection of air, and direct visualization of fluid flowing distally through the tubes into the peritoneum or its accumulation in the cul-de sac. Accumulation of fluid in the cul-de sac at

the end of the procedure indicates patency of at least 1 tube. Hysterosalpingo-contrast-sonography (HyCoSy) is a similar method used to assess tubal patency wherein ultrasound contrast agents with a stream of echogenic air bubbles is used to assess tubal patency [36]. The advantages of SIS are its ease of use, lack of ionizing radiation, cost-effectiveness, and ability to concurrently visualize the uterine cavity and adnexa. Its disadvantages include the inability to visualize the entire fallopian tube anatomy and confidently determine if one or both tubes are patent [2, 3] (Figs. 11, 12).

Various studies have shown that SIS has an equivalent diagnostic accuracy as hysterosalpingogram and chromopertubation at laparoscopy. Sankpal et al. showed an equal concordance rate (86%) between three-dimensional (3D) SIS and X-ray HSG in detecting tubal occlusion. They concluded that while SIS is adequate for assessment of distant fimbriae, however, the complete tubal architecture, especially the proximal part, could not be evaluated properly [2].

In another study by Christianson et al., authors found that there was no significant difference between the clinical pregnancy rates between women who had tubal patency

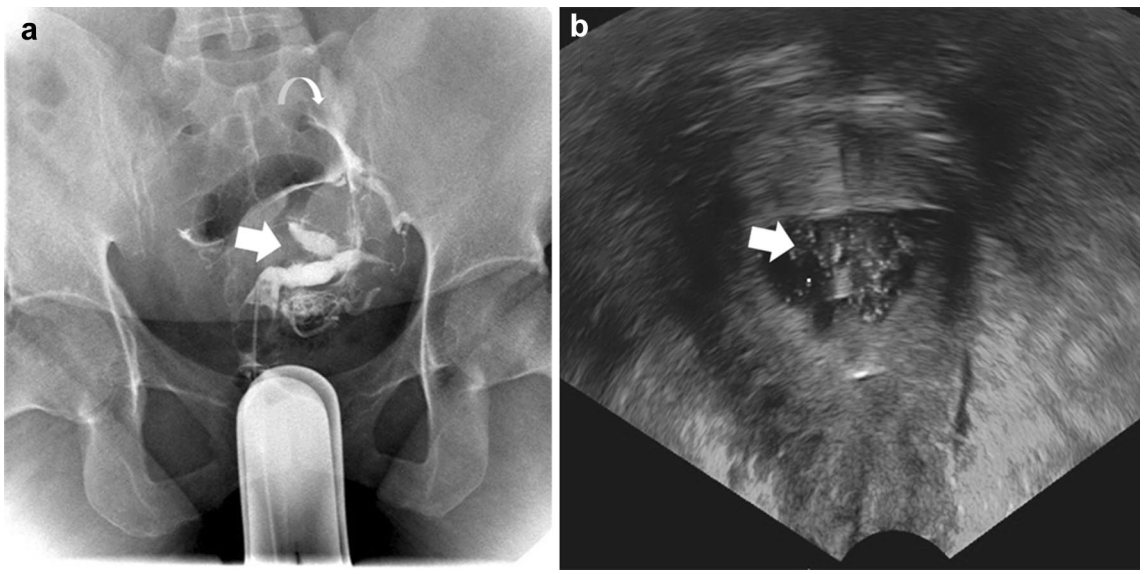

Fig. 11 Comparison between HSG and SIS. **a** 35-year-old female with remote history of pelvic inflammatory disease. Uterus has irregular morphology on HSG (arrow) which is non-specific; however, HSG accurately evaluates the patency of both the tubes and the peritoneal contrast spillage (curved arrow). **b** Irregular synechiae (arrow) are best evaluated on SIS

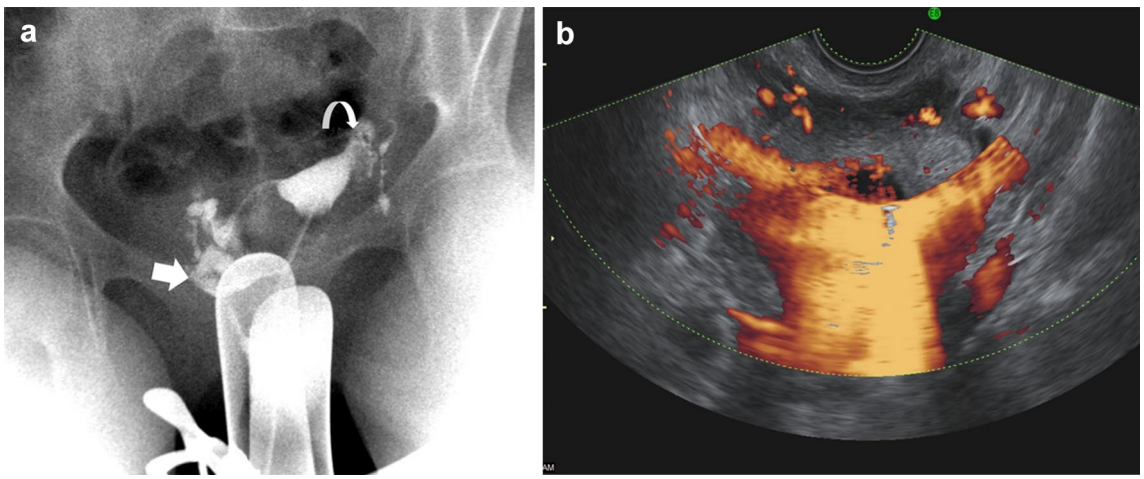

Fig. 12 Comparison between HSG and SIS for tubal patency. 27-year-old female with infertility work-up. **a** Note the irregular appearance of the isthmic portion of the fallopian tube (curved arrow) and contained spillage due to peritubal adhesions (arrow). HSG has superior role to SIS in evaluation of the proximal fallopian tube irregularities and block. **b** Color Doppler application during SIS to assess tubal patency

confirmed by HSG versus SIS in a large cohort of patients with PCOS [3].Socolov et al. reported the role of SIS with saline and air as a contrast solution versus HSG and laparoscopic chromopertubation in evaluating tubal patency [37]. They found that in comparison with laparoscopy, SIS was found to have a higher sensitivity (81.4%), compared to HSG (61.9%) in diagnosing tubal patency [37]. A meta-analysis by Holz et al. using Echovist-200 showed a concordance of 83% between HyCoSy and HSG when detecting tubal pathology. The same concordance was observed between HyCoSy and laparoscopy with chromopertubation [38]. A comprehensive analysis by Campbell et al. showed a concordance of 84–91% between HyCoSy using Echovist-200 and HSG, and a concordance of 80–93% between HyCoSy and laparoscopic chromopertubation [39].

Hence, SIS as well as HyCoSy can be used as an initial screening modality for tubal factor infertility, because of its ability to detect tubal occlusion and its superior accuracy than HSG in the simultaneous evaluation of the uterine cavity and intrauterine lesions [40]**.**

Hysteroscopy versus SIS

Hysteroscopy is considered as the reference standard for evaluating the uterine cavity pathologies. However, its drawbacks are that it is expensive, and invasive; it may lead to complications like perforation, bleeding owing to its invasive nature [41]. It also has a limited role in evaluating the myometrial and adnexal pathologies. SIS has emerged as a promising modality which is a cost effective, minimally invasive alternative that has shown promise in evaluating endometrial lesions in patients with AUB.

Scwarzler et al. noted comparable sensitivity (90%) and specificity (91%) of SIS and diagnostic hysteroscopy for the assessment of intrauterine pathology of polyps and fibroids [42]. In a study by Epstein et al., SIS has shown a nearly perfect agreement with hysteroscopy in cases of focal endometrial lesions. Sensitivity values of – 80% have been reported in SIS as well as hysteroscopy for diagnosing endometrial polyps. Although SIS was inferior to hysteroscopy in differentiating benign versus malignant endometrial lesions, neither SIS nor hysteroscopy could reliably discriminate between the two based on appearances [43].

A study by Saidi et al. showed that while SIS had a sensitivity of 90% and specificity of 83% in evaluating AUB, diagnostic hysteroscopy showed a sensitivity of 82% and specificity of 65% [44]. In a study by Cicinelli et al., SIS had sensitivity, specificity, and predictive values approaching 100% in the evaluation of submucosal myomas, as did hysteroscopy [45]. In one of the studies by Bingol et al., SIS showed a sensitivity of 87%, specificity of 100% for endometrial hyperplasia, and a sensitivity of 100% for polypoid lesions [46]. For submucosal myoma SIS showed a sensitivity of 99%. Hysteroscopy had a sensitivity and specificity of 98%, and 83%, respectively, for overall uterine pathologies [46].

Hence, SIS owing to its cost effective and non-invasive nature, and comparable sensitivity with diagnostic hysteroscopy can be used as an alternative initial screening modality in working up females with AUB. Big advantage of hysteroscopy is its ability to perform biopsy simultaneously, thus providing histopathological diagnosis.

Pelvic MRI versus SIS

MRI is increasingly being used for evaluation of the female pelvis owing to its increased contrast resolution, superior soft tissue characterization, and multiplanar imaging capabilities. Limited literature is available comparing SIS and MRI in the evaluation of endometrial pathologies. MRI is a superior imaging modality for the assessment of fibroids. It allows a large field of view and is also used in the preoperative mapping of adenomyosis [47]**.**

MRI is being utilized to provide road map as well as detect the volume and signal intensity changes of fibroids post Uterine artery embolization [48]. MRI is also superior in the evaluation, and local staging of endometrial cancer as it can assess the extent of myometrial invasion and determine the preoperative staging [49]. Pelvic MRI is more accurate than SIS in evaluating adenomyosis wherein it can demonstrate the widened junctional zone in these patients [50]. MRI is the reference standard for evaluating congenital mullerian duct anomalies [51, 52]. The advantage of SIS over MRI is its ability to concurrently evaluate the tubal patency and assess tubal factors of infertility. In our experience, when compared to MRI, SIS provides high spatial resolution imaging for details of endometrial lesions. SIS also provides confident diagnosis of submucosal extent of the fibroids, and better evaluation of the endo-myocardial interface (Fig. 13). SIS can be performed in patients who cannot undergo MRI due to contraindications such as claustrophobia, metallic implants, and renal failure (non-contrast imaging only).

Conclusions

SIS improves visualization of the endometrial lesions and helps differentiating it from sub-endometrial causes yielding better diagnostic accuracy. It has the additional advantage of simultaneously assessing the tubal patency with comparable accuracy. SIS has a great role in diagnostic work-up especially related to abnormal uterine bleeding and infertility. SIS should be used as an adjunct screening method for pelvic imaging, especially in cases wherein limited information is achieved by routine transvaginal scans.

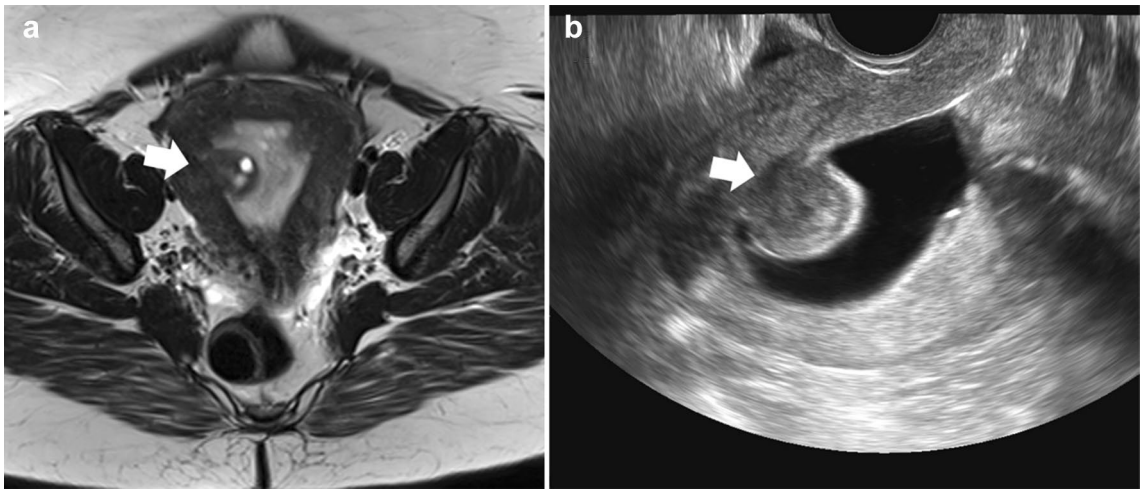

Fig. 13 Comparison between MRI and SIS in evaluation of submucosal fibroid. **a** MRI pelvis in a 31-year-old female with heavy menstrual cycles. Axial T2-weighted image shows aT2 hypointense mass with endocavitary extension (arrow) and cystic changes. **b** When compared to MRI, SIS image shows better soft tissue resolution and relation of the mass (arrow) to endometrial canal. The soft tissue resolution and localization is excellent with SIS as compared to MRI in case of small lesions and when the endometrial/sub-endometrial location is indeterminate

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