American College of Radiology
ACR Appropriateness Criteria®
Female Infertility

Variant 1: **Female infertility. Evaluation of ovulatory function and ovarian reserve. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
US pelvis transvaginal	Usually Appropriate	O
US pelvis transabdominal	Usually Appropriate	O
MRI pelvis without IV contrast	May Be Appropriate	O
MRI pelvis without and with IV contrast	Usually Not Appropriate	O

Variant 2: **Female infertility. Clinical features or history of polycystic ovary syndrome. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
US pelvis transvaginal	Usually Appropriate	O
MRI pelvis without IV contrast	May Be Appropriate	O
US pelvis transabdominal	May Be Appropriate	O
US color Doppler pelvis	May Be Appropriate	O
MRI pelvis without and with IV contrast	Usually Not Appropriate	O

Variant 3: **Female infertility. History or clinical suspicion of endometriosis. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
US pelvis transvaginal	Usually Appropriate	O
MRI pelvis without IV contrast	Usually Appropriate	O
US pelvis transabdominal	Usually Appropriate	O
US pelvis transrectal	Usually Appropriate	O
US color Doppler pelvis	May Be Appropriate	O
Fluoroscopy hysterosalpingography	May Be Appropriate	☢☢
MRI pelvis without and with IV contrast	May Be Appropriate (Disagreement)	O
US sonohysterography with tubal contrast agent	May Be Appropriate (Disagreement)	O
US sonohysterography	Usually Not Appropriate	O

Variant 4: **Female infertility. Suspicion of tubal occlusion. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Fluoroscopy hysterosalpingography	Usually Appropriate	☢☢
US sonohysterography with tubal contrast agent	Usually Appropriate	O
US pelvis transvaginal	Usually Appropriate	O
MRI pelvis without IV contrast	May Be Appropriate	O
US pelvis transabdominal	May Be Appropriate	O
MRI pelvis without and with IV contrast	May Be Appropriate	O
US sonohysterography	Usually Not Appropriate	O

Variant 5: **Female infertility. Recurrent pregnancy loss. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI pelvis without and with IV contrast	Usually Appropriate	O
MRI pelvis without IV contrast	Usually Appropriate	O
US pelvis transvaginal	Usually Appropriate	O
US sonohysterography	Usually Appropriate	O
US pelvis transabdominal	Usually Appropriate	O
Fluoroscopy hysterosalpingography	May Be Appropriate (Disagreement)	☢☢
US color Doppler pelvis	May Be Appropriate (Disagreement)	O
US sonohysterography with tubal contrast agent	May Be Appropriate (Disagreement)	O

FEMALE INFERTILITY

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Summary of Literature Review

Introduction/Background

Overall, infertility affects about 15.5% of women [1]. Infertility investigations are generally initiated after 12 months of unprotected intercourse without resultant pregnancy in women <35 years of age, whereas they are initiated after 6 months of unprotected intercourse without pregnancy in women >35 years of age. An investigation may commence sooner in couples with a known condition or medical history predisposing to infertility.

The most common known causes of infertility are male factor (26%), ovulatory failure (21%), and tubal damage (14%), although in 28% of couples infertility remains unexplained [2]. Female-specific causes of infertility include deterioration of oocyte quality with increasing maternal age; ovulatory disorders, most notably polycystic ovarian syndrome (PCOS); history of salpingitis, such as that caused by chlamydia infection; endometriosis; and uterine cavity abnormalities interfering with implantation causing inability to become pregnant or causing recurrent pregnancy loss [3]. These potential causes of female infertility will be discussed here.

Imaging can be used to count ovarian follicles and help determine ovarian reserve, particularly in advanced maternal age. Imaging can also be useful in diagnosing polycystic ovarian morphology (PCOM) in women suspected of having PCOS. PCOS is the leading cause of anovulatory infertility, affecting at least 7% of adult women [4]. Women with PCOS experience hyperandrogenism, infertility, and have PCOM defined as >25 small follicles in at least one ovary or a single ovarian volume >10 mL on transvaginal ultrasound (TVUS) [5]. Because PCOM may be present in up to one-third of reproductive-aged women [6], the imaging findings of PCOM are not sufficient for the diagnosis of PCOS but serve to support the diagnosis of PCOS in women with the clinical features.

Endometriosis affects at least one-third of women with infertility and up to 10% of reproductive-aged women [7]. Although endometriosis is associated with infertility, the mechanism is unclear [8]. Imaging is useful in characterizing some features of endometriosis; however, small endometrial implants are not well detected on imaging. Therefore, laparoscopy remains the standard for both diagnosis and staging of endometriosis [9,10].

Women with a history of pelvic infection or surgery may develop intrauterine synechiae, fallopian tube abnormalities that include occlusion, and peritubular adhesions [11], potentially causing infertility. Imaging evaluation in these women focuses primarily on the fallopian tubes.

Müllerian anomalies, synechiae in the endometrial cavity, and cervical incompetence [12] can cause recurrent pregnancy loss, which affects approximately 5% of couples [13]. Evaluation for a cause of recurrent pregnancy loss should be performed after two or more consecutive early pregnancy losses [14]. The true incidence of Müllerian duct abnormality (MDA) remains unknown; however, it is typically quoted as approximately 4% in the infertile population with higher ranges of up to 13% in recurrent pregnancy loss populations. Using imaging to differentiate among the different types of Müllerian anomalies is important because they are treated differently and have different implications for difficulty with pregnancy. The most common MDA is septate uterus, a surgically correctable lesion [15]. Patients with a septate uterus typically have difficulty conceiving or have first-term pregnancy loss compared with those with a bicornuate uterus, which have a higher incidence of preterm birth [16]. Intrauterine adhesions have been reported in up to 39% of women with recurrent pregnancy loss, though it is unclear how often these

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adhesions cause the loss of pregnancy [17]. Although hysteroscopy is the reference standard for visualizing intrauterine adhesions [18], imaging examinations can aid in making this diagnosis with a less invasive approach. Uterine fibroids are suspected to be related to recurrent pregnancy loss; however, there is insufficient evidence to confirm a causal relationship. Uterine adenomyosis, although previously felt to be more common in multiparous women, has now been associated with increased rates of spontaneous abortion and implantation failure [19]. In approximately 18% of women, a uterine abnormality such as fibroids or MDA is identified as a causative factor for recurrent pregnancy loss [20].

Infertility investigation begins with a thorough history and physical examination. A detailed history, including previous pregnancies and infertility treatments, menstrual history, frequency of intercourse, medication and toxin exposures, and factors predisposing to pelvic adhesions (surgery, endometriosis, pelvic inflammatory disease [PID]), is necessary. Physical examination is not limited to the pelvis; it also includes palpation of the thyroid, a thorough breast examination to look for secretions, and assessment for signs of androgen excess [21]. Following clinical and laboratory evaluation, imaging is often used in the assessment of infertility. Given that some etiologies of infertility are clinically silent, appropriate imaging studies should be performed at the discretion of the referring physician [21].

For women with galactorrhea and a need for imaging, please refer to the ACR Appropriateness Criteria® topic on "Neuroendocrine Imaging" [22].

Special Imaging Considerations

MR hysterosalpingography (HSG) is an additional technique that can demonstrate tubal patency and may be useful in women in whom both MRI and HSG need to be performed [23]; however, it remains an investigational tool [24].

Discussion of Imaging Modalities by Variant

Variant 1: Female infertility. Evaluation of ovulatory function and ovarian reserve. Initial imaging.

MRI Pelvis

T2-weighted MRI can be used to determine antral follicle counts and was shown in one study to be superior to TVUS for detecting follicles ≤3 mm [25]. MRI without intravenous (IV) contrast might be useful in the few patients for whom the ovaries are not adequately visualized with ultrasound (US). To our knowledge, there is no literature supporting the use of contrast-enhanced MRI to assess antral follicle counts [26].

US Pelvis Transabdominal

Although transabdominal US and TVUS may be performed together for evaluation of the ovaries, transabdominal US should be relied upon only if the ovaries are not adequately evaluated via a transvaginal approach.

US Pelvis Transvaginal

TVUS can be used to monitor follicle development [27], perform antral follicle counts [28], and measure ovarian volume. When the ovarian volume is <3 cm^3 and <5 antral follicles are present, this suggests diminished ovarian reserve [29].

Variant 2: Female infertility. Clinical features or history of polycystic ovary syndrome. Initial imaging.

PCOS is the most common endocrine disorder of reproductive-aged women. However, the definition and associated ovarian morphology criteria continue to evolve. Imaging can confirm the findings of PCOM; however, the diagnosis of PCOS requires additional clinical criteria. The 2014 report by the Androgen Excess and Polycystic Ovary Syndrome Society has recommended an updated threshold for PCOM of ≥25 follicles, ≥10 mL of ovarian volume, or both [5].

MRI Pelvis

A recent study in obese adolescents with suspected PCOS demonstrated that MRI without IV contrast can provide reproducible and reliable ovarian volume assessment; however, ovarian follicle counts had only moderate interobserver agreement. Nonetheless, in the obese adolescent or patient in whom TVUS is unacceptable and transabdominal US limited, MRI may provide additional information on PCOM [25,26,30].

US Pelvis Color Doppler

Although increased central stromal vascularity has been demonstrated in the ovaries of women with PCOS, there is limited evidence to indicate color Doppler should be performed routinely in the evaluation of PCOM [31].

US Pelvis Transabdominal

Transabdominal US is often performed in conjunction with TVUS; however, in some settings it may be performed in isolation. The transabdominal approach is generally not suitable to record an accurate follicle count but is considered reliable to determine if the ovarian volume is >10 mL. On occasion, with a high superficial location, the ovary may be better seen for follicle counts than via the TVUS route but remains less reliable because of lower transducer frequency.

US Pelvis Transvaginal

In 2014, the Androgen Excess and Polycystic Ovary Syndrome Society revised the criteria for diagnosing PCOM. The revised criteria consist of ≥25 follicles that are 2 to 9 mm in diameter, in at least one ovary assuming the ovaries are well visualized transvaginally with an 8 MHz or higher transducer [5]. Increased echogenicity of the ovarian stroma has been reported as the most sensitive and specific sign of polycystic ovaries; however, this is a subjective finding [32]. Ovarian volume >10 mL can also be used to suggest the diagnosis of PCOM.

Variant 3: Female infertility. History or clinical suspicion of endometriosis. Initial imaging.

Fluoroscopy Hysterosalpingography

HSG to assess tubal patency and the uterine cavity has been proposed as part of an infertility workup in women with endometriosis [8]. However, in one study, 21% of women undergoing infertility evaluation were found to have endometriosis at surgery despite a normal HSG [33]. Although HSG may be helpful in diagnosing tubal occlusion or patency in patients with endometriosis, other imaging modalities are more sensitive in detecting endometriosis.

MRI Pelvis

MRI has been shown to have a sensitivity of 82% to 90% and specificity of 91% to 98% for the diagnosis of endometriomas and can be used when the findings on TVUS are indeterminate [34-36] or when assessment for deep infiltrating endometriosis is required prior to fertility-sparing surgery. Although IV contrast is useful for the assessment of PID and for determining if ovarian masses have enhancing components, IV contrast is not routinely used for the assessment of endometriosis [34]. The typical MRI features of an endometrioma are high signal on T1-weighted with low signal on T2-weighted images (T2 shading) from intracellular methemoglobin, crosslinking of proteins, and iron. Additionally, the T2 dark spot sign has 93% specificity in differentiating endometriomas from hemorrhagic cysts, whereas T2 shading is sensitive but not specific for endometriomas [37]. Deep infiltrating endometriosis presents as low signal intensity regions with or without hyperintense foci on T2- and/or T1-weighted images. Despite administration of gadolinium, studies do not attempt to demonstrate a difference in detection of deep infiltrating endometriosis with gadolinium as compared to without [38,39].

Adhesions are frequently present in endometriosis and can be suspected, in the presence of a uterus, fixed in retroversion, low-signal intensity bands, obliteration of organ interfaces, and/or obliteration of the cul-de-sac [40]. In a study of 159 women who underwent surgery for clinical suspicion of deep infiltrating endometriosis, MRI was 92.4% sensitive and 94.6% specific in detecting intestinal endometriosis, 88% sensitive and 83.3% specific in detecting deep infiltrating endometriosis in posterior locations (uterosacral ligament, retrocervical, rectovaginal septum, vaginal fornix), and 50% sensitive and 97.3% specific in detecting bladder wall endometriosis [38].

Adherence to or angulation of bowel loops toward the posterior surface of the uterus has been shown to be 83.7% sensitive to diagnose cul-de-sac obliteration, whereas displacement of pelvic free fluid was 95% sensitive and presence of a retrouterine fibrous mass was 97.1% sensitive [40]. These findings may have been enhanced in this study because of the administration of vaginal and rectal sterile US gel as well as an IV antispasmodic. Another study similarly identified serosal uterine fibrotic plaques as having the best accuracy for posterior cul-de-sac obliteration [41] but did not assess displacement of free pelvic fluid. Overall, MRI has value in assessing for endometriomas and other signs of endometriosis, such as angulation of bowel loops toward the posterior surface of the uterus, displacement of pelvic free fluid, and detection of retro-uterine fibrous masses.

US Pelvis Color Doppler

Endometrial implants have limited vascularity. The presence of Doppler blood flow in a suspected endometrial implant should prompt investigation for neoplasm [42]. Doppler can also be useful in differentiating endometriomas and endometrial implants, which are typically avascular, from other ovarian masses and normal structures [43].

US Pelvis Transabdominal
As previously mentioned, a combined transabdominal US and TVUS approach may be employed in pelvic imaging, combining the anatomic overview provided by the transabdominal US approach with the greater spatial and contrast resolution of TVUS imaging. Please see the section on "US Pelvis Transvaginal" for further details.

US Pelvis Transrectal
Transrectal US can also be useful in the detection of deep infiltrating endometriosis. Compared with surgery, transrectal US was shown to be 97% sensitive and 96% specific for the detection of rectovaginal endometriosis and was 80% sensitive and 97% specific in diagnosing uterosacral ligament implants [44]. In another study, 317 patients underwent pelvic MRI, TVUS, and transrectal US prior to laparoscopy. This study showed transrectal US had the highest sensitivity at 82.8%, but MRI was the most specific at 93.9% for evaluation of the uterosacral ligament, and the three techniques were similar for assessing the rectovaginal septum, bladder, and distal ureters. MRI was superior to TVUS and transrectal US in diagnosing retrocervical endometriosis [45]. Transrectal US is limited to a small anatomic area [43] but can be useful in some patients, especially those unable to undergo TVUS [45].

US Pelvis Transvaginal
TVUS, especially when combined with real-time physical examination, can be useful in the detection of both ovarian and nonovarian endometriosis. Some studies have demonstrated superiority of TVUS over MRI in the detection of rectosigmoid and retrocervical endometriosis [46-49]. TVUS can demonstrate macroscopic endometriomas that are often bilateral. On US, an endometrioma typically appears as an adnexal or ovarian mass with homogenous low-level internal echoes. The presence of echogenic foci in the wall (hemosiderin deposits) or multilocularity further increases the likelihood that a mass with this appearance is an endometrioma [50]. Nonovarian endometriosis can be assessed best with dynamic US by looking for the uterine sliding sign, assessing for nodules at sites of tenderness, assessing ovarian mobility, and looking for hypoechoic nodules outside of the ovaries [51].

US Sonohysterography
To our knowledge, there is no relevant literature to support performing isolated US sonohysterography in patients with a history or clinical suspicion of endometriosis.

Contrast sonohysterography or saline-infusion sonohysterography (SIS) provides an assessment of the uterine cavity. Although the endometrium can be assessed by TVUS, SIS is particularly useful in assessing potential causes of infertility, including intrauterine adhesions, endometrial polyps, and leiomyomas [52]. Antibiotic administration or prophylactic use of antibiotics is at the discretion of the referring physician if there is a prior history of PID or if hydrosalpinx is noted at the time of the study.

US Sonohysterography with Tubal Contrast Agent
Hysterosalpingo-contrast sonography (HyCoSy) involves instilling echogenic contrast, typically an agitated air and saline mixture, into the uterus with real-time US to observe the material distending the uterine cavity, filling the fallopian tubes, and spilling out over the adjacent ovary [53]. Accuracy of HyCoSy is similar to HSG when compared with laparoscopy with chromopertubation in determining tubal patency with sensitivity of 75% to 96% and specificity of 67% to 100% when compared directly with laparoscopy with chromopertubation [54]. It has been proposed that TVUS with 3-D imaging of the uterus and ovaries followed by SIS and HyCoSy with agitated saline can be performed in one session as a comprehensive infertility examination [42]. In women with endometriosis, HyCoSy has been shown to be 91% accurate compared with laparoscopy in diagnosing tubal patency [55]. This modality can also detect endometriomas as well as pelvic adhesive disease and endometriotic nodules, especially in the hands of well-trained operators.

Variant 4: Female infertility. Suspicion of tubal occlusion. Initial imaging.

Fluoroscopy Hysterosalpingography
HSG allows detection of tubal patency, tubal size, tubal irregularity, and peritubal disease. It can also detect intrauterine synechiae, which typically present as irregular endometrial filling defects [11]. Tubal flushing during HSG has also been shown to increase pregnancy rates up to 38% compared with pregnancy rates of up to 21% in women being investigated for infertility who did not undergo HSG. Pregnancy rate in this study was highest in women who underwent HSG with oil-soluble contrast [56]. However, unlike performance of HSG with water-soluble contrast agents, the use of oil-based contrast material for HSG carries the increased risk of oil emboli if there is myometrial intravasation [57]. Although HSG has been historically regarded as the imaging study of choice in assessing tubal patency, it is only 65% sensitive and 85% specific for diagnosing tubal patency when compared

with laparoscopy with chromopertubation [58], which is widely accepted as the reference standard for evaluating tubal patency.

MRI Pelvis
MRI is useful in the detection of hydrosalpinges, most commonly due to prior PID, and is superior to TVUS in the assessment of PID, although this refers to acute PID, which is outside of the scope of this topic (95% sensitive and 89% specific compared to 81% sensitive and 78% specific) [59]. Hydrosalpinges are detected in subclinical or chronic PID secondary to scarring of the fallopian tubes or tubal obstruction by peritoneal bands from previous inflammation [60]. In a blinded study of 41 patients with hydrosalpinx at surgery, hydrosalpinx was accurately diagnosed in 31 patients (75.6%) on MRI [61]. Although IV contrast is useful in assessing additional complications of PID, it is not necessary for the evaluation of hydrosalpinges [34,60].

US Pelvis Transabdominal
A combined transabdominal US and TVUS approach may be employed in pelvic imaging, combining the anatomic overview provided by the transabdominal approach with the greater spatial and contrast resolution of transvaginal imaging. Please see the section on "US Pelvis Transvaginal" for further details.

US Pelvis Transvaginal
Hydrosalpinx may occur in the setting of distal tubal occlusion, most commonly due to prior PID [62]. The finding of hydrosalpinx has implications for patients who may undergo in vitro fertilization [63]. TVUS has been shown to be 86% sensitive in detecting hydrosalpinx [64]. Apart from detection of hydrosalpinges, TVUS has not been shown to be effective in documenting tubal patency.

US Sonohysterography
To our knowledge, there is no relevant literature to support performing isolated US sonohysterography in patients with suspicion of tubal occlusion; however, the presence of increased fluid in the posterior cul-de-sac following sonohysterography may indicate tubal patency.

US Sonohysterography with Tubal Contrast Agent
HyCoSy involves instilling echogenic contrast, typically an agitated air and saline mixture, into the uterus with real-time US to observe the material distending the uterine cavity, filling the fallopian tubes, and spilling out over the adjacent ovary [53]. HyCoSy is similar to HSG when compared with laparoscopy with chromopertubation in determining tubal patency [54]. It has been proposed that TVUS with 3-D imaging of the uterus and ovaries followed by SIS and HyCoSy with agitated saline can be performed in one session as a comprehensive infertility examination [42]. HyCoSy has been shown to be 91% accurate compared with laparoscopy in diagnosing tubal patency in women with endometriosis [55].

Hysterosalpingo-foam sonography in combination with 2-D or 3-D imaging has demonstrated improved accuracy of 93.7% and better concordance with laparoscopy compared with 2-D or 3-D air or saline HyCoSy [65,66] for assessment of tubal patency. The addition of high-definition flow (bidirectional Doppler feature) achieved even higher accuracy at 96.9%, comparable with the reference method of laparoscopic chromopertubation with dye [65]. However, high-definition flow still needs to be validated by other groups.

Variant 5: Female infertility. Recurrent pregnancy loss. Initial imaging.

Fluoroscopy Hysterosalpingography
In 24 cases of surgically proven MDA, MRI was 100% accurate, 2-D TVUS was 92% accurate, and hysterosalpingogram was only 16.7% accurate in characterizing MDAs [67]. Although HSG can visualize the uterine cavity, it cannot always provide complete information about the external uterine contour, preventing accurate distinction between a septate and a bicornuate uterus. A study of 54 women with suspected Asherman syndrome discovered 3-D US was 100% sensitive, and HSG was 66.7% sensitive in grading intrauterine adhesions compared with hysteroscopy [68]. Another study of only 19 women discovered HSG and sonohysterography were both 100% sensitive, and conventional TVUS was only 52% sensitive for detecting intrauterine adhesions compared with hysteroscopy [69]. Additional studies have shown HSG to be 75% to 81% sensitive and 80% specific compared with hysteroscopy in diagnosing intrauterine adhesions [70,71]. Antibiotic administration or prophylactic use of antibiotics is at the discretion of the referring physician if there is a prior history of PID or if hydrosalpinx is noted at the time of the study. Although HSG may provide useful information about the uterine cavity, such as the presence of adhesions, it is not reliable in categorizing MDAs and has been largely replaced by MRI and 3-D US for assessment of the uterine cavity in recurrent pregnancy loss.

MRI Pelvis
MRI provides accurate assessment of uterine abnormalities potentially contributing to infertility such as MDA [67], adenomyosis [72], and leiomyomas [73]. On both TVUS and MRI, a fundal cleft >1 cm can be used to diagnose a bicornuate uterus and differentiate it from a septate uterus (fundal cleft <1 cm) [67]. A fundal indentation <5 mm above the interostial line can also be used for identification of a bicornuate uterus [74]. In 24 cases of surgically proven MDA, MRI was 100% accurate, 2-D TVUS was 92% accurate, and hysterosalpingogram was only 16.7% accurate in the classification of MDA [67]. MRI demonstrates 78% to 88% sensitivity and 67% to 93% specificity in detecting adenomyosis, typically thickening of the junctional zone, often with T2 hyperintense foci [72]. Nondegenerated fibroids are classically well circumscribed with low T2 signal. The imaging features of degenerated fibroids can vary greatly on MRI, however [73]. Although MRI may be useful in detecting intrauterine adhesions, no large studies comparing its efficacy to hysteroscopy have been performed [75]. When comparing diagnostic modalities to hysterectomy for the detection of intracavitary abnormalities, MRI, SIS, and hysteroscopy were equally effective and superior to TVUS [76].

US Pelvis Color Doppler
Power Doppler has been shown to be useful in detecting stalks within endometrial polyps and peripheral or rim vascularity in submucosal fibroids [77]. Color Doppler has also been shown to be useful in differentiating the central vascular pattern of adenomyosis from the peripheral vascularity of fibroids [78]. This procedure is not performed in isolation but in conjunction with TVUS.

US Pelvis Transabdominal
A combined transabdominal US and TVUS approach may be employed in pelvic imaging, combining the anatomic overview provided by the transabdominal approach with the greater spatial and contrast resolution of TVUS imaging. Please see the section on "US Pelvis Transvaginal" for further detail.

US Pelvis Transvaginal
On both TVUS and MRI, an external fundal cleft >1 cm can be used to diagnose a bicornuate uterus and differentiate it from a septate uterus (fundal cleft <1 cm) [67]. A fundal indentation <5 mm above the interostial line can also be used for identification of a bicornuate uterus [74]. In 24 cases of surgically proven MDA, MRI was 100% accurate, 2-D TVUS was 92% accurate, and hysterosalpingogram was only 16.7% accurate [67]. For detecting intrauterine adhesions, a study of 19 women showed that HSG and sonohysterography were both 100% sensitive, and conventional TVUS was only 52% sensitive compared with hysteroscopy [69].

In another study of 133 women undergoing infertility evaluation who underwent both hysteroscopy and TVUS, TVUS detected submucosal fibroids in 10 of the 11 patients diagnosed with submucosal fibroids at hysteroscopy, yielding a sensitivity of 91% and specificity of 100% [79]. When comparing diagnostic modalities with hysterectomy for the detection of intracavitary abnormalities, MRI, SIS, and hysteroscopy were equally effective and superior to TVUS [76].

Three-dimensional US has become useful in the evaluation of female infertility in its ability to improve upon detection of lesions within the uterine cavity and improve classification of congenital uterine anomalies [80-83]. It has been widely used in conjunction with SIS [83]. It has been shown to have similar accuracy to MRI for detecting Müllerian anomalies [84]. Additionally, in a study of 54 women with suspected Asherman syndrome, 3-D US was 100% sensitive and HSG was 66.7% sensitive in grading intrauterine adhesions compared with hysteroscopy [68].

US Sonohysterography
Contrast sonohysterography or SIS provides an assessment of the uterine cavity. Although the endometrium can be assessed by TVUS, SIS is particularly useful in assessing potential causes of infertility, including intrauterine adhesions, endometrial polyps, and leiomyomas [52]. Antibiotic administration or prophylactic use of antibiotics is at the discretion of the referring physician if there is a prior history of PID or if hydrosalpinx is noted at the time of the study.

In a study of 140 women who underwent hysteroscopy during infertility evaluation, all had an HSG and 93 also underwent SIS. Compared with hysteroscopy, HSG was 52.6% accurate and SIS was 75% accurate in detecting fibroids [85]. A systematic review of studies involving women with abnormal uterine bleeding demonstrated hysteroscopy and SIS to be better than TVUS in detecting submucosal fibroids [86]. When comparing diagnostic modalities with hysteroscopy for the detection of intracavitary abnormalities, MRI, SIS, and hysteroscopy were equally effective and superior to TVUS [76]. In a study comparing HSG, TVUS, and SIS with hysteroscopy, SIS

demonstrated 75% sensitivity and 93% specificity in detecting intrauterine adhesions. This was similar to HSG but far superior to TVUS [71].

Three-dimensional SIS was shown to be 100% accurate in classification of anomalies in women with bicornuate, septate, and arcuate uteri [83] when compared with hysteroscopy, although this was not statistically different from the performance of 3-D TVUS or 2-D SIS. Another study demonstrated 3-D SIS had similar accuracy to hysteroscopy in detected intracavitary polyps, leiomyomas, adhesions, and uterine septum [87].

US Sonohysterography with Tubal Contrast Agent

It has been proposed that TVUS with 3-D imaging of the uterus and ovaries followed by SIS and HyCoSy with agitated saline can be performed in one session as a comprehensive infertility examination [42]; to our knowledge, there is no role for US sonohysterography with instillation of tubal contrast agent in the evaluation of women with recurrent pregnancy loss.

Summary of Recommendations

- **Variant 1:** US pelvis transvaginal and US pelvis transabdominal are usually appropriate for the initial imaging of the evaluation of ovulatory function and ovarian reserve in female patients with infertility. These procedures are complementary (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).
- **Variant 2:** US pelvis transvaginal is usually appropriate as the initial imaging for female infertility patients with clinical features or history of PCOS.
- **Variant 3:** US pelvis transvaginal, MRI pelvis without IV contrast, US pelvis transabdominal, and US pelvis transrectal are usually appropriate for the initial imaging of female infertility patients who have a history or a clinical suspicion of endometriosis. These procedures are complementary (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care). The panel did not agree on recommending MRI pelvis without and with IV contrast or US sonohysterography with tubal contrast agent for female infertility patients who have a history or clinical suspicion of endometriosis. There is insufficient medical literature to conclude whether or not these patients would benefit from these procedures. These procedures are controversial but may be appropriate.
- **Variant 4:** Fluoroscopy hysterosalpingography, US sonohysterography with tubal contrast agent, and US pelvis transvaginal are usually appropriate for the initial imaging of female infertility patients who have a suspicion of tubal occlusion. Although US pelvis transvaginal and fluoroscopy hysterosalpingography are complementary (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care), US sonohysterography with tubal contrast agent can be performed as a standalone procedure in this patient population.
- **Variant 5:** MRI pelvis without and with IV contrast, MRI pelvis without IV contrast, US pelvis transvaginal, US sonohysterography, or US transabdominal is usually appropriate for the initial imaging of female infertility patients who had a recurrent pregnancy loss. Although most of these procedures are equivalent alternatives, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care; US pelvis transabdominal is complimentary to US pelvis transvaginal and would not be performed in isolation for this indication. The panel did not agree on recommending fluoroscopy hysterosalpingography, US color Doppler pelvis, and US sonohysterography with tubal contrast agent in female infertility patients who had recurrent pregnancy loss. There is insufficient medical literature to conclude whether or not these patients would benefit from these procedures. These procedures are controversial but may be appropriate.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [88].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

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