International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Different Methods for Assessment of Fallopian Tubes Patency in Sub-Fertile Patients: A Review Article

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Abstract

This review explores different methods for assessing fallopian tubes patency in subfertile patients. Traditional methods like Hysterosalpingography (HSG) and laparoscopy with choromotubation, though effective, are invasive and associated with discomfort, allergy and surgical risks. Recent methods as Hysterosalpingo-Contrast Sonography (HyCoSy) and Hysterosalpingo-Foam Sonography (HyFoSy) were introduced for assessment tubal patency and uterine cavity assessment, offering a balance between safety and accuracy. Tubal factor infertility, accounting for 25-30% of female infertility cases, encompasses issues such as inflammatory changes, pelvic-peritoneal adhesions, and various iatrogenic causes. Advancements in tubal patency assessment techniques are outlined, with a focus on HyCoSy and HyFoSy. Despite its efficacy, HyCoSy has limitations, prompting the development of HyFoSy. HyFoSy utilizes foam, eliminating the need for radiation exposure and offering a more patient-friendly experience. The procedure's feasibility is demonstrated through studies, showing high concordance rates with laparoscopy and HSG results. Also, this research highlights the significance of HyFoSy as a minimally invasive, well-tolerated technique with promising diagnostic accuracy in assessing tubal patency. While acknowledging its limitations, the study positions HyFoSy as a valuable first-line method for tubal patency assessment in clinical practice, contributing to the comprehensive understanding and management of infertility.

Keywords: HyFoSy, HyCoSy, Fallopian Tubes Patency, Sub-Fertile

Full-length article *Corresponding Author, e-mail: drmahatalaat@gmail.com

1. Introduction

Fallopian tubes are the pathways for gametes and embryos. Infertility is defined as failure to achieve pregnancy after one year of unprotected regular intercourse [1]. Tubal factors of infertility are identified in 30-40% of subfertile women [2]. Previous pelvic surgery, genital tract TB, persistent infection, and pelvic inflammatory disease are main risk factors. Fallopian tubes patency assessment is an essential part of regular infertility screening [3]. Traditional diagnostic methods like Hysterosalpingography (HSG) and laparoscopy with choromotubation are associated with invasiveness, pain, allergy, and radiation exposure, however laparoscopy is still the gold standard for tubal patency assessment and can also be used therapeutically [4].

Hysterosalpingo-contrast sonography (HyCoSy) was introduced as a new method for tubal patency assessment as it combines SIS and HSG. It was a simple, safe, and appropriate outpatient screening method. The echogenic substance utilized was Echovist, a suspension of slowly dissolving galactose microparticles in water. No adverse responses have been documented with Echovist, however galactose sensitivity was a contraindication and the kits were expensive. Echovist is no longer accessible for gynecology [5]. HyFoSy was created as an alternative to HyCoSy. The HyFoSy method visualizes Fallopian tubes using foam. Its texture is fluid enough to pass through Fallopian tubes and stable enough to demonstrate echogenicity for at least five minutes, unlike saline [6]. Foam is created by mixing 3–4 ml of 2% lidocaine gel with 12–13 ml of saline rigorously [7].

1.1. Tubal Factor Infertility

Infertility, defined as the inability to conceive after a year of unprotected regular sexual intercourse, poses a public health challenge affecting 10-15% of couples globally [8]. Among its various causes, tubo-peritoneal factors emerge as the most significant contributor, constituting 25-30% of female infertility cases. This category encompasses inflammatory changes in the fallopian tube, impacting ovulation, ovum pick-up, and the transport of egg, sperm, or embryo, with pelvic-peritoneal adhesions being the predominant pathology [9]. In the quest to address infertility causes, attention has focused on understanding reproductive aging physiology. Among infertile couples, male infertility accounts for 35%, with causes ranging from hypothalamic-pituitary dysfunctions to idiopathic cases [10]. Female infertility constitutes approximately 65%, involving dysfunction in crucial steps like ovulation, sperm transport, embryo implantation, and fallopian tube function [11]. Beyond typical infertility causes, pelvic tuberculosis, infecting 9.4 million annually, presents a noteworthy factor. Pelvic tuberculosis, reported in 10-20% of pulmonary tuberculosis cases, manifests with symptoms like pelvic pain, general malaise, and menstrual irregularity, contributing to infertility. While surgery was historically the treatment, current approaches reserve it for cases unresponsive to

medical therapy, emphasizing the complexity of managing tuberculosis-related infertility [12].

Other contributors to tubal factor infertility include scarring from previous surgeries, ruptured appendix [13], and inflammatory bowel disease. Despite previous beliefs, population-based studies show infertility rates in women with Crohn's disease comparable to the general population [14]. However, postoperative fertility rates may decrease due to pelvic adhesions and organ damage, emphasizing the impact of surgical interventions on fertility [15]. Anatomical distortions, such as myomas near the tubal ostium, may cause proximal tubal blockage. The surgical repair of cornual regions is crucial, with intraoperative chromotubation assessing tubal patency [16]. Iatrogenic causes, including bilateral tubal ligation and permanent hysteroscopic methods like Essure and Adiana involve interstitial placement, scarring, and subsequent occlusion, are additional causes [17].

2. Traditional methods for tubal patency assessment

2.1. Hysterosalpingography

The Hysterosalpingography (HSG) is a diagnostic radiography technique performed on an outpatient basis to assess the condition of the uterus and determine the patency of the fallopian tubes. The use of this technique is very advantageous in identifying congenital malformations, leiomyomas, synechiae, polyps, tubal occlusion, salpingitis isthmica nodosum, hydrosalpinx, and peritubal adhesions [18]. The procedure is often conducted within a time frame of 2 to 5 days after the onset of menstruation. The use of doxycycline, at a dosage of 100 mg twice daily for a duration of 5 days, is indicated as a preventive measure against post-operation pelvic inflammatory disease (PID) due to the potential risk of lower genital tract infection during the hysterosalpingography (HSG) procedure [19]. The patient undergoes examination in a supine posture on a fluoroscopy-read table, during which a metal "acorn" cannula or a balloon catheter is inserted into the cervix and lower region of the uterus [20]. The cannula or catheter is used to provide either water-soluble or oil-soluble contrast material, facilitating the delivery of the contrast media into the uterine cavity and both fallopian tubes. There are three fundamental films that are acquired in this context: (1) a scout film of the lower abdomen and pelvis, (2) a film aimed at documenting the uterine contours and tubal patency, and (3) a post-evaluation film designed to identify regions of contrast loculation that may suggest the presence of peritubal adhesions. Supplementary oblique films may be required in cases when the tubes are obstructed by the uterus or when there are indications of abnormality in the uterine cavity. While classical laparoscopy with chromopertubation is often considered the most reliable method, it is worth noting that hysterosalpingography (HSG) has a modest sensitivity of 65% but an exceptional specificity of 83% when used in infertile individuals [21]. Nevertheless, in the event that the hysterosalpingogram (HSG) reveals an obstruction, there is a significant likelihood (60%) that the fallopian tubes are really unobstructed. Conversely, if the HSG exhibits patency, there is a little probability (5%) that the tubes are blocked [22].

The main factors contributing to the intermediate sensitivity are as follows: the administration of the HSG contrast material induces cornual spasm more often compared to the diluted dye used in laparoscopic chromopertubation, and the interpretation of the HSG results is susceptible to intraobserver variability [23]. Hysterosalpingography (HSG) has many benefits compared to laparoscopy. In addition to its expedited nature, less invasiveness, and cost-effectiveness, HSG is capable of providing detailed visualization of the uterine cavity and the lumen of the fallopian tubes [24]. Furthermore, it has been shown that the use of oil-soluble contrast media might enhance the likelihood of conception in women with patent tubes during the months after the treatment. This is attributed to the ability of the oil-soluble contrast material to effectively eliminate tubal debris and mucus from the tubal lumen [25].

In addition to the contraindication of contrast allergy, two further contraindications for hysterosalpingography (HSG) are pregnancy and active pelvic infection. Conducting the treatment within the time frame of menstrual cycle days 6 to 11 is advantageous in terms of both pregnancy prevention and optimal assessment of the uterine cavity, as it allows for the presence of a thin proliferative endometrium. The physician is granted the authority to make decisions about the use of prophylactic antibiotics [26]. In relation to conception rates after a post-procedure, a meta-analysis conducted by Cochrane revealed that the rates of pregnancy ranged from 17% to 23% when using water-soluble contrast media, and from 24% to 38% when employing oil-soluble contrast media. These rates were compared to a pregnancy rate of 8% to 21% in cases where the HSG treatment was not performed [27]. A frequently cited meta-analysis done in the Netherlands examined 20 relevant publications and included a patient population of over 4,100 individuals. The research ultimately determined that relying only on hysterosalpingography (HSG) findings for diagnosing peritoneal adhesions was deemed inaccurate. Consequently, care is suggested when assuming the presence of proximal tubal occlusion based on HSG results. According to the authors, proximal occlusions might occur as a result of brief spasms in 20% of instances, or due to the presence of debris or minor adhesions in 40% of cases [28].

2.2. Ultrasonography and sonohysterosalpingography

The use of transvaginal sonography with saline infusion yields exceptional visualization of the boundaries of the uterine cavity and the structure of the ovaries. The use of sonographic contrast agents, such as sterile saline, air, Echovist, Albunex, and Infoson, facilitates improved vision of the uterine contours and fallopian tubes. In the event where at least one fallopian tube remains open, it is seen that fluid collects in the cul-de-sac throughout the surgery (reference 30). The interpretation of qualitative ultrasound pictures is contingent upon the expertise and experience of the technician and healthcare professional. Despite being used in conjunction with SIS, ultrasonography remains incapable of detecting or evaluating the openness of both healthy and sick fallopian tubes. Therefore, although ultrasonography with saline infusion sonohysterography (SIS) is a useful technique in the first assessment of subfertility, an additional test is necessary to ascertain tubal patency [31].

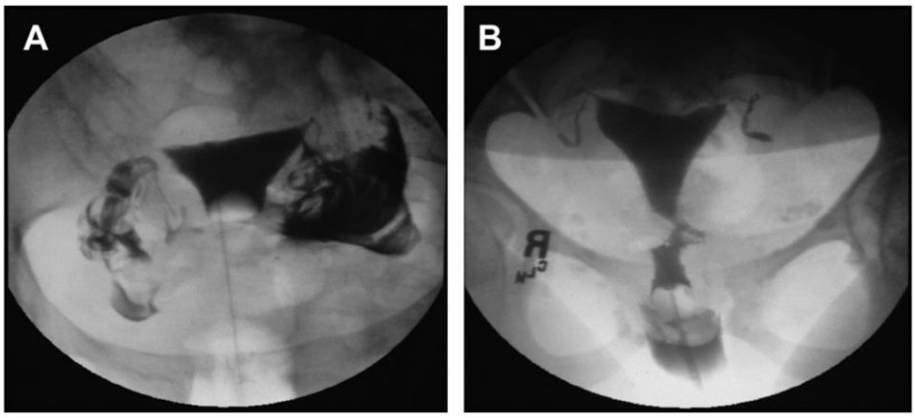

Figure (1): (A) Normal HSG with patent fallopian tubes.(B) Abnormal HSG showing bilateral distal tubal occlusion [29]

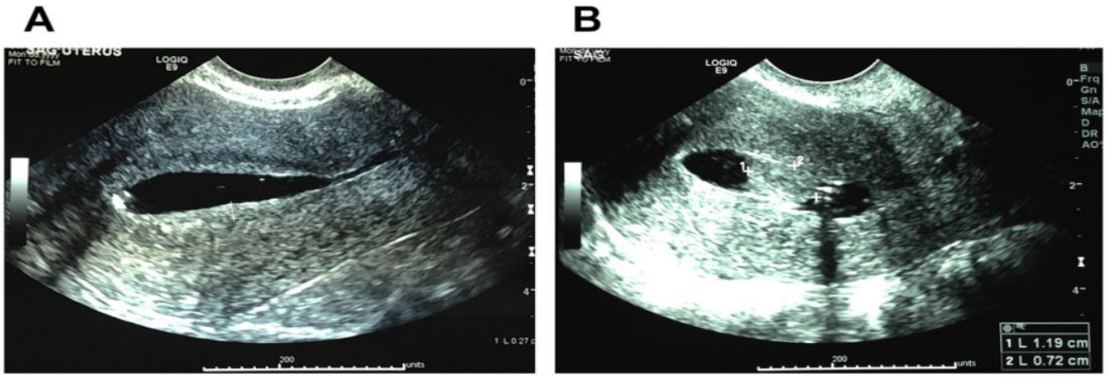

Figure (2) :(A) A normal SHG. (B) A SHG demonstrating an intracavitary myoma [34]

Figure (3): Laparoscopy with chromopertubation demonstrating a patent fallopian tube with dilute methylene blue dye emanating from the fimbriae [37]

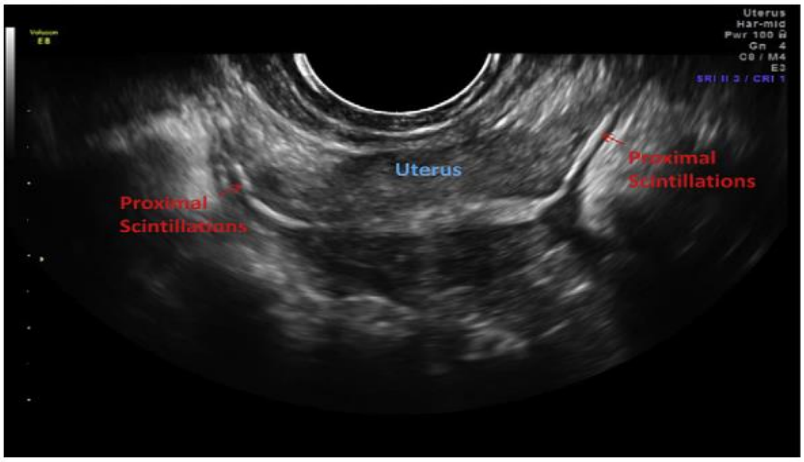

Figure (4): Echogenic contrast identified in bilateral proximal tubal segments during hysterosalpingo-contrast sonography [46]

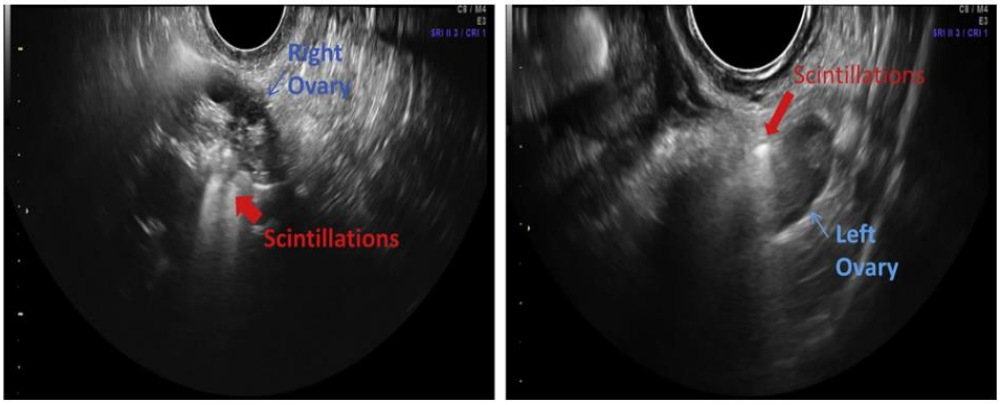

Figure (5): Echogenic contrast identified as scintillations (arrow) flowing over right and left ovaries during hysterosalpingo-contrast sonography [47]

The use of three-dimensional imaging techniques for the generation of coronal images, together with the application of Doppler technology to accentuate fluid dynamics inside the fallopian tubes, has the potential to enhance the diagnostic efficacy of Saline Hysterosalpingography (SHG). The use of second harmonic generation (SHG) has several benefits, mostly due to its expeditious nature and cost-effectiveness. Moreover, this diagnostic procedure may be conveniently conducted in an outpatient environment, eliminating the need for anesthesia, sedation, or exposure to radiation. Post-procedure complications of a serious nature, such as fever and peritonitis, were seen in a mere 0.95% of the surgeries [32]. While sonographic pictures may be considered less superior compared to fluoroscopy, it is worth noting that saline hysterosonography (SHG) has higher sensitivity and specificity in the assessment of tubal patency when compared to hysterosalpingography (HSG). A comprehensive research was conducted to compare the accuracy of Hysterosalpingography (HSG), Sonohysterography (SHG), and laparoscopy. The findings of this meta-analysis revealed that SHG exhibited higher performance compared to HSG, and its effectiveness was equivalent to that of laparoscopic chromo-pertubation in demonstrating tubal patency [33].

2.3. Laparoscopy and Chromopertubation

The use of laparoscopy with chromopertubation is the conclusive method for assessing tubal pathology. The procedure is performed under the administration of general anesthesia and is often accompanied with chromotubation, which involves the infusion of a diluted blue dye via a cannula inserted through the cervix into the uterus. This allows the dye to penetrate the uterine cavity and fallopian tubes. Additionally, hysteroscopy is used to assess the uterine cavity [35]. Laparoscopy offers a comprehensive visual examination of the abdominal and pelvic regions, facilitating the identification and management of several pathological conditions, including distal tubal occlusive disease, endometriosis, and adnexal and pelvic adhesions. The use of intraoperative chromotubation as a diagnostic tool for assessing tubal patency has been shown to be superior to hysterosalpingography (HSG) in terms of reduced observer intervariability [36].

3. Recent methods of tubal patency assessment

3*.1. Hysterosalpingo-Contrast Sonography*

Hysterosalpingocontrast sonography (HyCoSy) emerged as a potentially viable alternative technique that incorporates the advantages of both saline infusion sonography (SIS) and hysterosalpingography (HSG). This approach has shown efficient time utilization and high tolerability, while maintaining a similar level of accuracy to HSG [38]. HyCoSy is a diagnostic procedure that evaluates the patency of the fallopian tubes by observing the flow of contrast material inside the tubes. It enhances pelvic ultrasonography by providing a thorough evaluation of the adnexae, uterine cavity, and myometrial condition [39]. Although HyCoSy is known to cause pain, post-operation vaginal bleeding, and vasovagal responses, it is generally regarded as a reasonably expeditious and noninvasive outpatient treatment, comparable to HSG. The issue of infection prevention lacks a consensus, hence placing the responsibility on healthcare practitioners to determine the need of preventive therapy [40]. The findings of a comparison analysis conducted on HyCoSy and HSG indicate that there were no notable disparities in terms of the duration of the operation, the amount of contrast used, the level of patient tolerance, or the occurrence of side effects. These results underscore the feasibility of using HyCoSy as a dependable and well-tolerated substitute for evaluating the patency of the fallopian tubes [41].

These developments represent a notable step forward in improving the accuracy and availability of tubal patency assessments in clinical settings. One significant benefit of HyCoSy compared to HSG is its widespread availability in the majority of infertility facilities, which are equipped with ultrasound devices capable of independently performing the treatment. This eliminates the need for dependence on external radiography centers [42]. A thorough meta-analysis was conducted, which included 1,007 women who had diagnostic imaging for subfertility linked to tubal issues. The results of this research revealed a significant agreement of 83% between HyCoSy and both HSG and laparoscopy with chromopertubation [43].

Nevertheless, Ojha et al. [44] observed a downside of the HyCoSy method in the form of a 10% false occlusion rate and a 7% false patency rate when compared to laparoscopy. The veracity of these results was substantiated by a prospective series carried out by Deichert et al.,

including a cohort of 425 women experiencing subfertility across 10 medical institutions. This research found that HyCoSy with Echovist-200 had a concordance rate of 86.3% with laparoscopy and 83.8% with HSG in assessing tubal patency. A study found that there were adverse events associated with HyCoSy, with a reported incidence of 5%. These occurrences included symptoms such as nausea, sweating, hyperventilation, and vasovagal syncope [45]. Notwithstanding these constraints, the HyCoSy process exhibited similarities to the conventional HSG and was acknowledged as a screening tool that is efficient in terms of time, methodologically straightforward, and well-tolerated during the preliminary assessment of subfertility [26].

3.2. Hysrerosalpingo Foam sonography

The absence of the Echovist gel in 2007 led to the creation of a gel called ExEm® and the introduction of Hysterosalpingo-Foam Sonography (HyFoSy) as a viable substitute in the field of infertility treatment. This alternative was shown to be safe, less uncomfortable, and quickly gained popularity in both infertility centers and outpatient clinics [48]. HyFoSy has a number of benefits in comparison to HSG, including the absence of radiation exposure, a more patient-centric encounter, less discomfort, and a shorter length. Additionally, it is worth noting that HyFoSy may be simply conducted by gynecologists as part of normal office checkups for fertility assessments, hence optimizing the diagnostic procedure [49].

The ExEm-gel substance is combined with purified water in order to generate a foam that maintains stability for a minimum duration of 5 minutes. Research conducted by Emanuel et al. (48) has provided evidence of the viability of HyFoSy, as it has shown a complete concurrence of 100% with tubal patency data obtained using DLS. Nevertheless, some limitations were observed, such as a false occlusion rate of 10% and a false patency rate of 7% when compared to laparoscopy **[44].** The diagnostic accuracy of HyFoSy has been supported by prospective investigations conducted by Van Schoubroeck et al. [50] and Dreyer et al. [49], which have shown its agreement with DLS findings. According to Dreyer et al. [49], HyFoSy demonstrated favorable pain ratings and procedure length compared to HSG. In a research conducted by Ramos et al. [51], it was shown that the method demonstrated a significant level of agreement (72.6%) with earlier findings obtained via hysterosalpingography (HSG).

Additionally, the study indicated little occurrence of adverse effects, thus underlining the treatment's overall safety profile. Further research conducted by Melcer et al. [52] and Zizolfi et al. [53] has provided further validation of the efficacy of HyFoSy in the diagnosis of tubal patency. These studies have shown a 100% concordance rate in evaluating the success of sterilization procedures. Research examining the rates of spontaneous conception after a medical treatment, as shown in the study conducted by Engels et al. [54], indicated that around 25% of patients successfully conceived during a twelve-month period subsequent to undergoing HyFoSy. Engels et al. [54] have also discovered some characteristics that predict spontaneous conception, such as a shorter period of infertility, unexplained infertility, and female individuals under the age of 35. The intravasation rates during HyFoSy were examined in a retrospective study conducted by Ford et al. [55].

The study found a rate of 6.9% and observed a correlation between intravasation rates and endometrial thickness and pain levels. However, the study did not find any link between intravasation rates and the amount of ExEm® Foam used. In conclusion, HyFoSy presents itself as a minimally invasive procedure that is well-tolerated and has good diagnostic accuracy. The usefulness of hysterosalpingography as a first-line tubal patency evaluation approach in clinical practice is reinforced by extensive prospective cohort studies and randomized control trials, as shown by Levaillant et al. [45].

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