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Original Research Article

EVALUATION OF TUBAL PATENCY IN INFERTILE WOMEN BY DOPPLER SALINE SONOSALPINGOGRAPHY: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Tubal pathology is a major contributor to female infertility, particularly in developing countries. Accurate and minimally invasive assessment of tubal patency is essential. Doppler Saline Sonosalpingography (DSSG) has emerged as a promising alternative to conventional methods for evaluating tubal factors. **Materials and Methods:** This cross-sectional study included 227 women with infertility evaluated using DSSG. Tubal patency, uterine, and adnexal findings were recorded. Associations with clinical risk factors were analyzed. In a subset of 102 patients, DSSG findings were compared with hysterosalpingography or laparoscopy. Diagnostic performance parameters were calculated. **Results:** The mean age was 28.9 ± 4.6 years, with primary infertility in 65.6% cases. Tubal block was observed in 43.6%, with distal block predominating (61.6%). A significant association was found between tubal block and secondary infertility ($p = 0.003$). Risk factors such as pelvic inflammatory disease ($p < 0.001$), tuberculosis ($p = 0.001$), and prior pelvic surgery ($p = 0.002$) were significantly associated with tubal obstruction. DSSG demonstrated sensitivity of 87.2%, specificity of 87.3%, and overall accuracy of 87.3%. **Conclusion:** DSSG is an effective and reliable modality for evaluating tubal patency, offering high diagnostic accuracy along with safety and cost-effectiveness, making it suitable as a first-line investigation in infertility workup.

INTRODUCTION

Infertility is a significant global health concern affecting approximately 10–15% of couples of reproductive age, with female factors contributing to nearly 40–50% of cases.[1] Among these, tubal pathology remains a major etiological factor, accounting for nearly 25–35% of female infertility, particularly in developing countries where pelvic inflammatory disease, genital tuberculosis, and post-surgical adhesions are prevalent.[2,3] Assessment of fallopian tube patency and function is therefore a cornerstone in the diagnostic workup of infertile women.

Traditionally, Hysterosalpingography (HSG) and Laparoscopy with chromopertubation have been employed for evaluation of tubal factors.[4] While laparoscopy is considered the gold standard due to its ability to directly visualize pelvic anatomy and detect peritubal adhesions, it is invasive, requires anesthesia, and is associated with higher cost and procedural risks.[5] HSG, though less invasive, involves radiation exposure, iodinated contrast use, and may yield false-positive or false-negative results due to tubal spasm or technical limitations.[6]

In recent years, ultrasound-based techniques such as saline infusion sonography (SIS) and sonosalpingography (SSG) have emerged as safer and more patient-friendly alternatives.[7] Doppler Saline Sonosalpingography (DSSG), an advancement of conventional SSG, utilizes transvaginal ultrasonography combined with color Doppler to assess tubal patency by visualizing the flow of saline through the fallopian tubes and its spillage into the peritoneal cavity [8]. The addition of Doppler enhances diagnostic accuracy by allowing real-time visualization of flow dynamics, thereby reducing observer dependency and improving sensitivity.[8]

DSSG offers several advantages, including absence of ionizing radiation, minimal invasiveness, cost-effectiveness, and the ability to concurrently evaluate

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uterine and adnexal pathology.[9] It has been reported sensitivity and specificity of Doppler-based sonosalpingography ranging from 80–95% and 85–96%, respectively, when compared with laparoscopy.[10,11] Moreover, it can be performed in an outpatient setting without anesthesia, making it particularly suitable in resource-limited settings.[11] Therefore, the present study aimed to assess the role of Doppler Saline Sonosalpingography in evaluating tubal factors in women with infertility and to determine its diagnostic utility in a clinical setting.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional observational study was conducted in the Department of Obstetrics and Gynaecology at a tertiary care teaching hospital over a period of 24 months (from January 2023 to December 2024). The primary objective was to evaluate the role of Doppler Saline Sonosalpingography (DSSG) in assessing tubal patency among women presenting with infertility. The study protocol was reviewed and approved by the Institutional Ethics Committee, and all procedures were carried out in accordance with ethical standards. Written informed consent was obtained from all participants prior to inclusion in the study.

Study Population

The study included women of reproductive age group (20–40 years) presenting with primary or secondary infertility, defined as inability to conceive after one year of regular unprotected sexual intercourse. Participants were recruited consecutively from the outpatient infertility clinic to reduce selection bias. Women with active pelvic inflammatory disease, abnormal uterine bleeding at the time of evaluation, known or suspected pregnancy, cervical or uterine malignancy, or severe systemic illness were excluded. Additionally, women with a prior history of tubal ligation or previously confirmed bilateral tubal block were not included in the study.

Clinical Evaluation

All participants underwent a detailed clinical assessment, including comprehensive history taking with emphasis on duration and type of infertility, menstrual history, obstetric history, history of pelvic infections, tuberculosis, and prior pelvic or abdominal surgeries. A general physical examination and detailed pelvic examination were performed in all cases. Baseline laboratory investigations were carried out as per institutional infertility workup protocols to rule out other contributory factors.

Doppler Saline Sonosalpingography (DSSG) Procedure

Doppler Saline Sonosalpingography was performed during the early proliferative phase of the menstrual cycle (day 6 to day 10) to ensure optimal endometrial conditions and to avoid interference with early pregnancy. The procedure was carried out under strict aseptic precautions in an outpatient setting using a high-resolution transvaginal ultrasound machine equipped with color Doppler.

With the patient in the lithotomy position, a sterile Cusco's speculum was inserted to visualize the cervix, which was cleansed with antiseptic solution. A sterile pediatric Foley catheter (6–8 Fr) was introduced gently into the cervical canal, and the balloon was inflated with 1–2 mL of saline to maintain catheter position. The speculum was then removed, and a transvaginal ultrasound probe was inserted.

Under real-time ultrasonographic guidance, 10–20 mL of sterile normal saline was slowly infused through the catheter. The uterine cavity, fallopian tubes, and adnexal regions were carefully visualized. Tubal patency was assessed by observing the flow of saline through the fallopian tubes and the presence of free fluid in the pouch of Douglas. Color Doppler imaging was utilized to enhance visualization of fluid movement within the tubes, thereby improving diagnostic confidence. Tubes were considered patent when continuous flow with peritoneal spill was observed, whereas absence of flow or spill was interpreted as tubal blockage. Delayed or minimal flow suggested partial obstruction.

Outcome Measures

The primary outcome measure was tubal patency status as assessed by DSSG, categorized as bilateral patency, unilateral block, or bilateral block. Secondary observations included uterine abnormalities, endometrial characteristics, and adnexal findings detected during the procedure. Wherever feasible, DSSG findings were compared with other diagnostic modalities such as hysterosalpingography or diagnostic laparoscopy with chromopertubation to evaluate diagnostic performance.

Data Collection and Statistical Analysis

Data were recorded in a predesigned structured proforma and entered into a Microsoft Excel spreadsheet before analysis. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 20.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The diagnostic accuracy of DSSG was determined by calculating sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy using laparoscopy or HSG as the reference standard. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Confidentiality of patient information was strictly maintained throughout the study. Participation was voluntary, and patients were informed about their right to withdraw from the study at any point without affecting their standard clinical care.

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RESULTS

A total of 227 women with infertility were included in the study. The mean age was 28.9 ± 4.6 years, with the majority belonging to the 25–29 years age group (40.5%), followed by 30–34 years (26.9%). Primary infertility was more common, accounting for 65.6% of cases. The mean duration of infertility was 3.8 ± 2.1 years, with over half of the participants (52.0%) having infertility duration between 2–5 years. A history of pelvic inflammatory disease was present in 28.2% of women, while 12.8% had a history of tuberculosis and 18.1% had undergone previous pelvic surgery.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 227)

Variable	Frequency (%)/mean ± SD
Age (years)	28.9 ± 4.6
Age group	
20–24 years	48 (21.1)
25–29 years	92 (40.5)
30–34 years	61 (26.9)
≥35 years	26 (11.5)
Type of infertility	
Primary infertility	149 (65.6)
Secondary infertility	78 (34.4)
Duration of infertility (years)	3.8 ± 2.1
Duration category	
<2 years	52 (22.9)
2–5 years	118 (52.0)
>5 years	57 (25.1)
History of PID	64 (28.2)
History of tuberculosis	29 (12.8)
Previous pelvic surgery	41 (18.1)

PID: Pelvic Inflammatory Disease.

On DSSG evaluation, bilateral tubal patency was observed in 56.4% of women, while tubal blockage was detected in 43.6% of cases. Among blocked tubes, distal block (61.6%) was more common than proximal block (38.4%). Unilateral tubal block was identified in 24.7% of participants, with right-sided involvement (55.4%) being slightly more frequent than left-sided (44.6%). Bilateral tubal block was noted in 18.9% of cases. [Table 2]

Table 2: Distribution of Tubal Status and Characteristics on Doppler Saline Sonosalpingography (DSSG) (n = 227)

Tubal Status	Frequency (%)
Bilateral patent	128 (56.4)
Blocked	99 (43.6)
Proximal block	38 (38.4)
Distal block	61 (61.6)
Unilateral block	56 (24.7)
Right tube block	31 (55.4)
Left tube block	25 (44.6)
Bilateral block	43 (18.9)

DSSG: Doppler Saline Sonosalpingography.

Overall, 59.0% of women had normal DSSG findings, while 41.0% demonstrated abnormalities. Uterine abnormalities were observed in 16.7% of cases, with fibroids being the most common (7.5%), followed by endometrial polyps (4.0%), congenital anomalies (3.1%), and adenomyosis (2.2%). Hydrosalpinx was present in 9.3% of women, predominantly unilateral (6.2%). Ovarian abnormalities were noted in 11.0% of cases, with polycystic ovarian morphology being the most frequent (7.0%). Peritubal adhesions (4.0%), restricted spill pattern (2.6%), and loculated peritoneal fluid (1.3%) were additional findings suggestive of peritoneal pathology. [Table 3]

Table 3: Uterine, Tubal, and Adnexal Findings on DSSG (n = 227)

Finding	Frequency (%)
Normal study	**134 (59.0)**
Abnormal findings	**93 (41.0)**
Uterine abnormalities	**38 (16.7)**
Fibroid uterus	17 (7.5)
Endometrial polyp	9 (4.0)
Congenital uterine anomalies (septate/subseptate)	7 (3.1)
Adenomyosis	5 (2.2)
Hydrosalpinx	**21 (9.3)**
Unilateral hydrosalpinx	14 (6.2)
Bilateral hydrosalpinx	7 (3.1)

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Ovarian	**25 (11.0)**
Polycystic ovarian morphology (PCOM)	16 (7.0)
Simple ovarian cyst	6 (2.6)
Complex ovarian cyst	3 (1.3)
Peritubal adhesions (suggestive)	**9 (4.0)**
Restricted spill pattern	**6 (2.6)**
Loculated peritoneal fluid	**3 (1.3)**

PCOM: Polycystic Ovarian Morphology.

A statistically significant association was observed between tubal status and type of infertility (p = 0.003). Bilateral tubal patency was more common in women with primary infertility (64.4%) compared to those with secondary infertility (41.0%). Conversely, unilateral (32.1%) and bilateral tubal block (26.9%) were more prevalent among women with secondary infertility than those with primary infertility. [Table 4]

Table 4: Association of Tubal Status with Type of Infertility (n = 227)

Tubal Status	Total (n=227)	Primary (n=149)	Secondary (n=78)	p-value
	Frequency (%)			
Bilateral patent	128 (56.4)	96 (64.4%)	32 (41.0%)	0.003
Unilateral block	56 (24.7)	31 (20.8%)	25 (32.1%)	
Bilateral block	43 (18.9)	22 (14.8%)	21 (26.9%)	

Tubal blockage was significantly associated with known risk factors. A history of PID was present in 49.5% of women with tubal block compared to 11.7% among those with patent tubes (p <0.001). Similarly, tuberculosis was significantly more frequent in women with tubal block (21.2% vs 6.3%; p = 0.001). Previous pelvic surgery was also significantly associated with tubal obstruction (28.3% vs 10.2%; p = 0.002). [Table 5]

Table 5: Association of Risk Factors with Tubal Block (n = 227)

Risk Factor	Tubal Block Present (n=99)	Tubes Patent (n=128)	p-value
	Frequency (%)		
History of PID	49 (49.5%)	15 (11.7%)	<0.001
Tuberculosis	21 (21.2%)	8 (6.3%)	0.001
Previous pelvic surgery	28 (28.3%)	13 (10.2%)	0.002

PID: Pelvic Inflammatory Disease.

Among the subset of 102 women who underwent comparison with reference standards, DSSG correctly identified 41 true positive and 48 true negative cases. There were 7 false positives and 6 false negatives. These findings indicate good agreement between DSSG and conventional diagnostic modalities in assessing tubal patency. [Table 6]

Table 6: Comparison of DSSG Findings with Reference Standard (HSG/Laparoscopy) (n = 102)

DSSG Finding	Tubal Block Present	Tubes Patent	Total
Positive (Block)	41 (TP)	7 (FP)	48
Negative (Patent)	6 (FN)	48 (TN)	54
Total	47	55	102

TP: True Positive; FP: False Positive; TN: True Negative; FN: False Negative; HSG: Hysterosalpingography.

DSSG demonstrated high diagnostic accuracy in detecting tubal pathology, with a sensitivity of 87.2% and specificity of 87.3%. The positive predictive value was 85.4%, while the negative predictive value was 88.9%. The overall diagnostic accuracy of DSSG was 87.3%, indicating its reliability as a diagnostic tool for tubal evaluation in infertility. [Table 7]

Table 7: Diagnostic Performance of DSSG in Detecting Tubal Block (n = 102)

Parameter	Value (%)
Sensitivity	87.2%
Specificity	87.3%
Positive Predictive Value (PPV)	85.4%
Negative Predictive Value (NPV)	88.9%
Overall Accuracy	87.3%

PPV: Positive Predictive Value; NPV: Negative Predictive Value.

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DISCUSSION

The present study evaluated the diagnostic utility of Doppler Saline Sonosalpingography (DSSG) in the assessment of tubal factors among infertile women and demonstrated that it is a reliable and clinically valuable modality. The mean age of participants (28.9 ± 4.6 years), with a predominance in the 25–29 years age group, is consistent with previous Indian studies by Gothwal et al., and Annu et al., reflecting the typical reproductive age at which couples seek infertility evaluation.[12,13] The higher proportion of primary infertility (65.6%) also aligns with hospital-based study by Vannya et al., where early evaluation is increasingly common.[14]

Tubal pathology was identified in 43.6% of cases in the present study, which is slightly higher than the globally reported prevalence (25–35%) but comparable to studies by Shetty et al., and Makwe et al., from developing countries.[15,16] This higher burden can be attributed to the increased prevalence of pelvic inflammatory disease (PID), genital tuberculosis, and post-surgical adhesions in the Indian population.[15] Notably, distal tubal block (61.6%) was more common than proximal block (38.4%), a finding consistent with previous literature.[15,16] Distal occlusion is typically associated with fimbrial damage, peritubal adhesions, and hydrosalpinx formation, resulting from chronic inflammation and fibrosis.[17] In contrast, proximal block may sometimes represent transient tubal spasm or mucus plugging, which can contribute to false-positive findings.[18]

A statistically significant association between tubal block and type of infertility ($p = 0.003$) was observed, with higher rates of obstruction among women with secondary infertility. This is biologically plausible, as secondary infertility is often linked to acquired insults such as postpartum infections, post-abortal sepsis, and pelvic surgeries, all of which predispose to tubal damage.[19] Similar associations have been reported in prior studies by Al Subhi et al., and Adedigba et al., reinforcing the importance of targeted tubal evaluation in this subgroup.[19,20]

The strong association between tubal block and risk factors such as PID ($p < 0.001$), tuberculosis ($p = 0.001$), and previous pelvic surgery ($p = 0.002$) further supports the etiological basis of tubal infertility. PID leads to epithelial damage, loss of ciliary function, and subsequent fibrosis, impairing ovum transport.[21] Genital tuberculosis, which remains endemic in India, causes caseation, strictures, and complete obliteration of the tubal lumen, often resulting in bilateral disease.[21,22] Surgical interventions, particularly those involving the pelvis, may lead to adhesion formation and mechanical obstruction.[23]

DSSG also enabled simultaneous evaluation of uterine and adnexal abnormalities, with 41.0% of women demonstrating abnormal findings. Uterine abnormalities (16.7%), particularly fibroids and polyps, may contribute to infertility through impaired implantation, while hydrosalpinx (9.3%) is both a consequence and marker of distal tubal disease. The strong association of hydrosalpinx with tubal block observed in this study is clinically relevant, as hydrosalpinx is known to adversely affect fertility outcomes, including in assisted reproductive techniques.[24] Ovarian abnormalities, especially polycystic ovarian morphology (7.0%), highlight the coexistence of multiple infertility factors, emphasizing the need for comprehensive evaluation.

A key strength of the present study is the comparison of DSSG findings with reference standards (HSG/laparoscopy), which demonstrated high diagnostic performance, with sensitivity (87.2%), specificity (87.3%), and overall accuracy (87.3%). These findings are consistent with previously reported sensitivity (80–95%) and specificity (85–96%) of sonosalpingography in studies by Reddy et al., and Kumari et al.[25,26] The high negative predictive value (88.9%) suggests that DSSG is particularly effective in ruling out tubal obstruction, making it an ideal first-line screening tool.

However, certain discrepancies were noted, including false-positive and false-negative cases. False positives may be attributed to tubal spasm, inadequate saline flow, or technical limitations, while false negatives may result from partial tubal patency or intermittent spill not detected during the procedure. These limitations highlight that while DSSG is highly reliable, it cannot entirely replace laparoscopy, which remains the gold standard for definitive diagnosis.

Compared to hysterosalpingography (HSG), DSSG offers several advantages, including absence of radiation exposure, better patient tolerability, and the ability to assess pelvic structures in real time. While HSG has slightly higher sensitivity in some studies by Singh et al., and Tripathy et al., it is associated with discomfort and potential false-positive results due to tubal spasm.[27,28] DSSG, particularly with Doppler enhancement, improves visualization of fluid dynamics and reduces observer variability, thereby enhancing diagnostic confidence.[29,30]

Limitations

This study has certain limitations. Being a single-center study, the findings may have limited generalizability. Only a subset of patients underwent comparison with reference standards, which may introduce verification bias. DSSG is operator-dependent and may be affected by technical expertise and patient factors such as tubal spasm. Additionally, laparoscopy, the gold standard, was not performed in all cases, limiting comprehensive validation.

CONCLUSION

Doppler Saline Sonosalpingography is a reliable, minimally invasive, and cost-effective modality for evaluating tubal factors in women with infertility. It demonstrates high diagnostic accuracy with good

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sensitivity and specificity, along with the added advantage of simultaneous assessment of uterine and adnexal pathology. The strong association of tubal block with risk factors such as pelvic inflammatory disease, tuberculosis, and prior pelvic surgery underscores its clinical relevance. Given its safety, outpatient feasibility, and absence of radiation exposure, DSSG can be effectively utilized as a first-line screening tool, reserving invasive procedures like laparoscopy for selected cases requiring further evaluation.

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