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Original Research Article

COMPARATIVE ANALYSIS OF HYSTEROSCOPIC BUBBLE TEST AND DIAGNOSTIC LAPAROSCOPY IN THE EVALUATION OF TUBAL PATENCY: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: The study aimed to evaluate the diagnostic performance of hysteroscopic bubble test as a minimally invasive alternative to laparoscopy for assessing tubal patency in infertile women and compare the findings with laparoscopy as the gold standard.

Material and Methods: A cross-sectional study was conducted on 80 females aged 20–40 years presenting with infertility at the Department of Obstetrics and Gynaecology, Sri Aurobindo Medical College and PG Institute, from January 2023 to November 2024. Each participant underwent both hysteroscopy and laparoscopy. Tubal patency was determined by the presence of the bubble sign during hysteroscopy and chromopertubation during laparoscopy. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of hysteroscopy were calculated using laparoscopy as the reference standard. p-value<0.05 was considered statistically significant.

Results: Hysteroscopy demonstrated high diagnostic performance, with sensitivity, specificity, PPV, and NPV values of 96.15%, 89.29%, 94.34%, and 92.59%, respectively. The overall diagnostic accuracy was 93.75%. There was a significant concordance between hysteroscopy and laparoscopy findings ($p < 0.0001$). Hysteroscopy successfully identified 50 true positive cases of tubal patency and 25 true negatives for occlusion.

Conclusion: Hysteroscopy is a reliable and minimally invasive alternative for tubal patency evaluation, offering excellent concordance with laparoscopy.

Key Words: Hysteroscopy, Tubal Patency, Infertility, Diagnostic Laparoscopy, Bubble Test.

INTRODUCTION

Infertility is a significant global health concern, affecting an estimated 10-15% of couples of reproductive age.[1] Among the various etiological factors, tubal factor infertility accounts for approximately 12-40% of cases.[1-3] Assessing tubal patency is a critical step in the diagnostic evaluation of female infertility, as fallopian tube obstruction can prevent fertilization and embryo transport, thereby hindering conception. Traditionally, diagnostic laparoscopy with chromopertubation has been regarded as the gold standard for assessing tubal patency due to its high diagnostic accuracy and ability to identify associated pelvic pathologies, such as endometriosis or adhesions.[4-7] However, its invasive nature, requirement for general anaesthesia, and associated risks have spurred the search for less invasive yet reliable alternatives.[3,8] The hysteroscopic bubble test has emerged as a promising minimally invasive method for evaluating tubal patency.[9] Performed during a routine

hysteroscopy, this test involves the visualization of air or fluid bubbles passing through the tubal ostia into the peritoneal cavity, indicating patency.[3,4] Hysteroscopy itself offers the added advantage of concurrently evaluating the uterine cavity for abnormalities such as polyps, fibroids, or adhesions, which may contribute to infertility.[10] Despite the advantages of the hysteroscopic bubble test, its diagnostic accuracy in comparison to diagnostic laparoscopy remains a subject of debate. While some studies report a high concordance between the two methods, others highlight discrepancies.[8] Accurate assessment of tubal patency is essential for determining appropriate management strategies, whether surgical intervention, assisted reproductive techniques, or expectant management.[4,11] This study aims to provide a comprehensive comparative analysis of the hysteroscopic bubble test and diagnostic laparoscopy in the evaluation of tubal patency in women undergoing infertility assessment. By examining the diagnostic accuracy, sensitivity, specificity, and concordance of these methods, the study seeks to determine whether the hysteroscopic bubble test can serve as a reliable alternative to diagnostic laparoscopy, particularly in settings where laparoscopic facilities may be limited.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Obstetrics and Gynaecology, Sri Aurobindo Medical College and PG Institute, from January 2023 to November 2024. The study included 80 consenting women aged between 20-40 years with primary or secondary infertility and a normal hormonal profile. Women with a history of pelvic inflammatory disease, previous tubal surgery, or contraindications to laparoscopy or hysteroscopy were excluded.

The evaluation included two diagnostic procedures performed in a every single patient. Hysteroscopic evaluation was performed using a diagnostic hysteroscope. A sterile air or saline solution was introduced into the uterine cavity, and the movement of bubbles through the uterine ostia was observed to determine tubal patency, indicated by the presence of the bubble sign. Laparoscopic evaluation, considered the gold standard, was conducted under general anaesthesia. Chromopertubation was performed by injecting methylene blue dye into the uterine cavity and observing its passage through the fallopian tubes into the peritoneal cavity.

Data collection focused on the concordance between the hysteroscopic bubble sign and laparoscopic findings. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of hysteroscopy were calculated in comparison to laparoscopy. SPSS 25.0 (trial version) was used to analyse the data. Continuous variables were presented as mean ± standard deviation (SD). Categorical variables were presented as number and precentage (%) and compared using the Pearson Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1 illustrates the demographic data of the participants, showing an average age of 30.2 ± 4.8 years and a BMI of 26.5 ± 3.2 kg/m². These values suggest that the study population represents women in their reproductive age with a slight tendency toward overweight, which may be relevant in infertility evaluation. Table 2 demonstrates that 60% of the participants presented with primary infertility, while the remaining 40% had secondary infertility. Table 3 identifies tubal factor infertility as the most common cause (32.5%), followed by ovarian (26.2%) and uterine factors (22.5%). Male factor infertility accounted for 18.8%. Table 4 shows that hysteroscopy detected 50 true positive cases of patent tubes and 25 true negatives of occluded tubes, compared to laparoscopy as the gold standard. The chi-square test revealed a significant concordance between the two methods ($p < 0.0001$), supporting the reliability of hysteroscopy in tubal patency assessment. Table 5 highlights the high diagnostic performance of hysteroscopy, with sensitivity and specificity values of 96.15% and 89.29%, respectively. The PPV (94.34%) and NPV (92.59%) indicate robust predictive capabilities, while the overall accuracy of 93.75% underscores its utility as a minimally invasive alternative to laparoscopy.

Table 1: Baseline characteristics of study participants

Parameter	Mean ± SD
Age (years)	30.2 ± 4.8
BMI (kg/m²)	26.5 ± 3.2

Table 2: Distribution of study participants according to their cause of infertility

Infertility	Frequency	Percentage (%)
Primary Infertility	48	60
Secondary Infertility	32	40
Total	80	100.0

Table 3: Causes of infertility among study participants

Cause of Infertility	Frequency	Percentage (%)
Tubal Factor	26	32.5
Uterine factor	18	22.5

Ovarian factor	21	26.2
Male factor	15	18.8
Total	80	100.0

Table 4: Comparison of Diagnostic Findings Between Hysteroscopy and Laparoscopy

Comparison of Diagnostic Findings		Laparoscopy		Total	P-value
		Patent Tubes	Occluded Tubes		
Hysteroscopy	Patent Tubes	50	3	53	<0.0001* (Significant)
	Occluded Tubes	2	25	27	
Total		52	28	80	

*Chi-square test applied. P-value significant.

Table 5: Diagnostic Performance Metrics of Hysteroscopy

Parameter	Value (%)
Sensitivity	96.15
Specificity	89.29
Positive Predictive Value (PPV)	94.34
Negative Predictive Value (NPV)	92.59
Accuracy	93.75

DISCUSSION

The present study aimed to evaluate the diagnostic accuracy of hysteroscopic bubble test in assessing tubal patency and compare it with diagnostic laparoscopy, the gold standard.

In our study, the mean age of participants was 30.2 ± 4.8 years, comparable to the findings of Ismaeil EAM et al,[3] where the mean age was 31.52 ± 5.5 years, and Hefny M et al,[10] who reported a mean age of 34.37 ± 6.80 years. Tripathy S et al,[6] observed a slightly lower mean age of 27.4 ± 5.1 years. These differences likely reflect variations in study populations and settings. Additionally, the mean BMI in our cohort was 26.5 ± 3.2 kg/m², consistent with the findings of Ismaeil EAM et al,[3] (27.5 ± 3.6 kg/m²) and Hefny M et al,[10] (27.85 ± 5.33 kg/m²). This suggests that our study population is representative of typical infertile women, with a slight tendency toward overweight, which may influence fertility outcomes.

In our study, 60% of participants had primary infertility and 40% had secondary infertility, a distribution similar to Ismaeil EAM et al,[3] who reported 57% primary and 40% secondary infertility. Hefny M et al. (10) also observed comparable proportions, with 48% primary and 30% secondary infertility. Tripathy S et al,[6] reported slightly higher primary infertility rates (56.3%) compared to secondary infertility (43.8%). These findings highlight the consistent global prevalence of primary infertility as a significant clinical concern among women seeking fertility evaluation.

Our findings indicate tubal factor infertility as the most common cause (32.5%), followed by ovarian (26.2%), uterine (22.5%), and male factors (18.8%). Ismaeil EAM et al,[3] similarly observed a higher prevalence of tubal factor infertility (38.5%). These results underscore the critical importance of evaluating tubal patency in infertility workups.

Our study demonstrated significant diagnostic concordance between hysteroscopy and laparoscopy, with a sensitivity of 96.15% and specificity of 89.29%. These results align closely with Ismaeil EAM et al,[3] who reported sensitivity and specificity of 91.9% and 90.9%, respectively. Similarly, Hefny M et al,[10] found sensitivity and specificity estimates of 91.9% and 90.9%, while Promberger R et al,[12] reported slightly lower sensitivity (86.4%) and specificity (77.6%).

In our study, the positive predictive value (PPV) and negative predictive value (NPV) were 94.34% and 92.59%, respectively. These values are comparable to the findings of Hefny M et al,[10] (PPV: 94.2%, NPV: 87.5%) and Promberger R et al,[12] (PPV: ~91%). The robust predictive capability of hysteroscopy observed in our study and previous research supports its utility as a minimally invasive diagnostic tool.

The overall diagnostic accuracy in our study was 93.75%, similar to the 91.5% reported by Hefny M et al,[10] and slightly higher than the 83.1% observed by Ahmed HH et al,[13] Such high diagnostic accuracy supports the role of hysteroscopy in evaluating tubal patency, especially in resource-limited settings or for patients unfit for laparoscopy.

Hysteroscopy offers significant advantages, including reduced procedural time, avoidance of general anaesthesia, and the ability to simultaneously evaluate intrauterine pathology. However, its limitations include an inability to assess peritubal adhesions and distal tubal pathology, as highlighted in our findings and those of Ott J et al,[14] who noted that hydrosalpinx and peritubal adhesions increased the risk of false-negative results. Laparoscopy remains indispensable for comprehensive pelvic assessment but carries higher risks and costs.

CONCLUSION

Hysteroscopic evaluation using the bubble sign is a reliable and minimally invasive alternative to diagnostic laparoscopy for assessing tubal patency. While hysteroscopy cannot completely replace laparoscopy, it can be considered a first-line

diagnostic tool, particularly in resource-limited settings or patients unfit for invasive procedures. Future research should focus on improving hysteroscopic techniques and developing adjunctive imaging modalities to enhance its diagnostic accuracy.

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