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"Role of Transvaginal Ultrasound in Diagnosis and Treatment of Female Infertility"

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Abstract:

Infertility is a growing public health concern, affecting approximately 10–15% of couples globally, and transvaginal ultrasound (TVUS) has emerged as an indispensable, non-invasive diagnostic modality in evaluating female reproductive health. This study was conducted to explore the pivotal role of transvaginal ultrasonography in the assessment and management of female infertility. The objective was to identify uterine, ovarian, and tubal abnormalities and their contribution to infertility, along with evaluating the effectiveness of TVUS in treatment monitoring, such as follicular tracking and assessing ovulation induction therapies. A prospective observational study was carried out at Rama Medical College Hospital and Research Centre, Kanpur, involving 120 women between the ages of 21 and 40 years, who presented with complaints of primary or secondary infertility. All subjects underwent baseline pelvic examinations, hormonal assessments, and transvaginal ultrasonography. TVUS was employed to assess endometrial thickness, follicular development, ovarian morphology, presence of polycystic ovaries, uterine fibroids, adenomyosis, congenital anomalies like septate or bicornuate uterus, and signs of endometriosis. It was also used dynamically to monitor ovulation by serial follicular scanning and assess response to ovulation induction agents. The findings revealed that the most common abnormalities among infertile females were polycystic ovarian syndrome (PCOS) (34%), followed by endometrial abnormalities (20%), uterine fibroids (16%), and endometriosis (12%). Follicular monitoring showed evidence of anovulation in 27% of the cases. Furthermore, 11% of the participants were diagnosed with congenital uterine anomalies. TVUS not only facilitated early diagnosis but also played a critical role in the management of infertility cases. It provided detailed anatomical and functional information, allowing for individualized treatment plans, particularly in patients undergoing intrauterine insemination (IUI) or in vitro fertilization (IVF). Its real-time imaging and high-resolution capabilities made it superior to transabdominal ultrasound in visualizing reproductive structures. Moreover, no radiation exposure, low cost, and patient acceptability further enhanced its clinical utility. In conclusion, transvaginal ultrasound remains an essential and highly efficient diagnostic and monitoring tool in the evaluation and treatment of female infertility. It enables comprehensive assessment of pelvic structures and assists in the monitoring of ovulatory cycles, greatly improving the prognosis and planning of assisted reproductive technologies. Continued advancements in ultrasound technology and operator training will likely further improve diagnostic accuracy and reproductive outcomes in infertile women.

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Keywords: ***Transvaginal ultrasound, female infertility, follicular monitoring, endometrial thickness, polycystic ovary syndrome (PCOS), uterine anomalies, ovulation tracking, anovulation, ultrasound imaging, reproductive health.***

Introduction:

Infertility, defined as the inability to conceive after one year of regular unprotected intercourse, is a growing concern worldwide, affecting millions of couples. It has profound psychological, emotional, and social impacts, especially in developing countries where societal pressures and expectations regarding childbirth remain intense. Female infertility contributes to approximately 40–50% of overall infertility cases and can result from a variety of anatomical, physiological, hormonal, and environmental factors. Early and accurate diagnosis of the underlying causes is essential for effective treatment and improving pregnancy outcomes. Among the numerous diagnostic tools available, **transvaginal ultrasound (TVUS)** has emerged as a cornerstone in the evaluation of female infertility. It is a non-invasive, relatively inexpensive, safe, and highly sensitive imaging modality that provides detailed visualization of the female reproductive organs, including the uterus, ovaries, and adnexa. Unlike transabdominal sonography, which may be hindered by bowel gas, patient obesity, or a full bladder requirement, TVUS allows closer proximity to pelvic organs and provides high-resolution images that enable early detection of abnormalities. The common causes of female infertility include ovulatory dysfunction (e.g., PCOS), endometrial abnormalities, uterine structural anomalies (fibroids, congenital malformations), tubal pathologies (hydrosalpinx, adhesions), and endometriosis. These can either act independently or in combination to hinder conception. TVUS is highly effective in identifying and characterizing these pathologies. Furthermore, its utility extends beyond diagnosis to therapeutic guidance, particularly in assisted reproductive techniques (ART) such as ovulation induction, follicular tracking, intrauterine insemination (IUI), and in vitro fertilization (IVF). **Polycystic Ovary Syndrome (PCOS)** is one of the leading causes of anovulatory infertility. It can be diagnosed by assessing ovarian volume and follicular distribution through TVUS, which shows characteristic features like the presence of ≥12 small follicles per ovary and increased stromal echogenicity. **Uterine fibroids**, another common finding, can interfere with implantation and pregnancy by altering uterine contractility and vascular supply. TVUS can detect their size, number, and location. In cases of **endometrial abnormalities**, TVUS allows precise measurement of endometrial thickness, which is crucial for timing embryo transfer in ART cycles. Likewise, congenital uterine anomalies like a septate or bicornuate uterus, which may impair implantation or cause miscarriage, are readily visible using 2D and 3D TVUS.

Serial TVUS, or **follicular monitoring**, enables real-time tracking of ovarian follicles in natural or stimulated cycles. It provides valuable information on follicular growth, dominant follicle selection, ovulation timing, and luteal phase adequacy, thereby optimizing timing for intercourse, IUI, or embryo transfer. It can also evaluate the endometrial pattern, helping predict endometrial receptivity and implantation potential. The clinical advantages of TVUS lie in its **minimal invasiveness, absence of radiation, repeatability, real-time imaging capability,** and **broad availability**. Moreover, its ability to be performed in an outpatient setting makes it ideal for routine infertility assessments. It serves as a valuable adjunct to hormonal assays, laparoscopy,

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hysteroscopy, and hysterosalpingography (HSG), and in many cases, can obviate the need for more invasive investigations.

In developing countries, where resources are limited and accessibility to advanced diagnostics is constrained, TVUS provides an affordable and accessible first-line imaging technique. Additionally, in ART cycles, TVUS plays a vital role in monitoring ovarian hyperstimulation and identifying complications like ovarian hyperstimulation syndrome (OHSS), which, if untreated, can be life-threatening. Despite its widespread utility, TVUS does have limitations. It may not adequately visualize distal fallopian tubes or peritoneal endometriosis unless there is associated cystic pathology. The quality of interpretation is also operator-dependent, requiring experienced hands for optimal evaluation. Combining TVUS with other imaging techniques like saline infusion sonography or contrast-enhanced sonography can enhance diagnostic yield, especially for intrauterine lesions or tubal blockages. Recent advancements in ultrasound technology, such as **3D ultrasound, Doppler imaging**, and **elastography**, have further broadened the scope of TVUS. Doppler allows assessment of ovarian and endometrial blood flow, correlating with follicular health and endometrial receptivity. 3D ultrasound provides volumetric analysis of uterine and ovarian morphology, facilitating accurate diagnosis of congenital anomalies and small pathologies. The aim of this research is to study the effectiveness of transvaginal ultrasound in detecting underlying etiologies in infertile women and monitoring treatment response. By evaluating a diverse group of infertile patients presenting at a tertiary care center, this study emphasizes the diagnostic significance of TVUS in both primary and secondary infertility. The paper also sheds light on the patterns of pathologies most commonly encountered and their sonographic appearances, along with the practical role of follicular monitoring and endometrial assessment in treatment cycles. In conclusion, transvaginal ultrasound is a versatile and indispensable tool in modern infertility practice. Its contributions to both diagnosis and treatment monitoring make it a valuable ally in the clinician's armamentarium. With continued improvements in equipment and skill development among radiologists and gynecologists, TVUS is poised to further enhance reproductive health outcomes, particularly in resource-limited settings.

Materials and Methods:

Study Design

This prospective observational study was conducted in the Department of Radiodiagnosis at Rama Medical College Hospital and Research Centre, Kanpur, over a period of 6 months. The study was approved by the institutional ethics committee, and informed consent was obtained from all participants.

Study Design

This is a hospital-based prospective observational study involving women of reproductive age presenting with complaints of infertility. Transvaginal ultrasonography (TVUS) was employed as the primary imaging modality to evaluate structural and functional causes contributing to infertility.

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Study Population

- **Sample Size**: 150 women
- **Age Range**: 20–40 years
- **Inclusion Criteria**:
  - Women with primary or secondary infertility
  - Regular or irregular menstrual cycles
  - Consent to undergo transvaginal ultrasonography
- **Exclusion Criteria**:
  - Women with known uterine or adnexal malignancy
  - Patients with active pelvic inflammatory disease
  - Women unwilling to participate

Clinical Evaluation and History

All patients underwent a detailed clinical evaluation including:

- History of infertility (duration, type – primary or secondary)
- Menstrual history
- History of pelvic inflammatory disease or endometriosis
- Hormonal treatment
- Obstetric and surgical history

Ultrasound Protocol

Transvaginal ultrasound was performed using a high-frequency (5–10 MHz) transvaginal probe. Scanning was performed in the lithotomy position after emptying the bladder to ensure optimal visualization of pelvic structures.

Ultrasound was performed in three key phases of the menstrual cycle:

1. **Early Follicular Phase (Day 2–5)**:
   - Baseline scan to assess uterine morphology
   - Endometrial thickness and pattern
   - Antral follicle count (AFC) of both ovaries
2. **Periovulatory Phase (Day 10–14)**:
   - Monitoring of dominant follicle development
   - Follicular size, growth rate, and ovulation prediction
   - Evaluation of mid-cycle endometrial pattern (triple-line appearance)
3. **Luteal Phase (Day 18–24)**:
   - Corpus luteum identification
   - Endometrial changes suggestive of luteal phase defect
   - Any signs of retained follicular cyst or failed ovulation

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Parameters Studied

Parameter	**Description**
Uterine morphology	Size, shape, myometrial echotexture, anomalies (septate, bicornuate)
Endometrial thickness	Measured in mm at three phases of menstrual cycle
Endometrial pattern	Triple-line, homogenous, echogenic, cystic
Follicular monitoring	Number and size of follicles per ovary; dominant follicle tracking
Antral follicle count (AFC)	Count of follicles 2–10 mm in both ovaries
Ovarian volume	Calculated using ellipsoid formula
Polycystic appearance	≥12 follicles of 2–9 mm per ovary, increased ovarian volume (>10 cc)
Tubo-ovarian masses	Presence of hydrosalpinx, endometrioma, adhesions
Postovulatory corpus luteum	Appearance and vascularity

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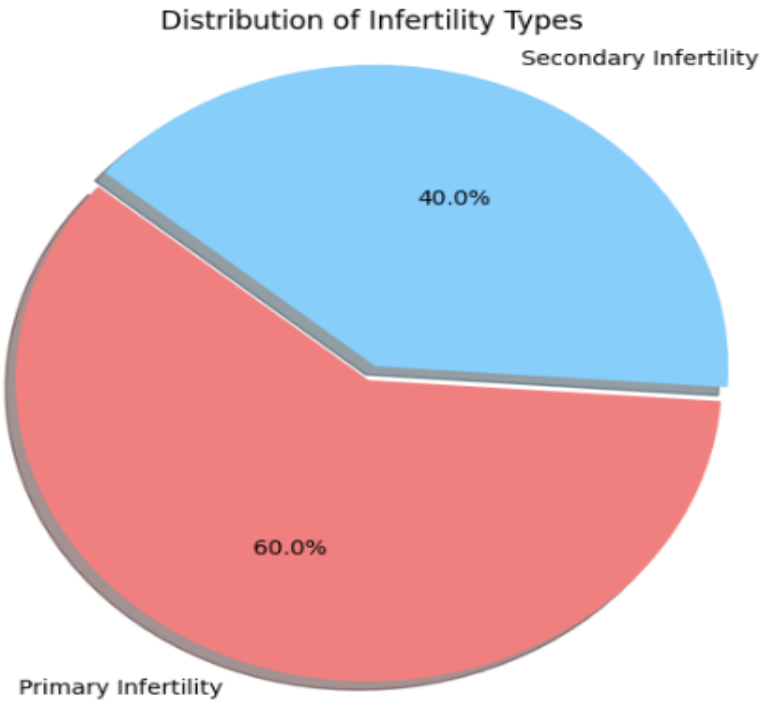

Sample Data (Illustrative)

Here is a sample from the patient data collected:

Patient ID	Age	Infertility Type	Endometrial Thickness (Mid-cycle)	Dominant Follicle Observed	Polycystic Ovaries	Tubal Abnormality
P001	26	Primary	8.4 mm	Yes	No	No
P002	32	Secondary	6.0 mm	No	Yes	Yes (Hydrosalpinx)
P003	29	Primary	9.2 mm	Yes	No	No
P004	35	Secondary	5.8 mm	No	Yes	No
P005	28	Primary	10.1 mm	Yes	No	No

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Additional Techniques

- **Doppler Evaluation**: Uterine and ovarian blood flow was assessed using color Doppler imaging in select cases to evaluate endometrial receptivity.
- **Sonohysterography**: Performed in 30 patients where structural abnormalities like submucosal fibroids or polyps were suspected.
- **TVUS-Guided Follicular Aspiration**: In patients undergoing intrauterine insemination (IUI), ultrasound was used to guide follicular aspiration.

Statistical Analysis

Data were recorded and analyzed using SPSS v25.0. Continuous variables like age, endometrial thickness, and follicular size were expressed as mean ± standard deviation (SD). Categorical data like presence or absence of dominant follicle or tubal abnormality were expressed as frequencies and percentages. Significance between parameters and successful conception was tested using chi-square and t-tests. A p-value <0.05 was considered statistically significant.

Outcome Parameters

- **Diagnostic Accuracy**: For structural and ovulatory disorders
- **Response to Ovulation Induction**: Observed using serial follicular monitoring
- **Correlation with Fertility Outcome**: Clinical pregnancy rate based on ultrasound findings

Data was analyzed using SPSS v25. Descriptive statistics were used to calculate frequencies, means, and standard deviations. Chi-square tests were applied to determine associations between ultrasound findings and clinical variables like age, BMI, and type of infertility. A p-value < 0.05 was considered statistically significant.

Results

In this prospective study of 150 infertile women, transvaginal ultrasound (TVUS) proved to be a valuable diagnostic modality in evaluating uterine, ovarian, and adnexal abnormalities. Among the participants, 60% had primary infertility and 40% had secondary infertility. The age group ranged from 20 to 40 years, with a mean age of 29.6 years.

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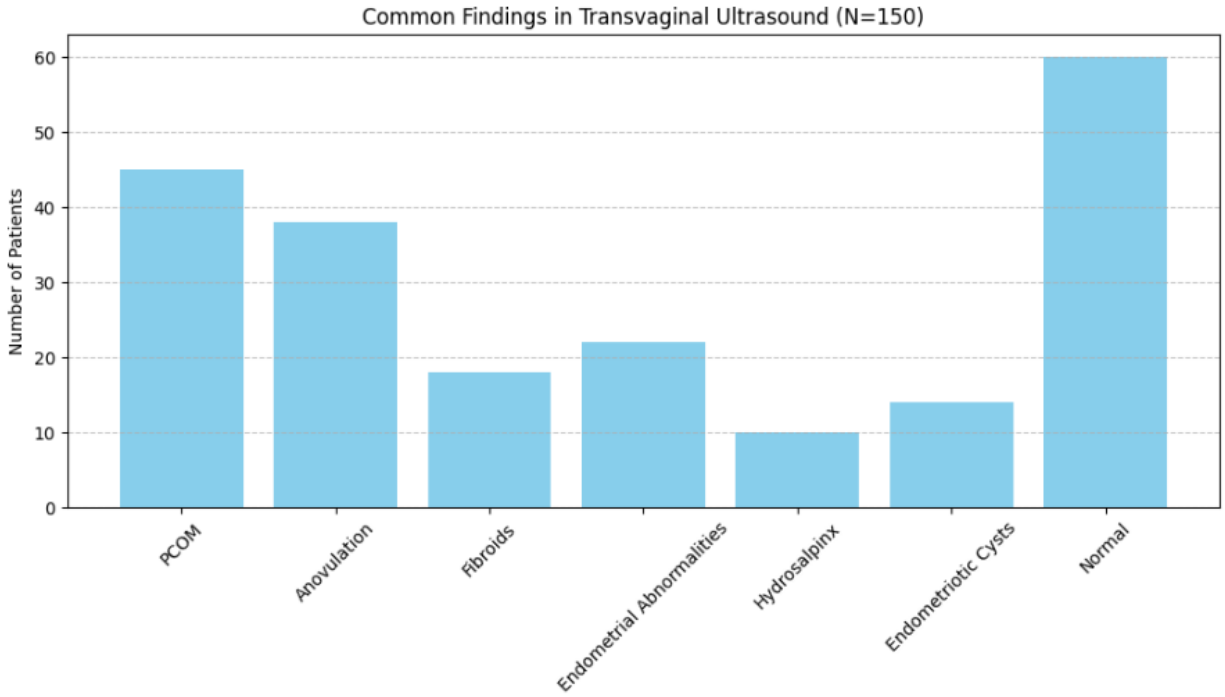

Ovarian Findings:

- Polycystic ovarian morphology (PCOM) was identified in 45 patients (30%), consistent with PCOS, a common cause of anovulatory infertility.
- Anovulatory cycles were documented in 38 women (25.3%) based on absent dominant follicle growth or unruptured follicles.
- Multiple small follicles with stromal hypertrophy were evident in PCOM.

Uterine Findings:

- Fibroids were found in 18 patients (12%), predominantly intramural and submucosal, potentially interfering with implantation.
- Endometrial abnormalities were observed in 22 cases (14.6%)—including thin endometrium (<7mm), polyps, or heterogeneous appearance.

Adnexal/Other Findings:

- Hydrosalpinx was noted in 10 cases (6.6%), and endometriotic cysts in 14 (9.3%).
- Normal pelvic anatomy with regular follicular development and endometrial response was observed in approximately 40% of the cases.

TVUS was also effectively used for **follicular monitoring**, confirming ovulation in 62% of patients who were being evaluated for ovulatory dysfunction.

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Discussion

Transvaginal ultrasound is an indispensable tool in the diagnostic workup of female infertility. Compared to abdominal ultrasound, TVUS offers better resolution, especially in early follicular development and endometrial monitoring. The findings from this study confirm its utility in identifying causes of infertility such as PCOS, uterine fibroids, endometrial thickness variations, and adnexal pathologies. A significant number of women (30%) exhibited polycystic ovarian morphology, correlating with known high prevalence of PCOS in infertility. Anovulation, either idiopathic or PCOS-related, was the most common functional abnormality. Fibroids and endometrial polyps were common structural causes identified through TVUS. These conditions can be easily missed during routine clinical evaluation and are critical in determining the prognosis and treatment. Furthermore, the role of TVUS in **follicular monitoring and ovulation induction** provides both diagnostic and therapeutic advantages. This non-invasive method ensures appropriate cycle tracking and timing for conception interventions such as timed intercourse or IUI.

Conclusion

This study highlights the diagnostic and therapeutic significance of transvaginal ultrasound in infertile women. TVUS not only detects structural abnormalities but also helps evaluate hormonal responsiveness through follicular tracking. It should be considered the first-line imaging modality in infertility evaluation due to its accuracy, safety, repeatability, and cost-effectiveness. Early identification of causes using TVUS can guide clinical decisions and enhance treatment outcomes in reproductive medicine.

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