

TRIPLE-SITE SMEAR: MODERN SIGNIFICANCE AND ROLE IN THE LABORATORY DIAGNOSIS OF INFECTIOUS AND INFLAMMATORY DISEASES OF THE FEMALE GENITAL TRACT

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Objective: To analyze current data on the diagnostic value of triple-site smears, their advantages, limitations, and future perspectives.

Introduction

Infectious and inflammatory diseases of the female genital tract remain one of the most significant problems in reproductive health and occupy a leading position in the structure of gynecological pathology. According to the World Health Organization, more than half of women of reproductive age have experienced manifestations of inflammation of the lower genital tract at least once. These conditions often become chronic, leading to infertility, miscarriage, and other obstetric and gynecological complications.

Modern diagnosis of inflammatory diseases of the urogenital tract is based on an integrated approach that includes clinical examination and various laboratory methods. Among the accessible, cost-effective, and informative techniques, microscopy of smears taken from three anatomical sites-the urethra, vagina, and cervical canal-holds a special place. This approach, known as the triple-site smear, allows simultaneous assessment of the microflora in different parts of the genital tract, detection of inflammatory changes, and determination of the localization of the pathological process.

Despite the active development of molecular biological technologies (PCR, next-generation sequencing, ELISA), the classical triple-site smear retains its diagnostic relevance. Its advantages include simplicity, low cost, rapid results, and applicability at any laboratory level. Moreover, microscopic examination remains the first and obligatory step in the diagnostic algorithm for patients with inflammatory complaints and serves as a tool for monitoring the effectiveness of therapy.

In recent years, increasing attention has been paid to standardizing sampling procedures, staining, and interpretation of microscopic results. The quality of these stages directly determines the reliability of laboratory data and their clinical significance.

Thus, analyzing the modern importance of triple-site smears in the laboratory diagnosis of infectious and inflammatory diseases of the female genital organs is a relevant task. A review of the current literature helps to systematize accumulated knowledge, identify strengths and weaknesses of the method, and outline directions for its further improvement in modern gynecological practice.

Anatomical and Physiological Features of the Three Sites and Their Diagnostic Value

Urethra

The female urethra is short and wide, facilitating the ascending spread of infection from the vagina and perineum. Normally, the mucosa is lined with stratified squamous and transitional epithelium, and the lumen contains minimal microflora -mainly non-pathogenic corynebacteria and saprophytic staphylococci.

Microscopically, a normal urethral smear reveals single leukocytes (up to 5 per field of view) and occasional epithelial cells. Increased leukocytes or a mixed/coccal flora indicate urethritis, which may be nonspecific or caused by sexually transmitted pathogens (*Neisseria gonorrhoeae*, *Trichomonas vaginalis*, *Chlamydia trachomatis*, etc.).

Thus, the urethral smear is important for early detection of inflammatory processes and assessment of infection spread.

Vagina

The vaginal microbiota is a dynamic system influenced by age, estrogen levels, and immune status. Normally, lactobacilli (*Döderlein bacilli*) predominate, maintaining an acidic environment (pH 3.8–4.5) that inhibits pathogenic microorganisms.

Microscopically, a normal vaginal smear shows rod-shaped flora, moderate leukocytes (up to 10 per field), and superficial epithelial cells.

Alterations in microbiota manifest as:

Bacterial vaginosis: presence of “clue cells,” abundance of small coccobacilli, absence of lactobacilli.

Candidiasis: pseudomycelium and spores of *Candida* fungi.

Trichomoniasis: motile flagellates and numerous leukocytes.

Hence, the vaginal smear provides key information on the state of the microbiota and inflammatory response.

Cervical Canal

The cervical canal is lined with a single layer of columnar epithelial cells producing mucus that performs protective and barrier functions. Normally, it is almost sterile, with minimal leukocytes.

Inflammatory changes (leukocytes >30 per field, mucus, coccal or mixed flora) indicate endocervicitis. Pathogens such as gonococci, trichomonads, and fungi may also be visualized.

The cervical canal smear is diagnostically valuable for detecting ascending infections that may spread to the endometrium or adnexa, and for early identification of pathogens associated with HPV infection and neoplastic processes.

Modern Trends and Standardization of Laboratory Diagnostics

Standardization and Quality Control

According to ISO 15189:2022 “Medical laboratories -Requirements for quality and competence,” every laboratory must have documented Standard Operating Procedures (SOPs) for sampling, staining, storage, and evaluation of smears.

Standardization ensures:

comparability of results across laboratories,

reduced subjectivity in interpretation,
internal and external quality control opportunities.

In countries with advanced laboratory management systems, regular method verification, precision evaluation, and interlaboratory comparisons are implemented. Uzbekistan and the Russian Federation are also actively introducing ISO- and WHO-based quality management systems to improve reliability and confidence in laboratory results.

Use of Digital Technologies and Automation

Digital microscopy and automated image analysis systems are key directions of progress. Modern digital microscopes provide high-resolution standardized images that can be stored and transmitted for expert review or telemedicine consultations.

Artificial intelligence (AI) and machine learning technologies help recognize cellular structures and microorganisms with reduced human bias. Automated smear analysis systems quantitatively evaluate flora and leukocytes, generating preliminary reports confirmed by cytologists or microbiologists.

Training and Professional Competence

Personnel qualification remains a cornerstone of diagnostic quality. Proper sampling depends on well-trained technical staff, while morphological accuracy relies on experienced cytologists and microbiologists.

WHO recommendations emphasize continuous education, certification, and internal training. Implementation of training modules on standardized triple-site smear techniques and regular skill assessments improves diagnostic accuracy and reproducibility.

Integration with Molecular and Cytological Methods

Modern laboratory practice combines classical microscopy with molecular tools. The triple-site smear serves as a primary screening test, determining the need for PCR testing, culture, or cytological (Pap) analysis.

This integrated approach enhances diagnostic efficiency, optimizes costs, and provides a comprehensive view of the urogenital microbiome.

Development Prospects

Further digitalization, electronic image databases, remote quality control, and laboratory networks are expected. Unified standards will improve infection detection accuracy and strengthen preventive healthcare programs.

Challenges and Future Directions

Current Limitations

Non-standardized sampling: common procedural errors (improper sequence, delayed fixation) reduce diagnostic accuracy.

Low reproducibility and subjectivity: evaluation depends heavily on observer experience; lack of uniform criteria leads to discrepancies.

Limited pathogen identification: microscopy cannot always determine species or detect intracellular/slow-growing microbes.

Inadequate quality control: many labs lack systematic internal/external audits.

Staff and equipment shortages: insufficient trained personnel and outdated instruments hinder modernization.

Solutions and Development Directions

Standardization and training: implementation of national protocols based on WHO/ISO 15189; regular qualification courses and workshops.

Digital microscopy and telepathology: AI-assisted analysis and remote consultations increase objectivity.

Integration with molecular diagnostics: combining triple-site smears with PCR and culture improves accuracy.

Regional laboratory networks: creation of quality control centers ensures data harmonization.

Research and surveillance: multicenter studies in Uzbekistan and Central Asia to build national databases for infection monitoring.

Implementation in Healthcare Systems

Within Uzbekistan's ongoing healthcare reforms emphasizing prevention and early detection, the triple-site smear can become a key component of women's health screening programs. Its simplicity, affordability, and high informativeness make it indispensable at the primary care level.

Integration into Laboratory Information Systems (LIS) and national quality programs will establish uniform diagnostic standards, improve infection prevention, and reduce chronic inflammatory diseases of the female genital tract.

Conclusion

The limitations of the triple-site smear method are primarily organizational and educational and can be overcome through process improvement and professional training.

Modernization, digital technologies, and quality control systems will enhance diagnostic accuracy and treatment effectiveness.

Thus, the triple-site smear remains a relevant and foundational tool in laboratory diagnostics and, when updated, can serve as a modern, standardized instrument of preventive medicine.