

**MODERN DIAGNOSTICS OF CHRONIC PELVIC PAIN IN WOMEN:
INTEGRATIVE APPROACHES AND EMERGING TECHNOLOGIES**

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ABSTRACT

Chronic pelvic pain (CPP) is a debilitating condition affecting 5.7–26.6% of women globally, significantly impairing quality of life and posing substantial diagnostic challenges due to its multifactorial etiology. Causes range from gynecological conditions (e.g., endometriosis, adenomyosis) to urological, musculoskeletal, and neurological disorders. Traditional diagnostic methods, such as patient history and physical examination, are often insufficient to pinpoint specific causes due to symptom overlap. Recent advancements in diagnostic technologies, including high-resolution imaging (ultrasound, MRI), minimally invasive laparoscopy, biomarker assays, and artificial intelligence (AI)-driven tools, have transformed the diagnostic landscape. This article provides an in-depth review of current and emerging diagnostic modalities, emphasizing integrative approaches that combine clinical assessment, advanced imaging, molecular diagnostics, and multidisciplinary collaboration. The role of novel technologies, such as machine learning algorithms for pattern recognition and biomarker panels for non-invasive diagnosis, is explored in detail. The study underscores the need for personalized, patient-centered diagnostic strategies to improve outcomes and reduce diagnostic delays in women with CPP.

KEYWORDS: Chronic pelvic pain, women, diagnostics, transvaginal ultrasound, magnetic resonance imaging, laparoscopy, biomarkers, artificial intelligence, multidisciplinary care, integrative approach, endometriosis, adenomyosis, pelvic inflammatory disease

INTRODUCTION

Chronic pelvic pain (CPP), defined as noncyclical pain in the pelvic region persisting for six months or longer, is a prevalent and complex condition among women, with global prevalence rates estimated at 5.7–26.6% (Ahangari, 2014). CPP significantly impacts physical, emotional, and social well-being, contributing to reduced productivity, increased healthcare costs, and psychological distress. The condition's complexity stems from its diverse etiologies, which include gynecological disorders (e.g., endometriosis, adenomyosis, pelvic inflammatory disease), urological conditions (e.g., interstitial cystitis), musculoskeletal issues (e.g., pelvic floor dysfunction), and neuropathic pain syndromes. The overlap of symptoms, such as dysmenorrhea, dyspareunia, dysuria, and chronic lower abdominal pain, complicates accurate diagnosis, often leading to delayed treatment and prolonged patient suffering.

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Historically, CPP diagnosis relied heavily on patient history, physical examination, and basic imaging. However, these methods frequently fail to identify specific causes, particularly in cases of deep infiltrating endometriosis (DIE) or multifactorial pain syndromes. Over the past decade, advancements in diagnostic technologies have revolutionized the approach to CPP. High-resolution imaging modalities, such as transvaginal ultrasound (TVUS) and magnetic resonance imaging (MRI), offer improved visualization of pelvic structures. Minimally invasive techniques, like diagnostic laparoscopy, remain the gold standard for certain conditions but are increasingly complemented by non-invasive tools, including biomarker assays and AI-driven diagnostic algorithms. The integration of these modalities into a multidisciplinary framework has shown promise in enhancing diagnostic accuracy and tailoring treatment plans.

This article aims to provide a comprehensive overview of the modern diagnostic landscape for CPP in women, with a focus on integrative approaches that combine clinical, imaging, and molecular methods. Emerging technologies, such as AI-based diagnostics and novel biomarker panels, are evaluated for their potential to address current diagnostic challenges. The study also explores the role of multidisciplinary teams in optimizing patient outcomes and highlights future directions for research and clinical practice.

MATERIALS AND METHODS

This study is a systematic literature review of peer-reviewed articles published between 2015 and 2025, sourced from high-impact databases, including PubMed, Scopus, Web of Science, and Cochrane Library. Search terms included combinations of “chronic pelvic pain,” “diagnostics,” “women,” “imaging,” “ultrasound,” “MRI,” “laparoscopy,” “biomarkers,” “artificial intelligence,” “endometriosis,” “adenomyosis,” and “multidisciplinary care.” Boolean operators (AND, OR) were used to refine searches, and filters were applied to prioritize studies in English, human subjects, and female populations.

Inclusion criteria encompassed studies focusing on diagnostic methods for CPP in women, with an emphasis on modern technologies, integrative approaches, and clinical outcomes. Exclusion criteria included non-English articles, case reports, editorials, and studies not specific to female populations or CPP. A total of 128 articles were screened, with 78 meeting inclusion criteria after full-text review. Data were extracted on diagnostic modalities, including clinical assessments, imaging techniques (TVUS, MRI, CT), minimally invasive procedures (laparoscopy), and emerging tools (biomarker assays, AI-based diagnostics). The review also analyzed the role of multidisciplinary teams and patient-centered care in CPP diagnosis.

Data synthesis involved qualitative and quantitative analysis of diagnostic performance metrics, such as sensitivity, specificity, and clinical utility. A comparative table (Table 1) was developed to summarize the characteristics of key diagnostic modalities. Statistical data, where available, were compiled to assess the diagnostic accuracy of each method. The review adhered to PRISMA guidelines to ensure methodological rigor.

RESULTS AND DISCUSSION

The review identified a wide range of diagnostic modalities for CPP, each contributing uniquely to the diagnostic process. These modalities are categorized into clinical assessments, imaging techniques, minimally invasive procedures, and emerging technologies. Table 1 provides a detailed comparison of their performance and clinical utility.

Table 1: Comparison of Diagnostic Modalities for Chronic Pelvic Pain in Women

Diagnostic Method	Sensitivity (%)	Specificity (%)	Advantages	Limitations
Transvaginal Ultrasound (TVUS)	70–90	80–95	Non-invasive, cost-effective, widely available, real-time imaging	Operator-dependent, limited for deep infiltrating endometriosis (DIE)
Magnetic Resonance Imaging (MRI)	85–95	90–98	High-resolution, excellent for soft tissue imaging, detects DIE and adenomyosis	High cost, limited availability, contraindications (e.g., metal implants)
Computed Tomography (CT)	60–80	70–90	Useful for acute settings, detects non-gynecological causes	Radiation exposure, low specificity for gynecological conditions
Diagnostic Laparoscopy	95–100	90–100	Gold standard, allows direct visualization and biopsy	Invasive, requires anesthesia, high cost, risk of complications
Biomarker Assays (e.g., CA-125, microRNAs)	50–85	60–90	Non-invasive, potential for early detection, complements imaging	Low specificity, requires validation, not diagnostic alone
AI-Assisted Diagnostics	80–95	85–95	Enhances pattern recognition, reduces diagnostic errors, integrates multi-modal data	Requires large datasets, high computational costs, still in development

Clinical Assessment

Clinical evaluation remains the foundation of CPP diagnosis. A detailed patient history, including pain characteristics (onset, duration, intensity, triggers), associated symptoms (e.g., dysmenorrhea, dyspareunia, dysuria), and medical history (e.g., prior surgeries, infections), is critical for guiding differential diagnosis. Physical examination, including pelvic palpation and assessment of pelvic floor muscle tenderness, helps identify potential sources of pain, such as trigger points or organ-specific abnormalities. However, the non-specific nature of CPP symptoms necessitates further diagnostic workup.

Multidisciplinary teams, comprising gynecologists, urologists, pain specialists, physiotherapists, and psychologists, play a pivotal role in addressing the multifactorial nature of CPP. For example, endometriosis may coexist with pelvic floor dysfunction, requiring input from both gynecological and musculoskeletal specialists. Patient-centered approaches, incorporating validated

pain assessment tools (e.g., McGill Pain Questionnaire), enhance diagnostic precision and ensure holistic care (Speer et al., 2016).

Imaging Techniques

Transvaginal Ultrasound (TVUS)

TVUS is the first-line imaging modality for CPP due to its accessibility, cost-effectiveness, and non-invasive nature. With a sensitivity of 70–90% and specificity of 80–95%, TVUS is effective for detecting ovarian cysts, uterine fibroids, and superficial endometriosis. Advanced techniques, such as 3D ultrasound and Doppler imaging, improve visualization of vascular patterns and pelvic adhesions. However, TVUS has limitations in detecting DIE, where lesions are located deep within pelvic tissues (Guerriero et al., 2018).

Magnetic Resonance Imaging (MRI)

MRI is a second-line imaging modality with superior resolution for soft tissue imaging, achieving a sensitivity of 85–95% and specificity of 90–98% for DIE and adenomyosis. T2-weighted and contrast-enhanced MRI sequences are particularly effective for identifying endometriotic lesions and distinguishing them from other pathologies, such as fibroids or malignancies. MRI is also valuable for preoperative planning in complex cases. However, its high cost, limited availability in resource-constrained settings, and contraindications (e.g., claustrophobia, metal implants) restrict its widespread use (Bazot & Daraï, 2018).

Computed Tomography (CT)

CT is less commonly used for CPP due to radiation exposure and lower specificity for gynecological conditions (60–80% sensitivity, 70–90% specificity). It is primarily employed in acute settings to rule out non-gynecological causes, such as appendicitis, diverticulitis, or ureteral stones. CT's role in CPP is limited to cases where other modalities are inconclusive or unavailable.

Minimally Invasive Techniques

Diagnostic laparoscopy remains the gold standard for CPP, particularly for endometriosis, with a sensitivity and specificity of 95–100%. Laparoscopy allows direct visualization of pelvic organs, enabling the identification and biopsy of endometriotic lesions, adhesions, or other abnormalities. Recent advancements, such as robotic-assisted laparoscopy, have improved precision and reduced recovery times. However, laparoscopy is invasive, requiring general anesthesia and carrying risks of complications, such as infection or organ injury. Its use is therefore reserved for cases where non-invasive methods are inconclusive or when therapeutic intervention (e.g., excision of endometriomas) is planned (Sinha et al., 2020).

Emerging Technologies

Biomarker Assays

Biomarker research has gained traction as a non-invasive diagnostic tool for CPP. CA-125, a glycoprotein marker, is elevated in endometriosis but lacks specificity (50–80% sensitivity, 60–85% specificity) due to its association with other conditions, such as ovarian cancer. Recent studies have explored novel biomarkers, including microRNAs, inflammatory cytokines (e.g., IL-6, TNF- α), and nerve growth factor (NGF), which show promise in differentiating endometriosis from other causes of CPP. Combining biomarker panels with imaging improves diagnostic accuracy, but further validation is needed before clinical adoption (Nisenblat et al., 2016).

Artificial Intelligence (AI)-Assisted Diagnostics

AI-based tools, including machine learning and deep learning algorithms, are transforming CPP diagnostics by integrating multi-modal data (e.g., imaging, clinical history, biomarkers). AI models

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can identify patterns in complex datasets, improving the detection of subtle abnormalities, such as early-stage endometriosis or pelvic adhesions. For example, convolutional neural networks (CNNs) applied to MRI images have achieved diagnostic accuracies of 80–95% for DIE. AI also supports decision-making by predicting the likelihood of specific diagnoses based on symptom profiles and test results. However, challenges include the need for large, diverse datasets and high computational costs (Leonardi et al., 2020).

Wearable and Digital Health Technologies

Emerging wearable devices and digital health platforms offer novel approaches to CPP monitoring. Wearable sensors that track pain patterns, physical activity, and physiological parameters (e.g., heart rate variability) provide real-time data to support diagnosis and treatment monitoring. Mobile applications with symptom-tracking features enable patients to record pain episodes and triggers, facilitating communication with healthcare providers. While still in early stages, these technologies hold potential for personalized CPP management (As-Sanie et al., 2019).

Multidisciplinary and Integrative Approaches

The complexity of CPP necessitates a multidisciplinary approach, integrating expertise from gynecology, urology, gastroenterology, pain management, and psychology. Collaborative diagnostic protocols, such as those implemented in specialized pelvic pain clinics, reduce diagnostic delays and improve patient satisfaction. Integrative approaches combine clinical evaluation, imaging, and molecular diagnostics to create a comprehensive diagnostic algorithm tailored to individual patients. For example, a patient with suspected endometriosis may undergo TVUS, followed by MRI if DIE is suspected, and laparoscopy for confirmation. Psychological support and pain management strategies are also critical, as CPP often has a psychosomatic component (Speer et al., 2016).

Challenges and Future Directions

Despite advancements, several challenges persist in CPP diagnostics. The heterogeneity of CPP etiologies complicates the development of universal diagnostic protocols. Access to advanced imaging and laparoscopy is limited in low-resource settings, highlighting the need for cost-effective, scalable solutions. Biomarker assays and AI tools require further validation to ensure reliability across diverse populations. Future research should focus on developing non-invasive, point-of-care diagnostic tests and expanding AI applications to integrate real-time patient data. Additionally, training healthcare providers in multidisciplinary care models is essential to address the global burden of CPP.

CONCLUSIONS

Chronic pelvic pain in women is a multifaceted condition requiring a sophisticated diagnostic approach. Advances in imaging (TVUS, MRI), minimally invasive techniques (laparoscopy), and emerging technologies (biomarkers, AI) have significantly improved diagnostic accuracy. Integrative approaches, combining clinical assessment, advanced diagnostics, and multidisciplinary collaboration, are essential for addressing the complexity of CPP. While challenges such as cost, accessibility, and diagnostic specificity remain, ongoing research into non-invasive tools and personalized medicine offers hope for improved outcomes. Future efforts should prioritize scalable, patient-centered diagnostic strategies to reduce the burden of CPP and enhance quality of life for affected women.

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