Menstrual Blood: An Underexplored Biological Resource with Diagnostic and Therapeutic Potential – A Review

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ABSTRACT

Menstrual blood has long been dismissed as physiological waste; however, accumulating scientific evidence now recognizes it as a biologically valuable fluid enriched with viable cells, signaling molecules, and regenerative factors. Recent research has identified menstrual blood–derived stem cells (MenSCs), along with immune cells, cytokines, and growth factors, highlighting their considerable promise in diagnostics and therapy. Notably, MenSCs have shown potential applications in conditions such as endometrial disorders, inflammatory diseases, and tissue regeneration, including emerging evidence in endometriosis and ischemic tissue repair. Menstrual blood collection is non-invasive, ethically acceptable, painless, and repeatable, offering clear advantages over conventional stem cell sources. This review critically consolidates existing literature on the composition, biological roles, diagnostic applications, and therapeutic prospects of menstrual blood, while addressing socio-cultural perspectives, ethical considerations, existing challenges, and future research directions.

Keywords: Menstruation, Menstrual Blood, Menstrual Blood–Derived Stem Cells, Regenerative Medicine, Biomarkers, Women's Health.

INTRODUCTION

Menstruation is a normal physiological process characterized by the periodic shedding of the endometrial lining in women of reproductive age. This process reflects intricate interactions between hormonal regulation, immune responses, angiogenesis, and tissue remodeling. Despite its universality, menstruation—and menstrual blood in particular—has been historically marginalized in biomedical research due to deep-rooted cultural taboos and misconceptions. Such perceptions have contributed to the limited scientific utilization of menstrual blood and its biological components.

In recent years, this narrative has begun to change with the discovery of menstrual blood–derived stem cells (MenSCs). These cells display hallmark features of mesenchymal stem cells, including self-renewal

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capacity, multilineage differentiation potential, and immunomodulatory activity [1,2]. Originating from the regenerative endometrium, MenSCs participate in cyclical endometrial repair. Compared with traditional stem cell sources such as bone marrow or adipose tissue, menstrual blood offers distinct benefits: non-invasive collection, repeated accessibility across menstrual cycles, minimal risk, and freedom from ethical controversy [3].

Growing experimental and translational evidence has challenged the long-standing view of menstrual blood as waste, demonstrating its complex cellular composition and clinical relevance [4]. Recognizing menstrual blood as a valuable biological resource represents a paradigm shift that could advance non-invasive diagnostics, ethically sound regenerative therapies, and inclusive women-centered biomedical research.

METHODOLOGY

This narrative review was conducted through a comprehensive literature search of electronic databases including **PubMed, Scopus, Web of Science, and Google Scholar.** Articles published between **2015 and 2025** were considered to capture recent advances. Search terms included *"menstrual blood," "menstrual blood-derived stem cells," "MenSCs," "diagnostic biomarkers," "regenerative medicine," and "women's health."*

COMPOSITION OF MENSTRUAL BLOOD

Menstrual blood is a heterogeneous biological fluid composed of cellular and molecular components shed from the endometrium. These include endometrial stromal and epithelial cells, erythrocytes, leukocytes, macrophages, natural killer cells, cytokines, chemokines, hormones, and growth factors [5]. Among these constituents, MenSCs have attracted significant scientific attention. These cells express mesenchymal stem cell markers such as CD73, CD90, and CD105, while lacking hematopoietic markers. MenSCs demonstrate high proliferative capacity, genetic stability, and adaptability, making them suitable candidates for regenerative applications [6,7].

BIOLOGICAL SIGNIFICANCE

Menstrual blood plays a central role in endometrial repair following menstruation. The presence of angiogenic factors and inflammatory mediators facilitates rapid tissue remodeling and healing [8]. MenSCs exhibit potent immunomodulatory and anti-inflammatory effects, suppressing pro-inflammatory cytokines while promoting tissue regeneration. These properties underpin their potential application in both local and systemic disease processes [9].

DIAGNOSTIC POTENTIAL

Recent investigations have positioned menstrual blood as a promising non-invasive diagnostic medium. The molecular and cellular constituents of menstrual blood reflect both endometrial and systemic health, enabling its potential use in the early detection of gynecological disorders such as endometriosis, endometrial malignancies, and infertility-related conditions [10,11]. Liquid biopsy strategies utilizing menstrual blood have gained traction due to ease of collection, improved patient acceptability, and feasibility for repeated sampling [12]. Such approaches hold particular value for population-level screening and application in low-resource or community-based healthcare settings.

Table 1. Diagnostic Applications of Menstrual Blood

Condition	Diagnostic Marker/Approach	Clinical Significance
Endometriosis	Cytokines, microRNAs	Early detection, disease monitoring
Endometrial cancer	Molecular biomarkers	Non-invasive screening
Infertility	Cellular and hormonal profiling	Assessment of endometrial receptivity

THERAPEUTIC APPLICATIONS

MenSCs have demonstrated encouraging therapeutic effects across a range of preclinical and emerging clinical studies. Experimental models indicate benefits in cardiac tissue repair, neurological disorders, liver injury, wound healing, and autoimmune conditions [13,14]. In reproductive and gynecological medicine, MenSCs have been explored for endometrial regeneration, management of intrauterine adhesions such as Asherman's syndrome, and treatment of infertility [15]. Their ability to promote angiogenesis, modulate immune responses, and enhance tissue regeneration positions them as promising candidates for future stem cell–based interventions.

Table 2. Therapeutic Applications of Menstrual Blood–Derived Stem Cells

Target Condition	Therapeutic Effect	Evidence Level
Endometrial damage	Tissue regeneration	Preclinical / Emerging clinical
Ischemic heart disease	Angiogenesis, repair	Experimental
Neurological disorders	Neuroprotection	Preclinical
Autoimmune diseases	Immunomodulation	Experimental

Table 3. Comparison of Stem Cell Sources

Feature	MenSCs	Bone Marrow Stem Cells	Adipose Stem Cells
Collection method	Non-invasive	Invasive	Minimally invasive
Ethical concerns	None	Minimal	Minimal
Proliferation rate	High	Moderate	Moderate
Repeatability	High	Limited	Limited

SOCIO-CULTURAL AND ETHICAL CONSIDERATIONS

Despite increasing scientific validation, menstrual blood remains stigmatized in many societies, influencing participation in research and acceptance of menstrual blood–based technologies [16]. Addressing these socio-cultural barriers is essential for the successful translation of research findings into practice. Ethically, menstrual blood offers a significant advantage as it is collected without invasive procedures, surgical risk, or embryo-related concerns [17]. Nurses, midwives, and public health professionals are instrumental in education, advocacy, and the integration of menstrual blood–based innovations into healthcare systems.

CHALLENGES AND FUTURE DIRECTIONS

Key challenges include the lack of standardized protocols for menstrual blood collection, processing, and storage. Large-scale clinical trials are needed to establish safety, efficacy, and long-term outcomes of MenSC-based therapies [18].

The development of **menstrual blood biobanking,** integration with **precision medicine**, and interdisciplinary collaboration between clinicians, nurses, and researchers represent critical future directions [19].

CONCLUSION

Menstrual blood is an underexplored yet biologically rich resource with significant diagnostic and therapeutic potential. Advances in stem cell biology and non-invasive diagnostics have transformed the perception of menstrual blood from waste to wealth. Continued interdisciplinary research, awareness, and policy support are essential to fully realize its clinical and public health applications.

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