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# Eosinophilic Changes in Peripheral Blood during Pregnancy in HIV-Positive Mothers

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**Abstract:** Eosinophils are critical components of the immune system, involved in allergic reactions, defense against parasitic infections, and modulation of immune responses. During pregnancy, the immune system undergoes significant adaptations, leading to changes in eosinophil dynamics that are essential for maintaining maternal-fetal tolerance. In HIV-positive mothers, these alterations may be further influenced by the immune dysregulation associated with HIV infection, resulting in complex eosinophilic changes in peripheral blood. This review explores the impact of pregnancy and HIV on eosinophil levels, examining how these changes can affect maternal and fetal health. Altered eosinophil dynamics during pregnancy in HIV-positive women have important implications for pregnancy outcomes. Eosinophils play a role in tissue remodeling and the immune response at the maternal-fetal interface, which is crucial for a successful pregnancy. Dysregulation of eosinophil function may lead to increased risks of complications such as gestational hypertension, preterm labor, and vertical transmission of HIV.

**Keywords:** Eosinophils, pregnancy, HIV-positive mothers, immune modulation, maternal-fetal health.

**Review Paper**

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## INTRODUCTION

Pregnancy is a unique physiological state characterized by extensive immunological adaptations that allow for the successful maintenance of a semi-allogeneic fetus. The immune system of a pregnant woman undergoes significant changes to balance the needs of maternal immune tolerance and defense against infections. Eosinophils, a type of white blood cell, play a pivotal role in this immunological landscape. Traditionally associated with allergic responses and defense against parasitic infections, eosinophils are also implicated in various immune regulatory functions that are crucial during pregnancy [1, 2]. In the context of pregnancy, eosinophils contribute to the establishment of a Th2-dominated immune response, which is essential for fostering maternal-fetal tolerance. These cells produce a range of cytokines and chemokines, such as interleukin-4 (IL-4), interleukin-5 (IL-5), and interleukin-13 (IL-13), which influence the activity of other immune cells and promote an anti-inflammatory environment. This shift is necessary for preventing maternal immune rejection of the fetus while also providing a protective mechanism against infections [3, 4]. However, the dynamics of eosinophils during pregnancy can be complex, particularly in women living with HIV. HIV (Human Immunodeficiency Virus) infection is characterized by chronic immune activation and dysregulation, which can lead to alterations in eosinophil levels and function. In HIV-positive mothers, the immune system is already compromised, and the presence of the virus can further complicate eosinophilic responses. Research indicates that eosinophilia—a condition defined by increased eosinophil counts—may be prevalent in this population, particularly in the presence of co-infections common in HIV-endemic regions [5, 6].

The relationship between eosinophils and HIV during pregnancy raises critical questions about the implications for maternal and fetal health. Eosinophils are involved in tissue remodeling and play a role in immune modulation at the maternal-fetal interface. Dysregulated eosinophil function could lead to adverse pregnancy outcomes, such as gestational hypertension, preterm labor, and increased risk of vertical transmission of HIV. Understanding how these changes occur in HIV-positive mothers is vital for developing effective monitoring and management strategies to optimize pregnancy outcomes [7, 8]. Eosinophils also influence the risk of vertical transmission of HIV from mother to child. Their presence at the maternal-fetal interface may

modulate the local immune environment, potentially impacting the likelihood of HIV transmission during pregnancy, childbirth, or breastfeeding. Identifying the specific mechanisms by which eosinophils affect vertical transmission dynamics is essential for informing clinical practices and interventions aimed at preventing mother-to-child transmission of the virus [9, 10].

**Eosinophils and Immune Function**

Eosinophils are specialized white blood cells that play crucial roles in the immune system, particularly in responding to parasitic infections, modulating allergic reactions, and regulating inflammatory responses. Originating from hematopoietic stem cells in the bone marrow, eosinophils are characterized by their distinctive bilobed nuclei and abundant cytoplasmic granules containing various mediators. Upon activation, eosinophils can migrate to sites of inflammation or infection, where they exert their effects through a range of mechanisms [11, 12]. One of the primary functions of eosinophils is to combat parasitic infections, particularly helminths. Eosinophils can recognize and bind to parasites through specific receptors, such as the FcεRI receptor, which recognizes IgE antibodies that may coat these pathogens. Upon binding, eosinophils degranulate, releasing cytotoxic granules that contain enzymes, such as major basic protein (MBP) and eosinophil peroxidase (EPO), which can damage and kill parasites. This cytotoxic response is essential for controlling parasitic infections and preventing their establishment in the host [13, 14]. In addition to their role in combating parasites, eosinophils are critical players in the pathogenesis of allergic diseases, such as asthma and allergic rhinitis. They contribute to the inflammatory response by producing a variety of cytokines, chemokines, and lipid mediators that attract other immune cells to the site of allergen exposure. Eosinophils release pro-inflammatory cytokines like interleukin-5 (IL-5), which further promote eosinophil survival and activation. This amplification of the inflammatory response can lead to tissue damage and contribute to the symptoms associated with allergic diseases [15, 16].

Eosinophils also play a regulatory role in modulating immune responses beyond their traditional functions. They can interact with T cells, dendritic cells, and other immune cells, influencing the adaptive immune response. For instance, eosinophils can produce immunomodulatory cytokines, such as IL-10 and transforming growth factor-beta (TGF-β), which can help shift the immune response towards tolerance and dampen inflammation. This regulatory capacity is particularly important during pregnancy, where eosinophils help maintain immune tolerance at the maternal-fetal interface [17, 18]. During pregnancy, eosinophils contribute to the establishment of a favorable immune environment that supports fetal development. The Th2-skewed immune response characteristic of pregnancy promotes the production of cytokines that enhance eosinophil activity and survival. Eosinophils can be found at the placenta and the maternal-fetal interface, where they play roles in tissue remodeling and immune modulation. Their ability to produce growth factors and extracellular matrix components is crucial for the successful implantation and development of the placenta [19, 20]. The intricate interplay between eosinophils and other immune cells underscores their importance in maintaining immune homeostasis. Eosinophils can interact with various cell types, including mast cells, basophils, and T helper cells, to coordinate immune responses. This cross-talk can lead to enhanced or dampened immune responses, depending on the context of the immune challenge. In this way, eosinophils serve as both effector and regulatory cells, adapting their functions to meet the needs of the immune system [21, 22]. In the context of HIV infection, the immune dysregulation associated with the virus can impact eosinophil function. HIV infection often leads to chronic immune activation, which can influence eosinophil counts and activity. The presence of co-infections, which are common in HIV-positive populations, can further complicate eosinophilic responses [23, 24].

**Changes in Eosinophil Levels During Pregnancy**

Pregnancy induces profound changes in the maternal immune system, resulting in altered eosinophil levels and dynamics. Eosinophils typically constitute 1-4% of the total white blood cell count in healthy adults, but their levels can fluctuate significantly during pregnancy due to various physiological and hormonal changes. One of the primary drivers of eosinophilic changes during pregnancy is the hormonal milieu, particularly the influence of progesterone and estrogen. These hormones promote the Th2-skewed immune response, which is characterized by increased levels of cytokines such as interleukin-4 (IL-4), IL-5, and IL-13. This shift not only enhances the production and survival of eosinophils but also contributes to their activation and recruitment to sites of inflammation or immune response. Consequently, pregnant women may experience an increase in peripheral eosinophil counts, especially during the second and third trimesters [25, 26]. Eosinophilia, defined as an elevated eosinophil count, is often observed during pregnancy. This condition can be attributed to several factors, including the physiological changes associated with pregnancy, increased vascular permeability, and tissue remodeling at the maternal-fetal interface. Eosinophils are known to play a role in tissue repair and remodeling, and their increased presence may reflect the demands of placental development and fetal growth. However, the extent of eosinophilia can vary among individuals and may be influenced by factors such as maternal health, nutritional status, and genetic predisposition. In some cases, eosinophil levels may remain stable or even decrease during pregnancy, particularly in women with pre-existing allergic conditions or chronic inflammatory diseases. The Th2 response typically promotes eosinophilia, but if the immune system is dysregulated due to pre-existing

conditions, this may alter the expected eosinophilic response. Additionally, changes in eosinophil levels can also occur in response to environmental factors, such as exposure to allergens or infections, which may further complicate the dynamics of eosinophils during pregnancy [27, 28].

The changes in eosinophil levels during pregnancy can have important clinical implications. Elevated eosinophil counts may be associated with conditions such as gestational hypertension, preeclampsia, or allergic disorders. Conversely, reduced eosinophil levels may indicate immune suppression, which could increase susceptibility to infections. Clinicians must be vigilant in monitoring eosinophil levels during pregnancy, as both eosinophilia and eosinopenia can signify underlying issues that may impact maternal and fetal health [29]. Moreover, the interplay between eosinophils and other immune cells during pregnancy is critical for understanding the broader implications of eosinophilic changes. Eosinophils interact with T cells, dendritic cells, and other leukocytes, influencing the overall immune response. Their ability to produce a wide array of cytokines allows them to modulate the activity of neighboring immune cells, further complicating the immune landscape during pregnancy [30]. In HIV-positive mothers, the dynamics of eosinophils may differ from those in HIV-negative populations. The chronic immune activation associated with HIV infection can affect eosinophil counts and functionality. HIV-positive pregnant women may exhibit altered eosinophilic responses due to the interplay between the virus, co-infections, and the physiological changes of pregnancy [31].

**Eosinophilic Changes in HIV-Positive Mothers**

Eosinophils play a critical role in the immune system, and their dynamics can be significantly altered in HIV-positive mothers, particularly during pregnancy. HIV infection leads to chronic immune activation and dysregulation, which can impact eosinophil levels and function. In HIV-positive mothers, the presence of the virus can lead to altered eosinophil counts, with some studies indicating that eosinophilia may be more prevalent in this population. The chronic immune activation associated with HIV can result in increased eosinophil production and survival. This increase may be attributed to elevated levels of cytokines such as IL-5, which is known to promote eosinophil differentiation and maturation. Additionally, the presence of co-infections—common among individuals living with HIV—can further influence eosinophil dynamics, as these infections often trigger immune responses that can lead to eosinophilia [32-34]. Eosinophils are known to play a role in allergic reactions and responses to parasitic infections, which can be particularly relevant in HIV-positive populations, especially in regions where parasitic infections are endemic. In some cases, co-infections with helminths or other pathogens can lead to an exacerbated eosinophilic response, reflecting the immune system's attempt to control multiple threats simultaneously. This can result in heightened eosinophil activation, which may have implications for maternal health and pregnancy outcomes [35]. The implications of altered eosinophil dynamics in HIV-positive mothers are multifaceted. Elevated eosinophil levels can contribute to tissue inflammation and damage, potentially increasing the risk of pregnancy complications such as gestational hypertension or preterm labor. Additionally, dysregulation of eosinophil function may compromise the maternal immune response, making pregnant women more susceptible to infections. This is particularly concerning given that HIV-positive mothers are already at an increased risk of various infections due to their compromised immune systems [36].

Eosinophils also play a role at the maternal-fetal interface, where they contribute to immune modulation and tissue remodeling. In HIV-positive mothers, altered eosinophil dynamics may impact the development and function of the placenta, influencing fetal health and growth. The presence of eosinophils in placental tissue has been associated with both protective and pathological effects, depending on their activation status and the overall immune environment [37]. The complex interplay between eosinophils, HIV, and other immune cells is essential for understanding the broader immunological context in HIV-positive mothers. Eosinophils can interact with T cells, dendritic cells, and macrophages, influencing the overall immune response and potentially affecting the risk of vertical transmission of HIV. Investigating these interactions may reveal new insights into how eosinophils can modulate the immune landscape during pregnancy and impact maternal and fetal health [38].

**Implications for Maternal-Fetal Health**

The dynamics of eosinophils in HIV-positive mothers during pregnancy have significant implications for both maternal and fetal health. Altered eosinophil levels can influence various physiological processes, affecting pregnancy outcomes and overall well-being for both the mother and the developing fetus [39]. One of the primary concerns related to eosinophilic changes in HIV-positive pregnant women is the risk of pregnancy complications. Eosinophilia, characterized by elevated eosinophil counts, can contribute to inflammation and tissue damage, potentially leading to complications such as gestational hypertension, preeclampsia, and preterm labor. These conditions not only pose risks to maternal health but can also jeopardize fetal well-being, increasing the likelihood of adverse outcomes, including low birth weight and developmental delays [40]. Eosinophils play a role in modulating the immune environment at the maternal-fetal interface, influencing placental development and function. Altered eosinophilic responses in HIV-positive mothers may impact placental perfusion and nutrient transfer, ultimately affecting fetal growth and development.

Research has shown that a balanced immune response is essential for optimal placental function, and dysregulation of eosinophils may lead to suboptimal outcomes for the fetus [41]. In addition to direct effects on pregnancy complications and placental health, eosinophils may also influence the risk of vertical transmission of HIV from mother to child. The immune microenvironment at the maternal-fetal interface is critical for determining the likelihood of HIV transmission. Eosinophils, through their interactions with other immune cells, can modulate this environment [42].

Furthermore, the presence of co-infections in HIV-positive pregnant women can complicate the implications of eosinophilic changes. Co-infections may exacerbate eosinophilia and alter immune responses, potentially leading to increased risks for both the mother and the fetus. For example, co-infections with helminths or other pathogens can heighten inflammatory responses, contributing to the risk of complications during pregnancy and adversely affecting fetal health [43]. Psychological and social factors also play a role in the health of HIV-positive mothers and their infants. The stigma associated with HIV can lead to increased stress and anxiety, which may further complicate immune responses and contribute to poor pregnancy outcomes. Ensuring that HIV-positive mothers receive comprehensive care that addresses both physical and mental health needs is essential for optimizing maternal-fetal health [44]. Additionally, understanding the implications of eosinophilic changes can inform clinical practices aimed at improving health outcomes for HIV-positive mothers and their infants. Monitoring eosinophil levels during pregnancy can provide valuable insights into the maternal immune status and help identify individuals at higher risk for complications. Implementing therapeutic strategies that target eosinophil function or address eosinophilia could enhance maternal and fetal health [45].

**Vertical Transmission of HIV**

Vertical transmission of HIV, also known as mother-to-child transmission (MTCT), occurs when the virus is transmitted from an HIV-positive mother to her child during pregnancy, labor, delivery, or breastfeeding. Several factors contribute to the risk of vertical transmission of HIV. One of the most significant factors is the maternal viral load. High levels of the virus in the mother's blood increase the likelihood of transmission during pregnancy and childbirth. Conversely, effective antiretroviral therapy (ART) can significantly reduce maternal viral load to undetectable levels, greatly diminishing the risk of transmission to the child. The World Health Organization (WHO) recommends that all HIV-positive pregnant women receive ART to prevent MTCT [46]. The timing of transmission also plays a crucial role in determining the risk of vertical transmission. During pregnancy, the risk is relatively low, but the risk increases during labor and delivery, especially if there are complications such as prolonged rupture of membranes or maternal bleeding. Strategies such as cesarean delivery may be recommended in certain situations, particularly for mothers with high viral loads at the time of delivery, to further reduce the risk of transmission [47]. Breastfeeding is another important consideration in the context of vertical transmission. While breastfeeding provides essential nutrients and immunological benefits to infants, it can also pose a risk of HIV transmission if the mother is not on effective ART. Current guidelines suggest that HIV-positive mothers on effective ART with an undetectable viral load can safely breastfeed, as the benefits of breastfeeding often outweigh the risks of transmission. However, in cases where mothers are not receiving treatment or have high viral loads, exclusive formula feeding may be recommended to eliminate the risk of transmission through breast milk [48].

Immune factors also play a role in vertical transmission. The maternal immune response at the maternal-fetal interface can influence the likelihood of HIV transmission. Eosinophils, which play a role in immune modulation, may impact the local immune environment and the transmission dynamics of HIV [49]. Co-infections and maternal health status can also influence the risk of vertical transmission. Conditions such as sexually transmitted infections (STIs) can increase the susceptibility of the infant to HIV infection, while maternal immunological status may affect the overall transmission dynamics. HIV-positive mothers with compromised immune systems may have different transmission risks compared to those who are otherwise healthy. Preventing vertical transmission of HIV is a global public health priority, and comprehensive strategies have been developed to address this issue. These strategies include routine HIV testing for pregnant women, universal access to ART, safe delivery practices, and appropriate infant feeding recommendations. Additionally, educating healthcare providers and communities about the importance of early diagnosis and treatment can significantly reduce the incidence of vertical transmission [49-55].

## CONCLUSION

Eosinophilic changes during pregnancy in HIV-positive mothers represent a complex interplay between immune dynamics, maternal health, and fetal development. The unique immunological challenges faced by this population necessitate a comprehensive understanding of eosinophils' roles and their implications for maternal-fetal health. Elevated eosinophil levels can influence pregnancy outcomes, impacting the risk of complications such as gestational hypertension and preterm labor, while also affecting placental health and the risk of vertical transmission of HIV.

Effective management of eosinophilic changes is crucial for optimizing health outcomes for both

mothers and their infants. Monitoring eosinophil levels during pregnancy can provide valuable insights into the maternal immune status, helping healthcare providers identify at-risk individuals and implement targeted interventions. Additionally, understanding the interactions between eosinophils, HIV, and other immune cells at the maternal-fetal interface may reveal new avenues for preventing vertical transmission and enhancing maternal health.

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