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Immunological paradox of pregnancy: science and prevention

Paradoja inmunológica del embarazo: ciencia y prevención

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Pregnancy is a unique physiological state in which the maternal immune system faces the challenge of tolerating the semi-allogeneic fetus without losing its ability to defend against pathogens[1,2]. This phenomenon, described as an immunological paradox, has aroused growing interest in biomedical research due to its impact on maternal and fetal health[3]. Understanding immunological adaptations during pregnancy is essential to prevent obstetric complications and design public health strategies that protect mothers and their children.

The maternal immune system undergoes dynamic changes that vary by trimester. In the former, a pro-inflammatory environment predominates, which facilitates vascular implantation and remodelling[4]. In the second, an anti-infla s and regulatory T cells that favor tolerance e returns, necessary for the onset of labor[3]. NK cells and decidual macrophages, whic immunity, a relative suppression of Th1 entral role in maternal-fetal tolerance[7].

The placenta acts as an immunomodulatory organ; molecules such as HLA-G, PD-L1 and IDO contribute to the suppression of cytotoxic responses[8]. The interaction between trophoblast and decidual immune cells ensures a regulatory microenvironment that prevents fetal rejection[9]. This immunological and hemodynamic balance is extremely delicate; Small alterations can trigger obstetric complications. In preeclampsia, endothelial dysfunction and imbalance between angiogenic and antiangiogenic factors lead to hypertension and multiorgan damage. In recurrent miscarriages, immunological alterations such as excess NK cells or maternal-fetal tolerance deficiency and thrombophilic factors that favor gestational loss have been described[10]. In both scenarios, the common denominator is the breakdown of maternal-fetal homeostasis. Therefore, early prenatal control and the identification of risk factors are key tools to reduce complications[11].

Pregnancy also increases susceptibility to viral infections such as influenza and SARS-CoV-2, bacterial infections such as *Listeria monocytogenes*, and parasitic infections such as toxoplasmosis and malaria[12]. These infections can trigger miscarriage, intrauterine growth restriction, and preterm birth[13]. Safe vaccination during pregnancy, including influenza, COVID-19, and pertussis, is a fundamental preventive strategy that should be promoted in all health systems[13].

Immunity in pregnancy is also related to obstetric complications. Preeclampsia is associated with an imbalance between pro-inflammatory and anti-inflammatory cytokines, as well as uterine NK cell dysfunction[14]. Recurrent miscarriages are linked to regulatory T deficiency and excess Th1[15] responses. As for autoimmune diseases, some improve during pregnancy, such as rheumatoid arthritis, while others worsen, such as systemic lupus erythematosus, reflecting the complexity of immune modulation[16].

After delivery, the immune system returns to a pro-inflammatory state. This change favors uterine involution, but it can also exacerbate latent autoimmune diseases[17]. Postpartum surveillance is crucial to prevent complications in women with a history of immunology and should be considered an integral part of maternal care[18].

Finally, immunity in pregnancy is not only a biological phenomenon, but also a public health challenge. Lack of access to health services, malnutrition, and socioeconomic vulnerability increase the risk of immunological complications[19]. Policies are needed to strengthen vaccination in pregnant women, promote nutritional education and prenatal care, and integrate reproductive immunology into medical training and clinical research[20].

In conclusion, pregnancy represents a unique immunological state in which the mother must balance tolerance and defense, guaranteeing fetal survival without compromising her ability to respond to infectious agents. This delicate balance, supported by highly specialized cellular and molecular mechanisms, explains both the vulnerability of the pregnant woman to certain infections and the appearance of obstetric complications related to immunity. Scientific evidence shows that immunity in pregnancy should be understood as a comprehensive public health challenge that requires prevention policies, safe vaccination programs, and nutritional and health education strategies. Recognizing maternal immunity as a priority will make it possible to move towards more effective antenatal care, reduce the burden of disease and contribute to the well-being of future generations.

Conflict of interest

The author declares that there is no conflict of interest.

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Ethical considerations

The respective ethical considerations were made and avoid the raising of names and institutions.

Use of artificial intelligence

I take it for granted that the entire document was written based on ethical and professional criteria, and AI was not used to make the text.

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