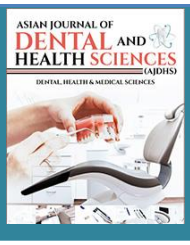

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The Vital Role of Blood Transfusions during Pregnancy: A Comprehensive Review

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Abstract

Pregnancy is a remarkable yet complex physiological state that can be accompanied by various complications, including obstetric hemorrhage and severe anemia, which significantly affect maternal and fetal health. Blood transfusions serve as crucial interventions to manage these complications and mitigate potential risks. This comprehensive review synthesizes the pivotal role of blood transfusions during pregnancy, encompassing their indications, benefits, risks, and advancements in transfusion medicine. Exploring the multifaceted landscape of transfusions in addressing obstetric challenges, anemia, and other maternal conditions, this article underscores the paramount importance of timely and appropriate transfusion interventions to safeguard the health and well-being of both mother and child. Through an in-depth analysis of current knowledge and emerging trends, this review aims to provide a holistic understanding of the significance of blood transfusions in optimizing outcomes during pregnancy.

Keywords: Blood Transfusions, Pregnancy, Maternal Health, Hemorrhage, Anemia, Obstetrics, Fetal Health, Transfusion Medicine

Introduction

Pregnancy is a transformative journey characterized by remarkable physiological changes to support the growth and development of the fetus. However, this period can also be fraught with potential complications that challenge maternal health and the well-being of the unborn child. Among these complications, obstetric hemorrhage and severe anemia stand as significant contributors to maternal morbidity and mortality worldwide.[1-6] Obstetric hemorrhage, often unpredictable and rapid in onset, remains a leading cause of maternal mortality globally, accounting for approximately one-quarter of all pregnancy-related deaths. Additionally, anemia, prevalent among pregnant individuals due to increased blood volume demands and physiological changes, poses risks to both maternal and fetal health. Addressing these challenges effectively requires comprehensive strategies, and blood transfusions emerge as indispensable lifesaving interventions.[7-12]

The administration of blood and blood products has revolutionized obstetric care, providing a crucial lifeline in managing acute blood loss, correcting anemia, and mitigating complications during pregnancy and childbirth. While the primary focus of blood transfusions is to stabilize maternal conditions, their impact extends to ensuring the optimal growth and development of the fetus.[13-14] This paper aims to provide a comprehensive overview of the importance of blood transfusions during pregnancy. It will delve into the indications, benefits, and risks associated with transfusions in obstetric care. Furthermore, it will explore advancements in transfusion medicine, including emerging techniques and strategies, emphasizing their impact on maternal and fetal outcomes. Understanding the critical role of blood transfusions in pregnancy is essential not only for healthcare providers but also for policymakers and the broader community. By elucidating the significance of timely and appropriate transfusion interventions, this review aims to underscore the necessity of a multidisciplinary approach and continued advancements in transfusion practices to ensure the optimal health and well-being of pregnant individuals and their babies.

Indications for Blood Transfusions during Pregnancy Obstetric hemorrhage

Obstetric hemorrhage, characterized by excessive bleeding during pregnancy, childbirth, or the postpartum period, stands as a critical indication for blood transfusions. It represents a major cause of maternal morbidity and mortality globally. Various factors contribute to obstetric hemorrhage, including uterine atony, placental abnormalities, trauma, and surgical complications. Managing obstetric hemorrhage effectively often necessitates prompt and targeted interventions, with blood transfusions playing a pivotal role in stabilizing the patient and preventing severe complications.[15-23] Postpartum hemorrhage resulting from uterine atony, a failure of the uterus to contract effectively after childbirth, is one of the most common causes of excessive bleeding. Transfusions are often

required when conventional measures like uterotonic medications fail to control bleeding.[24-30]

Conditions such as placenta previa or placental abruption may lead to significant bleeding, requiring transfusions to address acute blood loss and maintain adequate perfusion to vital organs. In cases of obstetric trauma during childbirth or surgical complications, such as uterine rupture or severe lacerations, immediate transfusions may be necessary to stabilize the patient and restore blood volume.[31-34] Transfusion protocols for obstetric hemorrhage involve rapid assessment, identification of the bleeding source, and simultaneous resuscitative measures. Timely administration of blood products, including packed red blood cells, fresh frozen plasma, platelets, and sometimes clotting factors, is essential to replace lost blood volume and correct coagulopathies.[35-38] Furthermore, a multidisciplinary approach involving obstetricians, hematologists, anesthesiologists, and blood bank specialists is crucial in optimizing transfusion therapy for obstetric hemorrhage. The aim is not only to prevent maternal complications but also to ensure the preservation of fetal well-being during these critical moments.

Benefits and Risks of Blood Transfusions in Pregnancy

Blood transfusions during pregnancy carry both potential benefits and risks, necessitating careful consideration and individualized management based on the specific clinical circumstances. Understanding these aspects is crucial in optimizing maternal care while minimizing potential complications.

Benefits:

Blood transfusions serve as life-saving interventions in cases of obstetric hemorrhage, trauma, or severe postpartum hemorrhage, effectively restoring blood volume and preventing hypovolemic shock.[39-41] Pregnant individuals may experience anemia due to factors such as iron deficiency, hemoglobinopathies, or other underlying conditions. Transfusions can rapidly replenish red blood cells and improve oxygen-carrying capacity, mitigating the risks associated with severe anemia for both the mother and the fetus.[42-45] Timely transfusions help prevent complications related to inadequate tissue perfusion, organ dysfunction, and coagulopathies, reducing the risk of maternal morbidity and mortality.[46]

Risks:

Adverse reactions to transfusions, including febrile reactions, allergic reactions, hemolytic reactions, and transfusion-related acute lung injury (TRALI), pose risks to the recipient. Proper blood typing, cross-matching, and screening for antibodies are essential to minimize these risks.[47] Despite stringent screening protocols, there remains a minimal risk of transmitting infectious agents through blood transfusions, including viruses (such as HIV, hepatitis B and C) and bacteria. Blood banks follow strict guidelines to minimize this risk. Transfusions can trigger immune responses leading to alloimmunization, where the recipient's immune system forms antibodies against transfused blood components. This may complicate future transfusions or pregnancies, potentially affecting fetal health in subsequent pregnancies.[48] Rapid administration of large volumes of blood products can result in fluid overload, especially in individuals with compromised cardiac function, leading to pulmonary edema and exacerbating pre-existing conditions. To mitigate these risks and optimize benefits, healthcare providers must weigh the indications for transfusion against the potential complications. Individualized patient assessment, close monitoring, adherence to transfusion protocols, and ensuring compatibility and safety of blood products are critical in minimizing risks associated with transfusions during pregnancy. The decision to administer blood transfusions during pregnancy should involve a thorough risk-benefit analysis, considering the urgency of the situation, the patient's clinical status, and potential alternatives. Careful monitoring for adverse reactions and appropriate post-transfusion care are imperative to ensure optimal outcomes for both the pregnant individual and the developing fetus.

Advances in Transfusion Medicine and Pregnancy

Transfusion medicine has witnessed significant advancements, revolutionizing approaches to blood product administration and transfusion strategies in obstetric care. These innovations aim to enhance safety, efficacy, and outcomes for pregnant individuals facing complications requiring blood transfusions.[49-50] Improved understanding of blood component therapy has enabled more precise and tailored transfusion approaches. Specific components such as packed red blood cells, fresh frozen plasma, platelets, and cryoprecipitate can be administered based on individual patient needs, optimizing hemostasis and minimizing unnecessary transfusions.[51] Rapid point-of-care testing methods have evolved, enabling timely assessment of coagulation parameters and hemoglobin levels. These advancements facilitate prompt decision-making in managing obstetric hemorrhage and anemia, allowing for targeted and personalized transfusion therapy.[52]

Enhanced collaboration between transfusion medicine specialists and maternal-fetal medicine experts has led to improved understanding of the impact of transfusions on both maternal and fetal outcomes. This interdisciplinary approach considers the unique needs of both the pregnant individual and the developing fetus, ensuring comprehensive and balanced care.[53] Implementation of pathogen reduction technologies in blood products has significantly reduced the risk of transfusion-transmitted infections. These technologies employ various methods to inactivate pathogens while preserving the integrity and functionality of blood components, enhancing the safety profile of transfusions.[54] Patient Blood Management (PBM) Programs have gained prominence, focusing on optimizing patient outcomes by minimizing unnecessary transfusions, reducing exposure to blood products, and promoting alternative strategies such as iron supplementation, erythropoiesis-stimulating agents, and hemostatic agents.[55]

Research into immunomodulation techniques aims to mitigate adverse immune reactions and alloimmunization in transfusion recipients. Strategies to induce immune tolerance to prevent alloimmunization are being explored, potentially impacting future transfusion and pregnancy outcomes.[56] Ongoing research into blood substitutes and alternative oxygen-carrying solutions aims to develop safer alternatives to traditional blood transfusions, reducing the risks associated with allogeneic blood products. These advances underscore the dynamic nature of transfusion medicine in pregnancy. Implementing these innovations requires ongoing research, multidisciplinary collaboration, and adherence to evolving best practices. By embracing these advancements, healthcare providers can optimize transfusion therapy, ensuring safer and more effective care for pregnant individuals facing obstetric complications that necessitate blood transfusions.

Impact on Maternal and Fetal Health

The impact of blood transfusions on maternal and fetal health during pregnancy is multifaceted and warrants careful consideration, as these interventions directly influence the well-being of both the pregnant individual and the developing fetus.

Maternal Health:

Blood transfusions play a crucial role in stabilizing maternal conditions during obstetric hemorrhage. Prompt administration of blood products helps restore blood volume, ensuring adequate tissue perfusion and mitigating the risk of maternal morbidity and mortality. Severe anemia in pregnancy poses risks to maternal health, including fatigue, cardiac strain, and impaired oxygen delivery to tissues. Transfusions can rapidly address anemia, improving maternal well-being and reducing the risk of complications. Transfusions help prevent or mitigate complications associated with hypovolemia, inadequate oxygenation, and coagulopathies, reducing the risk of organ dysfunction and improving overall maternal outcomes.[57]

Fetal Health:

Maternal blood transfusions enhance oxygen-carrying capacity, ensuring improved oxygen delivery to the placenta and subsequently to the developing fetus. This is particularly beneficial in cases of maternal anemia, optimizing fetal growth and development. While transfusions primarily focus on maternal stabilization, their effects extend to the fetus. Timely interventions can indirectly mitigate potential fetal complications resulting from maternal distress due to hemorrhage or anemia.[58]

Balancing Maternal and Fetal Well-Being

Optimizing maternal health through transfusions is crucial for ensuring a favorable intrauterine environment for the developing fetus. However, healthcare providers must carefully weigh the benefits of transfusions for the mother against potential risks to the fetus, considering factors such as gestational age, indications for transfusion, and the overall health status of both the mother and the fetus.[59] Monitoring fetal well-being during and after transfusions through techniques like fetal heart rate monitoring and ultrasound assessments is vital. Multidisciplinary collaboration between obstetricians, hematologists, neonatologists, and other specialists ensures comprehensive care, aiming to minimize risks to the fetus while addressing maternal health concerns.[60-61] Understanding the interconnectedness of maternal and fetal health in the context of blood transfusions during pregnancy underscores the importance of individualized care, close monitoring, and informed decision-making to optimize outcomes for both the mother and the unborn child.

Ethical and Societal Perspectives

Ethical and societal perspectives surrounding blood transfusions during pregnancy are integral aspects that influence decision-making, healthcare delivery, and patient outcomes. Respecting the autonomy of pregnant individuals in decision-making regarding transfusions is crucial. Healthcare providers must ensure that individuals are adequately informed about the risks, benefits, and alternatives to transfusions, considering religious, cultural, and personal beliefs that may impact their acceptance of this intervention.[62] The ethical principles of beneficence (doing good) and non-maleficence (avoiding harm) guide healthcare professionals in balancing the benefits of transfusions for maternal health against potential risks to both the mother and the fetus. Striking this balance requires a careful evaluation of the clinical situation while prioritizing the well-being of both patients.[62]

Religious beliefs and cultural norms significantly influence attitudes toward blood transfusions during pregnancy. Certain religious groups have prohibitions or reservations against blood transfusions, necessitating respectful dialogue, and alternative approaches to care that align with patients' beliefs. Ensuring equitable access to transfusion services is essential. Socioeconomic factors, geographical location, and healthcare disparities may affect access to timely transfusions. Efforts to provide access to safe and culturally sensitive transfusion services are imperative to prevent adverse maternal and fetal outcomes. Legal frameworks govern healthcare decisions, including transfusions during pregnancy. Healthcare providers must adhere to established guidelines, ensuring patient safety and respecting patient rights, including the right to refuse treatment based on religious or personal beliefs. Public awareness and education campaigns are vital to dispel misconceptions, increase awareness about the importance of blood transfusions in pregnancy, and foster understanding and support within communities. This helps address stigmas or fears surrounding transfusions and encourages informed decision-making.

Ethical considerations in research involving transfusions during pregnancy involve safeguarding the rights and well-being of pregnant participants. Ethical research practices ensure that advancements in transfusion medicine benefit pregnant individuals without undue risks. Navigating these ethical and societal considerations demands a patient-centered approach that respects cultural diversity, promotes patient autonomy, and upholds ethical principles while delivering optimal healthcare. Collaboration among healthcare providers, ethicists, community leaders, and policymakers is crucial in developing inclusive policies and practices that respect patients' beliefs while ensuring the best possible care outcomes for pregnant individuals requiring blood transfusions.

Future Directions

Future directions in blood transfusions during pregnancy are poised to bring about significant advancements in maternal and fetal care. Advances in technology and understanding of individual patient factors (such as genetics, immunology, and hemodynamics) may lead to tailored transfusion approaches. Precision medicine principles could enable customized transfusion therapies based on specific patient needs, minimizing risks and optimizing outcomes. Ongoing research aims to further reduce the risks associated with transfusions, including efforts to enhance blood safety, prevent transfusion reactions, and develop alternative transfusion products or strategies that minimize immunological responses.

Research into non-blood alternatives, such as synthetic oxygen carriers, hemoglobin-based oxygen carriers, and oxygen therapeutics, continues to advance. These alternatives aim to provide oxygen-carrying capacity without the risks associated with traditional blood transfusions. Strategies to modulate the immune response and prevent alloimmunization post-transfusion are under exploration. Novel techniques may aim to induce immune tolerance, reducing the risks of adverse reactions and sensitization in pregnant individuals. Advancements in point-of-care testing technologies are expected to further improve the rapid assessment of hemoglobin levels, coagulation parameters, and immunological responses. This will facilitate real-time decision-making and personalized transfusion interventions.

Integration of telemedicine and remote consultation services could enhance access to expert guidance in managing obstetric complications necessitating transfusions, especially in underserved or remote areas lacking immediate access to specialized care. Continued research focusing on the long-term maternal and fetal outcomes following blood transfusions during pregnancy is essential. Studying the potential effects on subsequent pregnancies, immune sensitization, and overall health of both mother and child will provide valuable insights. Further exploration into ethical dilemmas, cultural sensitivities, and religious perspectives regarding blood transfusions in pregnancy is critical. Policies and practices

should evolve to respect diverse beliefs while ensuring optimal care.

The future of transfusion medicine in pregnancy lies in advancing safety, efficacy, and individualized care. Collaborative efforts among researchers, healthcare providers, policymakers, and communities will drive these advancements, shaping the landscape of maternal-fetal medicine and transfusion practices for improved outcomes and patient-centered care. Continued innovation and research in these areas will further refine and enhance transfusion therapies for pregnant individuals facing obstetric challenges.

Recommendations

Recommendations concerning blood transfusions during pregnancy encompass a multifaceted approach aimed at optimizing care, ensuring patient safety, and improving outcomes. Encourage the establishment of multidisciplinary teams comprising obstetricians, hematologists, anesthesiologists, neonatologists, and transfusion specialists. Collaborative efforts ensure comprehensive care, facilitating timely decision-making and optimal management of pregnant individuals requiring blood transfusions. Develop evidence-based protocols and clinical guidelines specific to blood transfusions during pregnancy. These guidelines should encompass indications, dosing, monitoring, and adverse event management, ensuring standardized and safe practices across healthcare settings. Emphasize patient-centered communication and informed consent processes. Healthcare providers should engage in open discussions with pregnant individuals, respecting their beliefs, preferences, and concerns regarding transfusions. Providing clear, understandable information aids in informed decision-making.

Offer continuous education and training programs for healthcare professionals involved in obstetric care. These programs should focus on transfusion protocols, ethical considerations, cultural competency, and advancements in transfusion medicine, enhancing the quality of care provided to pregnant patients. Ensure equitable access to safe and culturally sensitive transfusion services, especially in underserved or remote areas. Addressing healthcare disparities and ensuring access to timely transfusions can significantly impact maternal and fetal outcomes. Encourage and support research endeavors focusing on transfusion medicine in pregnancy. Research initiatives should explore alternative transfusion strategies, long-term outcomes, immunomodulation techniques, and safety measures to continually improve transfusion practices and minimize risks.

Develop policies that balance patient autonomy, safety, and ethical considerations surrounding transfusions during pregnancy. These policies should respect diverse cultural and religious beliefs while prioritizing maternal and fetal well-being. Foster public awareness campaigns highlighting the importance of blood transfusions in pregnancy. Promote community support, dispel myths, and encourage dialogue to increase acceptance and understanding of transfusions among diverse populations. By implementing these recommendations, healthcare systems can enhance the quality of care provided to pregnant individuals, ensure patient safety, and improve outcomes associated with obstetric complications requiring blood transfusions. Continuous evaluation and adaptation of practices based on emerging evidence and ethical considerations are essential to advancing transfusion medicine in the context of pregnancy.

Conclusion

The significance of blood transfusions during pregnancy cannot be overstated in safeguarding the health and well-being of both the pregnant individual and the developing fetus. Obstetric complications such as hemorrhage and severe anemia pose substantial risks, necessitating prompt and effective interventions, where blood transfusions play a pivotal role. Striking a balance between optimizing maternal health and ensuring fetal well-being remains a core challenge. This balance necessitates a personalized, patient-centered approach that respects individual beliefs, preferences, and cultural considerations. Multidisciplinary collaboration, evidence-based protocols, and continuous advancements in technology and research are critical to evolving transfusion practices, minimizing risks, and improving outcomes. Ultimately, the comprehensive understanding and application of advancements in transfusion medicine during pregnancy underscore the commitment to providing optimal care. By embracing emerging knowledge, fostering collaboration, and advocating for patient-centered approaches, we pave the way for continued advancements that ensure the well-being of pregnant individuals and their babies, embodying the essence of compassionate and evidence-based obstetric care.

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Authors contribution

All the authours were involved in conceptualisation, methodology, visualization, validation, drafting and editing of the article

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Conflict of Interest

The authors declare that they have no conflict interests.

Ethical Clearance

Not applicable

References

1. Obeagu EI, Agreen FC. Anaemia among pregnant women: A review of African pregnant teenagers. J Pub Health Nutri. 2023; 6 (1). 2023;138. links/63da799664fc860638054562/Anaemia-among-pregnant-women-A-review-of-African-pregnant-teenagers.pdf.

2. Obeagu EI, Ezimah AC, Obeagu GU. Erythropoietin in the anaemias of pregnancy: a review. Int J Curr Res Chem Pharm Sci. 2016;3(3):10-18. links/5710fae108ae846f4ef05afb/ERYTHROPOIETIN-IN-THE-ANAEMIAS-OF-PREGNANCY-A-REVIEW.pdf.

3. Obeagu EI, Adepoju OJ, Okafor CJ, Obeagu GU, Ibekwe AM, Okpala PU, Agu CC. Assessment of Haematological Changes in Pregnant Women of Ido, Ondo State, Nigeria. J Res Med Dent Sci. 2021 Apr;9(4):145-8. links/608a6728a6fdccaebdf52d94/Assessment-of-Haematological-Changes-in-Pregnant-Women-of-Ido-Ondo.pdf.

4. Obeagu EI, Obeagu GU. Sickle Cell Anaemia in Pregnancy: A Review. International Research in Medical and Health Sciences. 2023 Jun 10;6(2):10-13. http://irmhs.com/index.php/irmhs/article/view/111.

5. Jakheng SP, Obeagu EI. Seroprevalence of human immunodeficiency virus based on demographic and risk factors among pregnant women attending clinics in Zaria Metropolis, 1Nigeria. J Pub Health Nutri. 2022;5(8):2022;137. https://6317a6b1acd814437f0ad268/Seroprevalence-of-human-immunodeficiency-virus-based-on-demographic-and-risk-factors-among-pregnant-women-attending-clinics-in-Zaria-Metropolis-Nigeria.pdf https://doi.org/10.9734/sajrm/2022/v13i230295

6. Obeagu EI, Obeagu GU, Chukwueze CM, Ikpenwa JN, Ramos GF. Evaluation of Protein C, Protein S and Fibrinogen of Pregnant Women with Malaria in Owerri Metropolis. Madonna University

journal of Medicine and Health Sciences ISSN: 2814-3035. 2022;2(2):1-9.

7. Villa CH, Anselmo AC, Mitragotri S, Muzykantov V. Red blood cells: Supercarriers for drugs, biologicals, and nanoparticles and inspiration for advanced delivery systems. Advanced drug delivery reviews, 2016; 106, 88-103. https://doi.org/10.1016/j.addr.2016.02.007 PMid:26941164 PMCid:PMC5424548

8. Ross PT. Risking reproduction reproductive health among women with sickle cell disease. Wayne State University. 2013.

9. Obeagu EI, Ezimah AC, Obeagu GU. Erythropoietin in the anaemias of pregnancy: a review. Int J Curr Res Chem Pharm Sci, 2016; 3(3), 10-8.

10. Obeagu EI, Agreen FC. Anaemia among pregnant women: A review of African pregnant teenagers. J Pub Health Nutri. 2023; 6 (1), 138.

11. Obeagu EI, Ogunnaya FU. Pregnancyinduced Haematological Changes: A Key to Marternal and Child Health. European Journal of Biomedical, 2023; 10(8), 42-3.

12. Obeagu EI, Hassan AO, Adepoju OJ, Obeagu GU, Okafor CJ. Evaluation of Changes in Haematological Parameters of Pregnant Women Based on Gestational Age at Olorunsogo Road Area of Ido, Ondo State. Nigeria. Journal of Research in Medical and Dental Science, 2021; 9(12), 462-4. https://doi.org/10.9734/jpri/2022/v34i12A35546

13. Kelly SE. The maternal-foetal interface and gestational chimerism: the emerging importance of chimeric bodies. Science as Culture, 2012; 21(2), 233-257. https://doi.org/10.1080/09505431.2011.628014

14. Sharma S, Banerjee S, Krueger PM, Blois SM. Immunobiology of gestational diabetes mellitus in post-medawar era. Frontiers in Immunology, 2022; 12, 758267. https://doi.org/10.3389/fimmu.2021.758267 PMid:35046934 PMCid:PMC8761800

15. Osborne C, Kolakowski M, Lobenstine D. Pre-and Perinatal Massage Therapy: A Comprehensive Guide to Prenatal, Labor and Postpartum Practice. Jessica Kingsley Publishers. 2021.

16. Gamde MS, Obeagu EI. Iron Deficiency Anaemia: Enemical to Pregnancy. European Journal of Biomedical, 2023; 10(9), 272-275.

17. Obeagu EI, Hassan AO, Adepoju OJ, Obeagu GU, Okafor CJ. Evaluation of Changes in Haematological Parameters of Pregnant Women Based on Gestational Age at Olorunsogo Road Area of Ido, Ondo State. Nigeria. Journal of Research in Medical and Dental Science. 2021;9(12):462-. https://doi.org/10.9734/jpri/2022/v34i12A35546

18. Obeagu EI, Ikpenwa JN, Chukwueze CM, Obeagu GU. Evaluation of protein C, protein S and fibrinogen of pregnant women in Owerri Metropolis. Madonna University Journal of Medicine and Health Sciences, 2022; 2(1): 292-298.

19. Obeagu EI. Comparative Study of Serum Iron and Hemoglobin Levels of Cord Blood of Normal Neonates and that of Maternal Blood in Federal Medical Centre Owerri. Journal of Clinical and Laboratory Research, 2021;4(1): 2768-0487.

20. Anyiam AF, Obeagu EI, Obi E, Omosigho PO, Irondi EA, Arinze-Anyiam OC, Asiyah MK. ABO blood groups and gestational diabetes among pregnant women attending University of Ilorin Teaching Hospital, Kwara State, Nigeria. International Journal of Research and Reports in Hematology, 2022; 5(2), 113-121.

21. Obeagu EI. Gestational Thrombocytopaenia. J Gynecol Women's Health, 2023; 25(3), 556163. https://doi.org/10.19080/JGWH.2023.25.556163

22. Jakheng SPE, Obeagu EI. Seroprevalence of human immunodeficiency virus based on demographic and risk factors among pregnant women attending clinics in Zaria Metropolis, Nigeria. J Pub Health Nutri. 2022; 5 (8), 137. https://doi.org/10.9734/sajrm/2022/v13i230295

23. Obeagu EI, Gamade SM, Obeagu GU. The roles of Neutrophils in pregnancy. Int. J. Curr. Res. Med. Sci, 2023; 9(5), 31-35.

24. Orefice R. Immunology and the immunological response in pregnancy. Best practice & research Clinical obstetrics & gynaecology, 2021; 76, 3-12. https://doi.org/10.1016/j.bpobgyn.2020.07.013 PMid:33191116

25. Robertson SA, Care AS, Moldenhauer LM. Regulatory T cells in embryo implantation and the immune response to pregnancy. The Journal of clinical investigation, 2018;128(10), 4224-4235. https://doi.org/10.1172/JCI122182 PMid:30272581 PMCid:PMC6159994

26. Burton GJ, Fowden AL, Thornburg KL. Placental origins of chronic disease. Physiological reviews, 2016; 96(4), 1509-1565. https://doi.org/10.1152/physrev.00029.2015 PMid:27604528 PMCid:PMC5504455

27. Chighizola CB, Lonati PA, Trespidi L, Meroni PL, Tedesco F. The complement system in the pathophysiology of pregnancy and in systemic autoimmune rheumatic diseases during pregnancy. Frontiers in immunology, 2020; 11, 2084. https://doi.org/10.3389/fimmu.2020.02084 PMid:32973817 PMCid:PMC7481445

28. Robinson DP, Klein SL. Pregnancy and pregnancy-associated hormones alter immune responses and disease pathogenesis. Hormones and behavior, 2012; 62(3), 263-271. https://doi.org/10.1016/j.yhbeh.2012.02.023 PMid:22406114 PMCid:PMC3376705

29. Okorie HM, Obeagu EI, Obarezi HC, Anyiam AF. Assessment of some inflammatory cytokines in malaria infected pregnant women in Imo State Nigeria. International Journal of Medical Science and Dental Research, 2019; 2(1), 25-36.

30. Emeka-Obi OR, Ibeh NC, Obeagu EI, Okorie HM. Evaluation of levels of some inflammatory cytokines in preeclamptic women in owerri. Journal of Pharmaceutical Research International, 2021; 33(42A), 53-65. https://doi.org/10.9734/jpri/2021/v33i42A32384

31. Ifeanyi OE, Vincent CCN, Ugochi CMJ. Studies on some cytokines of apparently healthy Nigerian women aged 10-40 years. Int. J. Curr. Res. Med. Sci, 2019; 5(12), 24-30.

32. Obeagu EI, Okoroiwu IL, Obeagu GU. Relationship between Thrombopoietin and Interleukin 3: A Review. Int J Curr Res Chem Pharm. Sci, 2022; 9(1), 7-13.

33. Obeagu EI, Muhimbura E, Kagenderezo BP, Nakyeyune S, Obeagu GU. An Insight of Interleukin-6 and Fibrinogen: In Regulating the Immune System. J Biomed Sci, 2022; 11(10), 83.

34. Ifeanyi O, Uzoma O, Amaeze A, Ijego A, Felix C, Ngozi A, ... Chinenye K. Maternal expressions (serum levels) of alpha tumour necrosis factor, interleukin 10, interleukin 6 and interleukin 4 in malaria infected pregnant women based on parity in a Tertiary Hospital in Southeast, Nigeria. Journal of Pharmaceutical Research International, 2020; 32(23), 35-41. https://doi.org/10.9734/jpri/2020/v32i2330786

35. Obeagu E, Felix CE, MTB O, Chikodili UM, Nchekwubedi CS, Chinedum OK. Studies on some cytokines, CD4, iron status, hepcidin and some haematological parameters in pulmonary tuberculosis patients based on duration of treatment in Southeast, Nigeria. African Journal of Biological Sciences, 2021; 3(1), 146-156. https://doi.org/10.33472/AFJBS.3.1.2021.146-156

36. Obeagu EI, Amedu GO, Okoroiwu IL, Okafor CJ, Okun O, Ochiabuto OM, Ukeekwe CO. Evaluation of plasma levels of interleukin 6 and iron status of football players in a Nigerian university. Journal of Pharmaceutical Research International, 2021; 33(59B), 383-388. https://doi.org/10.9734/jpri/2021/v33i59B34393

37. Obeagu EI, Obeagu GU, Guevara MEC, Okafor CJ, Bot YS, Eze GC, ... Uwakwe OS. Evaluation of Plasma Levels of Interleukin 6 and Iron of Volleyball Players Based on Heights and Weight of a Nigerian University Students. Asian Journal of Medicine and Health, 2022; 20(10), 147-152. https://doi.org/10.9734/ajmah/2022/v20i1030515

38. Macpherson AJ, de Agüero MG, Ganal-Vonarburg SC. How nutrition and the maternal microbiota shape the neonatal immune system. Nature Reviews Immunology, 2017; 17(8), 508-517. https://doi.org/10.1038/nri.2017.58 PMid:28604736

39. García-Roa M, del Carmen Vicente-Ayuso M, Bobes AM, Pedraza AC, González-Fernández A, Martín MP, ... Gutiérrez L. Red blood cell storage time and transfusion: current practice, concerns and future perspectives. Blood Transfusion, 2017; 15(3), 222.

40. Obeagu EI, Babar Q, Obeagu GU. Allergic blood Transfusion reaction: A Review. Int. J. Curr. Res. Med. Sci. 2021; 7(5):25-33.

41. Obeagu EI, Oshim IO, Ochei KC, Obeagu GU. Iron and blood donation: A Review. Int. J. Curr. Res. Med. Sci. 2016; 2(10):16-48.

42. Okoroiwu IL, Obeagu EI, Elemchukwu Q, Ochei KC, Christian GS. Frequency of Transfusion Reactions Following Compatible Cross Matching of Blood: A Study in Owerri Metropolis. International Journal of Current Research and Academic Review. 2015; 3(1):155-60.

43. Ogar CO, Okoroiwu HU, Obeagu EI, Etura JE, Abunimye DA. Assessment of blood supply and usage pre-and during COVID-19 pandemic: a lesson from non-voluntary donation. Transfusion Clinique et Biologique. 2021; 28(1):68-72. https://doi.org/10.1016/j.tracli.2020.10.004 PMid:33080420 PMCid:PMC7836417

44. Brand A. Immunological complications of blood transfusions. La Presse Médicale, 2016; 45(7-8), e313-e324. https://doi.org/10.1016/j.lpm.2016.06.024 PMid:27499223

45. Montgomery RA, Tatapudi VS, Leffell MS, Zachary AA. HLA in transplantation. Nature reviews nephrology, 2018; 14(9), 558-570. https://doi.org/10.1038/s41581-018-0039-x PMid:29985463

46. Neal MD, Raval JS, Triulzi DJ, Simmons RL. Innate immune activation after transfusion of stored red blood cells. Transfusion medicine reviews, 2013; 27(2), 113-118. https://doi.org/10.1016/j.tmrv.2013.01.001 PMid:23434246

47. Tormey CA, Hendrickson JE.Transfusion-related red blood cell alloantibodies: induction and consequences. Blood, The Journal of the American Society of Hematology, 2019; 133(17), 1821-1830. https://doi.org/10.1182/blood-2018-08-833962 PMid:30808636 PMCid:PMC6484385

48. Johnsen J. Pathogenesis in immune thrombocytopenia: new insights. Hematology 2010, the American Society of Hematology Education Program Book, 2012(1): 306-312. https://doi.org/10.1182/asheducation.V2012.1.306.3798320 PMid:23233597

49. Remy KE, Hall MW, Cholette J, Juffermans NP, Nicol K, Doctor A. Pediatric Critical Care Blood Research Network (Blood Net). Mechanisms of red blood cell transfusion-related immunomodulation. Transfusion, 2018; 58(3), 804-815. https://doi.org/10.1111/trf.14488 PMid:29383722 PMCid:PMC6592041

50. Alegre ML, Lakkis FG, Morelli AE. Antigen presentation in transplantation. Trends in immunology, 2016; 37(12), 831-843. https://doi.org/10.1016/j.it.2016.09.003 PMid:27743777 PMCid:PMC5135637

51. Davenport RD. An introduction to chemokines and their roles in transfusion medicine. Vox sanguinis, 2009; 96(3), 183-198. https://doi.org/10.1111/j.1423-0410.2008.01127.x PMid:19076338

52. Brown CJ, Navarrete CV. Clinical relevance of the HLA system in blood transfusion. Vox sanguinis, 2011; 101(2), 93-105. https://doi.org/10.1111/j.1423-0410.2011.01474.x PMid:21535436

53. Leventhal JS, Schröppel B. Toll-like receptors in transplantation: sensing and reacting to injury. Kidney international, 2012; 81(9), 826-832. https://doi.org/10.1038/ki.2011.498 PMid:22297675

54. Hendrickson JE, Tormey CA. Understanding red blood cell alloimmunization triggers. Hematology 2014, the American Society of Hematology Education Program Book, 2016(1), 446-451. https://doi.org/10.1182/asheducation-2016.1.446 PMid:27913514 PMCid:PMC6142457

55. Sarkesh A, Sorkhabi AD, Ahmadi H, Abdolmohammadi-Vahid S, Parhizkar F, Yousefi M. Aghebati-Maleki L. Allogeneic lymphocytes immunotherapy in female infertility: lessons learned and the road ahead. Life Sciences, 2022; 299, 120503. https://doi.org/10.1016/j.lfs.2022.120503 PMid:35381221

56. Aguilar-Nascimento JE, Zampieri-Filho JP, Bordin J O. Implications of perioperative allogeneic red blood cell transfusion on the immune-inflammatory response. Hematology, Transfusion and Cell Therapy, 2021; 43: 58-64. https://doi.org/10.1016/j.htct.2020.03.003 PMid:32532624 PMCid:PMC7910182

57. Vamvakas EC, Blajchman MA. Deleterious clinical effects of transfusion-associated immunomodulation: fact or fiction? Blood, The Journal of the American Society of Hematology, 2001; 97(5), 1180-1195. https://doi.org/10.1182/blood.V97.5.1180 PMid:11222359

58. Tormey CA, Hendrickson JE. Transfusion-related red blood cell alloantibodies: induction and consequences. Blood, The Journal of the American Society of Hematology, 2019; 133(17): 1821-1830. https://doi.org/10.1182/blood-2018-08-833962 PMid:30808636 PMCid:PMC6484385

59. Gonzalez CA, Gonzalez S. Fetal and neonatal allo-immune response. Transfusion and Apheresis Science, 2020; 59(5): 102945. https://doi.org/10.1016/j.transci.2020.102945 PMid:32958398

60. Brown JB, Neal MD, Guyette FX, Peitzman AB, Billiar TR, Zuckerbraun BS, Sperry J. L. Design of the study of tranexamic acid during air medical prehospital transport (STAAMP) trial: addressing the knowledge gaps. Prehospital Emergency Care, 2015; 19(1), 79-86. https://doi.org/10.3109/10903127.2014.936635 PMid:25076119 PMCid:PMC4623322

61. Yusoff SM, Bahar R, Hassan MN, Noor NHM, Ramli M, Shafii NF. Prevalence of red blood cell alloimmunization among transfused chronic kidney disease patients in hospital Universiti Sains Malaysia. Oman medical journal, 2020; 35(5): e177. https://doi.org/10.5001/omj.2020.95 PMid:33083035 PMCid:PMC7538639

62. Day JD, Cockrell C, Namas R, Zamora R, An G, Vodovotz Y. Inflammation and disease: modelling and modulation of the inflammatory response to alleviate critical illness. Current opinion in systems biology, 2018; 12, 22-29. https://doi.org/10.1016/j.coisb.2018.08.008 PMid:30886940 PMCid:PMC6420220