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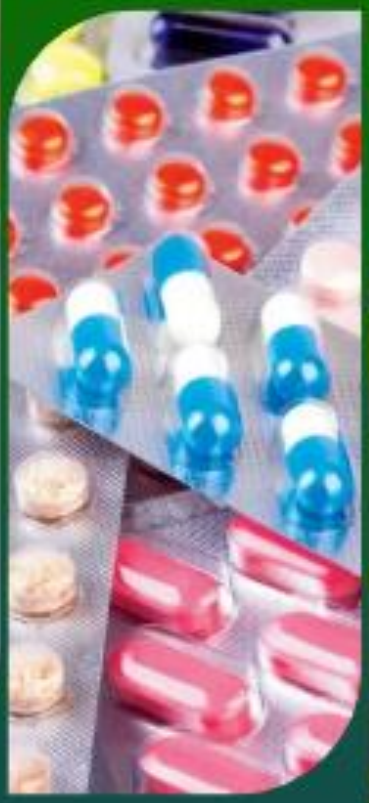

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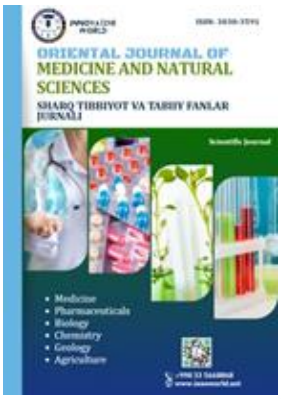

Clinical Consequences of Donor Red Blood Cell Membrane Alterations in Blood Transfusion

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Annotatsiya: Maqolada donor eritrotsitlarining saqlanish jarayonida yuz beradigan membrana o'zgarishlari — energiya tanqisligi, ionlar muvozanati buzilishi, oksidlanish va mikrovezikulalar hosil bo'lishi kabi holatlar tahlil qilingan. Ushbu o'zgarishlar transfuziya samaradorligini pasaytiradi, immun va trombotik asoratlar chaqiradi hamda organ disfunktsiyasiga olib kelishi mumkin. Mualliflar bu jarayonlarni kamaytirish uchun saqlash muddatini qisqartirish, qonni yuvish va filtrlash, hamda antioksidant vositalar qo'llashni tavsiya etadi.

Kalit so'zlar: Eritrotsit membranasi, donor qon, saqlash shikastlanishi, oksidlovchi stress, mikrovezikulalar, transfuzion asoratlar, antioksidantlar.

Abstract

Blood transfusion remains a cornerstone of modern medicine, often serving as a lifesaving intervention. However, during storage, donor red blood cells (RBCs) undergo biochemical and structural changes, collectively known as storage lesions, that affect their membrane integrity. These alterations may reduce transfusion efficacy and cause clinical complications such as immune reactions, thrombosis, and organ dysfunction. This review highlights the structural basis of RBC membranes, the nature of storage-induced changes, their clinical consequences, and potential strategies to mitigate these effects.

Introduction

Red blood cell transfusion is widely used in clinical practice for the management of anemia, trauma, surgical procedures, and hematological disorders. The success of transfusion largely depends on the structural and functional integrity of donor erythrocytes. During storage, erythrocytes are subjected to metabolic depletion, oxidative stress, and membrane remodeling, which together are referred to as storage lesions. These changes compromise red blood cell survival and functionality, potentially leading to adverse clinical outcomes. This article reviews the nature of donor erythrocyte membrane alterations and their clinical implications.

Structure and Function of the Red Blood Cell Membrane

The RBC membrane is a highly specialized structure composed of a phospholipid bilayer, integral proteins, and an underlying cytoskeletal network. It ensures cell deformability, ion exchange, and stability while maintaining oxygen transport efficiency. Key components include spectrin,

ankyrin, band 3 protein, and various ion channels. Any disturbance in these elements during storage can significantly impact RBC functionality.

Storage Lesion and Biochemical Changes in Donor RBCs

During storage, RBCs undergo a series of structural and metabolic changes known as storage lesions. These include:

- Depletion of adenosine triphosphate (ATP) and 2,3-bisphosphoglycerate (2,3-BPG).
- Imbalance of intracellular and extracellular ions (Na+, K+, Ca2+).
- Lipid peroxidation and oxidative damage.
- Externalization of phosphatidylserine.
- Shedding of microvesicles from the membrane.

These alterations not only shorten the lifespan of transfused RBCs but also have important immunological and hemodynamic consequences.

Clinical Consequences of Membrane Alterations

The membrane changes in donor erythrocytes are associated with several clinical effects:

- Reduced oxygen delivery capacity.
- Increased risk of alloimmunization and hemolytic reactions.
- Enhanced prothrombotic activity due to microvesicle release and phosphatidylserine exposure.
- Inflammatory responses leading to transfusion-related acute lung injury (TRALI).
- Organ dysfunction caused by impaired microcirculation.

Diagnostic and Monitoring Approaches

Various laboratory methods are employed to study and monitor RBC membrane alterations, including:

- Flow cytometry for detecting phosphatidylserine and microvesicles.
- Biochemical assays to measure ATP, 2,3-BPG, and potassium leakage.
- Morphological studies using electron microscopy.

These approaches provide valuable insights into the quality and functional viability of stored RBCs.

Strategies to Minimize Adverse Effects

Several strategies have been proposed to mitigate the negative impact of storage lesions, such as:

- Shortening storage duration to maintain RBC quality.
- Washing and filtering donor blood before transfusion.
- Adding antioxidant agents (e.g., vitamin C, N-acetylcysteine).
- Using rejuvenation solutions to restore ATP and 2,3-BPG levels.

These measures aim to enhance the safety and efficacy of blood transfusions.

Discussion

The balance between transfusion necessity and potential risks must be carefully considered in clinical practice. Storage lesions represent a significant

challenge in transfusion medicine. While current practices ensure safety, further optimization of storage conditions and post-storage treatments are essential. Advanced molecular tools are improving our understanding of these processes and could lead to more effective solutions in the future.

Conclusion

Donor erythrocyte membrane alterations during storage have clinically significant consequences. Recognition of these changes is essential for improving transfusion outcomes. Innovations in blood storage technology and targeted interventions hold promise for minimizing adverse effects and maximizing patient benefit.

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