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Platelets And Their Vital Functions: A Comprehensive Educational Medical Study

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Abstract:

This study aimed to shed light on platelets in terms of their structure, vital functions, and medical importance, focusing on associated disorders to promote health awareness and community education. The study addressed the nature of platelets, their primary role in blood coagulation, and their various medical uses, particularly in supporting cancer patients during chemotherapy. It also highlighted the importance of platelet donation as a vital means to improve treatment outcomes. To achieve the study's objective, a descriptive methodology was used to describe the current reality and necessary requirements, along with practical recommendations. The results confirmed that platelets are produced through two main methods: the manual method and apheresis, each with its advantages and disadvantages. It was indicated that platelet disorders directly affect patients' health, with symptoms ranging from bleeding to thrombosis, necessitating early detection and appropriate treatment. It was also shown that Platelet-Rich Plasma (PRP) contributes to stimulating tissue regeneration and increasing mature bone density by up to 30%, and plays a central role in various stages of wound healing by promoting the proliferation of stem cells, osteoblasts, and fibroblasts. The results confirmed that the assessment of response to platelet transfusion is performed using apheresis technology by calculating the Corrected Count Increment (CCI) after the transfusion procedure. The study recommends increasing community awareness campaigns, integrating platelet concepts into educational curricula, and encouraging regular voluntary donation. It also recommends training medical personnel and stimulating scientific research to develop platelet-related treatments, aiming to improve the quality of healthcare, especially in the fields of hematology and oncology.

Keywords: Platelets, Platelet Disorders, Blood Coagulation, Platelet Donation, Health Awareness, Platelet-Rich Plasma (PRP).

Introduction:

Platelets are small, disc-shaped, anucleate cells with a diameter ranging from 2.0 to 4.0 micrometers. They circulate in the bloodstream for 7 to 10 days before being removed, primarily by the reticuloendothelial

system. Approximately 100 billion platelets are produced daily from megakaryocytes to maintain a normal platelet count ranging between 150 and 400 × 10^9/L (Albanyan, 2015).

With the increasing demand for platelet concentrates, collecting more than one platelet unit through apheresis from a single donor provides significant benefits by strategically improving donor and inventory management. This also contributes to reducing the cost per produced unit by at least half, in addition to lowering operational costs. The U.S. Food and Drug Administration (FDA) requires that a donor's platelet count before donation be no less than 150 × 10^3/μL, and the post-donation count be no less than 100 × 10^3/μL. These criteria are adjusted in apheresis devices during platelet collection (Malodan et al, 2023).

Platelet transfusion is one of the most prominent forms of vital therapeutic support for patients suffering from thrombocytopenia, a condition that exposes patients to the risk of severe bleeding and serious health complications. Platelet transfusion is primarily used to treat acute bleeding in these patients, as well as to prevent bleeding in cases of chronic thrombocytopenia or that resulting from diseases or treatments affecting platelet production. It is also beneficial in cases of rare functional platelet disorders, where the count is not necessarily low, but the platelets do not function properly (Aboul Enein et al, 2007).

Platelet-Rich Plasma (PRP) is of great importance in medical fields, particularly in accelerating the healing of soft and hard tissues, due to its high concentration of platelets and potent growth factors. Studies have proven that PRP contributes to stimulating tissue regeneration and increasing mature bone density by up to 30%. Moreover, the growth factors secreted from it, such as PDGF, play a pivotal role in various stages of wound healing by promoting the proliferation of stem cells, osteoblasts, and fibroblasts. Due to its biological properties, PRP has become a promising therapeutic option in fields such as orthopedics and oral and maxillofacial surgery, especially after its official approval by international health bodies, which has enhanced its use in treating musculoskeletal problems (Sari, 2022).

Platelets are a fundamental component of blood and play a vital role in maintaining body balance by contributing to the blood coagulation process and preventing bleeding. With the growing interest in health awareness, it has become important to highlight this blood component, which is often neglected in general health culture.

Therefore, this research aims to provide a comprehensive educational medical study on platelets by clarifying their nature, vital functions, and location in the body, in addition to reviewing their medical importance, especially in pathological conditions such as cancer and bleeding disorders. The research also addresses the importance of platelet donation and its clinical uses, presents the most prominent signs and symptoms resulting from imbalances in their count, along with medical examinations and available treatments. The research concludes with practical guidance for maintaining platelet health, within a framework aimed at promoting community education and preventive awareness.

Study Problem:

Platelets, also known as thrombocytes, are small blood cells that play a vital role in blood coagulation by forming a plug to stop bleeding. Platelet donation is important because they are essential for patients undergoing cancer treatment, surgeries, or those with bleeding disorders. Several factors affect platelet levels, including donor health, the apheresis process, and storage conditions.

Platelets are a fundamental component of blood, playing a vital role in the blood coagulation process and stopping bleeding. However, many individuals are unaware of their nature and functions, do not realize the importance of donating them, or understand the impact of their disorders on public health, especially in cases like cancer.

Despite the critical importance of platelets in the human body and their pivotal role in maintaining circulatory integrity and preventing bleeding, public awareness of their nature, functions, and medical uses remains limited within the community, even among some educated groups. There is also a noticeable deficiency in recognizing the importance of platelet donation, especially for cancer patients and those suffering from chronic blood disorders. This deficiency is exacerbated by the scarcity of simplified educational resources that inform individuals about the symptoms of platelet disorders, methods of examination, and ways to maintain their balance.

Hence, the research problem emerges in the need to shed light on platelets in terms of their structure, functions, medical uses, and the importance of maintaining their balance, which contributes to raising health awareness, addressing the knowledge gap, and preventing complications resulting from their decrease or dysfunction. This is achieved by providing comprehensive educational medical content that contributes to raising the level of health awareness and explains the dimensions of these vital blood components in a simplified yet scientific manner.

Consequently, the research problem of the study can be formulated in the following main question: **What is the physiological and medical role of platelets, and how important is it to preserve and support their use in modern treatments?**

Study Objectives:

The main objective of the study is to highlight platelets in terms of their functions, medical importance, and the most prominent associated disorders, aiming to raise health awareness and promote community education about them.

From this main objective, the following sub-objectives emerge:

1. To identify the nature, structure, and location of platelets in the body.
2. To clarify the functions of platelets in the body and their role in the blood coagulation process.
3. To review the most prominent medical uses of platelets, especially in treating cancer patients.
4. To highlight the importance of platelet donation in supporting patients and improving treatment outcomes.
5. To monitor defects associated with platelets in donors.
6. To review examination and treatment methods for conditions related to low or high platelet counts.
7. To provide scientific recommendations and proposals that contribute to enhancing community awareness of the importance of platelets, highlighting their therapeutic role, particularly in supporting cancer patients, with a focus on encouraging regular voluntary donation as part of community health responsibility.

Study Importance:

The importance of the study stems from two aspects, one theoretical and the other practical, as explained below:

Theoretical Importance: The theoretical importance of this study lies in its contribution to enriching scientific knowledge about one of the fundamental components of blood, namely platelets, in terms of their structure, functions, and vital roles. The study also enhances the theoretical understanding of associated disorders, which benefits students, healthcare practitioners, and those interested in the medical field.

Practical Importance: The practical importance lies in providing simplified scientific information that contributes to raising community awareness about the importance of platelets and supporting donation programs, especially for patients suffering from chronic diseases like cancer. The study also helps in

understanding the warning signs associated with platelet disorders and methods of prevention and treatment. Furthermore, this study contributes to clarifying the difference between whole blood donation and platelet donation and highlights the groups that desperately need them, which may encourage voluntary donation. Additionally, the study may help raise people's awareness of the importance of periodic check-ups, contributing to the early detection of health problems and avoiding serious complications like bleeding or thrombosis.

Study Methodology:

Given the nature of the study and the research problem it addresses, and in light of the objectives the study seeks to achieve, it is evident that the descriptive method is the most appropriate research methodology for preparing the current study.

Especially since research using the descriptive method seeks to describe the reality of problems and phenomena as they are, or to determine the ideal state these phenomena should be in, based on specific criteria, while providing recommendations or proposals that would contribute to modifying reality to achieve the desired state of these phenomena (Al-Nuaimi et al., 2015).

Previous Studies:

A number of relevant previous studies are presented below:

First: Arabic Studies:

A study (Bakri et al., 2019). This study aimed to prepare a physical rehabilitation program supported by Platelet-Rich Plasma (PRP) injections to measure its effect on alleviating pain and improving the range of motion of the knee joint in individuals with first-degree medial meniscus tears. The researcher used the experimental method with three experimental groups: the first underwent both rehabilitation exercises and injections, the second underwent exercises only, and the third received injections only. The sample consisted of 11 students from the Faculty of Physical Education at Beni Suef University. The results showed that the rehabilitation program accompanied by PRP injections achieved the greatest improvement in pain reduction (70.17%) and increased range of motion (20.89%), compared to the rehabilitation program alone or injections only. The injections-only group showed no improvement in range of motion; rather, a regression of 2.78% was observed.

A study (Ismail, 2020). It aimed to study the effect of applying Platelet-Rich Plasma alongside rehabilitation exercises in and out of water on osteitis pubis in a group of athletes. This included assessing the extent of this intervention's impact on pain relief and improving pelvic joint flexibility in adduction, abduction, flexion, and extension movements. The experimental method was followed using a single experimental group design, suitable for the nature and objectives of the study. The sample consisted of 10 football players from the junior and youth categories, selected purposively from among those diagnosed with osteitis pubis by specialized medical diagnosis, and the study was applied to 8 of them as the core sample. The results showed statistically significant differences between pre- and post-measurements of the strength of the muscle groups responsible for pelvic joint movements (adduction, abduction, flexion, extension), where this strength improved significantly after applying the training program and PRP therapy.

A study (Zaghloul & Gaballah, 2020). It aimed to study the effect of a rehabilitation program on the concentration of some blood cytokines after PRP injection, aiming to accelerate the recovery of athletes with hamstring muscle tears. The research was based on the experimental method and included a sample of 16 athletes suffering from a second-degree tear of the biceps femoris muscle. Various tools were used, such as measuring muscle strength with a dynamometer, measuring range of motion, and analyzing blood samples to examine growth factor concentrations. The rehabilitation program included aquatic exercises and various devices to improve strength and flexibility. The results showed that integrating aquatic

rehabilitation with PRP injections significantly contributed to increased muscle strength, improved range of motion, and accelerated recovery due to elevated growth factor concentrations.

A study (Al-Kinani & Muhammad, 2021). This study aimed to study the impact of using in-water rehabilitation training supported by Platelet-Rich Plasma (PRP) technology on accelerating the healing of first-degree muscle tears in junior squash players. The study relied on the experimental method, and a number of tools were used to measure various variables, including a form for collecting basic data, a stadiometer for measuring height, a medical scale for weight, an ultrasonography device for diagnosing injuries, a centimeter tape for circumferential measurements, a goniometer for determining range of motion, in addition to tools specific to the rehabilitation program, and a dynamometer for measuring muscle strength. The rehabilitation program was applied to a sample of ten junior female players aged between 12 and 14 years, who had a first-degree muscle tear in the gastrocnemius muscle, all from the Mansoura Sports Club during the 2019/2020 training season. The results showed statistically significant differences at a significance level of (0.05) between pre- and post-measurements in a number of physical and physiological indicators, indicating the effectiveness of the program used.

A study (Al-Trabelsi, 2022). This study addressed the impact of an exercise program coupled with PRP injections on treating knee joint roughness after meniscectomy. The conceptual framework included an explanation of the concept of PRP and the erythrocyte sedimentation rate. The research used the experimental method, and its tools included devices for measuring height and weight, pain assessment, and a Biodex device for measuring strength and range of motion. The research was applied to a sample of 12 athletes with knee roughness, aged between 22 and 30 years, with sports experience of up to ten years. The results showed statistically significant differences in range of motion and muscle strength after the program.

A study (Sayed, 2022). It aimed to reveal the effect of PRP injections with aquatic rehabilitation on athletes with a partial tear of the medial meniscus. The research followed the experimental method and used a set of diverse tools and techniques to assess motor functions, strength, and balance. The sample included 12 players randomly selected from the motor rehabilitation center, excluding any cases with chronic diseases. The results showed that combining aquatic rehabilitation with PRP injections contributed to improving the range of motion of the knee joint by 20.89%, while aquatic rehabilitation alone led to an improvement of 14.55%. Using injections only did not improve the range of motion but caused a regression of 2.78%. Based on this, the research recommended the importance of integrating PRP injections with organized rehabilitation programs to enhance recovery in injured individuals.

A study (Al-Karsawi, 2024). The study aimed to design a physical rehabilitation program accompanied by an isokinetic device and PRP injections to evaluate its effect on the functional capacities of athletes with knee joint roughness. The variables included measuring the muscle strength of the thigh muscles in flexion and extension movements at angles (90°, 180°), thigh circumferences, calf circumference, knee range of motion in flexion and extension, pain level, in addition to comparing the affected knee joint with the healthy one. The researcher used the experimental method with two groups: an experimental group (10 individuals) who underwent the rehabilitation program with PRP injections, and a control group (10 individuals) who received PRP injections only. The participants' ages were between 30 and 35 years. The results showed a noticeable improvement in the knee's motor functions in the experimental group compared to the control, indicating the effectiveness of integrating the rehabilitation program with PRP injections.

Second: Foreign Studies:

A study (Aboul Enein et al, 2007). The objective of this study was to analyze the effect of a set of donor factors and technical criteria of devices on platelet (PLT) yield in 127 platelet apheresis collections, to improve yield and achieve clinical and economic benefits. 127 procedures were analyzed. Donor predictor variables included age, sex, processed blood volume, hemoglobin (Hb) level, and pre-donation platelet count. The anticoagulant (AC) pump rate, processing time, and volume of plasma collected with platelets were assessed as device-related factors. The effectiveness of platelet transfusion post-procedure was

evaluated in 23 thrombocytopenic patients, studying the impact of platelet dose, ABO blood group, and platelet storage duration. The results showed that females provided higher yields compared to males ($P<0.01$). Platelet yield had a positive correlation with pre-donation platelet count ($r=0.512$) and total blood volume (TBV) ($r=0.404$), and a negative relationship with pre-procedure hemoglobin level ($r=-0.306$). Both processing time and anticoagulant pump rate had a positive effect on platelet yield.

A study (Du et al, 2016). This study aimed to explore whether T lymphocytes, B lymphocytes, platelet antigens CD41a and CD61, or antiplatelet antibodies play a role in platelet transfusion refractoriness. The study included 47 patients diagnosed with platelet transfusion refractoriness and 32 patients who showed an effective response to platelet therapy. Flow Cytometry technology was used to detect the percentage of cytotoxic T cells ($CD3^+CD4^-CD8^+$), helper T cells ($CD3^+CD4^+CD8^-$), B lymphocytes ($CD19^+$), in addition to detecting the expression of platelet glycoproteins CD41a and CD61. Antiplatelet antibodies were measured using the Solid-Phase Agglutination method. The results indicate that the activation of cytotoxic T cells, inhibition of helper T cells, elevated expression of platelet glycoproteins CD41a and CD61, along with the formation of antiplatelet antibodies, constitute immune mechanisms contributing to platelet transfusion refractoriness.

A study (Hao et al, 2017). This study aimed to evaluate the clinical efficacy of manually derived buffy coat platelet concentrates compared to automatically collected concentrates via apheresis technology, in terms of their therapeutic effect on patients. The study included two groups, the first comprising 72 patients who received automatically collected platelet concentrates, and the second comprising 83 patients who received manually derived platelet concentrates. The Corrected Count Increment (CCI) was measured before and after transfusion, in addition to assessing patients' clinical symptoms. The results showed that the mean CCI after one hour was 13.56±4.45 and 8.67±4.21 after 24 hours in the first group, while in the second group it was 15.83±4.65 after one hour and 9.57±3.36 after 24 hours. The efficacy rate according to the CCI value was 53% in the first group and 64% in the second, while the efficacy rates based on clinical symptoms were 67% and 60% respectively. The study concluded that the clinical efficacy of manually derived platelet concentrates was similar to those collected automatically, supporting their potential use in clinical applications.

A study (Kukar et al, 2018). The study aimed to identify donor-related factors affecting the quantity of platelets collected via plateletpheresis, in order to improve the efficiency of platelet transfusion and reduce the need for repeated transfusions. The study was conducted in the Department of Hematology and Blood Transfusion (IHBT) on a sample of 140 healthy donors selected according to the provisions of the Drugs and Cosmetics Act, over a period of one full year. Plateletpheresis procedures were performed using a Haemonetics MCS Plus device, and the variables analyzed included: donor age, sex, hemoglobin concentration, hematocrit, and pre-donation platelet count. Pearson's correlation coefficient was used to analyze the relationship between these variables and platelet yield. The results showed that the mean platelet yield was $3.19\pm0.48 \times 10^{11}$ units, while the mean pre-donation platelet count was $2.77\pm0.46 \times 10^5/\mu L$, and the mean donor age was 30.31 ± 8.14 years. The study revealed a statistically significant positive correlation between the pre-donation platelet count and platelet yield ($r=0.318$, $P=0.0001$), while no significant relationship was recorded with the other variables such as hemoglobin, hematocrit, or age. The study concludes that selecting donors with a higher pre-donation platelet count can contribute to improving collection efficiency, reduces the number of platelet transfusions, and thus reduces patients' repeated exposure to donors, yielding tangible clinical and economic benefits.

A study (Prawita et al, 2019). The aim of this study was to determine the therapeutic response to platelet transfusion by measuring the Corrected Count Increment (CCI) one hour and 24 hours post-transfusion. This study is a cross-sectional descriptive study that included patients who received platelet transfusion via apheresis technology. 35 samples of platelet count were examined before and after the transfusion procedure. The Corrected Count Increment (CCI) was measured one hour and 24 hours after transfusion. Descriptive statistical analysis was used to calculate the percentage and arithmetic mean. The study results

revealed that the mean number of platelets transfused was 2.7×10^{11} units. The mean platelet count before transfusion was $18.5 \times 10^{3}/\mu L$. The mean increase in platelet count after one hour was $25.4 \times 10^{3}/\mu L$, and after 24 hours it was $22.6 \times 10^{3}/\mu L$. The response to platelet transfusion, measured by CCI, reached the desired target in 63% of patients one hour after transfusion, and in 60% of them 24 hours after transfusion.

A study (Sari, 2022). This study aimed to investigate the effect of demographic and clinical factors on the platelet count in Platelet-Rich Plasma (PRP). To achieve the study's objective, a quantitative and survey methodology was used in preparing the study, and data was collected using a questionnaire. Data from 50 patients who received PRP therapy at our stem cell center were retrospectively reviewed through the electronic system. The results of this study indicate that gender, the presence of hypertension, and coronary artery disease are associated with the platelet count in PRP. Additionally, other demographic and clinical factors such as age, body mass index, blood type, diabetes, smoking, and alcohol consumption did not have a significant effect on the platelet count in PRP.

A study (Malodan et al, 2023). This study aimed to determine the threshold values of donor factors affecting the possibility of collecting high and double-dose platelets using Trima/Spectra Optia and MCS+ cell separators, by using Classification and Regression Tree (CART) analysis. The study included high-yield platelet collections ($\geq 4.5 \times 10^{11}$ platelets) using MCS+, Trima Accel, and Spectra Optia devices, where the results were classified into double dose ($\geq 6 \times 10^{11}$) and high dose (≥ 4.5 to less than 6×10^{11}). A predictive model was built using CART technology and R programming to identify donor factors associated with achieving these high yields. The study results revealed that platelet count and donor weight are the most important factors affecting the collection of a high quantity of platelets. Also, Trima/Spectra Optia devices show superiority in achieving higher success rates for double and high doses, as they require lower requirements in terms of platelet count and body weight compared to the MCS+ device.

Third: Commentary on Previous Studies:

Previous studies show a clear interest in specialized areas of platelets, particularly in therapeutic and sports applications such as PRP injections and their effect on accelerating recovery from muscle and joint injuries, in addition to focusing on rehabilitation programs accompanying these treatments. Some studies also addressed the technical aspects of platelet collection and the impact of donor factors and techniques used to improve the quality of treatments provided. Furthermore, some studies investigated immune responses related to platelet transfusion, reflecting a diversity in scientific research areas concerning platelets.

However, most previous studies focused on limited applied and therapeutic aspects of platelets, especially in the sports and rehabilitation therapy fields, or on the technical aspect of platelet collection and transfusion. They also often limited themselves to small samples and partial subjects, without comprehensive coverage of all biological, functional, medical, and social aspects related to platelets.

Hence, the importance of the current study emerges, which provides a comprehensive and integrated overview of platelets and their vital functions, in terms of:

* Detailed definition of platelets, their structure, and location within the body, providing a solid scientific foundation for understanding their nature and vital functions.

* Clarifying the functional roles of platelets, particularly in blood coagulation, a crucial aspect linking the vital functions of platelets to important medical processes.

* Reviewing modern medical uses of platelets, with a special focus on their role in treating cancer patients, a topic of great importance in the medical field that previous studies have not sufficiently addressed.

* Highlighting the importance of platelet donation, linking scientific knowledge with community practices, and promoting health awareness and social responsibility, an important axis not detailed in previous studies.

* Monitoring the signs and symptoms associated with platelet disorders and their examination and treatment methods, contributing to the educational and awareness aspect that benefits patients and the medical community.

* Providing scientific recommendations and proposals aimed at enhancing community awareness and supporting patients, with an emphasis on encouraging regular voluntary platelet donation as part of public health strategy.

Thus, the current study represents a distinctive contribution characterized by comprehensiveness and integration, as it combines the scientific, medical, educational, awareness, and social aspects all at once, making it a pioneering study that fills knowledge and application gaps not sufficiently covered by previous studies. It also enhances the possibility of improving medical practices and supporting patient treatment efforts, especially those with cancer, by raising community awareness and encouraging active participation in platelet donation.

The Concept of Platelets:

Blood represents approximately 8% of total body weight and is a special type of connective or linking tissue, consisting of a fluid (plasma) in which various types of blood cells float. Blood is composed of two main parts (Sayed, 2022):

1. **Blood Cells:** Represent about 45% of blood components and include:

* Red Blood Cells: Responsible for transporting oxygen and carbon dioxide.

* White Blood Cells: Play a pivotal role in immune defense.

* Platelets: Their number is about 150,000 to 450,000 per cubic millimeter of blood, and they are a main element in the coagulation process and stopping bleeding by forming the primary hemostatic plug upon injury.

2. **Plasma:** A clear yellow fluid that makes up about 55% of blood volume and consists of:

* Proteins, including: Albumin: regulates osmotic pressure and contributes to the transport of some substances like calcium. Globulins: of various types, such as alpha and beta (responsible for transporting hormones, fats, and vitamins) and gamma (which contains specific antibodies for immunity).

* Nutrients: such as glucose, amino acids, and fats.

* Hormones, vitamins, and enzymes: which plasma transports to various body tissues.

* Mineral salts and dissolved gases: such as sodium, potassium, calcium, magnesium, phosphate, in addition to oxygen and carbon dioxide.

Platelets are one of the fundamental components of blood; they are small, anucleate cells produced within the bone marrow from large cells called "megakaryocytes." When an injury or tissue damage occurs, the body responds immediately by sending platelets to the injury site, where they adhere to the surface of damaged blood vessels and activate to release their contents of growth factors and active proteins. These substances work to stimulate neighboring cells, activate the process of forming new blood vessels, and promote cell division and tissue regeneration, accelerating the healing process. Due to this vital role, researchers have found the possibility of preparing Platelet-Rich Plasma (PRP) from the patient's own blood and injecting it into injury sites to provide a higher concentration of platelets, which helps accelerate healing, especially in cases where the body suffers from slow recovery or chronic damage that is difficult to repair on its own (Ziyadah et al., 2022).

Platelets are defined as small, disc-shaped, anucleate blood cells that are among the fundamental components of blood and play a pivotal role in the blood coagulation process and stopping bleeding upon injury. Despite their small size, they are highly effective, as they contribute to accelerating the wound healing process by secreting growth factors and stimulatory proteins that promote tissue regeneration and accelerate recovery. These functions are vital in the body's natural healing mechanisms (Bakri et al., 2019).

Platelets exist within the bloodstream and are part of the main blood components alongside red blood cells, white blood cells, and plasma. These platelets are produced in the bone marrow and then released into the blood to perform their vital functions, such as contributing to blood coagulation and tissue regeneration upon injury. The use of Platelet-Rich Plasma stimulates tissue healing because it contains several growth factors and other various cytokines (Munir, 2022).

Platelet-Rich Plasma (PRP) is a component derived from blood plasma, prepared by concentrating platelets within a small volume of plasma. Blood plasma primarily consists of water and contains a variety of dissolved substances, including salts, various proteins such as albumin (albumin), clotting factors, immune proteins, hormones, in addition to other functional proteins involved in many vital processes in the body (Ismail et al., 2021).

Platelets typically constitute a small percentage of blood components. When using the local injection technique with Platelet-Rich Plasma (PRP) in injured muscle fibers, plasma is separated from the patient's own blood and then the platelets are concentrated in it so that their percentage in the injected sample is much higher than their normal percentage in blood. In some PRP preparations, platelet concentrations can reach 4 to 7 times the normal concentration, which is approximately 90% of the content of the injected sample and not of the total blood. This high concentration enhances the release of growth factors and cytokines that contribute to stimulating cell regeneration and accelerating the healing process of damaged muscle tissue (Zaghloul & Gaballah, 2020).

Al-Trabelsi (2022) describes Platelet-Rich Plasma as: "human blood whose components are separated to obtain a high concentration of platelets (clotting factors in the blood), which have a high potential to improve tissue treatment and accelerate the healing of soft tissues, such as muscles, tendons, and ligaments, as they stimulate the growth of new cells at the injection site" (p. 232).

Also, Platelet-Rich Plasma is defined as: a modern technique used in the treatment of many pathological conditions, based on separating a sample of the patient's blood, then processing this sample to obtain platelet-rich plasma, which is a concentrated source of autologous platelets that are injected into areas needing treatment. It contains several growth factors and other various cytokines that promote the healing of tissues and bones and eliminate inflammation and pain (Al-Karsawi, 2024).

Platelet-Rich Plasma:

Platelet-Rich Plasma (PRP) is defined as a portion of plasma components extracted from autologous blood, characterized by containing a platelet level higher than the normal level in plasma. PRP contains a high percentage of platelets, growth factors, and clotting factors. It was first used by cardiac surgeons in 1987. After a long period of discontinuation, its use was reintroduced in the first decade of the twenty-first century by oral and maxillofacial surgeons. With its approval by the U.S. Food and Drug Administration (FDA) in 2012, PRP became widely used in many musculoskeletal problems (Sari, 2022).

Platelet-Rich Plasma (PRP) is considered one of the modern and effective treatments in the field of tissue regeneration and chronic wound care. Plasma contains a large group of growth factors that contribute to stimulating cell growth and tissue regeneration, helping to accelerate the skin healing process and improve the rebuilding of damaged tissues. It also contributes to increasing the proliferation of stem cells derived from adipose tissue, which supports the body's ability to regenerate and recover better. Thanks to these properties, Platelet-Rich Plasma is widely used in cosmetic and reconstructive surgeries, especially in treating chronic ulcers and damage resulting from some chronic diseases like diabetes (Cervelli et al, 2009).

Platelet-Rich Plasma (PRP) is defined as a blood-derived component containing a high concentration of platelets exceeding the normal rate. It is obtained by drawing a blood sample from the person themselves, then processing it using a centrifuge device that separates the different blood components. Among these components, the plasma containing a high concentration of platelets is isolated. This plasma is characterized by containing large amounts of growth factors and biologically active proteins, which play an important role in tissue regeneration and accelerating the healing process (Bakri et al., 2019).

The benefits of Platelet-Rich Plasma (PRP) include the following as explained by (Cervelli et al, 2011):

1. Enhancing wound healing: Due to its high concentration of platelets that release growth factors contributing to accelerating the healing process.

2. Stimulating tissue growth: PRP stimulates the proliferation of cells such as fibroblasts and keratinocytes that help regenerate skin and body tissues.

3. Improving skin quality: Increases the production of collagen and keratin, enhancing skin elasticity and tone, and helping treat signs of aging like skin sagging.

4. Reducing inflammation and swelling: The use of PRP reduces pain and swelling after surgeries or injuries.

5. Accelerating recovery after cosmetic surgeries: Such as facelifts and breast reduction, where PRP speeds up healing and reduces the need for drains and compression bandages.

6. Increasing bone density and soft tissues: When used with bone graft materials, PRP accelerates bone formation and increases its density.

7. A natural and safe method: Because it is prepared from the patient's own blood, reducing the risk of immune reactions or infection transmission.

From the above; it is evident that Platelet-Rich Plasma enhances the body's natural repair processes, as it is used in many fields such as cosmetics, orthopedic surgery, injury treatment, and skin disease treatment.

The Importance and Functions of Platelets:

The primary function of platelets is to contribute to the blood coagulation process and stop bleeding. When an injury occurs in a blood vessel, platelets quickly interact with the injured site, adhering to the damaged vessel lining, activating, and then releasing chemicals that stimulate the aggregation of other platelets and the formation of a "primary hemostatic plug." Platelets also secrete a set of growth factors and cytokines that contribute to tissue healing and cell regeneration, which is medically utilized in wound treatment and stimulating repair in bones and soft tissues, especially when using Platelet-Rich Plasma (PRP). Additionally, platelets play a role in some immune and inflammatory processes, making them an important element in physiological balance and bodily defense (Ismail et al., 2021).

Platelets are a pivotal element not only in stopping bleeding and coagulation but also in supporting healing and cellular regeneration processes. Among their most vital functions is their ability to stimulate the formation of new blood vessels (angiogenesis), particularly in injured muscle tissue, through their secretion of important growth factors such as: Vascular Endothelial Growth Factor (VEGF), Platelet-Derived Growth Factor (PDGF), and Transforming Growth Factor-beta (TGF-β). These factors play a crucial role in activating endothelial cells, which line blood vessels, contributing to the rebuilding of fine capillaries at the injury site. Platelets also secrete cytokines and regulated inflammatory compounds that coordinate the body's response to injury and accelerate tissue repair and wound healing by activating fibroblasts and local stem cells (Zaghloul & Gaballah, 2020).

Platelets are widely known for their important and vital role in the blood clotting process, as they are used in treating many ligament injuries due to their ability to carry and transport some enzymes and growth factories associated with the healing process (Bakri et al., 2019).

Platelet Transfusion:

Platelets are small cells in the blood that play a fundamental role in the blood clotting process and stopping bleeding. When a person suffers wounds or bleeding, platelets gather at the injury site to form a clot that helps close blood vessels and prevent blood loss. Therefore, having a sufficient amount of platelets in the blood is necessary to maintain body health and prevent continuous bleeding.

In health services, blood transfusion is a vital procedure to save patients' lives and improve their health condition. Blood transfusion is performed only based on clear medical indications and emergency cases, as its inappropriate or irrational use may lead to serious, potentially fatal consequences (Krisnawati et al, 2019).

Platelet transfusion is used as a critical supportive treatment to prevent or reduce the risk of bleeding and is considered an effective procedure in improving patient condition and reducing deaths resulting from bleeding, especially since its use began in the 1950s. Research shows that prophylactic platelet transfusion in patients with hematological malignancies, such as acute leukemia, plays a major role in reducing bleeding (Ren et al, 2021).

Platelet transfusion is used to treat and prevent bleeding in patients who suffer from a deficiency in platelet count or function. Platelets prepared for transfusion can be obtained from platelet concentrates, which are collected either via the Platelet-Rich Plasma (PRP) method or the buffy coat method from whole blood, or through platelet apheresis. The platelet recovery rate in the patient's body is affected by the transfused dose, which in turn depends on the quantity of platelets collected (platelet yield) (Kukar et al, 2018).

Platelet transfusion is an effective and supportive treatment for saving the lives of patients with thrombocytopenia. There are two main types of transfused platelets (Prawita et al, 2019):

1. Random Donor Platelets: Collected from several donors and prepared in the laboratory.

2. Apheresis Platelets: Collected using a special device that separates platelets directly from a single donor, sometimes called "single-donor platelets." This type contains a larger amount of platelets compared to regular platelets and reduces the risk of infection transmission because it is from a single source only.

The procedures for platelet transfusion are as follows:

1. Platelet Collection:When using the automated donation method (Apheresis), the donor sits connected to a specialized machine that draws blood, separates the platelets from other blood components, and then returns the remaining blood to the donor's body. This process typically takes between one to two hours.

2. Platelet Testing: Prior to transfusion, stored platelet units undergo testing to ensure their safety and freedom from contaminants or diseases, guaranteeing patient safety.

3. Administering Platelets to the Patient: Platelets are infused directly into the patient's vein intravenously within a hospital setting. The transfusion usually takes between thirty minutes to an hour.

4. Monitoring and Follow-up: After the transfusion is completed, the medical team closely monitors the patient's condition for any adverse reactions or potential complications. The platelet count is also measured after a specific period, often after one hour and 24 hours, to assess the effectiveness of the platelet transfusion and the body's response to it.

Assessing the response to platelet transfusion is crucial for determining the treatment's success rate and planning subsequent medical management for patients. The response to apheresis platelet transfusion can

be evaluated by calculating the Corrected Count Increment (CCI) post-transfusion. The CCI represents a measure of the response to platelet transfusion, correcting the increase in platelet count based on blood volume and the number of platelets transfused (Prawita et al, 2019).

Platelet Transfusion Refractoriness (PTR) is a clinical challenge, defined as the lack of improvement in platelet count or symptoms post-transfusion. The effectiveness of platelet transfusion is assessed using two indices (Ren et al, 2021):

1. CCI (Corrected Count Increment):If it is less than 7.5 at one hour or less than 4.5 at 24 hours, it indicates refractoriness.

2. PPR (Percentage Platelet Recovery): If it is less than 60% at one hour or less than 40% at 24 hours, it is considered an indicator of ineffectiveness.

Benefits of Platelets for Cancer Patients:

Millions of Platelet Concentrates (PCs) are transfused worldwide annually, with a significant portion used to treat patients undergoing chemotherapy or radiotherapy. Platelet transfusion has become an essential part of therapy for these patients. However, this procedure can cause serious side effects and adds a significant financial burden to patient care costs, especially for those requiring frequent platelet transfusions (Albanyan, 2015).

Acute Leukemia (AL) is a malignant disease caused by the abnormal proliferation of hematopoietic stem cells. Many patients have achieved remission, long-term survival, and even complete cure in some cases. A prominent clinical symptom of this disease is thrombocytopenia. With advancements in transfusion medicine, platelet transfusion has become a crucial therapeutic procedure for acute leukemia patients, especially in preventing bleeding. However, platelet transfusion refractoriness represents a major challenge, as it increases the risk of bleeding in patients and escalates the demand for platelets, complicating the treatment process (Ren et al, 2021).

Some cancer patients suffer from thrombocytopenia due to underlying blood disorders like leukemia and aplastic anemia, or due to bone marrow suppression caused by radiotherapy or chemotherapy. A low platelet count leads to bleeding complications that can be fatal; therefore, platelet transfusion is vital and necessary in managing cancer cases. Platelet transfusion is used either prophylactically or therapeutically to reduce the risk of bleeding, enhance the clotting process, or control active bleeding. Platelet concentrates are primarily produced via two different methods, as explained by (Hao et al, 2017):

1. The first method is the manual method, which relies on harvesting platelets from donated whole blood using the Platelet-Rich Plasma (PRP) method or the Buffy Coat method.

2. The second method is Apheresis (collecting platelets from a single donor via centrifugal separation).

In Plateletpheresis technology, platelets are separated and the other components are returned to the donor, aiming to collect a large quantity of platelets from a single donor. This provides a more consistent product and reduces patient exposure to multiple donors. The new generation of cell separators has improved the quality of collected platelets while reducing donor interventions. Over the past decades, these technologies have seen significant improvements in production efficiency and component quality (Kukar et al, 2018).

From the above, it is clear that thrombocytopenia can occur due to bone marrow suppression during treatments like chemotherapy or radiotherapy. Bleeding problems or related symptoms are particularly common in patients with hematological diseases, either due to the disease itself or its complications. Platelet transfusion has been proven to prevent severe bleeding and improve survival chances in patients with thrombocytopenia; thus, it has become an essential part of ensuring the continuity of treatment in oncology patients.

Factors Affecting Platelets:

Platelet transfusion is one of the most important means of medical support for patients with thrombocytopenia, and the success of treatment depends on the rational use of transfused platelets. Platelets for transfusion are provided by platelet centers, obtained either using the Platelet-Rich Plasma (PRP/PC) method or the Buffy Coat method from whole blood, or through Apheresis technology. Due to the low number of blood donors versus the increasing demand for blood transfusion, it has become necessary to maximize the benefit from each donation, leading to a growing trend towards using automated blood donation technologies. Automated apheresis technologies have been introduced to meet the needs of platelet inventory in transfusion services. This technology relies on separating blood components through centrifugation, filtration, or both, where venous blood is drawn from the donor, separated into its cellular and non-cellular (plasma) components, then the required part is collected and the remaining blood is returned to the donor (Kukar et al, 2018).

A set of factors affect platelets, outlined below as addressed by (Albanyan, 2015):

1. Firstly: Donor-Related Factors: These are the most influential on platelet function and quality, and include:

* Genetic or congenital platelet defects such as inherited bleeding disorders or a family history of clotting problems.

* Acquired defects due to: Diet (e.g., deficiency of vitamins important for platelet formation). intake of certain medications (e.g., Aspirin and non-steroidal anti-inflammatory drugs NSAIDs). The general health status of the donor (e.g., chronic or acute diseases affecting bone marrow or platelet function).

* **Frequency of Platelet Donation:** Frequent donation may lead to long-term changes in platelet function.

* **Plateletpheresis Procedure:** The apheresis process itself may activate platelets during collection or have unclear long-term effects.

2. Secondly: Factors Related to Pre-Donation Assessment Quality:The lack of a direct test for platelet function before donation; reliance is only on questionnaires and a simple clinical exam, which may overlook cases with temporary or mild defects.

3. Thirdly: Factors Related to Platelet Use: These include:

* **Not testing platelet function before or after transfusion:** Relying solely on "increased platelet count" as evidence of successful transfusion, without assessing their actual functional efficacy.

* **The importance of Single Donor Platelets (SDP):** When the dose depends on a single donor, any defect in their platelets has a more direct impact on treatment quality.

The quantity of platelets collected via cell separation technology is primarily influenced by donor-specific factors, alongside variations in procedures and the type of separator used. Numerous studies have shown a clear positive correlation between the donor's pre-donation platelet count and the final product yield. However, studies investigating donor factors that predict achieving a high yield from donation using this technology are still limited. The donor's platelet count is considered the strongest predictor for collecting High-Dose (HD) and Double-Dose (DD) platelet products using Trima/Spectra Optia and MCS+ devices. Meanwhile, donor weight contributed only marginally to improving success rates for collecting high doses. Other factors like donor age and hematocrit level did not significantly affect the success rate on either device, according to Classification and Regression Tree (CART) analysis (Malodan et al, 2023).

In the same context; a set of factors that collectively affect the quantity and quality of platelets and thus the efficacy of Platelet-Rich Plasma (PRP) therapy or platelet transfusion have been indicated. These factors, as pointed out by a study (Sari, 2022), are as follows:

1. Gender (Sex):It was observed that the average platelet count is higher in females than in males.

2. Chronic Diseases: Such as hypertension and coronary artery disease, which cause a decrease in platelet count.

3. Age and Body Mass Index (BMI): Some studies showed no significant effect on platelet count.

4. Other factors like diabetes, blood type, smoking, and alcohol consumption: Did not show a clear effect on platelet count.

5. Frequency of Donation and Plateletpheresis Procedure:Can affect platelet function in both the short and long term.

6. General Health Status of the Donor: Includes medication intake or the presence of acquired or genetic defects in platelets.

Platelet recovery in the patient is influenced by the transfused platelet dose, which in turn depends on the quantity of platelets collected. Studies have shown that transfusing high-yield platelets can reduce the number of transfusions needed for thrombocytopenic patients, thereby reducing the risk of infection transmission, allergic reactions, and the likelihood of alloimmunization. When a high quantity of platelets is collected, the original unit can be split into several units, provided each unit independently meets specified standards, which achieves tangible economic benefits (Kukar et al, 2018).

Donor-Related Platelet Defects:

Donor-related platelet defects can be defined as all defects affecting platelets, whether temporary or permanent, that may impair the efficacy of platelet therapy, resulting from factors related to the donor themselves, and not due to collection, processing, or storage processes. Unlike some storage-related defects, which may be reversible after transfusion, donor-related defects are often irreversible (Albanyan, 2015).

According to (Hao et al, 2017), transfusion efficacy is affected by immune and non-immune factors. Immune factors mainly result from sensitization due to antibodies against HLA antigens, and sometimes antibodies against Human Platelet Antigens (HPA) or a combination thereof. Non-immune factors include the quantity and quality of transfused platelets, in addition to clinical factors like fever, bleeding, sepsis, hepatosplenomegaly, disseminated intravascular coagulation (DIC), and the effect of certain medications. On the other hand, apheresis platelets have greater clotting ability compared to manually prepared platelets, both in vitro and in vivo. There are clear advantages to single-donor platelets, including reduced disease transmission, lower rates of alloimmunization, and improved functional and storage characteristics. In contrast, obtaining an equivalent dose of manually prepared platelets requires 4 to 6 donors each time, increasing the probability of alloimmunization leading to Platelet Transfusion Refractoriness (PTR), which is the failure to increase platelet count after two consecutive transfusions of ABO-compatible platelets.

Among the defects and problems that hinder platelet transfusion are the following (Ren et al, 2021):

1.Immunological Mismatch: A leading cause of platelet transfusion failure is immunological incompatibility between donor and recipient, particularly concerning:

* Human Leukocyte Antigens (HLA).
* Human Platelet Antigens (HPA).
* ABO blood group incompatibility.

2. Alloimmunization: Occurs in some patients, especially those receiving frequent platelet transfusions, where their immune system produces antibodies against the transfused platelets, leading to their rapid destruction and lack of benefit. Antibodies can be directed against:

* HLA antigens.
* HPA antigens.
* CD36 protein (this is a rare case).

3. Platelet Transfusion Refractoriness (PTR):A condition where no rise in platelet count is observed after transfusion, or hemorrhagic symptoms persist, assessed by indices such as:

* Low CCI at 1 hour or 24 hours.
* Low Percentage Platelet Recovery (PPR).

4. Contamination or Problems in Stored Platelets: Platelets must be thoroughly inspected before transfusion to ensure they are free from contamination or damage. Any deterioration in quality may lead to ineffective transfusion or complications.

5. Non-Immune Factors: Such as:

* Splenomegaly, which causes sequestration and rapid destruction of platelets.
* Bacterial or viral infection.
* Active bleeding or increased consumption of platelets in the body.

In light of the above, it is clear to researchers that recent studies indicate that donor-related platelet defects represent a fundamental challenge in achieving platelet transfusion efficacy and improving treatment outcomes. While platelets face various problems, donor-related defects stand out as constant and often irreversible factors, placing an additional burden on the healthcare system to ensure the quality and safety of blood products. Despite significant advancements in platelet collection technologies like automated apheresis, which reduce the risks of alloimmunization and infection transmission, the limited availability of these products and the necessity to use manually prepared platelets keep immune and non-immune factors present and influential on the success of platelet transfusion. Therefore, understanding these defects in their various clinical and immunological dimensions is a necessary foundation for developing effective strategies that reduce the incidence of platelet refractoriness and improve the quality of care provided to patients.

Consequently, the following solutions can be proposed to address donor-related platelet defects:

1. Precise Immunological Matching: It is essential to perform advanced testing for HLA and HPA antigen compatibility between donor and recipient, along with ensuring ABO blood group compatibility, to reduce the risks of platelet refractoriness and antibody formation.

2. Promoting the Use of Apheresis: Encouraging the use of apheresis technologies that collect a large quantity of platelets from a single donor, reducing repeated exposure to different donors and lowering the probability of immune system sensitization.

3. Continuous Monitoring and Strict Donor Deferral: Deferring donors with low platelet counts (< 200,000/µl) or those with health factors that may affect platelet quality, while providing ongoing monitoring programs to maintain product safety and quality.

4. Rigorous Pre-Transfusion Platelet Testing: Conducting accurate laboratory tests to detect bacterial contamination or damage in stored platelets, to avoid complications and ensure transfusion efficacy.

5. Medical Training and Awareness: Raising awareness among medical teams about the importance of monitoring platelet transfusion response indicators like CCI and PPR for early detection and management of refractory cases.

6. Managing Cases with Splenomegaly or Chronic Infection: Implementing integrated treatment programs for patients with splenomegaly or chronic infections that reduce platelet consumption and improve patient responses to platelet transfusion.

Summary of Study Results:

In light of what has been discussed in the previous pages of the research, the researcher has reached a set of results as follows:

1. Platelets are small cellular components originating in the bone marrow, considered one of the essential elements in blood, circulating in the bloodstream to play a vital role in protecting the body from bleeding.

2. Platelets play a pivotal role in the blood coagulation process, rapidly aggregating at injury sites to form a platelet plug that helps stop bleeding, and they secrete chemicals that stimulate clot formation.

3. Platelets are used in many medical applications, most notably supporting cancer patients during chemotherapy that weakens platelet production, as well as in cases of severe bleeding, and heart and liver surgeries.

4. The importance of platelet donation stands out as a vital means of saving patients' lives, especially those suffering from malignant blood diseases like leukemia, where patients need regular donations to compensate for continuous deficiency.

5. Some cancer patients suffer from thrombocytopenia due to underlying blood disorders like leukemia and aplastic anemia, or due to bone marrow suppression caused by radiotherapy or chemotherapy.

6. Results showed that platelet concentrates are produced using two main methods: The first is the manual method, which relies on extracting platelets from donated whole blood units, using either the "Platelet-Rich Plasma" or "Buffy Coat" techniques; the second method is apheresis technology, where platelets are collected directly from a single donor using periodic and precise blood separation devices.

7. Platelet disorders, whether in the form of a decrease or increase in their count, lead to symptoms ranging from spontaneous bleeding and frequent bruising to clot formation, and these disorders may be an indicator of serious diseases.

8. Methods for detecting platelet issues include routine blood tests, such as a Complete Blood Count (CBC), and complex cases may require additional tests including bone marrow function tests or immune antibody analysis. Treatments vary depending on the cause and include medications, platelet transfusion, or treating the underlying cause.

9. Platelet-Rich Plasma (PRP) is of great importance in medical fields, particularly in accelerating the healing of soft and hard tissues, due to its high concentration of platelets and potent growth factors.

10. Platelet-Rich Plasma (PRP) contributes to stimulating tissue regeneration and increasing the density of mature bone by up to 30%. Growth factors secreted from it, such as PDGF, play a central role in various stages of wound healing by promoting the proliferation of stem cells, osteoblasts, and fibroblasts.

Study Recommendations:

Based on the findings, the researchers propose a set of recommendations hoped to be useful and increase awareness about the importance of platelets:

1. Necessity of utilizing the research content in awareness campaigns, medical bulletins, and health magazines, especially in schools, health centers, and hospitals, to educate patients and their families about the importance of platelets and their role in treatment and prevention.

2. It is recommended to implement educational campaigns targeting the community to inform them about platelet function, the importance of donating them, and their role in saving patients' lives, particularly in hospitals and centers specialized in treating cancer and blood diseases.

3. Incorporating the topic of platelets into educational health curricula by integrating basic concepts about platelets and their disorders into secondary and university education curricula related to health and sciences, to promote early medical awareness among students.

4. Increasing attention to conducting periodic platelet tests, especially for patients at risk of bleeding or those receiving chemotherapy, to ensure early medical intervention when needed.

5. Encouraging regular voluntary platelet donation by establishing specialized centers for platelet collection and providing moral and social incentives for regular donors, especially in major cities and government hospitals.

6. Providing training programs for healthcare personnel on platelet disorders by holding workshops and training programs for medical workers on how to manage patients with platelet disorders, recognize their symptoms, and learn about modern treatment methods.

7. Funding and encouraging scientific studies and research focusing on developing platelet-based therapies, especially in the fields of oncology, microsurgery, and autoimmune diseases.

Future Proposals:

The researchers propose a set of research studies, hoped to be carried out by future researchers:

1. Conducting an analytical study on the awareness of Saudi society about the importance of platelet donation, aiming to measure the level of awareness, identify reasons hindering donation, and propose solutions to promote a culture of voluntary donation.

2. Conducting a comparative study between the efficacy of autologous platelets and donor-derived platelets in cancer treatment, aiming to compare treatment outcomes and complications of each type in cancer patients undergoing chemotherapy.

3. Studying the effect of dietary habits and lifestyle on platelet levels among youth in Saudi society.

4. Conducting a field study on the challenges facing platelet donation centers in the Kingdom of Saudi Arabia, aiming to identify logistical, administrative, and technical challenges, and propose practical solutions for developing donation services.

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[The Arabic references are listed exactly as provided. Translation is not typically provided for reference lists unless specifically requested, as they are citations.]

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