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Current Trend in Blood Transfusion Science, Where are we?

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Abstract

There is an improvement in the blood transfusion science. Blood currently do not have an alternative though research is on-going to improve the aspect of blood products and substitutes. Voluntary blood donation has been advocated against family replacement and commercial donation for safety purposes. The coordinated blood transfusion services remains one of the best practice in blood transfusion science though effort should be put in place to embrace technologies that aid transfusion medicine just as apheresis has aided the production of blood fractions and products globally and in Nigeria but requires political will to equip government hospitals with apheresis machines and other technological advanced equipment to aid the services.

Keywords: Current trend; Blood transfusion science; Apheresis; Technology

Introduction

Blood transfusion is a life-saving procedure in which whole blood or parts of blood are put into a patient's bloodstream intravenously. Another person may donate the blood or it may have been taken from the same patient and stored until it is needed for that patient. This process is also called transfusion. This transfusion process comes with its risks including infectious and non-infectious complications which may arise due to several factors. Blood transfusion is a key component of modern-day health care and therefore it is of utmost importance to ensure that blood and blood products meet the appropriate national standards of safety and efficacy for transfusion and the benefit of the blood recipients in their clinical management process [1]. This paper review the blood transfusion practices from historical era to the current practice across the globe and in Nigeria in particular with hopes of improvement to make the services life-saving, easy and affordable.

History of Transfusion

The first historical attempt at blood transfusion was defined by the 15th-century raconteur Stefano Infessura. Infessura narrates that, in 1492, as Pope Innocent VIII dropped into a coma, the blood of three boys was infused into the dying pope (through the mouth, as the concept of circulation and methods for intravenous access did not exist at that time) at the recommendation of a physician [2]. These boys used for this purpose were ten years old and had been promised a ducat each. However, the process was not successful and not only did the pope die, but so did the three young teenagers [3]. Some authors have condemned Infessura's account, accusing him of anti-papalism. This, however, did not stop further research in the field of transfusion, the 17 century began with more sophisticated research starting with the experiment of William Harvey's experiments on blood circulation, with successful experiments in transfusion between animals. Nevertheless, successive attempts on humans continued to have fatal results. The first fully documented human blood transfusion was administered by Dr Jean-Baptiste Denys, well-known physician to King Louis XIV of France, on June 15, 1667. He transfused whole blood of a sheep into a 15-year old boy, who survived the transfusion. Denys achieved another transfusion into a labourer, who also survived. These cases were however believed to be successful due to

the small amount of blood transfused to them which allowed them to withstand the allergic reactions that were expected to have come with the process [3]. Denys went ahead to carry out blood transfusion on a third patient know as Swedish Baron Bonde. He received two transfusions which were not successful as Bonde died after the second transfusion. In the winter of 1667, Denys executed several transfusions on Antoine Mauroy with calf's blood, who on the third process died. Much debate surrounded his death. Mauroy's wife asserted Denys was responsible for her husband's death. But Mauroy's wife was accused of causing his death. Though it was later determined that Mauroy died from arsenic poisoning, Denys' experiments with animal blood provoked a raised high controversy in France. Finally, in 1670 the practice was banned. In time, the British Parliament and even the pope followed suit and hence blood transfusions fell into oblivion for the next 150 years [4].

First Successful Transfusion

After several attempts, Dr James Blundell, a British obstetrician, performed the first successful blood transfusion of human blood in the year 1818, for the treatment of postpartum haemorrhage. He used the patient's husband as a donor and mined four jots of blood from his arm to transfuse into his wife [4]. Blundell performed ten more transfusions during the years 1825 and 1830, five of which were beneficial, and his results published. He also invented several instruments for the transfusion of blood. In 1840, at St George's Hospital Medical School in London, Samuel Armstrong Lane, aided by Dr Blundell, performed the first successful whole blood transfusion to treat haemophilia. The largest sequences of early successful transfusion were carried out at the Edinburgh Royal Infirmary between 1885 and 1892. Edinburgh subsequently became the home of the first blood donation and blood transfusion services [5].

Development of Blood Banking

While the first transfusions had to be made directly from donor to receiver before coagulation, in the 1910s it was discovered that by the addition of anticoagulant and refrigerating the blood it was possible to store it for some days, this opened the way for blood banks. The first non-direct transfusion was performed on March 27, 1914, by the Belgian doctor Albert Hustin, who used sodium citrate as an anticoagulant. The first blood transfusion using blood that had been stored and cooled was performed on January 1, 1916. Oswald Hope Robertson, a medical researcher and U.S. Army officer, is generally credited with establishing the first blood bank while serving in France during World War I. Alexander Bogdanov founded the first academic institution devoted to the science of blood transfusion in Moscow in 1925. Bogdanov was motivated, at least in part, by a search for eternal youth, and remarked with satisfaction on the improvement of his eyesight, suspension of balding, and other positive symptoms after receiving 11 transfusions of whole blood. Some scholars (e.g. Loren Graham) have speculated that his death may have been a suicide, while others attribute it to blood type incompatibility, which wasstill incompletely understood at the time. Following Bogdanov's lead, the Soviet Union put together a national system of blood banks then in the 1930s. News about the encounter of the Soviet Union travelled to America, wherein 1937 Bernard Fantus, director of the therapeutics at the Cook County Hospital in Chicago, established the first hospital blood bank in the United States [6]. In creating a hospital laboratory that preserved and stored donor blood, Fantus originated the term "blood bank". Within a few years, hospital and community blood banks were established across the United States [7]. Three years later, the introduction by J.F. Loutit and Patrick L. Mollison of acid-citrate-dextrose (ACD) solution, which reduces the volume of anticoagulant, permitted transfusions of greater volumes of blood and allowed longer-term storage. Carl Walter and W.P. Murphy, Jr., introduced the plastic bag for blood collection in 1950. Replacing breakable glass bottles with durable plastic bags allowed for the evolution of a collection system capable of safe and easy preparation of multiple blood components from a single unit of whole blood. Further extending the shelf life of stored blood was an anticoagulant preservative, CPDA-1, introduced in 1979, which increased the blood supply and facilitated resource-sharing among blood banks. As of 2006, there were about 15 million units of blood transfused per year in the United States [8].

Blood Transfusion Services

Red Blood Cell Transfusions

Red cells carry oxygen from the lungs, on a substance called haemoglobin, to every part of the body. Haemoglobin is a protein that contains iron. Red blood cells also carry carbon dioxide out of the organs and tissues back to the lungs. Your lungs remove these waste products when you breathe out. These red blood cells are also involved in more blood transfusions than any other part of the blood [9].

Platelet Transfusions

Platelets are bits of cells in the blood that help stop bleeding. People who do not have enough platelets have a high risk of dangerous bleeding. Each whole unit of blood has a small number of platelets. Platelets are collected through a process called Apheresis. During apheresis, whole blood is taken from the donor. This blood is spun to separate the blood into its separate components. Only the needed part is collected. The rest of the blood is transferred back to the donor. Platelets are cells in the blood that help to arrest

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bleeding. Individuals who do not have enough platelets have a high risk of unsafe bleeding. Every whole unit of blood has a minute number of platelets. Platelets are collected through a method called apheresis. In the course of apheresis, whole blood is collected from the donor. This blood is spun to take apart the blood into its separate components [10]. Only the desired component is collected, the rest of the blood is transferred back to the donor.

Plasma Transfusions

Blood cells float in plasma, the clear, yellow component of blood. Plasma is made up of 70% water. It consists of factors that help form clots that help to arrest the bleeding that occurs when blood vessels are broken by an injury. Plasma also carries nutrients to the various tissues across the body.

Granulocyte Transfusions

Granulocytes are certain forms of white blood cells a body requires to fight bacterial and fungal infections. Some patients may encounter serious, life-threatening infections that do not respond to the right antibiotics and they may also have very low levels of granulocytes. This may arise due to the disease or adopted treatment for their disease. These patients may need transfusion of granulocytes for a short duration of time to help fight those infections. Granulocytes are collected from donors via apheresis. As with platelets, it is for better if a patient receives granulocytes from a donor of the same blood type.

Whole Blood Transfusion

The whole blood contains all the components of blood such as red cells, platelets, plasma etc. as collected from donors. The practice of whole blood transfusion is mostly practiced in Nigeria. The whole blood used in Nigeria has been sourced from commercial, family replacement and voluntary blood donation [11,12] in this order from highest to lowest.

Modern Advances in Blood Transfusion Services

Blood supply system in the country functions as part of the medical laboratory service in all the hospitals, whereby the individual hospital blood bank is obliged and responsible to carry out the task of enrollment of blood donors, blood collection, screening of blood units for infections, storage and making it accessible for transfusion to the individual clinical departments of the hospital. Such a fragmented organizational structure poses many constraints and challenges.

Even though blood transfusion is a life-saving procedure, it has some risks, as well as infectious and non-infectious complications. There is a deliberation in the medical literature concerning the suitable use of whole blood and blood products. Clinical trials investigating their use indicates that waiting to transfuse at lower haemoglobin levels is beneficial [13].

Compatibility Testing

Compatibility testing is performed to ascertain if a particular unit of blood can be transfused safely into a particular patient. This includes ABO-Rh blood typing, antibody screening (for unexpected red blood cell antibodies that could cause a problem in the recipient).Compatibility testing is also performed to help prevent haemolytic transfusion reactions which can be caused by antibodies of the ABO blood group antigens. This form of testing includes confirmation of the ABO & Rh type of the donor blood and the following tests on the recipient's blood.

a) ABO and Rh typing and antibody screen for unexpected antibodies
b) Crossmatch involving donor red cells and recipient serum

A sample must be collected from the patient within three days of the planned transfusion for compatibility testing if any of the following conditions are present:

a) The patient has been transfused with a blood component containing red blood cells in the preceding three months
b) The patient has been pregnant within the preceding three months
c) Patient history is uncertain

Blood Grouping

A blood type or blood group is a classification of blood based on the presence and absence of antibodies and also based on the absence or presence of inherited antigenic substances on the surface of red blood cells. These antigens may be carbohydrates, glycoproteins, proteins or glycolipids, depending on the blood group system. A number of these antigens are also seen on the surface of other types of cells of a range of tissues. Numerous of these red blood cell surface antigens can stem from one allele and collectively form a blood group system [14]. Blood types are inherited and signify contributions from the two parents. Many pregnant women carry a foetus with a blood type which is different from their own, which is not a problem. What can matter is whether the baby is RhD+ baby can form antibodies against foetal RBC's. Sometimes these maternal antibodies are IgG, a small immunoglobulin, which can cross the placenta and cause haemolysis of foetal RBC's, which in turn can lead to haemolytic diseases of the new-born called erythroblastosis

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fetalis, an illness of low foetal blood counts that ranges from mild to severe. Sometimes this is lethal for the foetus; in these cases, it is called hydrops foetalis [15].

ABO System

The ABO system is the most important blood group system in human blood transfusion. The associated anti-A and anti-B antibodies are typically immunoglobulin M, abbreviated IgM, antibodies, ABO IgM antibodies are produced in the first years of life by sensitization to environmental substances such as bacteria, food, and viruses. The actual terminology used by Dr Karl Landersteiner in 1901 for the classification is A/B/C; in a later publication "C" became "O" [16]. However a total of 35 human blood group systems are now acknowledged by the international society of blood transfusion [17]. Two of the most important ones are ABO and the RhD antigen; which helps to determine someone's blood types (A, B AB and O, with +/– or Null denoting RhD status) [18].

ABO typing is accomplished by:

a) Testing patient's red cells with anti-A and anti-B sera (Forward typing)
b) Testing a patient's serum for anti-A and anti-B (Reverse typing)

Rh (Rhesus) Blood Group System

This blood group system is the second most significant blood group system in human blood transfusion with about 50 antigens currently. The most significant Rh antigen is the D antigen because it is most likely to incite an immune system response of the five main Rh antigens. It is normal for D-negative individuals not to have any anti-D IgG or IgM antibodies because anti-D antibodies are not typically produced by IgG anti-D antibodies following a sensitizing incident: Possibly a feto-maternal transfusion of blood from a fetus in pregnancy or sometimes a blood transfusion with D positive RBCs [19]. Rh disease can develop in these cases [20]. Rh-negative blood types are much less common in the proportion of Asian populations (0.3%) than they are in White (15%) [13].

The various blood groupings and compatibility testing are carried out diligently in Nigeria using tile or tube methods following the standard.

The Genesis of Blood Donation

Science and technological developments became more and more involved in the development of transfusion during the 20th Century. The voluntary blood donor scheme was pioneered in London by Percy Lane Oliver (1921) following a request of the Red Cross service to provide two blood donors at short notice. The development of electrical refrigeration resulted shortly after in the first 'blood bank' being set up in Barcelona in 1936. Dr Phillip Levine discovered the 'Rhesus' (now termed Rh) blood group system, associated with the potentially fatal condition of Haemolytic Disease of the Newborn, in 1941. Quite a number of the other major developments in transfusion medicine during the 20th Century were given momentum by wars and major conflicts. Freeze-dried plasma was developed in 1940, acid-citrate-dextrose (ACD) anticoagulant solution was developed for the storage of blood by Loutit and Mollison in 1943, and plasma fractionation was designed by Edwin Cohn in 1944, to be followed by the development of a method of freezing blood. The current voluntary blood donation process together with the sophisticated methods for the collection, storage, processing and testing of blood required by the complex medical and surgical procedures of the present day is a long way from the early beginnings of drinking the blood of gladiators. However, most of the important developments in transfusion medicine have only been achieved in the last sixty years.

Types of Blood Donation

1) **Voluntary non-remunerated blood donor:** An individual who donates blood (and plasma or cellular components) out of his/her own free will and receives no payment for it, either in the form of cash or in-kind which could be regarded as a substitute for money. Such persons are usually frequent donors who donate blood at least once a year.
2) **Family/replacement blood donor:** A person who gives a replacement unit of blood only when a family member or friend requires transfusion. This can also happen when such a donor is paid by the patients' family on the basis of a hidden arrangement.
3) **Paid / Professional Blood Donor:** A person who donates blood in exchange for money of other forms of favours. Professional blood donors are however banned in some countries where the rule of law is respected.
4) **Autologous donor:** A patient who donates his/her blood to be stored and reinfused, if needed, during surgery. Preoperative autologous donation:
   a) Done prior to elective surgery.
   b) All the donor screening criteria have to be applied as in a homologous donor. Minimum Hb% should be 11gm%.
   c) 1 unit can be collected every 5-7 days.
   d) The first donation should be 35 days prior to surgery and the last donation 72 hours before the surgery date.
   e) Oral iron supplement to be given to the donor-patient. Prior consent from the donor-patient should be taken for the blood units to be used for autologous donation if unused by him/her eg. All

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autologous blood units must undergo the various screening tests.

5) **Apheresis Donation:** A donor who donates only one of their blood components through the process of cell separation. This donor may be either voluntary or replacement donor [21].

Code of Ethics for Blood Donation and Transfusion

In 2013, the code of ethics for blood donation and transfusion was established. These codes of ethics which were organised by the national standards for blood transfusion service was designed for blood transfusion and hospital transfusion practice and targeted towards ensuring safe blood donation process void of any for complication. The codes cover ethics for blood donation, ethics for blood transfusion science personnel and ethics for hospital transfusion practice. This aspect has been improved of recent to add to dignity of human blood with respect to consent of both the donor and the receiver [22,23].

Ethics for Blood Donation

a) That blood donation should be on a voluntary basis and no-remuneration shall be given to the donors.
b) No individual should be compelled to donate blood.
c) The donor should be made to understand the risks of donating infected blood to others and his/ her ethical responsibility to the recipient.
d) The donor should always provide informed consent before the donation of blood and to the subsequent use of the blood by the transfusion service.
e) Blood donation should be based on the donor selection criteria laid down and must not involve any form of discrimination such as gender, nationality or religion.

Ethics for Blood Transfusion Service Personnel

1) Blood transfusion service personnel should explain to the donor the risks involved with the donation procedure. The donor's health and safety should be the ethical responsibility of the staff.
2) Blood should be collected under the general responsibility of either a registered/licensed medical practitioner or an authorized blood transfusion science personnel who can handle a donor adverse reaction.
3) There should be anonymity between the donor and the recipient and the confidentiality of donor information should also be assured.
4) Blood is a public resource and hence access to it should not be restricted and also wastage of blood and blood components must be avoided at all times.
5) A profit motive should not be the basis for the establishment and operation of future private blood banks or blood service in the country [24].

Ethics for Hospital Transfusion Practice:

a) No financial incentive or motive of personal gain nor any coercion from the patient's party should form the basis to prescribe a blood transfusion. Rational clinical needs should be the only basis of prescribing blood transfusion.
b) The prescribing clinician should inform the patient of known risks and benefits of blood transfusion and of alternative therapies if any. The patient's decision to accept or refuse the procedure must be accorded respect.
c) In the occasion that the patient is unable to give prior informed consent or in case of a minor, the clinician should discuss with the family of the patient and hence decide whether transfusing the blood is in the best interest of the patient.
d) Transfusion therapy must be carried out under the overall responsibility of a registered medical practitioner or other qualified and authorized health care professional.
e) Blood and blood components (cells, plasma or plasma derivatives) should be prescribed based on patient needs and the procedure carried out while ensuring optimal safety of the patient.

The Global blood Transfusion Advances

All over the world researchers are making all necessary efforts to help improve the quality of blood transfusion services. These efforts have yielded some level of results which are the current advances in the field of blood transfusion. Some of these trends are as follows;

Apheresis and Apheresis Blood Donation

Blood obtained from a healthy donor can be separated into various component parts during blood donation, while the needed component is collected and the "unused" components are returned to the donor [1]. Fluid replacement is most times not needed in this type of collection. There are large categories of component collections.

Types of Components Apheresis

1) **Plasmapheresis:** Blood Plasma, Plasmapheresis is helpful in collecting fresh frozen plasma (FFP) of a particular ABO group. Aside from fresh frozen plasma for this procedure, immunoglobulin products, plasma derivatives and collection of rare white blood cell and red blood cell antibodies are also used commercially
2) **Erythrocytapheresis:** Red blood cells' Erythrocytapheresis involves the separation of erythrocytes from whole blood. It is usually carried out using the method of centrifugal sedimentation. This method is used for red blood cell collection procedure for donating erythrocytes and is referred to as "Double Reds" or Double Red Cell Apheresis [25].

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3) **Plateletpheresis (thrombapheresis, thrombocytapheresis):** Blood platelets. Plateletpheresis is the collection of platelets by apheresis while returning the white blood cells, red blood cells and components plasma. The result is usually the comparable between six and ten random platelet concentrates. Quality control requires that platelets apheresis be greater than or equal to 3.0 x 1011 in number and have a pH of greater than or equal to 6.2 in 90% of the products tested and must be used within the space of five days [26].
4) **Leukapheresis:** Leukocytes (white blood cells). Leukapheresis is a procedure that involves the separation and collection of white blood cells. The procedure is a short-term process that takes between 80-150 minutes from a donor in a physically stable position. Leukapheresis can be performed in a continuous intermittent, or discontinuous manner, though most procedures use continuous [27].

Evidence-Based Guidelines For Therapeutic Apheresis

In 2010, the American Society for Apheresis published the 5th edition of evidence-based guidelines for the practice of apheresis medicine. These guidelines are based upon a systematic review of existing scientific literature. Clinical utility for a given disease is denoted by assignment of an American Society for Apheresis Category (I-V). The strength and quality of evidence are denoted by standard grade recommendations. American Society for Apheresis Categories are defined as follows:

Category I - This is for disorders where therapeutic apheresis is accepted as a first-line treatment,

Category II - This is for the disorders where therapeutic apheresis is accepted as a second-line treatment

Category III - This is for disorders where the optimal role of therapeutic apheresis is not clearly established

Category IV - This is for disorders where therapeutic apheresis is considered ineffective or harmful.

Fluid Replacement during Apheresis

When an apheresis system is used for treatment, the system is removing relatively small amounts of fluid (usually not more than 10.5mL/Kg body weight). That fluid must be replaced to keep intravascular volume in the right state. The fluid replaced is different depending on what is obtainable in different institution. If a crystalloid like normal saline is used, the infusion amount should be triple what is removed as the 3:1 ratio of normal saline for plasma is preferred to keep up the oncotic pressure. A number of institutions use normal serum albumin, it is however expensive n and can be difficult to find. Some believe in the use of fresh frozen plasma or a similar blood product, but there are dangers including citrate toxicity (from the anticoagulant), ABO incompatibility, cellular antigens and infection [28].

Electronic Cross Matching

Crossmatching has for long been a major technique in blood transfusion practice. The procedure which conventionally takes between one to two hours in most instances has delayed the delivery of safe blood and blood components. The challenge with this is the fact that in so many underdeveloped nations such delays lead to numerous deaths in various hospital facilities. This has prompted the need for a less time-consuming method to carry out this procedure and hence the invention of electronic cross-matching. This procedure involves the use of a computer program and newly developed standard operating procedures which utilises currently available software [29]. The standard operating procedures for processing donor blood involves bar code entry of the unit number, component name and ABO/Rh type; computer entry and interpretation of serologic reactions; warning of discrepancies between bar code-entered blood type and result interpretation; and quarantine of the donor unit in such instances. This procedure is done in lesser time and can help provide a safe and efficient means of detecting donor-recipient incompatibility without performing serologic crossmatch [30].

Erythropoetin and Blood Transfusion

Erythropoietin is a glycoprotein cytokine synthesized by cells adjacent to the proximal renal tubules in response to signals from a renal oxygen-sensing device, possibly a heme protein. Erythropoietin in the bone marrow binds to and activates specific receptors on the erythroid progenitor cells. In the presence of this erythropoietin-receptor complex the progenitor. In general, erythropoietin stimulates the bone marrow to produce red blood cells. Recent research has it that recombinant human erythropoietin increases haemoglobin and hematocrit values and decreases the number of red blood cells transfusion in patients in the intensive care unit. An article by Lee Elder Indicates that although no actual statistics have been published, the Jehovah's Witness blood policy has resulted to numerous premature deaths amongst followers who observe the policy [31], this is to say that the religious or rather doctrinal beliefs of Jehovah's witnesses which have restricted the followers who adopt the policy has become a cause of concern even in transfusion practice. Erythropoietin helps reduce the need for allogeneic blood transfusion and is seen as the next alternative for blood transfusion. Several cases have reported that the recombinant human erythropoietin (rHuEPO) has been successfully administered to critically ill Jehovah's Witnesses [32], if this continually becomes a success, the several lives would be further saved especially that of those who do not believe in the science of blood transfusion. Research is

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however still ongoing in this area and more research is also up to determine an alternative to blood transfusion [33].

Blood Transfusion in Space

At the moment no major haemorrhage or blood transfusions have taken place in space and the risk is quite low, transfusions for astronauts on missions in space should be cautiously organised. Researchers from the, National Aeronautics and Space Administration (NASA), general medical community and the US army are however receiving articles describing transfusion in various remote locations in the world so as to come up with a procedure for blood transfusion in space [34]. So far lyophilized blood products, haemoglobin based oxygen carries and fresh whole blood theoretically could be used in space. The risk involving this, however, lies on the carrying protocol and storage procedure on the space ship. An alternative for this plans indicates that "Floating" blood banks where matching fresh whole blood is donated by crew members may be the most efficient process which may not cause too much equipment not already in the space ship. Research in this area is still ongoing to establish to first ever blood transfusion in space.

Pathogen Reduction Technology (PTR)

Blood transfusion in its entirety is lifesaving although it causes a small residual risk of transmitting pathogens. Even though donor deferrals and testing help reduce this risk, residual risk is usually possible due to infections load below the limit of detection and the lack of testing for emergent pathogens [35]. Pathogen reduction technology is a proactive step taken towards improving the quality of blood safety before transfusion. This procedure helps to prevent transfusion transmissible reaction the expectation of a pathogen reduction system is that it achieves high enough levels of pathogen reduction to reduce or prevent the likelihood of disease transmission while preventing adequate cell and protein quality. It uses riboflavin (Vitamin B2) plus UV lights to induce damage in nucleic acid-containing agents. The system has been shown to be effective against clinically relevant pathogens and inactivates leukocytes without significantly compromising the efficiency of the product or result in the product [36].

Use of Drone in Delivery of Blood Products

Some latest trends in the field of blood transfusion have drifted into not just making the process safe but also making if faster. Blood transfusion only happens when blood to be transfused is available [37]. This is quite a challenge especially in rural communities; hence only this new effort is commendable and noted as a trend. An effort by the South African National Blood Service (SANBS) has seen this dream come through, this drone blood delivery service developed by the blood service named the "Tron drone" has a range of over 100km and can travel up to 180km/L [38]. The drone service is already in use in countries like South Africa, Ghana and Rwanda the process of this service include;

Step 1: Order - An order for blood or blood product is sent from a hospital or location facility responsible for the drone service.

Step 2: Fulfilment-A trained specialist begins preparation of the product for delivery.

Step 3: Launch-The drone is packed, preparation and launched in less than 5 minutes.

Step 4: After delivery- The drone returns and is quickly prepared to fly again.

According to Ziphine [38]; 27,421 lifesaving deliveries have been made by drones. A research by Timothy, et al. [39] revealed no evidence of red blood cells hemolysis platelet count, pH and MPVs in the blood transported by these drones the research also indicated that temperature of all units of blood products transported was maintained till delivery hence proving why this should be adopted and utilized in other countries around there world. Nigeria is not yet here and should be encouraged to learn from such African countries who have commenced the practice.

Telemedicine

Telemedicine is the remote diagnosis and treatment of patients by means of telecommunication technology. It literally means "healing at a distance" and signifies the use of information and communication technologies to improve patient outcomes. It is aimed at providing clinical support, overcome geographical barriers, bridge time and to improve health outcome. Telemedicine has now been utilized in blood transfusion science. Its role in healthcare generally cannot be overemphasized. However, the telemedicine system has been used to meet the user-defined requirements of information storage in the transfusion laboratory in Slovenia. According to their work, the telemedicine system systematically stores all diagnostic data and results for further reference, hence enabling process traceability this has helped to eliminate the need for switching between different applications (email, videoconferencing and an interface for communication with telescope 32 reader). Telemedicine system provides automated image capture of the ID-Cards teleconsultation and exchange of immuno-haematological expertise between a central expert and distant laboratory personnel enabling improved decision making [40].

Conclusion and Recommendations

Blood transfusion globally has received so much acceptance, this procedure has also saved several lives across the world. It is important to appreciate how much impact the

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advancement of blood transfusion has made in the healthcare sector. Though so much effort is been made by researchers to further advance this, it would be good to recommend that government at all levels commit to enhancing research in this area. Furthermore, it is advised that 1-3% of the population of a country should donate blood to meet the country's transfusion needs. In view of this, the world health organisation reported in 2007 that 3 out of 73 countries who has donation rates less than 1% of their population which represents less than 10 donations in every 1000 persons have always experienced complications arising from the unavailability of blood and blood products. Globally, more than half a million women die each year during pregnancy, childbirth or in the postpartum period – 99% of them in the developing world. About 25% of those deaths are caused by severe bleeding during childbirth, making this the most frequent cause of maternal mortality. Whatsoever effort is made to advance this field, it is truly important that blood transfusion services be made safer, available and cost-free just so that mortality rates arising from unsafe or unavailable blood would be greatly reduced. Developing countries such as Nigeria and many others must also see the need to improve on the quality of blood transfusion services, they must accept the recent advances in this field as this would aid to achieving the needed improvement in blood transfusion services.

As a result of the increase in technological advancement cutting across the field blood transfusion science, It is recommendable that healthcare institutions strengthen their evidence-based transfusion medicine through the documentation and analysis of institutional blood use, the use of alternative blood products and improved technologies so as to improve the quality of blood transfusion services across the globe and in Nigeria in particular.

Some of the challenges hindering the advancement of blood transfusion globally include lack of government support, absence of national blood policies/plans, legislative frameworks and effective regulation, the fragmentation of blood transfusion services; lack of clarity of roles amongst multiple national stakeholders; poor institutional coordination and poor integration of blood programmes within the national framework of healthcare systems [41]. Addressing this enormous challenge would grant us a safe landing in the delivery of blood transfusion services worldwide.

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