

Cord blood banking: the prospects and challenges of implementation in Nigeria

Abstract

From time immemorial, umbilical cord blood has been regarded as a waste product that has been discarded along with the placenta. It is now known to contain potentially life-saving hematopoietic- progenitor stem cell that has been used successfully as an alternative allogeneic donor source to treat a variety of pediatric genetic, hematologic, immunologic, and oncologic disorders. Stem cells from umbilical cord blood also offers several distinct advantages over bone marrow or peripheral stem cells; hence the need to bank it. These scientific advances have resulted in the establishment of not-for-profit (public) and for-profit (private) cord blood-banking programs for allogeneic and autologous cord blood transplantation. Recently, cord blood cells are used for cellular therapy and regenerative medicine as an alternative natural source of treatment. Advantages of umbilical cord blood stem cells over bone marrow stem cells for transplants include: ease of collection; reduced risk of transmission of infection; reduced processing time; and rejection of samples etc. However, cord blood is disadvantaged in that the volume collected is fixed and relatively small; engraftment takes longer time and there may be transmission of the rare genetic diseases of the blood or immune system etc. Issues confronting intending institutions are: the policies, ethical issues and the challenges faced. Implementation of cord blood banking in Nigeria as a developing country is challenging due to: finance, religious and traditional beliefs, erratic power supply, lack of awareness of Hematopoietic Stem Cell Transplant, lack of technical expertise etc. The use of Stem cell therapy is advancing in medical research and therefore this would be a major achievement in the medical sector if it is fully implemented in Nigeria.

Keywords: umbilical cord, transmission, embryo, blood bank, myeloblastic leukemia

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Abbreviations: SCID, severe combined immunodeficiency; HSCs, hematopoietic stem cells; HLA, human leukocyte antigen; GVHD, graft-versus-host disease; EBV, Epstein-Barr virus; CMV, cytomegalovirus; IRB, institutional review board; RBC, red blood cell; MNC, mononuclear cells; AXP, automated processing platform; CFU-GM, colony-forming units granulocyte-macrophage; HSCT, hematopoietic stem cell transplantation

Introduction

After a baby is born and the umbilical cord is cut, some blood remains in the blood vessels of the placenta and the portion of the umbilical cord that remains attached to it. This blood is called umbilical cord blood. Umbilical cords have traditionally been viewed as disposable biological by-product.¹ Cord blood banking is a process by which after the delivery of the baby, the cord blood is collected from the umbilical cord. The cord blood is then processed, where stem cells are isolated and stored in vapour phase of liquid nitrogen for future use. Cord blood is currently used to treat approximately 70 diseases including leukemias, lymphomas, anaemias, and Severe Combined Immunodeficiency (SCID).² Cord blood contains all the normal elements of blood which are red blood cells, white blood cells, platelets and plasma. It is also, rich in multi-potent hematopoietic stem cells (HSCs), similar to those found in bone marrow.³ One example of a pluripotent stem cell is the embryonic stem cell, found in the blastocyst stage of the developing embryo. It is believed that stem cells form reservoirs of repair cells to replace cells and tissues that

degenerate over the life span of the organism. It is this capacity for self-renewal and for differentiation into repair cells that offers great potential for regenerative medicine.

Recent medical advances have indicated that these stem cells found in cord blood can be used to treat the same disorders as the hematopoietic stem cells found in bone marrow and in the bloodstream but without some of the disadvantages of these types of transplants. Cord blood banking is well established in most developed countries. It is fast growing in developing countries such as Kenya, Namibia and Mauritius as the awareness of the necessity of cord blood banking is increasing. There is intense competition in the developed markets between private and public cord blood banks. As there is growth potential in developing countries, it is possible to shift technological expertise, infrastructure and even storage of cord blood units from developed to developing countries since the costs tend to be lower in those countries. Cord blood banking is a necessity as the stem cells harvested possess not only hematopoietic ability but they can also be used for bone regeneration and as immune modulatory cells in allogeneic transplantation. This and other potential applications of cord blood make it more attractive and reliable.

Clinical indications of cord blood banking

Since 1988 it has been shown that the hematopoietic stem cells present in umbilical cord blood can primarily be used in allogeneic transplantation, or alternatively in autologous transplantation, for a number of genetic diseases, immunodeficiency diseases or

blood malignancies. Their current use is mostly for the treatment of haematological malignancies in children, of which acute lymphoblastic leukemia and acute myeloblastic leukemia are the most likely conditions. After transplantation, the hematopoietic stem cells repopulate the bone marrow and provide a source of blood cells. It currently constitutes an increasingly used alternative to bone marrow transplantation. A few other conditions do benefit from stem cell therapy, but the therapeutic role in a large number of conditions is at present still only speculative.⁴ Cord blood hematopoietic stem cells (HSCs) are relatively easy to isolate, giving them an advantage over other adult stem cell types. Cord blood HSCs are also believed to have greater plasticity than HSCs found in bone marrow or the blood stream. The limits and possibilities of using HSCs to repair tissues and treat non-blood related disorders are currently being studied. Factors already shown to influence the outcome of cord blood transplantation include the numbers of cells in the cord blood, the size of the recipient, and the degree of human leukocyte antigen (HLA) match between the donor and the recipient.

Cord blood is being used increasingly on an experimental basis as a source of stem cells, as an alternative to bone marrow. Most cord blood transplants have been performed in patients with blood and immune system diseases. Typically, cord blood stem cells are used in stem cell transplantation to rebuild a patient's blood and immune system, following treatment such as chemotherapy, which destroys blood cells. Cord Blood transplants have also been performed for patients with genetic or metabolic diseases. The most common disease category is leukemia. The next largest group is inherited diseases (of red blood cells, the immune system and certain metabolic abnormalities). Patients with myelodysplasia and severe aplastic anemia have also been successfully transplanted with cord blood.^{2,5}

Four main types of physical conditions are treated with stem cell transplants: cancers, blood disorders, congenital metabolic disorders, and immuno deficiencies. Examples of cancers that are treated with stem cells are both lymphoma and leukemia. Non-malignant hemologic disorders also account for a fair share of the recipients of stem cells. Examples of these blood disorders are various types of anaemias, such as sickle-cell anemia and Fanconi's anemia (the first disorder treated with umbilical cord blood stem cells). Stem cells have also been used to treat various metabolic disorders, such as adrenoleukodystrophy. The fourth major category of uses for stem cells is in treating immunodeficiencies, such as Duncan's disease or adenosine deaminase deficiency.⁶⁻⁸

Umbilical cord blood storage

Non-directed donations: In this situation, patients are recruited for altruistic donation of cord blood. This cord blood is processed; HLA typed and stored in a public stem cell bank and it is available for clinical use in any suitable recipient worldwide. The use of allogeneic hematopoietic stem cell transplantation is limited by the need to find an HLA-compatible donor. For those patients who need a bone marrow transplant with no suitable family member, unrelated donor cord blood banks have been set up alongside registries of bone marrow donors to facilitate matching, in order to use cord blood stem cells.^{9,10}

Directed donations in "low risk families": This is the market that is presently being targeted by the privately owned commercial stem cell banks and where perhaps the greatest controversy exists. It is difficult at present, with the available data, to estimate the likelihood for directed donation in a low-risk person being used by the individual who had stem cells stored from their umbilical cord. The chances of

using personal cord blood for hemopoietic disorders before the age of 20 years is low and estimates vary between 1 in 2 700 to 1 in 20 000. The logic here is that cord blood obtained from an unaffected child might be useful in a currently affected or future affected sibling in the family with a high risk of certain diseases. If the cells are HLA compatible, they may be used for the affected sibling. Future use for other conditions such as neurological, cardiac and degenerative disease is at present, purely speculative. This type of donations is discouraged as they raise ethical criticism.¹¹

Directed donations in "at risk families": Cord blood obtained from an unaffected child might be useful in a currently affected, or a future affected, sibling in the family with a high risk of certain diseases. If the cells are HLA compatible, they may be used for the affected child. If not, they may be usable for a future HLA compatible sibling.¹² However, no major controversy exists and many experts advise the need for these donations in families affected with genetic diseases.¹³

Advantages of cord blood banking

There are several advantages of using umbilical cord blood stem cells over bone marrow stem cells for transplants¹⁴

Cord blood collection is easy and poses no medical risk to the mother or newborn baby: The first advantage is that umbilical cord blood is relatively easy to collect and the process is a safe, simple procedure. Collection of cord blood for the express purpose of harvesting stem cells is performed in a manner which would not alter the delivery of the baby; would not increase the likelihood of any adverse reaction in the infant or mother; and would not preclude appropriate medical management of the infant or mother, including collection of cord blood diagnostic specimens. Collection, therefore, poses no risk to mother or baby). The collection process for cord blood is not painful to either mother or child and can be done either prior to or after the delivery of the placenta. Once considered a substance to be thrown away after a birth, now the cord blood can be easily saved.^{11,13} Bone marrow transplants, on the other hand, require the donor to be hospitalized, anesthetized, and experience post collection pain and discomfort. Thus, compared to cord blood, bone marrow collection and transplantation of stem cells are more costly.⁷

Cord blood is collected in advance, tested and stored frozen, ready to use: Cord blood is donated in advance for anyone who might need it in the future. All routine testing is completed and the unit is stored frozen, ready to use. If a match is found, it can be reserved immediately. Confirmatory HLA typing and any special testing required is usually completed within few days. After it is saved and sent to a storage facility, the cord blood is quickly available for use within day to weeks after processing. In contrast, bone marrow stem cells can take much longer to find a match, collect the sample, and process. The process for bone marrow transplantation can take from weeks to months.¹⁵

Cord blood transplants do not require a perfect match: Cord blood does not have to be as closely matched as bone marrow or peripheral blood transplants. Bone marrow transplants typically require a 6/6 HLA match. While a closely matched cord blood transplant is preferable, cord blood has been transplanted successfully with as few as 3/6 matches. Studies have shown that cord blood transplants can be performed in cases that the donor and the recipient are partially matched.¹⁶ Because partially matched cord blood transplants can be performed, cord blood increases the patient's chance to find a suitable donor. With cord blood, a relatively small donor pool can effectively

support most patients' needs. Consequently, cord blood stem cells require less rigorous antigen tissue matching for transplants than bone marrow stem cells.¹⁷ Research indicates that a mismatch of up to two antigen sites still provides successful clinical outcomes.^{1,18} In fact, researchers report that the rate of rejection for cord blood stem cell transplants is half the rate of rejection for bone marrow transplants. When compared directly in cases of mismatched antigens, there was clearly less rejection in transplants involving cord blood stem cells than bone marrow stem cells.⁷

Cord blood transplants are associated with lower incidence of GVHD: Graft-versus-host disease (GVHD) is a common complication after an allogeneic transplant where the patient's immune system recognizes the cells as "foreign" and attacks the newly transplanted cells. The stem cells obtained from umbilical cord blood are also less likely than bone marrow stem cells to be rejected in transplants. Considered to be immunologically immature, umbilical cord blood stem cells produce significantly fewer natural killer cells, creating a substantial decrease in rejection. This can be a potentially life threatening complication. The risk for developing GVHD is lower with cord blood transplants than with marrow or peripheral blood transplants as the immune cells in cord blood seem to be less likely than those in bone marrow from unrelated donors to attack the patient's own tissues.³ Patients who do develop GVHD after a cord blood transplant typically do not develop severe cases.

Cord blood transplants are associated with lower risk of viral infections: Another advantage of using umbilical cord blood stem cells is the decreased risk of the transmission of infectious disease. This particular advantage is partly because umbilical cord blood is almost never contaminated by Epstein-Barr virus or cytomegalovirus.¹¹ Cord blood is also less likely to transmit certain common viruses, like Epstein-Barr virus (EBV) and cytomegalovirus (CMV), which poses serious risks for transplant patients with compromised immune systems and are potentially lethal infections for transplant recipients.

Cord Blood is readily available for use: For patients with uncommon tissue types, cord blood may be an option if a suitable adult donor cannot be found, since cord blood is cryogenically preserved and stored, it is more readily available than bone marrow or peripheral blood from an unrelated donor, allowing transplants to take place within a shorter period of time.¹⁹

Disadvantages of Cord Blood Banking

Despite the benefits of using umbilical cord blood stem cells for transplant, the process also has some disadvantages.

- i. The main disadvantage of cord blood is that the volume collected is fixed and relatively small. Therefore, the number of stem cells available for transplantation is low compared to the number of cells that can be collected in customizable bone marrow or peripheral blood stem cell harvests.¹⁷
- ii. It takes longer for stem cells to engraft. For stem cell transplants to be successful, measurable signs of engraftment must occur. The two measurable signs of engraftment are the recovery of both neutrophil and platelet production. These two clinical signs of recovery take longer to occur in umbilical cord blood stem cell transplants than in bone marrow stem cell transplants. In other words, the laboratory values for white blood cell production and platelet production take longer to increase after umbilical cord blood stem cell transplants than after bone marrow stem cell transplants.⁷

- iii. One of the factors that influence engraftment time is cell dose.²⁰ Cell dose is directly related to the volume of umbilical cord blood collected. Cell dose refers to the amount of useful stem cells in the sample of blood. Generally, the amount of stem cells in cord blood is approximately 10% less than the amount obtained from bone marrow.⁷ A single unit of umbilical cord blood usually contains 50 to 200 ml of blood.¹¹ If an amount of cord blood is less than this minimum volume, the unit cell dose of the sample would not be high enough.³
- iv. The average total nucleated cell dose in a cord blood graft, for example, is less than about 1/10th that of the average bone marrow graft. As a consequence, engraftment to the patient's blood is slower with cord blood than with bone marrow transplants.
- v. Cord blood transplant patients, therefore, may be more vulnerable to infection in the first two to three months after their transplant. This problem is greatest for adolescents and adults because they require a relatively large number of cells.²¹
- vi. A cord blood transplant also may give the patient one of the rare genetic diseases of the blood or immune system. Although the medical history of the donating families is obtained, and Cord blood is tested for common genetic diseases, some genetic diseases may not be apparent in the child for months or years and will not be found or even suspected by current screening methods. At present, it is not possible to test for all of these rare diseases. Thus, there is a chance that a cord blood transplant may transmit to a patient a rare serious genetic disease that was not recognized beforehand.²²

Applications of cord blood banking

- i. Beyond hematopoietic transplantation, additional potential applications of UCB include immunotherapy, tissue engineering and regenerative medicine. Work that was begun in the early 1980s revealed that cord blood was comparable to bone marrow in terms of its utility in stem cell transplantation.²³
- ii. In addition to its use as a substitute for bone marrow, cord blood has recently been used in a variety of regenerative medicine applications. Work done by different scientists has shown that cord blood contains a mixture of pluripotent stem cells capable of giving rise to cells derived from the endodermal, mesodermal, and ectodermal lineages.²

Ethical issues regarding cord blood banking

Donors of cord blood should know that they are not merely depositing the leftover by-products of the birth process with interested researchers and physicians rather; they are making a choice to do something that may potentially benefit either unknown beneficiaries or members of their own families.²⁴ Pregnant women receive a great deal of information sometimes conflicting about the donation process and the consequences of different types of banking. It is crucial to disclose several kinds of information to the potential donor, including who has access to the cord blood once it is donated, where it is stored, how it is stored, and how the donor's privacy is protected.²⁵ In a society as that of Nigeria, the idea of cord blood banking is not widely accepted as there are many issues concerning tissue transplantation. The major issue is that of religion and traditional belief of the indigenens regarding the allogeneic transplantation of body tissues.

Informed consent

Until recently, cord blood was considered one of the many biological waste materials discarded after the birth of a baby.^{25,26} The possibility of using cord blood as a source of stem cells for transplantation altered this view and introduced different rules and regulations for appropriate decision making, handling, and use of this biological material. It is ethically important to obtain informed consent for the donation of any cord blood unit, regardless of the timing of collection or the potential use of the unit. Informed consent procedures for the donation of cord blood should follow a consistent set of protocols that educate the donor about the various options for cord blood use. The requirements should be modeled on already established criteria for transfusion of whole blood and other unfrozen blood products.²⁶

Standards for obtaining informed consent of donors

Because cord blood transplantation is considered an experimental procedure, review and approval of the design and implementation of the informed consent process is the responsibility of the Institutional Review Board (IRB) designated by the collection center. Cord blood collectors must be able to tailor the informed consent process to accommodate the local population, which may have specific cultural, religious, and historical attitudes toward the donation of the body or any of its parts. They should present to IRBs an informed-consent process that engenders confidence that use of the donated cord blood will not conflict with personal beliefs or practices. Further, the IRB must adequately assess the methods proposed to maximize the collection of cord blood to be certain they do not conflict with the steps needed to protect the donor's rights and welfare. Recommendation 5.4 affirms that "secure links between the medical records of the donor and the banked cord blood unit must be established to ensure the safety of transplantable products and the patients receiving the transplants. These records must be kept confidential and afforded the full protection of the law. If an abnormality is discovered during testing, the results must be delivered to the donor in a manner that is appropriate in relation to the severity of the abnormality". Finally, Recommendation 5.5 declares that "those who collect cord blood for public banks should disclose to potential donors all possible clinical and research uses of the cord blood and, furthermore, that donation will terminate a prospective donor's ability to direct the use of the cells."²⁷

Collection of umbilical cord blood

All patients are required to sign informed consent forms prior to collection of cord blood. All mothers are tested for infectious diseases as is typically done with blood donors (i.e., reactivity for HIV, Hepatitis B and C, etc). In the majority of cases, the collections are made after delivery and ligation of the cord, prior to expulsion of the placenta. Prior to collection of CB, the cord is wiped with alcohol or betadine to ensure sterility of the collection.¹² There are a variety of methods used to collect cord blood, although primarily either large syringes (60cc) or small bags (approximately 400cc) are used. The syringe collections provide visual feedback to the collector, allowing them to control not only the rate and volume of the collection, but also to restart collections that have stopped for any reason. Unattended bag collections, although somewhat more facile to perform, are not able to provide this option. Furthermore, first-time or inexperienced collectors routinely are able to collect larger volumes using the syringe method, with greater sterility of collection.

Routinely, collections are completed within 5 minutes (prior to placental expulsion). Regardless, both types of collection kits are

provided in a sterile condition for use during surgical deliveries, as well as being pre-anticoagulated and containing all necessary shipping materials. These kits meet all regulatory requirements for shipping blood, including double containment and a crush-resistant container. Furthermore, the collection kits are insulated and padded for safety during transport, and studies have shown that these kits protect the sample from temperature extremes during shipment.¹² Analysis of the last 195,000 CB collections made by more than 41,000 physicians at 3,128 birthing sites has shown that cord blood collection is simple and reproducible. For all samples, the average range is 70 to 80cc in size, regardless of the birthing situation (vaginal or surgical deliveries). Cord blood collections from twin and triplet births are smaller, as expected (as the newborns are generally smaller), but are routinely large enough for clinical use.²²

Furthermore, as more than 99% of all samples are sterile upon testing, the collection method invariably allows for a CB collection free of microbial and fungal contamination (as assessed by MacConkey blood agar plate cultures and by an automated BacT Alert system, bioMérieux). Finally, analysis of these collections for clinical utility revealed that approximately 10% of all collections did not meet the laboratory's volume criteria for sample acceptance (i.e., greater than 30cc); however, volume is not an accurate measure of clinical utility as a high yield of stem cells can be obtained from a relatively low volume of blood. Thus, all collections, regardless of size, are processed, frozen, and banked as the majority will be clinically useful for both transplant and regenerative medicine applications. In order to successfully obtain the stem cells from the umbilical cord, there should be no alteration in the usual management of the third stage by either the attending medical doctor or nursing staff. Commonly, it is safe and appropriate, to collect the cord blood with the placenta still in-utero. However should the necessity arise, then collection should be made from the placenta only after it has been completely delivered, an exercise to maximize safety of the mother and infant. In general it would be acceptable that the attending doctor or the nursing staff is responsible for obtaining blood from the umbilical cord, however collection may have to be through a trained third party. Cord blood collection should not be done where the attending clinician believes it to be contra-indicated. This may include patients who have premature birth, an associated nuchal cord or maternal hemorrhage at the time of the delivery.²⁸

Processing of cord blood

Presently, the vast majority of CB collections are red blood cell (RBC) reduced prior to cryopreservation. Several methods are in use to accomplish this goal, including Hespan sedimentation to obtain a modified Buffy coat, 12 density gradient centrifugation to obtain enriched mononuclear cells (MNC),²⁸ and 2 automated processes (Sepax and automated processing platform [AXP])²⁹ that result in a Buffy coat product. The Hespan, Sepax, and AXP processing methods result in cord blood products composed of all nucleated cell populations found in the original collection (MNC, neutrophils, some RBCs), while the Ficoll method enriches for the stem-cell-containing MNC subpopulation (generally greater than 85% MNC with a few contaminating neutrophils and nucleated RBC). Cell counts obtained in the final Ficoll product are generally half the cell counts found in the other processes for this reason, although the stem cell recovery may be close.¹² Both density gradient centrifugation and more recently with the automated AXP process methods reproducibly recover greater than 95% of the cord blood stem cells in a typical collection and result in a reduced final volume of approximately 20cc for final storage. The latter method (AXP) allows for greater throughput with fixed personnel numbers (increasing the economy of operations) and

is an FDA-cleared, functionally closed system which is capable of processing cord blood collections of any volume.¹³

Red blood cell reduction not only facilitates the banking procedure, but it also helps to eliminate concerns about ABO or Rh incompatibility between donor and recipient upon clinical use of the sample. Further, much higher recoveries, as well as higher cell viabilities, are obtained upon thawing such RBC-depleted products. Also, by performing RBC reduction, the sample is amenable to immediate use in gene therapy, cell expansion, as well as storage in multiple aliquots for later multiple uses. Using either the Ficoll or AXP method, more than 95% of the original mononuclear cell population in the sample, as well as more than 95% of the CD34+ cells and colony-forming units granulocyte-macrophage (CFU-GM) progenitors (both surrogate measures for stem cell recovery) have been recovered. Upon analysis of the samples processed by the AXP method (the preferred method for the reasons stated above), a final product encompassing 882×10^6 total nucleated cells, or 12.6×10^6 nucleated cells/cc of cord blood collected and processed was obtained.

This number of cells is more than 4 times the minimum number of CB cells that has been successfully used for clinical transplant. Thus, the failure rate of cord blood collection based on cell numbers is less than 4%. As CD34+ cells constitute approximately 1% of CB mononuclear cells, 23 an average of 6×10^6 CD34+ cells are obtained from a single CB sample (an average of 5×10^4 CD34+ cells/kg patient body weight is routinely used for transplant), implying that the average CB sample contains enough cells to transplant both a child as well as a full-sized adult recipient. Samples of all sizes and obtained from all types of birthing/delivery modes can be easily processed with these methodologies with high recoveries. As expected, samples obtained from multiple births provide smaller numbers of cells after processing (due to the initial smaller starting volumes) but are well above minimum thresholds needed for clinical use. Processing does not introduce a significant risk of contamination when performed properly, as shown by an overall microbial contamination rate due to processing of <1%.¹

Prospects and challenges of implementing cord blood banking in Nigeria

There are several challenges to the implementation of cord blood banking in Nigeria.

Maternal factors: From a survey on the awareness of pregnant women in Benin city, Nigeria it was discovered that most pregnant women wont donate their child's cord blood for banking and hematopoietic stem cell transplant (HSCT). However 70.2% of the pregnant women were willing to donate placenta cord blood. Reasons for those not willing to donate placenta cord blood were mainly that of fear of losing their child's destiny (Placenta) with a figure of 22.2%, that it is a strange idea (17.8%), religious and traditional beliefs (15.6%), (8.9%) respectively.³⁰

Religious and traditional beliefs of Nigerians: Cultural and traditional beliefs hinder science and health care delivery in Nigeria as such cord blood banking isn't an exception. Most Nigerians are ignorant of advanced methods of therapy and believe that the umbilical cord is a significant item and should not be tampered with. There is a traditional practice of burying of the umbilical cord and placenta or dumping into the river when a child is born. Solution to this is to create awareness of the benefits of umbilical cord blood banking and Hematopoietic stem cell transplant.^{31,32}

Shortage of medically trained personnel: Low trained personnel to population density are a major challenge to implementing cord blood banking in Nigeria. There are few adequately trained personnel for sample collection to provide cord blood banking services and stem cell transplantation. Trained medical laboratory scientists to collect sample and provide cord blood banking services are fewer compared to the population demand of cord blood. Trained doctors, nurses, medical laboratory scientists and other related personnel's are lacking in this field of interest. This poses a major challenge to the cord blood banking and health sector at large as it recedes development in this sector.³³

Poor funding of the health sector: As a result of the importance of health of health to human lives, Nigeria's health care sector has received adequate attention from both the federal government and international development partners. Several commitments have been made to fund the sector, yet the statistics of health care growth in Nigeria is still very poor. Little fund is invested into medical research in this country and this affects delivery of up-to-date medical services including cord blood banking.³⁰

Erratic power supply: Currently in Nigeria, the impaired electricity is one of the major infrastructure problems affecting the industry and health sector of the country, the fluctuating electric current affects and damages the equipment worth millions and productivity is low. These equipment and machines are easily affected by these changes and need constant power supply to function in its proper state.

Inadequate facilities: The facilities needed to start up a cord blood bank are expensive to purchase and maintain. Poor funding affects the purchase of the equipment and maintenance. There is poor maintenance culture in most hospitals and laboratories thereby greatly affecting the performance of these machines.

Lack of awareness of hematopoietic stem cell transplantation: Hematopoietic stem cell transplantation (HSCT) is a recent advancement in medicine. Research on stem cell transplants began in the 1950s, with successful bone marrow transplants occurring in the 1970s, often to treat cancer patients whose own bone marrow was destroyed by chemotherapy and radiation. The first successful umbilical cord blood stem cell transplant was reported as occurring in the late 1980s. There is lack of awareness of HSCT among Nigerian population and this ignorance affects the provision of informed consent from expectant mothers for donation of cord blood.³⁰

Proposed solution to the challenges of implementing cord blood banking in Nigeria: The traditional beliefs against donation of cord blood should be discouraged by creating awareness of cord blood banking and Hematopoietic Stem Cell Transplant (HSCT). There is need to educate and reassure pregnant women in Nigeria to donate placenta cord blood, which hitherto is a biological waste. Cord blood in the future could be an important source of stem cells for HSCT for the purpose of initiating blood banking in Nigeria as Stem Cell Transplantation has become an approved curative therapy for malignant and non-malignant disorders. This can be done through workshops, seminars, medical outreach in rural and sub-urban areas to inform the population about the benefits of cord blood banking and its prospects in medicine.

Medical personnel qualified to collect cord blood and provide cord blood banking services should be trained appropriately. This would increase the number of hands trained to provide these medical services for efficient service delivery. Adequate funding should be

allocated to the health sector and medical research in particular by the federal government. Other sources of funding are non-governmental organizations and international agencies. These funds provided should be invested appropriately for better productivity in areas such as cord blood banking. The condition of the erratic power supply should be improved upon by provision of steady power supply. This can be done through the use of power generating plants to provide constant electricity in medical facilities in hospitals and medical research centers. Adequate medical equipment and facilities needed for cord blood sampling and banking should be provided in hospitals and blood banks through the proper use of funds allocated to this aspect. Awareness of cord blood banking and HSCT should be provided to enlighten the population on the merits of this recent advancement. This can be done through media, workshop, symposium etc and discouragement of fallacies and cultural notions regarding umbilical cord and the placenta of the child.

Conclusion

The use of Umbilical cord blood as substitute for bone marrow as source of Hematopoietic stem Cell is starting to gain ground in Nigeria but before it can be up to the level seen in other parts of the World, the challenges facing its in this part of the world needs to be overcome. The Government and multinational organizations needs to put more effort into improving this area which could well become the bedrock of modern therapeutic procedures.

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Conflict of interest

The author declares no conflict of interest.

References

1. Fox NS, Stevens C, Ciobotariu R, et al. mbilical cord blood collection: Do patients really understand? *J Perinat Med*. 2007;35(4):314–321.
2. Gluckman E, Ruggeri A, Volt F, et al. Milestones in umbilical cord blood transplantation. *Br J Haematol*. 2011;154(4):441–447.
3. Waller-Wise R. Umbilical cord blood: information for childbirth educators. *J Perinat Educ*. 2011;20(1):54–60.
4. Broxmeyer HE, Gluckman E, Auerbach A, et al. Human umbilical cord blood: A clinically useful source of transplantable hematopoietic stem/progenitor cells. *Int J Cell Cloning*. 1990;8(Suppl 1):76–89.
5. Kirsten Riggan. Cord blood stem cells: an overview. *Dignitas*. 2009;17(1):2.
6. Grewal SS, Barker JN, Davies SM, et al. Unrelated donor hematopoietic cell transplantation: Marrow or umbilical cord blood? *Blood*. 2003;101(11):4233–4244.
7. Moise KJ. Umbilical cord stem cells. *Obstet Gynecol*. 2005;106(6):1393–1407.
8. Cord Blood: Establishing a national cord blood stem cell bank program. the national academies of sciences, engineering, and medicine, Washington, USA: National Academy Press; 2005. p. 75–103.
9. David T Harris. Collection, Processing and banking of umbilical cord blood stem cells for clinical use in transplantation and regenerative medicine. *Laboratory Medicine*. 2008;39(3):173–178.
10. McGuckin CP, Forraz N. Umbilical cord blood stem cells: An ethical source for regenerative medicine. *Med Law*. 2008;27(1):147–165.
11. Gonzalez-Ryan L, VanSyckle K, Coyne KD, et al. Umbilical cord blood banking: Procedural and ethical concerns for this new birth option. *Pediatric Nursing*. 2000;26(1):105–110.
12. Harris DT. Cord blood banking for transplantation. *The Canadian Journal of Clinical Medicine-Medical Scope Monthly*. 1997;4(1):1–8.
13. Percer B. Umbilical cord blood banking: Helping parents make informed choices. *Nurs Womens Health*. 2009;13(3):216–223.
14. Sugarman J, Kurtzberg J, Box TL, et al. Optimization of informed consent for umbilical cord blood banking. *Am J Obstet Gynecol*. 2002;187(6):1642–1646.
15. Pablo Rubinstein. Why cord blood? *Human Immunology*. 2006;67(6):398–404.
16. Wolf S. Storing lifeblood: Cord blood stem cell banking. *AJN*. 1999;99(8):60–69.
17. Sullivan MJ. Banking on cord blood stem cells. *Nat Rev Cancer*. 2008;8(7):555–563.
18. Ballen KK. Advances in umbilical cord blood transplantation. *Curr Stem Cell Res Ther*. 2006;1(3):317–324.
19. Harris DT, Badowski M, Ahmad N, et al. The potential of cord blood stem cells for use in regenerative medicine. *Expert Opin Biol Ther*. 2007;7(9):1311–1322.
20. Gunning J. Umbilical cord cell banking: An issue of self-interest versus altruism. *Med Law*. 2007;26(4):769–780.
21. Dinç H, Sahin NH. Pregnant women's knowledge and attitudes about stem cells and cord blood banking. *Int Nurs Rev*. 2009;56(2):250–256.
22. M-Reboredo N, Díaz A, Castro A, et al. Collection and Processing and Cryopreservation of Umbilical Cord Blood for Unrelated Transplantation. *Bone Marrow Transplant*. 2000;26(12):1263–1270.
23. McKenna D, Sheth J. Umbilical cord blood: Current status & promise for the future. *Indian J Med Res*. 2011;134:261–269.
24. Pinch WJE. Cord blood banking: Ethical implications. *AJN*. 2001;101(10):55–59.
25. Gluckman E. Ethical and legal aspects of placental/cord blood banking and transplant. *Hematol J*. 2000;1(1):67–69.
26. Fernandez MN. Eurocord position on ethical and legal issues involved in cord blood transplantation. *Bone Marrow Transplant*. 1998;22(Suppl 1):S84–S85.
27. Petrini C. Umbilical cord blood collection and storage and use: Ethical Issues. *Blood Transfus*. 2010;8(3):139–148.
28. Harris DT, Schumacher MJ, Rychlik S, et al. Collection, separation and cryopreservation of umbilical cord blood for use in transplantation. *Bone Marrow Transplant*. 1994;13(2):135–143.
29. Harris DT, Rogers I. Umbilical cord blood: A unique source of pluripotent stem cells for regenerative medicine. *Curr Stem Cell Res Ther*. 2007;2(4):301–309.
30. Nwannadi IA, Alao OO, Swende T, et al. Umbilical cord blood donation and banking: awareness among pregnant women, in Makurdi, Nigeria. *IOSR Journal of Dental and Medical Sciences*. 2014;13(1):16–19.
31. Bazuaye GN. Challenges of setting up the first stem cell transplant centre in a developing country. *International Journal of Tropical Disease & Health*. 2013;3(4):292–299.
32. Bazuaye GN, Enabudoso EJ. Willingness of pregnant women in Benin City Nigeria to donate placenta cord blood for stem cell transplantation. *Annals of Biomedical Sciences*. 2011;10(1):55–60.
33. Oyekunle AA. Hematopoietic stem cell transplantation. prospects and challenges in Nigeria. *Annals of Ibadan Postgraduate Medicine*. 2006;4(1):17–27.