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RESEARCH ARTICLE

UMBILICAL CORD BLOOD -The Hidden Treasure

SaiKrishna.G*1, Lakshmi Bharathi.Ch1, Saathvika.T1, Komal Krishna.T2

1- JSS college of Pharmacy, Mysuru-570015, Karnataka, India.
2- JSS college of Physiotherapy, Mysuru-570015, Karnataka, India.

Correspondence
SaiKrishna.G
Seetharamnagar, 2nd lane,
D.no: 8-22-17, Guntur, A.P,
India
Email Id:
sknanu06@gmail.com

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ABSTRACT

The sample of blood taken from a newborn baby's umbilical cord is called cord blood. It is a rich source of hematopoietic stem cells, which are precursors to blood cells. These cells have been used to treat certain diseases of the blood and immune system. It is the blood that remains in the umbilical cord and placenta after delivery of the new born. Cord blood contains all the normal elements of blood i.e, RBC, WBC, Platelets and Plasma. It is also rich in hematopoietic stem cells, similar to those found in bone marrow. Collection of the cord blood can only be done immediately after birth of a child, usually within ten minutes of giving birth. Cord blood has been used in the treatment of more than 80 diseases so far, amongst which leukemia has been the most common disease category.Generally, it is the umbilical cord and blood that are usually discarded after the birthing process. These useful biological materials that are uniquely capable of curing many diseases are simply treated like trash. However, apart from blood disorders, the cord blood and it`s use for other diseases is not a routine procedure that is opted and remains a major challenge for the stem cell community.

INTRODUCTION

The blood contained within the umbilical cord and blood in the contiguous placental circulation is called the cord blood. Thousands of patients every year are found to have blood disorders and diseases such as lymphoma, leukemia and sickle cell anemia. Such conditions are usually treated by transplanting thebone marrow. The stem cells within the bone marrow are typically obtained from thepatient`s family members or bone marrow registries. However, finding bone marrow stemcells that is compatible, or genetically similar, to that of the patient is a not an easy task and suchsources are also very confined. Often, the donation of bone marrow from family members has a25% chance of being compatible with the patient`s cells. A new way for curing suchdiseases has come up as a potential alternative through the stem cellsacquired from the umbilical cord blood.[1]

HISTORY

In the 1970s, researchers considered umbilical cord blood as a potential source of stem cells, originally thrown away after delivery of the baby. In the 1980s, researchers and doctors had successfully transplanted stem cells that were extracted from the umbilical cord blood to cure a genetic disease known as FanconiAnemia that causes defects in thebone marrow that result in the inability to produce blood cells. From then, scientists have done extensive research to find out the potential therapeutic uses of cord blood. To date, there are more than 70 diseases that can be treated by the use of stem cells from the cord blood.[2]

CORD BLOOD BIOLOGY:[3]

Umbilical Cord Blood is primarily composed of monocytes and lymphocytes, which reside in the mononuclear cell fraction. Compared to bone marrow and peripheral blood the lymphocyte population of UCB is immunologically immature. UCB has a higher ratio of CD4+ and CD8 T cells, a higher concentration of natural killer cells, and a lower concentration of highly reactive NK T cells when compared with bone marrow and the peripheral blood. Cytokine expression in UCB is lower than in peripheral blood and bone marrow, and UCB shows a greater expression of anti-inflammatory cytokines compared with pro-inflammatory cytokines. The anti-inflammatory propertiesand the immunologically immature characteristics of UCB are the reason for the low frequency and decreased severity of GvHD in allogeneic transplants, and may promote indirect cellular therapeutic benefits for regenerative medicine applications. Expressing the cell surface glycoprotein CD34+, the hematopoietic lineage is the largest stem cell population in UCB. Approximately 1% of the MNC in UCB express CD34+.UCB stem cells have a higher proliferative potential with reports of up to eight-fold greater rates than bone marrow stem cells, which may be because of the longer chromosome telomeres in this young source of stem cells.[4]

In addition to hematopoietic stem cells, UCB has also been reported to containmesenchymal cell progenitors, endothelial cell precursors, and multipotent–pluripotent stem cellsthat may prove to be of great use for regenerative medicine applications to treat and cure conditions or damage affecting non-hematopoietic tissues.

TYPES OF CORD BLOOD BANKS [5, 6]

Cord blood can be donated to a public cord blood bank for use by someone in need or stored at a family cord blood bank for baby's or family's use.

Public Cord Blood Banks

Public cord blood banks save and use cord blood for transplants for helping the people withkind of treatable diseases or for scientific research to learn more about the possible uses of the cord blood. Transplants done are anonymous and no information about the owner of the cord blood is given to the person receiving it. The cord blood that is donated becomes the property of the public cord blood bank. At this time, in the United State there is only one public cord blood bank available that accepts the cord blood donations from the babies born in Arizona. They are Cryo-banks International.

Family Cord Blood Banks

Using family cord blood banks, the family can control the use of the cord blood. According to the studies, there is less graft versus host disease complications and there are better survival rates when cord blood from a related source is transplanted. Yet, there is no guarantee that the saved cord blood will be able to be used in all situations.

Who Can Bank Cord Blood

Currently, only about 3% of parents now choose to save the cord blood. The reason for this is simple, cost. It costs approximately one lakh rupees for the initial umbilical blood draw followed by a yearly storage fee ranging from 5,000 to 10,000 rupees. Anyone with the financial means to afford this should consider it. The potential upside is almost limitless. There are claims that cord blood stem cells are a stepping stone to immortality. This is purely hype but it isn't completely false. The implications for ending disease by replacing cells are effectively removing the disease at its root.[7]

Anyone can donate the cord blood from their childbirth at no cost. It is then put in a public cord blood bank that can be used by anyone. This is similar to an organ bank but much more effective as the genetic match doesn't have to be as close for the stem cells to be used. "The reason that people might store their own child's cord blood for their family would be if there's already a family member who has canceror another disease that might be treated by a transplant, or because there may be uses in the future that will be valuable for things like tissue repair or tissue regeneration.

STEPS INVOLVED IN CORD BLOOD BANKING[9]

Collection: The care of mother or child should not be affected by collection of cord bloodand there should be no significant deviation from normal procedures. If the process is initiated within ten minutes of the birth of the infant, the collections of cord blood are generally more successful.

I. **Labeling of cord blood:** At the completion of collection, the primary collection container should bear, at least, sufficient identification information to identify the product, the source and destination, the donor and recipient (if known), the conditions that are recommended for storage and transportation, and product

characteristics such as anticoagulant used.

II. **Processing and storage methods**

a. **Processing:** Cord blood processing should commence within 48 hours of collection. Cord blood storage temperature pre-processing, should be maintained at between 1°C and ambient temperature, depending on methods used.

b. **Storage vessels:** Cord blood should be collected and stored in bags,vials, or other containers that are approved for cryopreservation of hematopoietic progenitor cells or should be validated by the cord blood bank to maintain viability.

III. **Separation methods:** Separation methods should be approved and described in written and demonstrated to be free from bacterial contamination. Methods should also be approved by the institutional review board or be well-described in the medical literature.

IV. **Sterility testing:** As a component of quality control for the procedure, sterility testing for bacterial and fungal contamination should be done on a sample collected after addition of the cryo-protectant mixture and the results should be evaluated. Testing of a sample of the cord blood may also be performed at the time of collection.

V. **Cryopreservation:** Cryopreservation of the cells should be done by methods detailed in written procedures using the reagents that are approved for human use. Methods used should be well described in the medical literature or should be approved by an institutional review board. There should be nonon-human animal colloids.

VI. **Storage temperature:** After processing, the storing of the cells should bewithin a temperature range of minus 196°C to minus 80°C. If the storage period is more than one year, then the cells should be stored at a temperature of less than -130°C. To store the cells continuouslyeither a mechanical freezer is used orliquid nitrogen tank that is equipped with an audible alarm.

VII. **Final Labeling:** The final product container must be labeled and/or tagged in correspondence with Department of Health regulations for labeling the hematopoietic progenitor cells. The label should be distinct, memorable and should contain the donor's identification code.

DISEASES TREATED USING CORD BLOOD STEM CELLS [15]

Individuals with certain illnesses are treated with chemotherapy and/or radiation that destroy their own stem cells. Following this treatment, they receive a stem cell transplant, usually through a large vein in the chest. The

transplanted stem cells make their way to the bone marrow. In the marrow, the stem cells continually make new copies of them and produce blood cells that rebuild a healthy blood and immune system. Transplanted stem cells can come from donated bone marrow (often called a bone-marrow transplant) or peripheral (circulating) blood, as well as from cord blood. In some cases, a person may receive a transplant of his or her own stem cells. Stem-cell transplants is a process that can be lifesaving for people suffering from leukemia (cancer of the white blood cells) and other types of cancers, or for people with serious blood disorders, such as aplastic anemia, in which the body does not produce enough blood cells. Cord blood is now the most common source of stem cells for children requiring a stem cell transplant. Donated bone marrow is the most common source for adults. However, cord blood is increasingly used in adults as well.

● Blood related disorders, such as leukemia, thalassemia (also known as haemo-globinopathies) and sickle cell anemia.

● Immune system disorders.

● Emerging Treatments like, Diabetes, Cerebral Palsy, Brain Injury.

● Metabolic disorders, such as Hurler syndrome (inherited condition that is caused by an enzyme deficiency). Some scientists have claimed that cord blood could potentially be used for curing diseases such as Alzheimer's, Parkinson's and conditions such as diabetes. Cord blood could be used to treat diseases that affect the brain, heart and spine is also claimed by the scientists. Other scientists argue that there is shortage of evidence to support these claims. It may be that in the future more diseases will be treated with cord blood. Presently, however, there is much more needfor the research in this aspect to be done.[16]

● Help to Cure Cancer**,** Umbilical cord blood contains stem cells that do not have to be harvested from fetuses. These cells can be used to cure several diseases including leukemia.

ETHICAL USE OF UMBILICAL CORD BLOOD STEM CELLS

Theumbilical cord blood stem cells collection and storage is completely ethical. There has been a lot of public debate recently, on the collection of other types of stem cells; these cells are collected from the aborted fetuses or human embryos that are grown in a lab. This debate does not include stem cells taken from umbilical cord blood of Adults or Non-Embryonic Stem Cells.

PROS AND CONS OF CORD BLOOD

Scientists have given evidence that the umbilical cord contains blood that is enriched with hematopoietic (blood-forming) stem cells. These cells may be used to cure genetic diseases, blood disorders, and certain cancers. Transplants performed with cord blood have various advantages when compared to other types of transplants. Stem cells from the cord blood are expected to match with a wider variety of patients, and not as bone marrow transplant in which there is a need for more specific match. Moreover, research has shown that the average time to find a compatible match with a cord blood is much shorter than that with a bone marrow transplant. [2] Another advantage is the noninvasiveness of the procedure. While, in bone marrow transplants there may be some pain to the donor. Cord blood allows easy access to the stem cells with no pain to the mother or the newborn.

A disadvantage of cord blood transplants when compared to bone marrow transplants is that the patient takes longer to recover. However, there are same healing effects as bone marrow stem cells even in cord blood stem cells. Another disadvantage of cord blood transplants is the reduced concentration of stem cells in it. Most

adults will require at least 2 units of cord blood in order to experience the full healing effect.

PROBLEMS AND ABNORMALITIES[17, 18]

A number of abnormalities can affect the umbilical cord that can cause problems which affect both mother and child

- Umbilical cord compression can result from conditions like entanglement of the cord,[9] a knot in the cord, or a nuchal cord, (in this the umbilical cord gets wrapped around the neck of the fetus) but these conditions do not always cause obstruction of fetal circulation.
- Umbilical cord prolapse
- Vasa praevia (obstetric complication in which fetal blood vessels cross internal orifice of the uterus)
- Single umbilical artery
- Velamentous cord insertion (umbilical cord getting inserted into the fetal membranes)

Umbilical nonseverance: Some parents choose to omit cord breaking entirely, which is a practice that is known as "lotus birth" or umbilical nonseverance. In this process they allow the entire intact umbilical cord to get dried like a sinew, which then gets separated naturally (typically on the 3rd day after birth), falling off and leaving a healed umbilicus.

Umbilical cord catheterization: It can be used as a route for placement of a venous catheter for infusion and medication as the umbilical vein is directly connected to the central circulation. For the percutaneous peripheral or central venous catheters or intraosseouscannulas the umbilical vein catheter is a reliable alternative.

Cord disposal: It is known that in some animals, the mother will consume the cord, thus separating the placenta from the offspring. It (along with the placenta) is usually eaten away by the mother, to provide nourishment and to dispose of the tissues that would attract the scavengers or predators. In chimpanzees, the mother gives no attention on umbilical severance, instead nursing her baby with the cord, placenta, and all, until the cord dries and separates by itself within a day of birth, at this time the cord is discarded.

ADVANTAGES OF STEM CELLS FROM CORD BLOOD:[18-21]

- **Safe, easy collection**: Collecting stem cells from cord blood poses no risk to mother or baby. Individuals who donate bone marrow must undergo a surgical procedure with general or spinal anesthesia. They may experience postoperative pain, and have a small risk of serious complications. Individuals who donate stem cells from blood must undergo several injections (shots) that stimulate release of stem cells into blood, occasionally causing bone pain and serious complications.
- **More matches**: For a bone-marrow transplant to succeed there should be a mostly perfect match of few tissue proteins (called human leukocyte antigens or HLAs) between the donor and the recipient. Family members, such as siblings, are most likely to be a tissue match. However, only about 30% of individuals who require a stem-cell transplant have a relative that is an appropriate tissue match. When stem cells of the cord blood are used, the cells of the donor appear more likely to "take" or engraft, even when there are partial tissue mismatches. This means that more individuals may be able to find an appropriate match using cord blood.
- **Faster availability**: Many individuals who do not have an appropriately matched family member can find a matched donor through national bone-marrow and cord-blood registries. It often takes at least two months to locate an appropriate bone- marrow donor compared to about two weeks for a cord-blood unit. The banked cord-blood cells also are available almost immediately. This can be crucial for patients with severe disorders who might die before an appropriate bone marrow donor can be found and complete the donation process.
- **More ethnic diversity**: It is more difficult for the members of non-white ethnic and racial groups to find a match through a bone-marrow registry because there are fewer registered potential donors from non-white groups. The increasing use of cord-blood cells may make timely treatment available for more of these individuals.
- **Reduced risk of graft vs. host disease (GVHD)**: In this complication, the donor cells attack the recipient's tissues. As the cord-

blood cells are immature and may lack the ability to attack the recipientthis appears to occur less frequently with cord blood than with bone marrow. A study said that a cord-blood transplant that the children received from a closely matched sibling were 59% less likely to develop GVHD than childrenreceiving a bone marrow transplant from a closely matched sibling.

- **Fewer infections**: Cord blood is less likely to contain viruses that can pose a risk to transplant recipients.

CONCLUSION:

India has great potential for UCB banking due to a high birth rate and genetic diversity. Nearly 70 per cent of patients of Indian origin who require bone marrow transplantation do not find a match within their own family. Hence umbilical cord blood banks are widely accepted source for hematopoietic stem cell transplantation. However, total number of UCB transplants performed in India has been very low mainly due to high cost and lack of awareness too.

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CONFLICT OF INTEREST:

Nil.

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