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Dendritic Cells in Autologous Hematopoietic Stem Cell Transplantation for Diffuse Large B-cell Lymphoma

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Introduction

Allogeneic stem cell transplantation (allo-SCT) is a life-saving treatment for a variety of hematologic and genetic disorders, including leukemia, lymphoma, and certain inherited immune deficiencies. The procedure involves transferring stem cells from a genetically different individual (the donor) to a recipient. The stem cells can come from three main sources: bone marrow, peripheral blood, and cord blood. While these three sources serve the same basic function, they differ significantly in their collection, processing, and clinical outcomes, which in turn affect their associated costs. Understanding the economic implications of using different stem cell sources is critical for healthcare providers, policymakers, and patients, especially given the increasing demand for stem cell transplantation and the high cost of treatments. This article presents a detailed economic comparison of bone marrow, peripheral blood, and cord blood stem cell transplantation, examining factors such as the cost of collection, processing, storage, and post-transplant care, as well as long-term outcomes.

Description

Bone Marrow Transplantation (BMT) has been the gold standard for allo-SCT for decades. In this procedure, stem cells are collected directly from the donor's bone marrow, typically from the iliac crest or sternum. The cells are then infused into the recipient after preparatory chemotherapy or radiation. Bone marrow contains a higher concentration of hematopoietic stem cells compared to peripheral blood, which may lead to faster engraftment in certain cases. Historically, BMT has been associated with lower rates of Graft-Versus-Host Disease (GVHD) compared to peripheral blood stem cells (PBSCs). The process of collecting bone marrow requires general anesthesia, making it more invasive for the donor. Bone marrow collection is a more time-consuming process compared to other methods. Peripheral blood stem cell transplantation (PBSC) is the most commonly used method today, owing to its simpler collection process. PBSCs are collected via apheresis, a procedure where the donor's blood is drawn, the stem cells are separated, and the remaining blood components are returned to the donor. This process is done over several hours, typically after the donor has received growth factors (e.g., G-CSF) to increase stem cell mobilization [1].

PBSC collection is less invasive than bone marrow harvesting, and it can be done on an outpatient basis. PBSCs generally have a higher number of stem cells, which can result in faster engraftment in the recipient. There is often less donor recovery time compared to bone marrow donation. PBSC transplants are more likely to cause GVHD compared to BMT. The apheresis process can be uncomfortable for donors, requiring them to undergo growth factor injections for several days prior to collection. Cord Blood stem cell Transplantation (CBT) uses stem cells harvested from the umbilical cord blood of a newborn. This method is gaining in popularity, particularly when a matched donor is not available, as cord blood units can be stored in cord blood banks and used later for transplantation. Cord blood is a less immunologically mature source of stem cells, which can reduce the likelihood of GVHD [2].

Cord blood can be stored in advance, offering an "off-the-shelf" source of stem cells when a donor match is needed, which is particularly valuable in diverse populations with limited access to matched donors. The number of stem cells in a single unit of cord blood is lower than that found in bone marrow or peripheral blood, which can affect the success of transplantation, particularly in adults. The collection process is non-invasive, but cord blood units need to be stored, processed, and often require matching before use, adding to the overall cost. The economic comparison of BMT, PBSC, and CBT involves multiple factors, including the cost of collection, processing, storage, transplantation, and long-term follow-up care. The costs associated with each type of stem cell source differ significantly, with some being more affordable upfront but leading to higher long-term expenses, while others are more expensive initially but have long-term cost benefits [3].

The collection of bone marrow requires general anesthesia and can involve a hospital stay for both the donor and the recipient. For the donor, there are costs associated with anesthesia, the surgical procedure, and recovery. On average, the collection costs for bone marrow range from $8,000 to $15,000 per donor. Peripheral blood collection through apheresis is less invasive but still requires the donor to undergo growth factor stimulation and multiple apheresis sessions. The cost of mobilizing and collecting stem cells from peripheral blood generally falls between $5,000 and $10,000 per donor. The collection of cord blood is relatively inexpensive since it occurs immediately after birth, and there is no need for anesthesia or invasive procedures. However, the costs of storing the cord blood in a public or private bank can vary, with storage fees typically ranging from $500 to $2,000 annually, depending on the bank. One-time collection and processing fees can be in the range of $1,000 to $3,000 [4].

After collection, both bone marrow and peripheral blood stem cells must be processed, which involves the isolation and concentration of hematopoietic stem cells. This processing is generally more straightforward and costs between $2,000 and $5,000 per transplant. There are no significant storage costs for these sources, as the stem cells are used immediately after processing. Processing and cryopreservation of cord blood are more expensive, primarily due to the need for long-term storage and matching procedures. The initial processing of cord blood typically costs between $1,500 and $3,000. Ongoing storage fees, as mentioned, range from $500 to $2,000 per year.

For patients requiring matching, additional costs for HLA typing and matching procedures can add several thousand dollars to the overall cost. Regardless of the stem cell source, the transplantation procedure itself involves significant costs. This includes the recipient's preparatory chemotherapy, the transplant procedure, inpatient hospitalization, and post-transplant care (e.g., immunosuppressive therapy, monitoring for GVHD, infection prevention, etc.). The costs of transplant procedures for both bone marrow and peripheral blood stem cells are similar. A typical allogeneic SCT can cost anywhere from $200,000 to $500,000 per patient, depending on the complexity of the transplant, the need for post-transplant therapies, and the length of hospitalization. Cord blood transplantation is generally more expensive due to the need for additional processing, matching, and potential difficulties with engraftment. The cost for a cord blood transplant can range from $300,000 to $600,000 or more, making it the most expensive option for stem cell transplantation [5].

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Conclusion

Allogeneic stem cell transplantation is a high-cost procedure, and the choice of stem cell source—bone marrow, peripheral blood, or cord blood—has significant economic implications. While bone marrow and peripheral blood are more commonly used and generally less expensive in the short term, cord blood offers an important alternative for patients without a suitable donor match, despite its higher upfront costs. The decision regarding the most cost-effective stem cell source should be made based on a comprehensive assessment of the patient's needs, the availability of donors, and the potential for long-term complications. For many patients, particularly those with limited access to matched donors or those requiring urgent transplants, the higher cost of cord blood may be justified by the reduced risk of GVHD and the availability of "off-the-shelf" stem cells. In the end, economic considerations must be weighed alongside clinical outcomes, and ongoing advancements in stem cell processing and technology may help to reduce costs while improving the effectiveness of allogeneic stem cell transplantation across all sources.

Acknowledgement

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Conflict of Interest

None.

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