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SPECIAL ARTICLE

Cord Blood Banking

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In several genetic, hematologic, and oncologic disorders, reconstitution of bone marrow can be a potentially lifesaving procedure. Allogeneic (related or unrelated) or autologous (self) bone marrow is the usual source of hematopoietic progenitor cells to achieve this goal. If autologous marrow is not available, the best option for successful reconstitution therapy is to secure marrow from a sibling with an identical HLA match. Close matching is important to achieve successful engraftment and to minimize the risk of potentially fatal graft-versus-host disease. Unfortunately, there is only a 25% chance for an identical HLA matching in a sibling. Although the number of patients who receive unrelated donor marrow transplants each year continues to increase, it is limited by the availability of suitable HLA-compatible donors, the risk of graft-versus-host disease and the risk of opportunistic infection.[1]

By reducing complications, increasing the pool of suitable donors, and lowering the time of potential donor searches, umbilical cord blood has become an attractive alternate source of stem hematopoietic cells for transplantation. Cord blood offered a number of advantages over bone marrow.(Table 1) With a large number of births per year, the potential donors were essentially unlimited. Over the past decade, clinical use of cord blood has shown that more ethnic minority patients have been able to be transplanted, the incidence and severity of graft-versus-host disease (GVHD) has been significantly reduced, and the costs of transplant have been considerably less than with bone marrow transplant.

Table 1. Benefits of Cord Blood Transplantation[2]

Greater HLA mismatch tolerance
Significantly reduced risk of graft-versus-host disease
Painless, noninvasive, risk-free retrieval
Essentially unlimited supply
Technically simple collection process
Immediate availability for clinical use
Superior proliferative capacity
Significantly lower cost
Lower risk of infectious complications

Umbilical cord blood offers many advantages over unrelated donor-derived bone marrow as a source of stem cells for an affected sibling, including a higher likelihood of an HLA match and its availability. Moreover, when used by unrelated third-party recipients, umbilical cord blood-derived stem cells seem to confer advantages in rates of engraftment and reduced graft-versus-host (GVH) disease even if there are one or two HLA loci mismatches.[3,4] The latter phenomena may reflect the cells' relative immunological immaturity and the higher proportion of stem cells in an umbilical cord specimen than in bone marrow.[5,6]

Umbilical cord blood banking

Umbilical cord blood banking consists of the collection, processing, and cryopreservation of the remaining blood within the umbilical and placental circulation following the birth of a child and typically prior to placental delivery. Umbilical cord blood contains a rich source of hematopoietic stem cells which are undifferentiated cells that have the capacity to differentiate into the various components of the hematologic and immune systems. These pluripotent stem cells can differentiate to form lymphoid precursors, which then produce B-lymphocytes, T-lymphocytes, natural killer cells, and plasma cells, as well as myeloid stem cells that give rise to the erythrocytes, platelets, neutrophils, monocytes, eosinophils, basophils, and macrophages.

Process for umbilical cord collection

After the infant has been delivered, the cord blood collection should be performed as soon as possible. Several methods for cord blood collection have been described.[7] A closed collection system is used because of its association with decreased bacterial and maternal fluid contamination. The system consists of a venipuncture devise connected by tubing leading to a collection bag, essentially a blood donation set. An anticoagulant and tissue culture medium (typically refrigerated) are added to the collection bag using sterile technique. Losses during umbilical cord blood processing must be minimized, since total volume of cord blood directly affects ultimate total number of stem cells available for transplantation. The unit is to be stored at room temperature until it reaches the bank. A minimal amount of sample is tested for viability, sterility, cell count and HLA typing. Umbilical cord blood may be stored in its original form or may be volume reduced prior to storage. In light of space issues and cost of liquid nitrogen, volume reduction prior to storage is very attractive to banks.

For more than a decade, cord blood stem cells have been used to treat many patients worldwide with different malignant and nonmalignant diseases and to treat patients with severe combined immunodeficiency syndrome through gene therapy techniques (Table 2).[8-11]

Table 2. Diseases potentially treatable with umbilical cord blood stem cell transplants[2]

Acute leukemias
Chronic leukemias
Myelodysplastic syndromes
Stem cell disorders
Myeloproliferative disorders
Lymphoproliferative disorders
Phagocyte disorders
Platelet abnormalities
Plasma cell disorders
Liposomal storage diseases

Histiocytic disorders
Inherited erythrocyte abnormalities
Congenital (inherited) immune system disorders
Other inherited disorders
Other malignancies

The premise for banking cord blood is the fact that cord blood stem cells are the progenitor cells that can reconstitute the blood and immune systems. These cells are particularly abundant in cord blood with concentrations nearly 10 times greater than that found in bone marrow and are more proliferative. Unlike the risks inherent in bone marrow transplants, they can be collected safely without maternal or neonatal risk following delivery.[5,12,13] When infused, cord blood stem cells migrate to the bone marrow where they engraft and develop into the cell lines of blood and immune system components mentioned above.

In some developing countries, patients may decide to bank their child's umbilical cord blood privately or publically. The cost of private cord blood banking is high. The marketing of private cord blood banking was aimed at motivating parents to store their child's cord blood in the event that child should develop a pediatric leukemia, it is more appropriate that patients approach the option of cord blood banking as a potential "family resource," where cord blood stem cells serve to treat diseases that occur among family members, including parents and siblings. It has been estimated that only 0.04% of children will be born with a life-threatening genetic disorder or develop a cancer potentially amenable to autologous umbilical cord blood stem cell transplants.[14] In addition, their parents or another offspring may also require the banked cells. However, in most cases the likelihood of needing a specimen remains less than 1%. Neither the American College of Obstetricians and Gynecologists (ACOG)[15] nor the American Academy of Pediatrics (AAP)[16,17] recommends routine private umbilical cord blood banking for all patients.

References

1. Wagner JE, Kernan NA, Steinbuch M, Braxmeyer HE, Gluckman E. Allogeneic sibling umbilical-cord-blood transplation in children with malignant and non-malignant disease. Lancet 1995;346:214-9.
2. Perlow J. Cord blood banking: an ob's perspective. Contemp Ob/Gyn 2002;11:31-43.
3. Kurtzberg J, Laughlin M, Graham ML, Smith C, Olson JF, Halperin EC, et al. Placental blood as a source of hematopoietic stem cells for transplantation into unrelated recipients. N Engl J Med. 1996;325:157-66.
4. Wagner JE, Rosenthal J, Sweetman R, Shu XO, Davies SM, Ramsay NK, et al. Successful transplantation of HLA-matched and HLA-mismatched umbilical cord blood from unrelated donors: analysis of engraftment and acute graft-versus- host disease. Blood. 1996;88:793-802.
5. Wiley JM, Kuller JA. Storage of newborn stem cells for future use. Obstet Gynecol. 1997;89:300-3.
6. Smith FO, Thomson, BG. Umbilical cord blood collection, banking, and transplantation: current status and issues relevant to perinatal caregivers. Birth. 2000;27:127-35.
7. Pafumi C, Farina M, Bandiera S, Cavallaro A, Pernicone G, Russo A, et al. Differences in umbilical cord blood units collected during cesarean section, before or after the delivery of the placenta. Gynecol Obstet Invest 2002;54:73-7.
8. Barker JN, Wagner JE. Umbilical cord blood transplantation: current state of the art. Curr Opin Oncol 2002;14:160-4.
9. Laughlin MJ, Barker J, Bambach B, Koc ON, Rizzieri DA, Wagner JE, et al. Hematopoietic engraftment and survival in adult recipients of umbilical-cord blood from unrelated donors. N Engl J Med 2001;344:1815-22.
10. Rubinstein P, Carrier C, Schardavou A, Kurtzberg J, Adamson J, Migliaccio AR, et al. Outcomes among 562 recipients of placental-blood transplants from unrelated donors. N Engl J Med. 1998;339:1565-77.
11. Kohn DB, Parkman R. Gene therapy for newborns. FASEB J 1997;11:635-9.
12. Gluckman E. Hematopoietic stem-cell transplants using umbilical-cord blood. N Engl J Med 2001; 344:1860-1.
13. Hows JM, Marsh JC, Bradley BA, Luft T, Coutinho L, Testa NG, et al. Human cord blood: a source of transplantable stem cells? Bone Marrow Transplant 1992;(suppl 1):105-8.
14. Leonard JF. Placental blood transplantation and autologous banking-caveat emptor. J Pediatr Hematol Oncol. 1997;19:183-6.

15. American College of Obstetricians and Gynecologists (ACOG) Committee on Obstetric Practice, Committee on Genetics. ACOG Committee Opinion Number 183, April 1997.
16. American Academy of Pediatrics News Release, July 6, 1999.
17. Cord blood banking for potential future transplantation: subject review. American Academy of Pediatrics. Work Group on Cord Blood Banking. Pediatrics. 1999;104:116-8.