Intersect, Vol 14, No 3 (2021)

Influential Factors Regarding the Choice to Donate Umbilical Cord Blood (UCB)

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Abstract

While most people think of bone marrow as *the* key source of stem cells, in recent years the collection and donation of umbilical cord blood (UCB) stem cells has become increasingly popular. Cord blood stem cells—which can be transplanted to donor matched individuals similar to the stem cells found in bone marrow—have been used to treat various immune and metabolic disorders, along with cancers such as leukemia and blood disorders such as anemia ("Options," n.d.; "Cord blood and," n.d.). These stem cells can be obtained through individual donations of UCB to public banks, or through privately banked samples kept for distribution only within a family ("Options," n.d.). Within the medical community, discussion of the pros and cons of UCB's applications is becoming increasingly common; however, the general population remains relatively unaware of UCB's value, biological mechanisms, and function. Thus there is a great discrepancy in knowledge between health care professionals and potential UCB donors regarding the utility and collection process of UCB stem cells. This literature review seeks to examine the social, economic, and biological factors influencing a family's decision to donate, privately store, or discard their baby's UCB. Furthermore, this review will analyze the impacts of both improved patient outreach measures and consent processes in relation to UCB education and donation, and the potential use of stem-cell duplication technologies and double UCB transfusions in relation to adolescent and adult patients.

Introduction and Qualifications for Collection of UCB

Umbilical cord blood (UCB) is rich in primitive stem cells similar to the mature stem cells found in bone marrow ("Options," n.d.). Within the realm of stem cell transplants, graft-versus-host disease can make finding a donor match relatively difficult. In graft-versus-host disease, the recipient's body rejects donor stem cells due to a lack of leukocyte antigen matches ("Graft-versus-host," n.d.). UCB stem cells however, are a more flexible option for transfusion because primitive stem cells can withstand a greater number of mismatched human leukocyte antigens (HLA) between the recipient and donor than mature stem cells (like those found in bone marrow) can tolerate ("Cord blood and," n.d.; Broder et al., 2013). This makes UCB a great potential resource for transfusion within minority communities with specific combinations of HLA markers because public bank UCB stem cells would likely be accepted with a greater frequency of mismatches than bone marrow stem cells, making it easier to find an acceptable match from a UCB bank than a bone marrow bank (Broder et al., 2013).

There are four main applications of UCB collected following the birth of a child. If the family would like to privately store the child's cord blood for potential future use, the blood will be collected and sent to a private bank, and the family will pay an initial storage cost plus annual storage fees for the duration of the UCB storage ("Family," n.d.; "Options," n.d.). If the family has identified a close relative who can make use of the UCB to treat their own medical ailments, the family can proceed with a "directed donation" in which UCB is collected and saved in a bank for that family member at little to no cost as long as the mother allows for the signs off the "property rights" of the sample to that family member ("Options," n.d.; Stewart et al., 2013). If the family has decided that they would like to donate the cord blood to a public bank, the UCB will be collected and sent to a partner public bank at no cost to the family ("Donating," n.d.; "Options," n.d.). Lastly, if the family would like, they can donate the UCB for research purposes which would negate the procedural costs of cord blood collection and storage similar to the procedures undertaken for public bank donation ("Options," n.d.; "Cord blood donation," n.d.).

Individuals who have expressed interest in collecting their child's UCB (either to store or donate it) may have additional medical procedures to determine if they are qualified to store UCB samples that may be used by others (whether strangers or family members). In order to collect and donate cord blood, the individual must first identify UCB banks in the area that are partnered with their obstetrician's hospital ("Donating," n.d.; "Family," n.d.; "Public," n.d.). This relationship is important to seek out because it ensures families that physicians at partnered hospitals are capable of safely collecting and storing the UCB until it is passed onto a bank that specializes in the storage and testing of viable cord blood, whereas unpartnered hospitals may be incapable of collecting UCB ("Donating," n.d.). Once the family is assured that donation is geographically possible through partnered area hospitals, the pregnant mother must undergo a series of procedural steps to determine her fitness for donation.

In order to donate UCB the mother must be deemed healthy by medical professionals, and she must only be carrying one child so as not to risk collecting and donating blood or tissue of mixed antibody composition (from multiple children with different blood types)

("Donating," n.d.; "Cord blood donation," n.d.). Paperwork detailing the biological parents' family history will then be filled out, along with information about the birthing plan, so that the physicians may be best prepared for the UCB procedure relative to the family's health risk factors and wishes ("Donating," n.d.). Because of this requirement, individuals seeking to donate UCB that utilized a donor gamete to obtain a pregnancy must be able to submit the donor's medical history, as obtained by an accredited facility ("Cord blood donation," n.d.). Once in labor, the mother should notify hospital staff that she wishes to donate the baby's UCB so that the physicians may prepare for the UCB collection procedure ("Donating," n.d.). This step is particularly critical if the hospital of choice operates using a self-selected donor system, which requires that patients initiate conversations about donation with staff and not the other way around (Broder et al., 2013).

Immediately following birth, the umbilical cord will be clamped, blood will be collected from the cord and placenta either before or after the delivery of the placenta (dependent on the procedure used for collection), and the mother's blood will be tested ("Donating," n.d.; Bassiouny et al., 2015). Once the sample reaches the UCB bank, the UCB will be tested for cell count, contamination, and tissue type to determine if the UCB is viable for donation ("Donating," n.d.; "Cord blood donation," n.d.). After viability testing, private samples deemed eligible for storage and future use will be placed in private storage, while eligible donation samples will be entered into a public registry accessible by doctors globally immediately prior to storage in a public bank ("Donating," n.d.; "Cord blood donation," n.d.). Between reception and use of the tissue or cord blood unit, all samples will be frozen and stored at a bank, be it public or private ("Donating," n.d.).

For families familiar with the beneficial components of UCB but disinterested in privately storing it or donating it, the option of delayed cord clamping remains. By waiting to clamp the umbilical cord immediately following birth, babies are able to receive an increased volume of nutrient-rich blood transferred from the placenta following birth "Cord blood donation," n.d.). Considering cord blood unit viability for collection is dependent on volume, cell count, and several other factors, delayed cord clamping significantly decreases the already low likelihood that an individual will produce a viable cord blood unit for storage or donation (~20% chance) since the clamp delay reduces the volume of collectable blood from the cord and placenta (Ciubotariu et al., 2018). While the duration of delay varies from case to case, long periods of delayed clamping (>60 seconds) have been shown to drastically decrease the volume of usable cord blood, to the point that individuals may consider it not worth it to donate the little, potentially unusable blood remaining in the cord and placenta post-clamp. Specifically, the frequency of successful collection of donatable cord blood drops from around 22.1%

(clamped 0-30 seconds following birth) to about 20% (clamped 30-60 seconds following birth), to a significantly lower 2.6% when clamping is delayed by over a minute (Ciubotariu et al., 2018). Thus, families hoping to donate UCB are encouraged to clamp the cord at most one minute after birth for the best chances of successful cord blood unit recovery.

In some cases, donation or storage of cord blood units is still possible post-delay, as UCB volume, cell count, and other qualifying factors vary depending on the type of birth, type of blood collection, positioning of the baby relative to the placenta, and several other factors (Faivre et al., 2018; Bassiouny et al., 2015; Ciubotariu et al., 2018). In the case of birth type, greater volumes of UCB are collected from C-section patients (mean of 101.02 mL; N=72) compared to those delivering vaginally (mean of 78.00 mL; N=28) (Bassiouny et al., 2015). This phenomenon is supported by the observed increase in volume collected from babies positioned above the placenta (as is typical in C-sections) as opposed to those level or below it (as is typical during vaginal delivery) due to the fact that gravitational forces push blood into the umbilical cord and placenta when the baby is higher than the placenta, while level/lower babies are on the receiving end of gravitational blood flow (Bassiouny et al., 2015; Faivre et al., 2018). Considering the type of blood collection, in utero procedures (which collect UCB after birth but before placental delivery) produced greater volumes of UCB (mean of 101.37 mL; N=73) than ex utero procedures (which collect UCB after placental expulsion) when compared (mean of 76.40 mL; N=27) (Bassiouny et al., 2015). Thus, while other factors at play may enable collection of viable UCB for donation despite delayed cord clamping, a family's intent to delay cord clamping should be considered a relevant factor when discussing the possibility of collecting UCB.

Motivating Factors for Public Bank Donation

Among families who choose to donate their child's UCB to public banks, there appear to be three notable motivators: morals and ethics, sustainability, and cost (Porter et al., 2011; Screnci et al., 2012) . From a moral standpoint, families who choose to donate UCB may claim that they would like to support the community, especially those in need or at risk (Porter et al., 2011). Motivation to donate UCB is similar to motivation to donate blood, being that individuals donate to sustain a public resource that they may need to take advantage of in the future. Emphasized in an Italian study examining UCB donation motivations between pregnant women and blood donors, this donation history likely led blood donors (76%, N=997; 73% of female blood donors, N=298) to exhibit greater intent to publicly donate UCB than pregnant women (55%, N=239) because it was already a value of theirs (Screnci et al., 2012). Others also value donating UCB because of the thought that they may be saving a child's life, as UCB is used to treat individuals with life-threatening illnesses such as leukemia (Porter et al., 2011).

In addition to their own moral convictions, many families' inclination to donate UCB to a public blood bank may be reinforced by ethical statements from religious authorities, advisors, or texts supporting donation and altruism. While religious texts may not directly address the issue of umbilical cord blood collection, individuals can interpret the messages within sacred texts and apply those interpretations to other aspects of life such as the fate of UCB (Jordens et al., 2012). Because little research addresses religious perspectives on UCB donation, analysis of religious perspectives on assisted reproduction will be used in this literature review to provide context for possible opinions regarding UCB donation. According to religious texts and teachings, Judaism, Catholicism, Anglicanism, Sunni and Shi'a Islam, Hinduism, and Buddhism all place significant value in forms of altruism and care for the community (Jordens et al., 2012; Sallam & Sallam, 2016). Such values support the presence of public resources such as public banks over the presence of commercial institutions such as private banks aimed at serving only the fortunate few. Additionally, opposition of commercializing or profiting off of body parts (Catholicism, Shi'a and Sunni Islam, Buddhism) encourages some religious individuals to reject services offered by private bank that charge individuals for the collection and storage of their child's cord tissue and/or UCB, instead favoring the free services of public banks (Jordens et al., 2012).

Differing opinions within religious communities regarding the collection and donation of UCB may stem, in part, from the degree to which other medical practices regarding reproduction are accepted (Jordens et al., 2012; Sallam & Sallam, 2016). For example, if individuals relate donation of gametes to donation of UCB (a product of reproduction), restrictions on gamete donation (Judaism, Catholicism, Sunni Islam) may deter UCB donation, while acceptance of gamete donation (Anglicanism, Shi'a Islam, Hinduism, Buddhism) may suggest that UCB donation is also permissible (Sallam & Sallam, 2016). Additionally, people of faiths that strongly discourage or forbid the destruction of embryos in research (Judaism, Catholicism, some sects of Anglicanism, Sunni Islam) may take greater issue with the potential manipulation and waste of donated UCB used in research if UCB is seen as an extension of life (Jordens et al., 2012; Sallam & Sallam, 2016). Ultimately, differing levels of practice, belief, and interpretation among individuals and families, sects, or religious authorities introduce variability into the degree to which religious beliefs impact a family's choice to donate to a public bank.

Those who choose to donate their child's UCB to a public bank may also do so for sustainability reasons, potentially in addition to the moral and ethical factors discussed. Some consider the sustainability of UCB, as it is a continually produced resource with "biovalue" (use in various biological settings) that can be utilized instead of simply discarded (Porter et al., 2011). Most patients aware of the uses of UCB do not want to waste it. This inverse relationship between education and discard rate is highlighted in a survey of 997 blood donors that cites, of the 930 respondents, 0% of blood donors would opt to discard UCB if options to donate to public banks (76% of respondents) or store UCB privately (9% of respondents) were available (Screnci et al., 2012). Comparatively, 28.5% of pregnant women surveyed (N=239) would opt to discard UCB when given the same options (Screnci et al., 2012). Thus, populations who appear to place value in the utility of UCB (donors and individuals recognizing "biovalue") are likely to donate at much higher rates than the standard, less-informed population. This suggests that teaching individuals about the uses of UCB would increase frequency of collection and donation, even if the family had no intention of keeping the UCB for themselves (Porter et al., 2011).

For families looking to collect and bank their child's UCB, public banking may also be more financially accessible than private banking. Private banks require both an initial fee to place a sample in storage (U.S. national private bank initial costs varying from \$199 - \$1999) and a recurring annual fee for continued storage in the facility (between \$89 and \$199 per year) whereas public bank collection and storage procedures are free to the donor ("Family," n.d.). While about 17.5% of pregnant women (N=68) in an Italian study cited these costs as the main deterrent to storing UCB in private banks, the costs did not appear to motivate individuals to donate that UCB to public banks instead (Screnci et al., 2012). So while these costs do not always influence a family to donate, for individuals that strongly believe in the value of UCB, it is possible that private bank costs will persuade families to donate to a public bank instead so as to fulfill their moral/ethical motivations despite financial limitations.

In addition to the costs, private bank storage may end up serving as a money pit for most families that do choose to keep their child's UCB because very few samples held in private banks end up used by the "owners" (Kaimal et al., 2009). In statistical calculations using both average and ideal probabilities for treatment cost, quality, and effectiveness, private cord blood banks are considered to be cost-ineffective (using a benchmark of \$100,000/life year saved) in 99.2% of trials based on their high cost and low chance of success or necessity (Kaimal et al., 2009). Thus, it is likely that families without an immediate need for stem cells would be less inclined to privately store UCB given the costs and unlikely possibility that they would ever need to use the sample.

Factors Leading to the Decision Not to Donate

If a family chooses not to donate their newborn's UCB to a public bank, the UCB will either be discarded or directed to a private bank depending on the family's preference. Some opt to keep their baby's cord blood for themselves (stored in a private) with the mindset that the UCB can serve as a form of biological "insurance" in the event that someone in the family may need a stem cell transplant in the future (Porter et al., 2011; Kim et al., 2015). In this case, the family may take comfort in the fact that they have a stem cell source immediately accessible to them, thus avoiding the potential stress of searching for a donor match. This "safeguarding the future" thought process was the leading motivation for the majority of a small group of pregnant women (11 out of 15) surveyed in an Italian study who wished to privately store their baby's UCB (N=15 out of the total 215 pregnant women surveyed, most of whom preferred donation or discarding) (Screnci et al., 2012). "Insurance" was also a motivating factor for 96.3% of women (n=109) surveyed in a Korean study on UCB who opted to privately store their child's cord blood unit, suggesting that this motivation is common globally (Kim et al., 2015).

In addition to the "insurance" factor, families who choose to privately bank UCB also cite its potential use in complex therapies that could be created in the future, essentially anticipating scientific advancements for which they will be prepared (Porter et al., 2011). Many families also overestimate the likelihood that they will need to use the UCB for their children (including siblings) in the future, although in most cases the UCB is never needed by the child or their siblings (Porter et al., 2011; Kaimal et al., 2009). Thus, the choice to privately store a child's UCB can be understood primarily as a means of preparing for the medical worst case scenario of any given family member. This tendency towards future planning and biological "insurance" may be further reinforced by social shaming and labeling of individuals who don't privately store as "bad mothers/parents" because perceivably they are not preserving resources for their own children but instead donating those resources or letting them "go to waste" (Porter et al., 2011). Thus, social climate can serve as a significant influence on a family's choice depending on the degree to which they value fitting in and being well-received by those critiquing their choices.

Some families choose not to donate simply because they are unaware of the fact that UCB is a resource of medical value that can be collected, stored privately or publicly, and transfused (Jordens et al., 2014; Screnci et al., 2012; Kim et al., 2015). Based on a Korean study of 177 women who chose to discard their child's UCB, 33.9% of respondents cited lack of knowledge as a key motivator for their decision (Kim et al., 2015). Of those who are aware, there tends to be confusion regarding the difference between public and private banking, as noted by two studies, one of which cited that 42% of pregnant women surveyed (N=239) could not explain the distinction, and the other of which cited that 44.2% of pregnant women aware of cord blood banking (N=1324) were unaware of the different types of banks (Screnci et al., 2012; Jordens et al., 2014). Furthermore, families may assume *any* form of collection is financially inaccessible, as was the case with 33.9% of women (n=177) who cited financial expenses as a deterrent and opted to discard their child's UCB (Kim et al., 2015). Even among obstetricians, the distinction between costs of private and public banks is not always clear, with 14% of bank-affiliated hospital obstetricians (N=137) and 31% of non-affiliated hospital obstetricians (N=155) unaware of the fact that public donation is free to donors (Walker et al., 2012).

Overall, there also appears to be a significant gap in knowledge of UCB use and collection across certain populations. Specifically, families that are from rural areas, attending public hospitals, educated up to high school at most, less than 25 years old, non-white, or non-English speaking are less likely to know about UCB banking than families that do not fit into these categories (Jordens et al., 2014). A family's ability to donate is negatively impacted by the first four factors listed because rural areas are typically farther from UCB banks than urban areas, private hospitals are typically more financially able to invest in UCB collection programs than public hospitals, and hospitals relying on self-selected donors require patients educated on the issue to initiate discussions about UCB collection rather than staff, which is more likely among highly educated, older patients (Jordens et al., 2014; Broder et al., 2013). Additionally, families that do not speak English may have difficulty receiving information about UCB collection if distributed brochures are only available in English (or other languages they do not speak), or if hospital staff are unable to translate and, as a result, receive informed consent from the family due to language barriers (Jordens et al., 2014; Broder et al., 2013). Lastly, marketing efforts led by private UCB banks may specifically target wealthy, white, highly educated, English-speaking areas to maximize potential profits, consequently neglecting to raise UCB collection awareness among communities comprised largely of lower-income residents or people of color, which in turn leads to a lack of diversity in the UCB donor pool (Broder et al., 2013).

In addition to differences within patient demographics, lack of education, or misinformation, among families may be the result of their sources of information. Considering that many pregnant women (42% of a survey of 239 pregnant women) rely on their gynecologist or obstetrician for information about UCB, access to a knowledgeable, confident obstetrician or gynecologist may be an important factor in numerous families' path to choose storage or donation (Screnci et al., 2012). About half of obstetricians surveyed in hospitals both affiliated (49%, N=137) and not affiliated (51%, N=155) with cord blood banks however, reported that they did not feel comfortable enough with the material to answer patient questions (Walker et al., 2012). Furthermore, the majority of obstetricians in both affiliated (87%, N=137) and nonaffiliated groups (84%, N=155) cited private UCB banks as their main source of information, which may be detrimental to a patient's unbiased understanding of all available resources because of private banks' inherently biased, commercialized messaging (Walker et al., 2012; Broder et al., 2013). This combination of potential bias or misinformation and a general lack of comfort and complete understanding on the side of obstetricians may lead a family to make a decision—without all relevant information—based on an incomplete perception of their options.

Securing the Future of Cord Blood

To better utilize the benefits of UCB, it is suggested that the UCB donation process improves through more extensive patient outreach and a more involved consent process for families (Broder et al., 2013; Jordens et al., 2014; Peberdy et al., 2016; Kim et al., 2015). To begin, individuals will need to have access to more thorough UCB education if they are to imagine becoming donors. In a Korean study, most families who choose to donate their child's UCB overestimated the effectiveness of UCB at treating ailments, while those who chose to discard the UCB largely felt skeptical or uninformed about the benefits of UCB transfusions, or thought it was too costly to donate (Kim et al., 2015). Patient education, however, can increase information accuracy, awareness and consideration of donating or storing UCB significantly, as exemplified by an Australian study in which 30% of individuals (N=1400) expressed consideration of UCB donation or storage before learning more about UCB banking, compared to 60.9% (N=1831) after banking education (Jordens et al., 2014). Additionally, families with personal experience and education about donation or transplant procedures such as those associated with blood and bone marrow have been shown to be more likely to collect UCB than those without that background (Jordens et al., 2014; Screnci et al., 2012). Thus, increasing rates of family education are likely to increase rates of informed UCB decisions.

In addition to patient education, efforts must also be taken to educate childbirth professionals. Often times, these professionals are the primary route to introducing the concept of UCB donation to families, however there is a significant gap in UCB education between individuals in traditional medical careers (e.g. obstetricians and maternity nurses in hospitals) and those in less traditional birth-related careers (e.g. midwives and doulas) (Peberdy et al., 2016). By educating childbirth professionals from various backgrounds (e.g. obstetricians, midwives, maternity nurses, doulas) on the rationale and process of UCB collection and donation, a greater number of birth-related touchpoints will be equipped to present information on UCB to patients or clients objectively, thus increasing families' complete, unbiased knowledge of their options (Broder et al., 2013; Peberdy et al., 2016). Furthermore, dedicating time and energy to informing doulas, midwives, and other birth professionals outside of hospitals—even extending education resources to health non-profits and clinics such as Planned Parenthood—would result in outreach to a broader range of patients who may not have access to the same resources as individuals visiting traditional hospitals, thus further diversifying the potential donor pool (Peberdy et al., 2016). Once a patient has been informed of their options through these various routes, the process of UCB donation can continue to the next step: obtaining family consent for the collection and storage or donation of their child's UCB.

By nature of the situation, cord blood technically belongs to the baby, as property rights recognize human tissue as the property of the individual, but consent is legally received from the mother on behalf of her child since the child cannot speak and offer consent itself (Stewart et al., 2013). While legally, consent is required only of the mother, some feel the process should be more inclusive through consultation with all parents prior to decision-making (Stewart et al., 2013; Jordens et al., 2014). This inclusive consent process, which is favored by 77% of surveyed pregnant women (N=1873), would ultimately require conversations with the entire family prior to delivery in the case that the family is not together at the time of delivery (Jordens et al., 2014). While there is no standardized method for receiving consent across institutions, some form of consent *is* required for UCB collection and storage, and guidelines are in place to suggest effective structures for discussing consent at different stages of pregnancy (e.g. third trimester, pre- and post-birth, etc.) (Armson et al., 2015). In some cases, consent is only received after the woman has been admitted to the hospital and started labor, which is not ideal considering her attention is likely elsewhere and she has little time to ask questions about the procedure details (Broder et al., 2013).

In response to concerns about consent requests this late in the process, phased approaches, which have recently become popular, promote a gradual approach to informing the family of their options relating to cord blood donation by providing different pieces of information at different stages of pregnancy (Broder et al., 2013; Armson et al., 2015). Ideally, information will be delivered in a timely manner similar in technique to the phased approach that allows for comprehensive discussion and multiple opportunities for the patient to ask questions and reevaluate decisions before committing to any given choice (Armson et al., 2015). This early approach was favored in a study of pregnant women (N=1873), three quarters of whom felt UCB banking information should be shared prior to pregnancy or before at least before the woman reaches 30 weeks of pregnancy, while an additional 20% suggested providing information post-30 weeks but before delivery (Jordens et al., 2014). Ultimately, it is suggested that providing the family with information in stages would better enable the couple to make informed, confident decisions in the best interest of the mother, the child, and the family unit.

While education and consent procedures are important steps in improving the collection and donation processes of UCB, one of the biggest obstacles to cord blood donation right now is not the willingness of individuals to donate, but the ability of medical facilities across the globe to obtain, test, store, and deliver UCB to banks (Broder et al., 2013). Across the entire United States, there are only 26 public and 19 private cord blood banks, several of which are clustered within the same state ("Family," n.d.; "Public," n.d.). This sparse distribution, which leaves many states without a nearby private or public bank, makes it significantly difficult for certain geographic regions to easily arrange for the collection and delivery of UCB samples to banks (Broder et al., 2013).

While some banks accept national donations, individual families are responsible for requesting that hospital staff collect and package UCB for shipping, which may require a significant amount of future planning as some banks have a registration deadline so that donation materials may be mailed to the family prior to birth ("Family," n.d.). If a family misses registration deadlines, forgets to pack the collection kit, neglects to initiate the conversation about UCB collection with staff, or delivers the child at a hospital that cannot safely collect and store UCB, the family may not be able to use the UCB even if they planned to (Broder et al., 2013; "Family," n.d.). Thus, logistics are a key barrier to donation, assuming a viable cord blood unit is produced and available for collection. Considering all of these factors, a combination of efforts aimed at better informing and equipping diverse birthing teams and patients for UCB donation and collection is thus an important next step in the journey towards increased collection and utilization of umbilical cord blood for medical research and treatment. Furthermore, the gap in access could be addressed if efforts were made to either i) increase funding for the construction or expansion of UCB banks to reach under-served areas of the country, or ii) equip non-UCB blood banks (e.g. the American Red Cross) with the tools and resources to facilitate the collection and donation of UCB units in areas without nearby UCB banks.

A final drawback of UCB transfusions raised by the scientific community is the limitation of cell dosage per unit of UCB in relation to the viability of certain transfusion recipients. As discussed earlier, UCB units are screened for stem cell count per sample so that the units can be appropriately matched to individuals in need based on their size ("Donating," n.d.; "Cord blood donation," n.d.). For adults and adolescents, this presents a barrier to treatment access because very rarely do single units of UCB contain the 2.5×10^7 cell count / kg patient weight needed for adolescent and adult patients (Scaradavou et al., 2013). This cell count measure is important because patients receiving inadequate cell dosage per unit transfused have been shown to experience higher rates of death and delays in recovery (Wagner et al., 2014). In an attempt to bridge this cell dosage limitation, some individuals have attempted to duplicate the stem cells in a given UCB unit. There have been successful duplications of cord blood stem cells through lab procedures, however this type of cell duplication is not yet practical or available for medical use nationwide ("Human," 2008).

The current, most widely used practice to accommodate for cell dose limitations within a UCB sample is a process called double UCB transfusion (DUCBT). Through this procedure, an adolescent or adult-sized patient who does not have access to an appropriately cell-dosed single UCB unit is transfused with two units of UCB (Hashem & Lazarus, 2015; Scaradavou et al., 2013). Given that this procedure results in similar survival outcomes for patients relative to single-dose treatment (with one study claiming a 1-year survival rate of 65% for DUCBT vs 73% for single UCB transfusion patients), the treatment has been viewed by many as a viable option for adult and adolescent patients (Wagner et al., 2014). As of 2013, DUCBT accounted for 80% of all adult UCB transplant procedures because of its success given the limited resources available for adult patients (Scaradavou et al., 2013).

While this procedure is certainly worthy of further research and clinical application, it is important to note that a variety of studies have found DUCBT patients are at higher risk for graft-vs-host disease and delayed platelet recovery (Hashem & Lazarus, 2015; Wagner et al., 2014). Furthermore, clinicians should be aware of the patient's disease progression timeline when considering DUCBT because studies have shown that treatment intervention early on in the course of a patient's disease is ideal in terms of survival outcome given that DUCBT has been shown to be a safe and viable option for patients with higher body masses who are otherwise unable to find appropriate single UCB units for transfusion (Scaradavou et al., 2013). Even so, researchers agree that the benefits of DUCBT outweigh the detriments, especially given the scarcity of UCB units with high enough cell-counts for a single transfusion to an adolescent or adult patient. Thus, DUCBT should be considered a worthwhile investment of time and resources in the treatment of adult and adolescent patients, facilitated by the aforementioned opportunities for improvement to the UCB collection and distribution network.

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