Correlation of ultrasound estimated placental volume and umbilical cord blood volume in term pregnancy

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Abstract

Objective: To investigate the correlation between ultrasound measured placental volume and collected umbilical cord blood (UCB) volume in term pregnancy.

Material and Methods: An observational cross-sectional study of term singleton pregnant women in the labor ward at Maha Chakri Sirindhorn Medical Center was conducted. Placental thickness, height, and width were measured using two-dimensional (2D) ultrasound and calculated for placental volume using the volumetric mathematic model. After the delivery of the baby, UCB was collected and measured for its volume immediately. Then, birth weight, placental weight, and the actual placental volume were analyzed. The Pearson's correlation was used to determine the correlation between each two variables.

Results: A total of 35 pregnant women were eligible for the study. The mean and standard deviation of estimated placental volume and actual placental volume were 534±180 mL and 575±118 mL, respectively. The median UCB volume was 140 mL (range 98-220 mL). The UCB volume did not have a statistically significant correlation with the estimated placental volume (correlation coefficient 0.15; $p=0.37$). However, the UCB volume was significantly correlated with the actual placental volume (correlation coefficient 0.62; $p<0.001$) and birth weight (correlation coefficient 0.38; $p=0.02$).

Conclusion: The estimated placental volume by 2D ultrasound was not significantly correlated with the UCB volume. Further studies to establish the correlation between the UCB volume and the estimated placental volume using other types of placental imaging may be needed.

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Introduction

Umbilical cord blood (UCB) is an established source of hematopoietic stem cells for transplantation (1, 2). It has become more popular in the new era of transplantation medicine (3). In cord blood banking, the qualified cord blood unit was determined by the number of the total nucleated cell count (TNC) and the cluster of differentiation 34+ (CD34+) cell concentration that is adequate for engraftment (4). For an efficient banking system, some researchers look for a reliable method to predict UCB cell yield from volunteer cord blood donors (5-7). Several maternal and neonatal factors may influence the quantity and quality of UCB collection; for example, gestational age, neonatal birth weight, placental weight, route of delivery, and length of umbilical cord (7-9). The method of UCB collection also has an influence on the volume collected (10).

UCB volume is a simple, rapid, and cost-effective parameter to estimate the blood forming potential of cord blood units. The volume collected correlates well with TNC and CD34+ cell measures; the high yield of hematopoietic cells were found in a greater volume of cord blood (11). Therefore, UCB volume is used as a criterion for UCB donor selection in many centers. The minimum threshold of volume needs at collection to bank units is 50 mL (12, 13).

Placenta is a connector between maternal and fetal circulation, and it is a reservoir for passing the blood to the fetus. Thus, placental volume should be another important factor that correlates to UCB volume. There are many modalities to estimate placental volume (EPV) prenatally such as two-dimensional (2D) ultrasound (14), three-dimensional (3D) ultrasound (15), and magnetic resonance imaging (MRI) measurement (16). The 2D ultrasound is mainly used for placental measurement in the prenatal period, and these specific placental parameters can calculate placental volume using the mathematic model with good correlation (17).

The purpose of the study is to find a correlation between ultrasound EPV and UCB volume. The ability to predict the UCB volume would help in selecting UCB donors before delivery.

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Material and Methods

This study is a cross-sectional study. The study population was singleton term pregnant women who had spontaneous vaginal delivery in our hospital from January 2014 to April 2014. The study protocol was approved by the ethical review board.
A pilot study of 10 pregnant women was performed. After data collection, the sample size was calculated using the expected correlation coefficient (r) of 0.74. This study required at least 35 participants.

Inclusion and exclusion criteria

A total of 50 Thai pregnant women in the labor room were recruited by the simple sampling method. The inclusion criteria were as follows: maternal age of >18 years, term singleton pregnancy, plan for a vaginal delivery, and consent to participate in the study. The exclusion criteria were as follows: any antenatal obstetrics complications, having any blood-borne transmission diseases such as viral hepatitis B or syphilis, history of hematopoietic malignancy, suspected fetal anomaly/fetal distress, abnormal amniotic fluid volume, rupture of amniotic membranes, and abnormality of placenta and umbilical cord. The authors also excluded cesarean delivery cases because the route of delivery may affect the collected UCB volume.

Placental volume measurement

Estimated placental volume (EPV)

All patients underwent ultrasound scans at hospital admission in the latent phase of labor using an ultrasound machine (Aloka®SSD900; BJC Healthcare, Bangkok, Thailand) with a 5 MHz 2D curvilinear abdominal transducer. After establishing a correct positioning according to the landmarks as previously described by Azpurua et al. (17), the measurement of placental height, width, and thickness were made on the same sonographic plane by the first author. Briefly, the placental location and cord insertion was identified. The ultrasound beam must be placed vertically to the placenta. The thickest non-folding part of the placenta was measured perpendicularly. The maximal placental width was measured in the range of between both edges of placenta. The placental height was the distance from the level of the width measurement to the base of the placenta vertically, as shown in Figure 1. All scans were performed during the uterine contraction-free period. After the complete linear measurement of three placental parameters, placental volume was later calculated using the convex–concave shell mathematic equation, $V = \left(\pi \frac{T}{6}\right) \times \{4H(W-T) + W(W-4T) + 4T^2\}$ (17).

Actual placental volume (APV)

The placenta was examined after delivery by a standard method (18). The membranes were trimmed at the placental edge, and all of the placental mass was wrapped up with a plastic bag and put in a bucket full of water to instead of water. The spilled water was measured for its volume using a scientific glass beaker as the principle of the water volume displacement. The APV was the spilled water volume plus UCB volume.

Umbilical cord blood (UCB) volume collection

Following delivery, the baby was placed in the same level of the placenta.The umbilical cord was clamped at 7 and 12 cm from the baby's side within 2 min after birth and then cut in the usual manner. A 16-gauge needle was inserted into the umbilical vein to allow drainage of UCB from the placenta to a standard 350 ml blood collecting bag, TERUMO® blood bag with Citrate Phosphate Dextrose Anticoagulant-1 (CPDA-1) (TERUMO Thailand Co. Ltd., Bangkok, Thailand), by gravity until blood flow stopped (19). The blood collection was monitored by a blood bag weighing machine (BIOMIXER® -323; Ljungberg & Kogel AB, Helsingborg, Sweden). The UCB volume was defined as the volume of blood in the collecting bag, excluding the pre-existing anticoagulant, measured in milliliters.

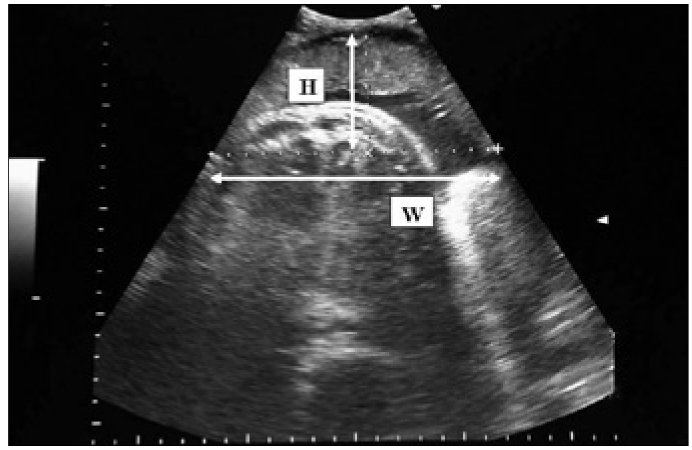

Figure 1. A two-dimensional ultrasound scan showing the measurement of placental width (W) and placental height (H) in centimeters

Statistical analysis

Statistical analysis was performed using SPSS IBM (Registration number 1975-01566-C) (Singapore Pte. Ltd., Singapore, China). The data was tested for a normal distribution. Continuous data was presented as mean and standard deviation (SD) or median and interquartile range (IQR) when appropriate. The Pearson's correlation coefficient (r) or the Spearman's rho correlation coefficient was calculated. Variable p-values <0.05 was considered statistically significant.

Results

A total of 50 pregnant women met the inclusion criteria. Five cases were excluded because the entire placental width could not be measured using ultrasound, and 10 cases were excluded because of poor visualization of the placenta due to its location. The median and interquartile range of maternal age and gestational age was 29 (IQR 26, 33) years and 38 (IQR 38, 39) weeks, respectively. The demographic and significant obstetrical parameters of the 35 participants were shown in Table 1. All the babies were healthy and showed no signs of respiratory distress. The mean and standard deviation of EPV and APV were 534 ± 180 mL and 575 ± 118 mL, respectively. The minimum, maximum, and mean of UCB collected were 98, 220, and 140 mL, respectively.
Figure 2 and 3 demonstrated the scatter plot of EPV, APV, and collected UCB volume in 35 participants. The APV was significantly correlated with UCB volume ($r=0.62$; $p<0.001$), where-

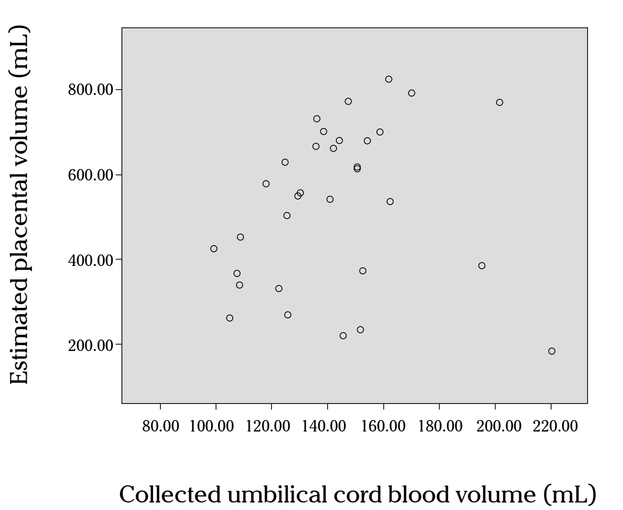

Figure 2. Scatter plot of estimated placental volume and umbilical cord blood volume. The correlation coefficient was 0.15; p=0.37

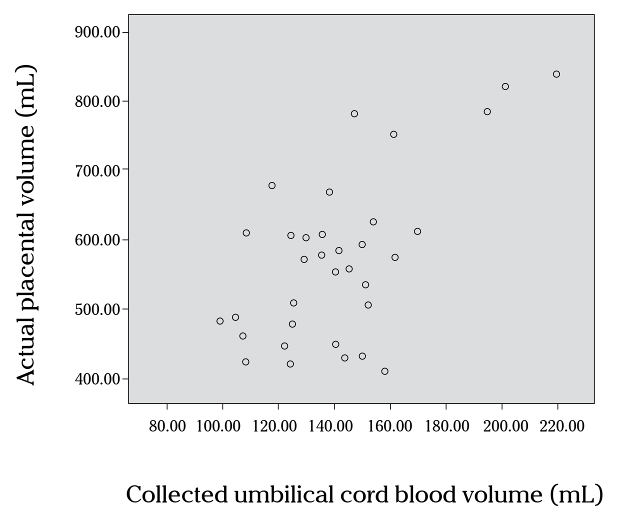

Figure 3. Scatter plot of actual placental volume and umbilical cord blood volume. The correlation coefficient was 0.62; p<0.001

Table 1. Demographic data of the participants (n=35)

	Median	(1st and 3rd interquartile range)
Age (year)	29	(26, 33)
Gestational age (week)	38	(38, 39)
Maternal BMI (kg/m^2)	25	(24, 29)
Neonatal birth weight (gram)	3090	(2890, 3300)

BMI: body mass index
n=number of patients
kg/m^2=kilogram per meter square

Table 2. Correlation of umbilical cord blood volume to other factors (n=35)

Factors	Correlation (r)	p value
Estimated placental volume	0.15	0.37
Actual placental volume	0.62	<0.001
Placental weight	0.57	<0.001
Neonatal birth weight	0.38	0.02

n=number of patients
r=correlation coefficient

as the EPV had no statistically significant correlation (r=0.15; p=0.37). The neonatal birth weight correlated with the UCB volume (r=0.38; p=0.02) as shown in Table 2.

Discussion

The collection of UCB for transplantation is still a good source of stem cell therapy. Currently, Thailand has only one public cord blood bank. The National Blood Center at Thai Red Cross Society serves the need of UCB transfusion for all of the Thai recipients. Because the UCB donors are limited by many factors, the UCB unit storages have never met its demand (20). Several factors play a role in the quality of the UCB unit, such as its volume, TNC, CD34+concentration, and sterility control (21). In this study, the authors focused primarily on UCB volume collected and its correlation with placental measurements. Because the placenta is the reservoir for the blood to be transferred to the baby, a larger placental volume should result in a higher volume of cord blood collected.

Interestingly, the authors found that EPV measured by the 2D ultrasound was not statistically correlated with UCB volume. The authors used 2D placental parameters to calculate its volume with a specific mathematic model (14, 17). Although this mathematical formula has been validated in previous studies and the authors limited the inter-operator variability, it is still possible that there were some errors in the EPV measurement. Another possibility that may have influenced the results with the EPV is a uterine contraction. More placental blood is shifted from the placenta into the baby during labor. This contributes to the poor correlations with the EPV measurement. A few limitations that may affect the reliability of the measurement included placental location, shape of the placenta, size of the placenta, and poor image quality. Differences in patients' demographics and a few number of participants also has an influence on the result. On the other hand, the method of UCB collection may interfere with the volume collected; therefore, the authors chose a simple technique based on gravity, which is commonly used in clinical practice. The mean volume of UCB collected in this research was >50 mL. This finding suggested that we can get enough UCB volume with our current technique.

In accordance with Wen SH et al. (9) and Urciuoli P et al. (22), the authors observed the positive correlation of placental weight and UCB volume. The APV and the UCB also show a high correlation in this study. These findings support the theory that the larger the placenta, the higher volume of cord blood will be collected. Therefore, the problem lies within what is the accurate method for antenatal estimation of the placental volume. Future studies are needed to explore a reliable modality for antenatal placental volumetric measurement. Other types of placental imaging such as a 3D ultrasound or placental MRI may be the interesting options.

Our data also demonstrated that the neonatal birth weight was correlated with the UCB volume. A previous study in the Italian population suggested that sonographic parameters such as fetal abdominal circumference and femur length may be used to predict UCB unit bankability (6). A further research in the Thai population to validate fetal biometric measurement for predicting UCB volume could also be beneficial.

The limitations of the study were a small number of participants, lack of sterility control, and no cell count report that may reflect the UCB transplant efficiency.

In conclusion, the EPV by 2D ultrasound is not correlated with UCB volume and cannot be used for prenatal selection of UCB donor. Other measures for estimation of placental volume should be further studied to improve the UCB bank efficiency.

Ethics Committee Approval: *Ethics committee approval was received from the ethical review board, Srinakarinwirot University (SWUEC/EX-23/2556, SWUEC/X-020/2557).*

Informed Consent: *Written informed consent was obtained from patients who participated in this study.*

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