Paediatrica Indonesiana

p-ISSN 0030-9311; e-ISSN 2338-476X; Vol.65, No.3 (2025). p.187-96; DOI: https://doi.org/10.14238/pi65.3.2025.187-96

Original Article

Comparison of umbilical cord milking and delayed umbilical cord clamping on hemoglobin levels in newborns

Roskya Sari A. Timumun[1], Fatmawati Madya[2], Andi Ariyandy[3]

Abstract

Background Umbilical cord milking is often used as an alternative to delaying cord clamping in the efforts to prevent anemia in newborns. However, there have been few studies to date on the benefits and risks of umbilical cord milking.

Objective To determine the effect of umbilical cord milking compared to delayed umbilical cord clamping on the hemoglobin levels of newborns.

Methods We performed simple randomization using lottery draw to allocate mother-newborn pairs to undergo either umbilical cord milking or delayed umbilical cord clamping. Using capillary blood obtained by heel prick, we measured the hemoglobin levels of the neonates before the intervention (pre-test) and 24 hours after birth (post-test). We compared pre- vs. post-test hemoglobin levels within each group, as well as between the two groups. We also compared the difference in hemoglobin increase between the two groups. In addition, we measured the time required to complete the umbilical cord milking procedure.

Results Fifty-six infants each were allocated into the umbilical cord milking and delayed cord clamping groups. The mean pre-test hemoglobin level was 18.05 (SD 1.418) g/dL and 17.28 (SD 1.505) g/dL in the umbilical cord milking and delayed cord clamping groups, respectively (P=0.085). The umbilical cord milking group had a significantly higher post-test mean hemoglobin level than the delayed cord clamping group [18.20 (SD 1.349) *vs.* 17.33 (SD 1.487) g/dL (P=0.025)]. Both groups experienced a significant rise in post-test, compared to pre-test mean hemoglobin levels (P=0.001 in both groups). The mean time required for umbilical cord milking was 19.911 (SD 2.1682), while the standard duration of delayed cord clamping was 2 minutes.

Conclusions Umbilical cord milking is more effective than delayed umbilical cord clamping in increasing the hemoglobin levels of newborns. **[Paediatr Indones. 2025;65:187-96; DOI: https://doi.org/10.14238/pi65.3.2025.187-96].**

Keywords: *umbilical cord milking; delayed umbilical cord clamping; hemoglobin; newborn*

Anemia remains a global health problem. According to data from the *World Health Organization* (WHO), approximately 269 million children worldwide suffer from anemia, caused mainly by iron deficiency.[1] The highest incidence of anemia in children is seen in African countries, at around 60.2%, with infants under six months of age being particularly affected. This is associated with the demographic location of sub-Saharan Africa as a malaria-endemic area.[2]

The prevalence of anemia in newborns varies significantly from country to country. In the Ethiopian region, the prevalence of anemia in newborns in Addis Ababa is 9%,[3] and a similar study conducted in Gondar found that the incidence of anemia in newborns was 25%.[4] Other studies were conducted in several sub-Saharan African countries, obtaining a prevalence of anemia in newborns of 35% in Nigeria,[5] 57% in Ghana,[6] 23% in Malawi,[7] and 61% in Benin.[8-10]

In Indonesia, the prevalence of anemia in babies also shows mixed data. *Survey Kesehatan Rumah*

From the Department of Midwifery, Postgraduate School1, Department of Obstetrics and Gynecology2 and Department of Physiology3, Faculty of Medicine, Universitas Hasanuddin, Makassar, South Sulawesi, Indonesia.

Corresponding author: Andi Ariyandy. Department of Physiology. Faculty of Medicine, Univesrsitas Hasanuddin, Jl. Perintis Kemerdekaan KM 10, Tamalanrea, Makassar 90245, Indonesia. Email:ariyandyasir@unhas.ac.id

Submitted June 23, 2024. Accepted June 2, 2025.

Tangga/SKRT 2009 (The 2009 Indonesian Household Health Survey) reported that the prevalence of iron deficiency anemia in the toddler age group was 48%.[11] A 2018 study revealed that the incidence of anemia in newborns at Hasan Sadikin Hospital, a referral hospital in Bandung, West Java, Indonesia, was 14.5%.[12] In Banjarbaru, South Kalimantan, in 2009, iron deficiency anemia was more commonly observed in infants, with a prevalence of 11.8% at age 0 months, 10.9%at one month old, and 11.3%at two months old.[13]

Anemia in infants is a serious health problem because if not treated correctly, it will interfere with mental and cognitive development. Iron deficiency anemia is related to the development of the baby's nerves, where iron is an essential factor in nerve myelination, metabolism, neurotransmission, and neurogenesis, thereby affecting behavior, memory, learning, and sensory systems. Iron deficiency during infancy poses a risk to mental and motor development, especially in language skills and body balance.[14]

To prevent anemia, one of the early efforts is to delay umbilical cord clamping in newborns.[15] Research on umbilical cord clamping methods continues to develop globally. Initially, clamping was done immediately within 30 seconds after birth, but this is not recommended because it causes a decrease in blood volume of 20 to 40 mL/kg of the baby's body weight, thereby increasing hypovolemic disorders and the risk of iron loss in the newborn baby.[16] Further research was then carried out regarding the timing of umbilical cord clamping; it was found that delayed cord clamping was more effective than immediate clamping.[17]

Part of the physiological adaptation of newborns is that cardiac output to the baby's lungs increases adequately by around 8-10% of that in prenatal life to 50% at birth.[18] Optimizing the increase in blood volume through placental transfusion is very important to allow time for blood to flow to the baby before clamping the umbilical cord.[19] During the transfer, the baby receives iron reserves of around 40-50 mg, which will help meet the baby's needs in the first three months and prevent iron deficiency that may occur when the baby is one year old.[20]

According to WHO recommendations, delayed umbilical cord clamping is carried out 1-3 minutes after birth.[21] In practice in Indonesia, delaying umbilical cord clamping is part of normal childbirth care, which is included in the series of active management of the third stage of labor, where clamping and cutting the umbilical cord is delayed for 2 minutes or until the umbilical cord stops pulsing.[22]

The benefits of delaying umbilical cord clamping have been studied by many experts, including being able to provide an additional approximately 30-35 mL/kg of blood volume to newborns through placental transfusion; this can increase the baby's hemoglobin level and prevent iron deficiency early in life.[23] In addition, delayed cord clamping is associated with increased hematocrits and higher ferritin levels in newborns.[24,25] Adequate ferritin levels ensures that iron supplies in newborn babies can meet their needs at the beginning of life.[26]

Even though delayed cord clamping has become the standard in assisting childbirth, it is rarely applied in hospital clinical guidelines because it requires time for the placental transfusion process to take place, and birth attendants prefer to immediately cut the umbilical cord.[27] Moreover, this method will not be effective for premature babies who require special treatment or full-term babies who need resuscitation, where time is of the essence.[28]

Another method offered to prevent anemia in neonates is umbilical cord milking as an alternative to delaying umbilical cord clamping. Umbilical cord milking involves massaging the umbilical cord three to four times from the direction of the placenta towards the baby, then clamping it and cutting it.[29] It has been suggested that in term neonates, cord milking and delayed cord clamping have comparable effects on hematological status without detrimental effects on other neonatal outcomes.[30]

Several studies have found that milking the umbilical cord has been proven to be beneficial in producing higher ferritin and hemoglobin levels and significantly reducing the occurrence of anemia in infancy.[31,32] The results of a recent meta-analysis of neonates who underwent umbilical cord milking showed that a peak hemoglobin increase of 1.18 g/dL (95%CI 0.65 to 1.71) was obtained in the first 24 hours after birth.[33,34] The additional volume of blood delivered through a placental transfusion of approximately 30-40 mL is equivalent to an amount of iron of around 40-50 mg, possibly more with umbilical cord milking. This iron can be used as reserves during

early stages of growth and development and maintain myoglobin and enzymes in muscles and other tissues in infants.[31]

Studies conducted on premature babies have proven that the act of milking the umbilical cord can reduce the number of blood transfusions received by babies treated in the neonatal intensive care unit (NICU) in the first six weeks of the baby's life; this is thought to be due to the increase in blood volume when the milking is done.[35] A study stated the same finding that this action is much more effective in premature babies with hypoxia or risk of respiratory failure because milking the umbilical cord does not take a long time for babies who need resuscitation.[36] This means that umbilical cord milking can be recommended for babies experiencing asphyxia.[37]

Currently, the method of milking the umbilical cord is still controversial because there is a need for further research evidence regarding the benefits and risks of this action. However, as far as research has been conducted, there have been no reports of adverse cases related to the umbilical cord milking method in full-term newborns. Previous research related to umbilical cord milking was carried out by only measuring post-treatment hemoglobin levels, while this study will focus on the increase in hemoglobin before and after treatment.[38]

Milking the umbilical cord can also be used as an alternative action to delay umbilical cord clamping in the third stage of labor; apart from being easy and cost-free, this action only requires a little time compared to delaying umbilical cord clamping, which takes 2 minutes while the benefits obtained are more or less the same by umbilical cord clamping. In this study, we aimed to determine the effect of umbilical cord milking compared to delayed umbilical cord clamping on the hemoglobin levels of newborn infants.

Methods

This experimental study was conducted at the Bokat Community Health Center, Bunobogu Community Health Center, and Gadung Community Health Center, Buol Regency, Central Sulawesi. The study population in this study consisted of normal neonates born in the Bokat Health Center, Bunobogu Health Center, and Gadung Health Center areas from November 2023 to March 2024.

The population in this study was composed of normal newborns born through spontaneous vaginal delivery in Bokat, Bunobogu, and Gadung Community Health Centers from November 2023 to March 2024. We included mothers with hemoglobin levels of ≥11 g/dL who gave birth normally and consented to participate in the study, as well as their normal newborns. A normal newborn was defined as a neonate who cried immediately after birth and was born at a full-term gestational age of 37-42 weeks with a birth weight of 2500-4000 grams. Normal birth was defined as spontaneous birth through the vaginal route at a full-term gestational age of 37-42 weeks without labor induction. Exclusion criteria were the presence of umbilical cord entanglement or short umbilical cord, complicated birth, high-risk pregnancies (e.g., placenta previa, hypertension, diabetes), and newborns with asphyxia, shoulder dystocia, or congenital anomalies.

Sample randomation and treatment allocation were carried out by drawing numbers in a lottery system. After obtaining written informed consent from the mothers or their representatives, each participant drew a number. Mothers who drew odd numbers were allocated to the intervention (umbilical cord milking) group and those who drew even numbers were allocated to the control (delayed cord clamping) group. Mothers and laboratory staff were blinded to the group assignments; the group allocation was known only to the investigators. The randomization process was double-masked to ensure unbiased implementation. s

The minimum required number of subjects was 51 in each group. To anticipate dropouts, we increased the sample size by 10%, resulting in 56 subjects in each group.

Immediately after birth and after ensuring the baby was not asphyxiated (cried spontaneously, appeared pink, and moved actively) a pre-test was conducted by measuring the baby's hemoglobin level at birth. This was done using a digital hemoglobin level measuring device (*Easy Touch® Blood Hemoglobin Monitoring System, Hangzhou Lysun Biotechnology Co.*, Hangzhou, China) using capillary blood obtained by heel prick of the baby's left heel. The first drop of blood resulting from the heel prick was wiped away, and the next drop was collected on the device's measuring

stick. Subsequently, cord milking or delayed cord clamping was performed, depending on the infant's group allocation. In the intervention group, cord milking was performed by stroking ("milking") the cord using the index finger and thumb starting from a distance of 20 cm from the placenta to the umbilicus. The cord was allowed to fill with blood before milking was repeated. This process was repeated four times, with each milking lasting 2 seconds. Afterward, the cord was clamped and cut. The baby was then cleaned and dried, and early breastfeeding initiation was performed. In the delayed cord clamping group (control group), blood was allowed to flow from the placenta to the baby for 2 minutes before the cord was clamped and cut, without milking. After 24 hours, a post-test measurement of hemoglobin level was taken using the same method as the pre-test measurement.

We compared pre- *vs.* post-test hemoglobin levels within each group using the paired samples t-test for normally distributed data and the Wilcoxon test for non-normally distributed data. Comparison of pre- and post-test hemoglobin levels between the two groups was done using the independent samples t-test for normally distributed data and Mann-Whitney U test for non-normally distributed data. Data processing was done using *Microsoft Excel* (*Microsoft,* Redmond, Washington) and *SPSS version 25* (*IBM,* Armonk, New York).

The study protocol has been approved by the Ethics Committee of the Faculty of Public Health, Universitas Hasanuddin.

Results

During the study period, 217 mothers gave birth in the participating health centers and were asked to participate in the study. Of these, 169 were eligible and provided informed consent (**Figure 1**). Forty-eight mothers were excluded before randomization due to expressing a preference for one of the two interventions, missed delivery, withdrawal, or

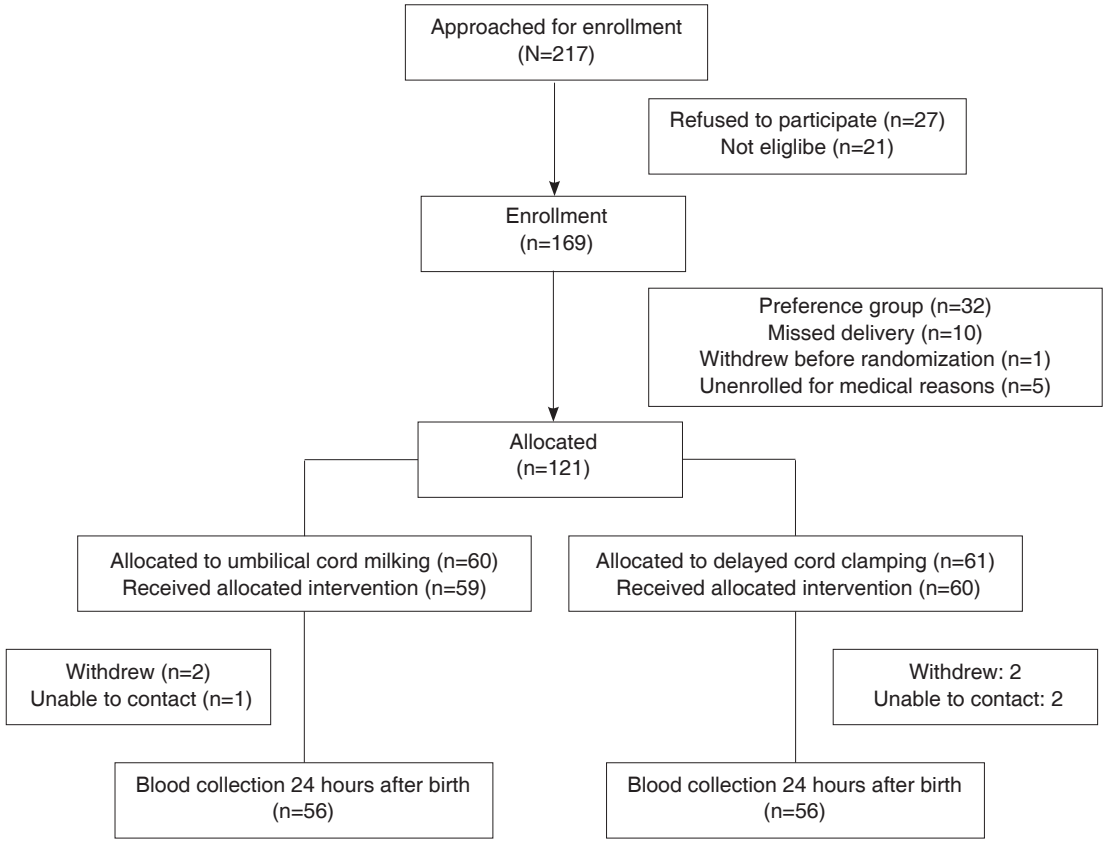

Figure 1. Subject recruitment flowchart

unenrollment due to medical reasons. Of the 121 mothers who underwent treatment allocation, 60 were allocated to umbilical cord milking and 61 to delayed cord clamping. Three subjects from the cord milking group and four from the delayed cord clamping group withdrew or could not be contacted following the intervention, leaving 56 infants in each group who underwent blood collection 24 hours after birth (**Figure 1**).

Table 1 describes the baseline characteristics of subjects in both groups. There appeared to be no significant differences between the two groups in mean maternal age, maternal hemoglobin, gestational age, and maternal parity, as well as in mean birth weight.

The average time required to milk the umbilical cord in our subjects was 19.911 (SD 2.1682) seconds. The maximum time needed for one milking was 25 seconds, and the minimum time was 16 seconds.

Comparison of mean hemoglobin levels between the umbilical cord milking and delayed cord clamping groups can be seen in **Table 2**. Pre- *vs.* post-test mean hemoglobin difference was 0.15 g/dL in the intervention group and 0.05 g/dL in the control group. Pre-test hemoglobin levels were similar between the two groups (P=0.085). However, post-test hemoglobin levels differed significantly between the cord milking *vs.* delayed clamping groups [18.20 (SD 1.349) *vs.* 17.33 (SD 1.487) g/dL; P=0.0250].

Discussion

Umbilical cord milking is known as an alternative to delayed umbilical cord clamping as a method to prevent anemia in newborns. Both methods can be easily applied. Cord milking is done upon birth by

Table 1. Characteristics of variables based on groups given umbilical cord milking and delayed umbilical cord clamping treatment

Characteristics	Umbilical cord milking (n=56)	Delayed umbilical cord clamping (n=56)	Total (N=112)
Maternal age, n (%)			
20-35 years	41 (73.2)	38 (67.9)	79 (70.5)
<20 years	8 (14.3)	7 (12.5)	15 (13.4)
>35 years	7 (12.5)	11 (9.8)	18 (16.1)
Maternal hemoglobin, n (%)			
11-12.75 g/dL	38 (67.9)	33 (58.9)	71 (63.4)
>12.75-14.5 g/dL	18 (32.1)	23 (41.1)	41 (36.6)
Gestational age, n (%)			
37-39 weeks	39 (69.6)	43 (76.8)	82 (73.2)
40-42 weeks	17 (30.4)	13 (23.2)	30 (26.8)
Parity, n (%)			
Primipara	22 (39.3)	21 (37.5)	43 (38.4)
Multipara	34 (60.7)	35 (62.5)	69 (61.6)
Birth weight, n (%)			
2500-3000 gr	37 (66.1)	31 (55.4)	68 (60.7)
>3000-3500 gr	12 (21.4)	17 (30.4)	29 (25.9)
>3500-4000 gr	7 (12.5)	8 (14.3)	15 (13.4)

*Chi-square test

Table 2. Comparison of mean hemoglobin levels between the umbilical cord milking and delayed cord clamping groups

Groups	Hemoglobin levels, g/dL		Pre- *vs.* post-test within-group Δ mean (g/dL)	Pre- *vs.* post-test within-group P value
	Mean pre-test (SD)	Mean post-test (SD)		
Umbilical cord milking	18.05 (1.418)	18.20 (1.349)	0.15	0.001[a]
Delayed cord clamping	17.28 (1.505)	17.33 (1.487)	0.05	0.001[b]
Between-group P value	0.085[c]	0.025[d]		

[a]Wilcoxon, [b]paired T-test, [c]Mann Whitney, [d]independent samples T-test

massaging the umbilical cord is for 20-30 cm four times at a speed of 10 cm per second towards the base of the baby's umbilical cord before being clamped and cut.[29] Hemoglobin levels play an essential role in determining the quality of life of newborn babies. Various efforts have been made in health services to achieve this. Umbilical cord milking can be an option for birth attendants, especially midwives, in preventing anemia at such an early age. Umbilical cord milking is also closely related to the role of placental transfusion, in which the blood volume can increase the baby's iron reserves. This is in line with a previous study, which reported that infants who had their umbilical cord milked had an increase in hemoglobin levels due to the volume of blood received by the baby, which was equivalent to 40-50 mg of iron or more.[20] In addition to increasing the baby's hemoglobin level, it will also provide sufficient iron reserves in the first three months of life.

Delayed umbilical cord clamping is one of the standard methods used in childbirth. After the baby is born, the umbilical cord will not be immediately clamped but will be left connected to the placenta for 2 minutes or until the umbilical cord stops pulsating. During the delay in clamping the umbilical cord, placental transfusion occurs, transferring a certain volume of blood to the baby. Delaying umbilical cord clamping in full-term babies with a gestational age of more than 37 weeks is beneficial in reducing the incidence of anemia.[16] Considering the importance of preventing anemia from an early age in babies, delaying umbilical cord clamping offers an easy method that can be used both in normal births and cesarean sections. However, in practice, theoretical concerns remain about the increased risk of hypothermia in the neonates due to a longer duration required for delayed cord clamping. Hypothermia contributes directly and indirectly to an increased risk of neonatal morbidity and mortality.[39] Optimizing actions according to procedure is important, since appropriate methods can reduce the occurrence of unwanted risks. In this study, milking the umbilical cord and delaying umbilical cord clamping have similar benefits in increasing hemoglobin levels in the infant. In contrast to delayed cord clamping, umbilical cord milking requires less time to complete, thus providing an effective and more efficient method.

The process of clamping and cutting the umbilical cord has undergone many changes over time. Before delayed cord clamping became common practice, the umbilical cord was immediately clamped and cut after birth. Delayed cord clamping has now become standard practice in many centers, and much research has been done regarding the optimal duration of delay. Currently, the standard is to delay cord clamping for two minutes.[39] It is accepted that the ideal time for umbilical cord clamping is 1-3 minutes to provide ample opportunity for additional blood flow from the placenta to the newborn.[29] However, studies have identified concerns in adopting delayed clamping methods in general, especially in infants who require timely resuscitation measures. In such infants, birth attendants must immediately cut the umbilical cord. However, this action may result in a sudden decrease in blood volume, leading to reduced preload in both the left and right ventricles.[16,40,41]

Umbilical cord-cutting management is an effective method to increase oxygen to the brain and oxygen in the arteries in its delivery to body tissues. Milking the umbilical cord and delaying umbilical cord clamping are the main strategies for managing placental transfusion to build up better iron reserves in newborn babies. Our study showed that newborns in the umbilical cord clamping group had a higher average hemoglobin level compared to those in the delayed umbilical cord clamping group. The highest increase in hemoglobin levels was in the umbilical cord milking group. There was a significant difference in post-test hemoglobin levels between the umbilical cord milking and delayed cord clamping groups (**Table 2**). We assume that the increase in hemoglobin levels in the umbilical cord milking group occurred because blood volume was actively transferred to the baby by optimizing the placental transfusion process. With regards of the time required to perform the procedure, umbilical cord milking is superior to delayed umbilical cord clamping.

Our assumption is in accordance with a previous finding that placental transfusion can actively increase the baby's blood volume.[42] This increases blood flow to the baby's lungs and brain, where pulmonary vasodilation occurs in response to spontaneous respiration and the baby's initial cry at birth. This event can physiologically facilitate the placenta, which is rich in fetal red blood cells and stem cells, to transfer blood volume and be accepted

optimally by the baby.

The umbilical cord milking group increased the baby's hematological values (hematocrit and hemoglobin) at 12 and 48 hours after birth.[43] The increase in hematocrit in newborns resulting from expressing the umbilical cord is attributable to the transfer of blood volume, adding red blood cells in the infant's circulation. Umbilical cord milking has also been shown to increase pulmonary blood flow immediately after birth and aid lung expansion at the start of breathing.[36] A study that compared umbilical cord milking and delayed umbilical cord clamping on hemoglobin levels in newborns, found that the umbilical cord milking group had a higher mean hemoglobin level compared to the delayed umbilical cord clamping group [14.41 (SD 1.13) g/dL *vs.* 14.21 (SD 1.01) g/dL; P <0.001]. This finding showed that umbilical cord milking is a more efficient technique than delaying umbilical cord clamping in maintaining the hemoglobin level in newborns.[44]

In this study, the average time needed to milk the umbilical cord for research subjects was 19.911 seconds. Timing was done for the entire process of milking the umbilical cord, which was carried out four times. After each milking, the umbilical cord was allowed to refill with blood before the next milking was carried out. A meta-analysis revealed that the time required to milk the umbilical cord was less than 20 seconds.[45] Although the ideal duration of umbilical cord milking is yet to be established, these findings once again strengthen the evidence that umbilical cord milking requires only a short time upon birth, making it highly feasible to do when assisting childbirth.

Sufficient iron availability is critical for various aspects of baby growth and development. Babies can optimally obtain this by preventing anemia from an early age. This study found that both methods of delaying umbilical cord clamping and umbilical cord milking could increase hemoglobin levels in babies. However, a superior method is milking the umbilical cord with a higher increase in hemoglobin levels. Additionally, milking the umbilical cord also has practical value in its application because it is straightforward and does not require a long time compared to delaying clamping the umbilical cord. This finding is significant considering the benefits it provides for the baby's life sustainably, so it is suitable for use in midwifery care, both in normal birth and cesarean section.

This research highlights the importance of preventing anemia in children, which can be done even in newborns. Normal hemoglobin levels are a measure or standard of health in infants and children. Milking the umbilical cord and delaying umbilical cord clamping is a simple method but rich in benefits in the process of monitoring the baby's sustainable growth and development. In this study, umbilical cord milking was more effective in increasing the hemoglobin levels of term newborn babies because the time used was shorter than delaying umbilical cord clamping, so this method can be recommended as a suitable method for practice by birth attendants in health services. In addition, this study examined hemoglobin levels before and after the umbilical cord milking intervention. It delayed umbilical cord clamping so that it could be assessed in detail how much the increase was within 24 hours.

A limitation of our study was that a digital Hb test kit is still used to check hemoglobin levels, which may affect the examination results. In addition, the duration of the intervention's monitoring was very short, so it was not possible to monitor any possible effects. logistical challenges also played a role. The distance between healthcare centers was significant, which led to cases where the baby was born before the researcher arrived. Additionally, parental refusal affected the number of neonates not included in the sample. Field observations indicated that decision-making was often dominated by family members, especially the parents, rather than the husband. Cases of low birth weight infants (LBW) were also identified, making them ineligible for inclusion. Other challenges included parents withdrawing from the study due to reluctance to have their baby's blood sample taken, or the researcher losing contact with the baby's parents. Moreover, collecting blood samples from newborns proved difficult due to the short time available, leading to unreadable or erroneous results on the digital Hb test device.

Based on our findings, it can be concluded that cord milking is more effective than delayed umbilical cord clamping in increasing hemoglobin levels in newborns. Considering the benefits of umbilical cord milking, it is recommended that health workers consider this method as an alternative to delayed

umbilical cord clamping, as the practice is easier and requires less time. Future research using continuous monitoring of hemoglobin levels and the infant's heart rate or extending assessment period to more than 24 hours may elucidate further the effects of umbilical cord milking.

Conflicts of interest

None declared.

Funding acknowledgement

The authors received no specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. World Health Organizations. Prevalence of anaemia in children aged 6-59 months. Website. 2021;12:2021. https://www.who.int/data/gho/indicator-metadata-registry/imr-details/4801
2. Stevens GA, Paciorek CJ, Flores-Urrutia MC, Borghi E, Namaste S, Wirth JP, *et al.* National, regional, and global estimates of anaemia by severity in women and children for 2000-19: A pooled analysis of population-representative data. The Lancet Global Health. 2022;10:e627-39. DOI: https://doi.org/10.1016/S2214-109X(22)00084-5
3. Tilahun D, Yimer MA, Zamanuel TG. High magnitude of neonatal anemia among sick newborns admitted to University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. Journal Blood Med. 2022;13:293-302. DOI: https://doi.org/10.2147/JBM.S361675
4. Tiruneh T, Shiferaw E, Enawgaw B. Prevalence and associated factors of anemia among full-term newborn babies at University of Gondar comprehensive specialized hospital, Northwest Ethiopia: A cross-sectional study. Ital J Pediatr. 2020;46:1-7. DOI: https://doi.org/10.1186/s13052-019-0764-1
5. Adediran A, Gbadegesin A, Adeyemo TA, Akinbami A, Osunkalu V, Ogbena A, *et al.* Cord blood haemoglobin and ferritin concentrations in newborns of anaemic and non-anaemic mothers in Lagos, Nigeria. Niger Med J. 2013;54:22. DOI: https://doi.org/10.4103/0300-1652.108889
6. Laar AK, Grant FE, Addo Y, Soyiri I, Nkansah B, Abugri J, *et al.* Predictors of fetal anemia and cord blood malaria parasitemia among newborns of HIV-positive mothers. BMC Res Notes. 2013;6:1. DOI: https://doi.org/10.1186/1756-0500-6-350
7. Ngwira A, Kazembe L. Analysis of severity of childhood anemia in Malawi: a Bayesian ordered categories model. Open Access Med Stat. 2016;6-9-20. DOI: https://doi.org/10.2147/oams.s95159
8. Koura GK, Ouedraogo S, Le Port A, Watier L, Cottrell G, Guerra J, *et al.* Anaemia during pregnancy: Impact on birth outcome and infant haemoglobin level during the first 18months of life. Trop Med Int Health. 2012;17:283-291. DOI: https://doi.org/10.1111/j.1365-3156.2011.02932.x
9. Dereje I, Etefa T, Gebremariam T, Getaye A, Tunta A, Gerbi A. Prevalence of anemia and associated factors among term newborns in nekemte specialized hospital, Western Ethiopia. J Multidiscip Healthc. 2021;14:2607-15. DOI: https://doi.org/10.2147/JMDH.S326962
10. Alamneh TT, Tilahun SF, Beyne MB, Fekadu SA, Assem AS, Kassa SF. Prevalence and associated factors of anemia among newborns at Tibebe Ghion Specialized Hospital, Northwest Ethiopia. Int J Gen Med. 2022;15:6465-74. DOI: https://doi.org/10.2147/IJGM.S365817
11. Ikatan Dokter Anak Indonesia. Pentingnya suplementasi besi untuk anak. In: Gatot D, Idjradinata P, Abdulsalam M, eds. Edisi Pertama. Badan Penerbit IDAI; 2011. p.1-9.
12. Asfarina I, Wijaya M, Kadi FA. Prevalensi anemia pada bayi baru lahir berdasarkan berat lahir dan usia kehamilan di RSUP Dr. Hasan Sadikin Bandung tahun 2018. Sari Pediatri. 2020;22:213-7. DOI: https://doi.org/10.14238/sp22.4.2020.213-7
13. Ringoringo HP, Wahidiyat I, Sutrisna B, Setiabudy R, Suradi R, Setiabudy R, *et al.* Model skoring untuk memprediksi anemia defisiensi besi pada bayi 0-6 bulan. Sari Pediatri. 2016;10:338. DOI: https://doi.org/10.14238/sp10.5.2009.338-44
14. Lozoff B, Brittenham GM, Wolf AW, McClish DK, Kuhnert PM, Jimenez E, *et al.* Iron deficiency anemia and iron therapy effects on infant developmental test performance. Pediatrics. 1987;79:981-95. DOI: https://doi.org/10.1542/peds.79.6.981
15. Sundararajan S, Rabe H. Prevention of iron deficiency anemia in infants and toddlers. Pediatr Res. 2021;89:63-73. DOI: https://doi.org/10.1038/s41390-020-0907-5
16. Snell L. Umbilical cord clamping: how timing affects infant health outcomes. [thesis]. [Minneapolis (MN]: Augsburg University; 2021.
17. De Bernardo G, Giordano M, De Santis R, Castelli P, Sordino D,

Trevisanuto D, *et al.* A randomized controlled study of immediate versus delayed umbilical cord clamping in infants born by elective caesarean section. Ital J Ped. 2020;46:1-6. DOI: https://doi.org/10.1186/s13052-020-00835-2

18. Chakkarapani AA, Roehr CC, Hooper SB, te Pas AB, Gupta S, ESPR Neonatal Resuscitation section writing group. Transitional circulation and hemodynamic monitoring in newborn infants. Pediatr Res. 2024;96:595-603. DOI: https://doi.org/10.1038/s41390-022-02427-8
19. Katheria A, Hosono S, El-Naggar W. A new wrinkle: Umbilical cord management (how, when, who). SeminFetal Neonatal Med. 2018;23:321-6. DOI: https://doi.org/10.1016/j.siny.2018.07.003
20. Güner S, Karaca Saydam B. The impact of umbilical cord clamping time on the infant anemia: A randomized controlled trial. Iran J Public Health. 2021;50:990-8. DOI: https://doi.org/10.18502/ijph.v50i5.6116
21. Chowdhury A, Neogi SB, Prakash V, Patel N, Pawar K, Koparde VK, *et al.* Implementation of delayed cord clamping in public health facilities: A case study from India. BMC Pregnancy Childbirth. 2022;22:1-9. DOI: https://doi.org/10.1186/s12884-022-04771-3
22. Rachma Anandita MY, Anggraeni L, Nurfaizah N. Hubungan delayed cord clamping terhadap kenaikan berat badan neonatus. Jurnal Kesehatan. 2022;13:86. DOI: https://doi.org/10.26630/jk.v13i1.2903
23. Ceriani Cernadas JM. Timing of umbilical cord clamping of term infants. Arch Arg Pediatr. 2017;115:188-94. DOI: https://doi.org/10.5546/aap.2017.eng.188
24. Yan J, Ren JD, Zhang J, Li J, Zhang X, Ma Y, *et al.* The short and long term consequences of delayed cord clamping on late pre-term infants. Int J Women's Health. 2023;15:361-8. DOI: https://doi.org/10.2147/IJWH.S385800
25. American College of Obstetricians and Gynecologists' Committee on Obstetric Practice. Delayed umbilical cord clamping after birth: ACOG Committee Opinion, Number 814. Obstet Gynecol. 2020;136:e100-e106. DOI: https://doi.org/10.1097/AOG.0000000000004167
26. Herold J, Abele H, Graf J. Effects of timing of umbilical cord clamping for mother and newborn: a narrative review. Arch Gynecol Obstet. 2024;309:47-62. DOI: https://doi.org/10.1007/s00404-023-06990-1
27. Ibrahim NO, Sukkarieh HH, Bustami RT, Alshammari EA, Alasmari LY, Al-Kadria HM. Current umbilical cord clamping practices and attitudes of obstetricians and midwives toward delayed cord clamping in Saudi Arabia. Ann Saudi Med. 2017;37:216-24. DOI: https://doi.org/10.5144/0256-4947.2017.216
28. Chaudhary P, Priyadarshi M, Singh P, Chaurasia S, Chaturvedi J, Basu S. Effects of delayed cord clamping at different time intervals in late preterm and term neonates : a randomized controlled trial American Academy of Pediatrics Clinical Trial Registry of India. Eur J Pediatr. 2023;182:3701-11. DOI: https://doi.org/10.1007/s00431-023-05053-6
29. Jain SN, Mehendale AM. A review on umbilical cord milking and its implications in neonatal health. Cureus. 2022;14:e30610. DOI: https://doi.org/10.7759/cureus.30610
30. Panburana P, Odthon T, Pongmee P, Hansahiranwadee W. The effect of umbilical cord milking compared with delayed cord clamping in term neonates: A randomized controlled trial. Int J Women's Health. 2020;12:301-6. DOI: https://doi.org/10.2147/IJWH.S233487
31. Koo J, Kilicdag H, Katheria A. Umbilical cord milking-benefits and risks. Front Pediatri. 2023;11:1-10. DOI: https://doi.org/10.3389/fped.2023.1146057
32. de Sousa Moreira Alves MD, de Freitas BHGM, Gaiva MA. Umbilical cord milking in newborns: scoping review. Ciencia y Enfermeria. 2022;28. DOI: https://doi.org/10.29393/ce28-14ucmm30014
33. Seidler AL, Gyte GML, Rabe H, Díaz-Rossello JL, Duley L, Aziz K, *et al.* Umbilical cord management for newborns < 34 weeks ' gestation : a metaanalysis. Pediatrics. 2021;147:e20200576. DOI: https://doi.org/10.1542/peds.2020-0576.
34. Nagy M, Nasef N, Gibreel A, Sarhan M, Aldomiaty H, Darwish M, et al. Impact of umbilical cord milking on hematological parameters in preterm neonates with placental insufficiency. Front Pediatr. 2022;9:827219. DOI: https://doi.org/10.3389/fped.2021.827219
35. Rabe H, Gyte GML, Díaz-Rossello JL, Duley L. Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal and infant outcomes. Cochrane Database Syst Rev. 2019;2019. DOI: https://doi.org/10.1002/14651858.CD003248.pub4
36. Katheria A. Umbilical cord milking: A review. Front Pediatr. 2018;6:335. DOI: https://doi.org/10.3389/fped.2018.00335
37. Katheria A, Reister F, Essers J, Mendler M, Hummler H, Subramaniam H, *et al.* Association of umbilical cord milking vs delayed umbilical cord clamping with death or severe intraventricular hemorrhage among preterm infants. JAMA. 2019;322:1877-86. DOI: https://doi.org/10.1001/jama.2019.16004
38. Katheria A, Garey D, Truong G, Akshoomoff N, Steen J, Maldonado M, *et al.* A randomized clinical trial of umbilical

cord milking vs delayed cord clamping in preterm infants: neurodevelopmental outcomes at 22-26 months of corrected age. J Pediatr. 2022;85:76-80. DOI: https://doi.org/10.1016/j.jpeds.2017.10.037

39. Malik S, Kapu M, Jain MK, Patel B, Kabra N. Effects of timing of cord clamping on neonatal hemoglobin and bilirubin levels in preterm and term infants - A prospective observational cohort study. PLoS ONE. 2024;19: e0295929. DOI: https://doi.org/10.1371/journal.pone.0295929
40. Uwins C, Hutchon D. Delayed umbilical cord clamping after childbirth: potential benefits to baby's health. Pediatr Health, Med Ther. 2014;5:161-71. DOI: https://doi.org/10.2147/phmt.s51867
41. Jozwiak M, Teboul JL. Heart–lungs interactions: the basics and clinical implications. Ann Intensive Care. 2024;14:122. DOI: https://doi.org/10.1186/s13613-024-01356-5
42. Anggraini DD, Argaheni NB, Yuhanah. Evidence based midwifery. In: Oktavianis, Sahara RM, Syahrani A, Saputra HM, eds. Evidance based midwifery. Padang: PT Global Eksekutif Teknologi; 2022. p.51-61.
43. Kumar B, Upadhyay A, Gothwal S, Jaiswal V, Joshi P, Dubey K. Umbilical cord milking and hematological parameters in moderate to late preterm neonates. Indian Pediatr. 2015;52:753-7. DOI: https://doi.org/10.1007/s13312-015-0711-1
44. Singh B, Kumar R, Patra S, Bansal N, Singh G, Raghava K, *et al*. Comparison of three methods of umbilical cord management in late preterm and term newborns on hemoglobin and ferritin levels at six weeks of age: a randomized controlled trial. Cureus. 2024;16:e59046. DOI: https://doi.org/10.7759/cureus.59046
45. Liyanage SK, Ninan K, McDonald SD. Guidelines on deferred cord clamping and cord milking: A systematic review. Pediatrics. 2020;146:e20201429. DOI: https://doi.org/10.1542/peds.2020-1429