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Effects of delayed versus early umbilical cord clamping on newborns' hematological profile: Quasi-experimental study among Palestinian newborns

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Abstract

Goal: The goal of the study is to evaluate and compare the effects of delayed umbilical cord clamping (DCC) versus early umbilical cord clamping (ECC) on neonatal hematological profile among Palestinian newborns in Gaza Strip, Palestine.

Methodology: The researcher used quasi-experimental design. The sample of the study was a purposive sample, consisted of 100 full-term newborns who underwent ECC and 100 newborns who underwent DCC. The study was conducted in labor department at AL-Emirate hospital. For data collection, the researcher used constructive questionnaire and blood samples from the infants (after birth and after one year). The researcher used SPSS version 25 for data analysis. Statistical analysis included frequencies, percentage, mean scores, t-test, and One way ANOVA.

Results: The results showed that 88% of mothers from the DCC group and 87% of mothers from the ECC group received folic acid during pregnancy and 90% of mothers from the DCC group and 81% of mothers from the ECC group received iron supplement during pregnancy, 59% of newborns from the DCC group and 55% of newborns from the ECC group were males, 92% of newborns from each group have a one-minute APGAR score (7 – 10). CBC analysis after birth showed that the newborns from the DCC group have significant higher hemoglobin compared to newborns from the ECC group (15.064±2.343g and 14.417±1.689g, p-value 0.026). Also, the newborns from the DCC group have significant higher Red Blood Cells compared to newborns from the ECC group (3.886±0.717 and 3.244±0.687g, p-value 0.000). After one year, infants from the DCC group showed significant higher hemoglobin than infants from the ECC group (13.363±0.673 and 12.681±0.845, p-value 0.000), significant higher hematocrit (40.486±3.003 and 38.257±3.548, p-value 0.000), significant higher RBCs (4.290±0.444 and 3.752±0.492, p-value 0.000), significant higher MCV (111.313±4.479 and 103.761±10.800, p-value 0.000), significant lower WBC (8.339±2.067 and 9.554±2.709, p-value 0.002), and significant higher platelets count (363.547±73.222 and 317.222±83.354, p-value 0.000). There were statistically no significant differences in Hgb level of newborns' from the DCC group related to gender, while newborns with one-minute APGAR score less than 7 showed significant lower CBC results after birth but no significant differences after one year. Also, newborns who have been admitted to NICU showed significant lower CBC results after birth and after one year. The study concluded that newborns who underwent DCC showed better Hgb and MCV, which means that they have better iron storage. The study recommends the use of DCC approach in term infants.

Keywords: Delayed Umbilical Cord Clamping; Immediate Umbilical Cord Clamping; Term Infants; Hematological profile; Gaza Strip; Palestine.

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1. Introduction

At the time of birth, the baby is still connected to the mother with the placenta through the umbilical cord (UC). The baby is separated from the placenta by clamping and cutting the UC. There are several optimal timings for clamping the UC, namely early cord clamping (ECC) which is carried out in the first 60 seconds after the baby is born, and delayed cord clamping (DCC) is carried out after the first minute after the baby is born (Amalia et al., 2023).

DCC in term neonates results in improved neonatal hemoglobin (Hgb) levels at 24 to 48 hours of life, improved iron stores at 3 to 6 months of age, and improved neurodevelopmental indices through 4 years of age (Rana et al., 2019). Given these benefits, the American College of Obstetricians and Gynecologists (ACOG) in 2017 expanded the recommendation for DCC for at least 30 to 60 seconds after birth from only preterm to both preterm and term neonates, irrespective of mode of delivery (Committee on Obstetric Practice, 2017). Benefits of DCC include im proved transitional circulation, better establishment of red blood cell volume, decreased need for blood transfusion, and lower incidence of necrotizing enterocolitis and intraventricular hemorrhage (Qian et al., 2019).

Several studies indicated the benefits of DCC for infants. A meta-analysis involved nine studies from Asia, Africa and United States indicated that DCC in newborns birth increased the hemoglobin level by 0.81 units compared to clamping the cord immediately after birth (Dilafa et al., 2023). Another study revealed that DCC is thought to not only provide no risk to the mother but provide benefit to the newborn in relation to their fetal to adult physiologic transition. While this technique may not be beneficial to all neonates, putting it into practice in those who would benefit and implementing it into standard hospital and clinic protocol could prove to have benefit in neonatal health outcomes (Snell, 2021).

2. Research problem

Despite global recommendations advocating for DCC in healthy newborns, ICC became a common practice in many clinical settings, including Palestine. The benefits of DCC such as improved iron stores, reduced anemia risk in infants, and potential hemodynamic advantages for both mother and newborn are well-documented in various populations. However, there is limited evidence in Gaza Strip (GS) on how DCC versus ICC specifically impacts maternal and neonatal health outcomes in the Palestinian context, where healthcare resources, maternal nutrition, and neonatal care practices may differ.

This study seeks to examine the comparative effects of delayed versus immediate umbilical cord clamping on neonatal hematological profile (Hgb, HCT, RBCs, MCV, WBCs, and platelets count).

By investigating these outcomes among Palestinian newborns, this study aims to provide context-specific evidence to guide clinical practices and improve perinatal care policies in Palestine. The findings will address critical gaps in local data in GS and contribute to the global discourse on optimal cord clamping timing in resource-variable settings.

2.1. Goal of the research

The goal of the research is to evaluate and compare the effects of DCC versus ECC on neonatal hematological profile among Palestinian newborns, providing evidence-based recommendations for clinical practice in Palestine.

2.2. Importance of the research

This research holds significant scientific value by refining global understanding of DCC's effects in underrepresented populations, while its practical applications can directly improve Palestinian neonatal health policies. By bridging the gap between international recommendations and local practice, the study has the potential to enhance survival, health, and developmental outcomes for the newborns in Palestine and beyond.

3. Literature review

The optimal timing of UCC has been debated in the scientific literature for over a century. Erasmus Darwin, the English physician from the early 19^{th} century, advised against promptly severing the UC, warning that doing so too soon could potentially weaken the newborn (Sharma et al., 2024). However, more recent randomized control trials (RCTs) of term and preterm infants as well as physiologic studies of blood volume, oxygenation, and arterial pressure have evaluated the effects of ECC versus DCC at least 30 – 60 seconds after birth (Rabe et al., 2012; McDonald et al., 2014).

3.1. Effect of Delayed versus early umbilical cord clamping on newborn

At the time of birth, the baby is still connected to the mother with the placenta through the UC. The baby is separated from the placenta by clamping and cutting the UC. The optimal timing of UCC has been debated in the scientific literatures for over a century. ECC is generally carried out in the first 60 seconds after birth "within the first 15 - 30 seconds", whereas DCC is carried out more than one minute after birth. UCC in newborns is an intervention that must be carried out, and there are several optimal timings for clamping the UC, namely ECC which is carried out in the first 60 seconds after the baby is born, and DCC is carried out in the first 1 minute after the baby is born (Amalia et al., 2023).

Compared with ECC, which was usually performed 10–15 seconds after delivery, DCC of at least 30 seconds at birth was of great importance for the amount of blood transfused from the placenta to the newborn (ACOG, 2012). When placental residual blood volume after clamping was measured, it was found that blood continues to flow through the umbilical arteries for approximately 20 to 25 seconds after delivery, while the umbilical vein continues to flow for up to 3 minutes. The delay in clamping allows for such placental transfusion to the infant. The placental transfusion is most rapid immediately after birth, in the first 15 to 30 seconds, and progressively slows until completion around 3 minutes (Alzaree et al., 2018).

Increasing evidence had shown the benefits of DCC in term and preterm infants including the higher Hgb levels and iron status, the improved infants' and children's neurodevelopment, the lesser anemia, the higher blood pressure, the fewer transfusions, and the lower rates of intraventricular hemorrhage, chronic lung disease, necrotizing enterocolitis, and late-onset sepsis. Potential disadvantages of DCC are polycythemia, jaundice, and increased requirement maternal postpartum hemorrhage or the need for maternal blood transfusion (Qian et al., 2019).

Early cord clamping and separation of mother and newborns after birth can have negative effects on both mother and infant, including hypothermia, inflammation, organ dysfunction, poor motor function, and reduced red blood cells received by the infant. This can lead to short term and long-term health problems for the newborn. DCC and early skin-to-skin contact are important interventions that can improve breastfeeding success, keep the newborn warm and calm, and have been shown to have multiple benefits for both term and preterm infants, including improved Hgb level and iron status, better neurodevelopment, and lower rates of anemia, blood pressure, and certain diseases (Bersamin, 2023).

Studies on ECC versus DCC ensured the safety of the infants by eliminating certain deliveries from study observation for ethical reasons. Deliveries that did not warrant DCC included infants with tight nuchal cords and infants that required intervention immediately after delivery such as asphyxiated infants or those in need of immediate resuscitation (Blank et al., 2018; Nelin et al., 2018; WHO, 2014) . The latter group of infants, interestingly, may in fact benefit more from DCC as this would allow further transfusion of blood and oxygen delivery through gas exchange from the placenta (Peberdy et al., 2020).

The World Health Organization (WHO) recommends waiting to clamp and cut the UC after the baby is born. These recommendations are based on the understanding that clamping is delayed because it allows blood to flow continuously from the placenta to the baby for 1 to 3 minutes after birth. This brief delay is known to increase iron stores in young infants by more than 50% at 6 months of age (WHO, 2014). Optimal DCC duration is unknown but two to five minutes is likely safe and effective for most infants and probably of greatest benefit to the least mature, without adversely affecting cord blood gases at birth, nor increasing maternal risk of PPH (Govindaswami et al., 2020). In addition, Garabedian et al. (2012) reported that DCC for one to three minutes is recommended to improve the health and nutrition of the baby. Placental transfusion related to DCC can add 30% blood volume and 60% red blood cells which are used as a source of iron for the baby.

In his study, Snell (2021) reported that the timing of UCC is commonly seen as an innocuous act. Many providers simply cut the cord as soon as they see fit without consideration as to what the impacts of this may be. ECC was initially considered a preventative measure for PPH, but this myth has since been debunked. Now, the practice is still commonly implemented, but for reasons unknown. Delaying the clamping of the UC is thought to not only provide no risk to the mother but provide benefit to the newborn in relation to their fetal to adult physiologic transition. While this technique may not be beneficial to all neonates, putting it into practice in those who would benefit, and implementing it into standard hospital and clinic protocol could prove to have benefit in neonatal health outcomes.

Statements from some of the literature show that the time to cut the UC is still a matter of controversy. Valid concerns about adopting DCC universally exist. However, these concerns include possibly delaying timely resuscitation when needed, potential interference with attempts at collecting blood for umbilical blood banking purposes, and potential for possible excessive placental transfusion, putting the newborn at risk for polycythemia. The risk of polycythemia is especially high in newborns born to women with gestational diabetes, severe intrauterine growth restriction, and in those living in high altitudes (Raju & Singhal, 2012).

However, many studies have found that delaying clamping and cutting the umbilical cord has proven to have many benefits including preventing anemia, increasing HCT levels, reducing the incidence of PPH, optimizing oxygen transfer to the baby, increasing the closeness of mother and baby and increasing the growth of the baby's brain (Ausuti et al., 2018). Other benefits include bilirubin levels (McDonald et al., 2014). Also, Andersson et al. (2014) found that DCC lead to a tendency toward positive neurodevelopmental effects, such as communication, gross motor, fine motor, problem solving and personal social domain, while Amalia et al. (2023) found that DCC is less effective on neurodevelopment and bilirubin levels.

Term infants with five minutes of DCC show ~100g birthweight increase, presumably the weight of additional transfused blood. Extremely preterm infants (<28-29weeks gestation) or extremely low birth weight (ELBW <1000g) neonates have survival advantage, improved euthermia, less likelihood of intubation in the labor room and/or during hospitalization, improved HCT, less transfusion risk and enhanced iron transfer. Improved iron transfer results in optimal infant brain myelination, a putative mechanism for neurodevelopmental functional enhancement (Govindaswami et al., 2020). In addition, Dilafa et al. (2023) found that DCC in newborns birth increased the Hgb level by 0.81 units compared to clamping the cord immediately after birth.

The advantages of DCC for term infants include higher Hgb levels, a decreased risk of anaemia and lower rates of chronic lung disease. There is also evidence proving the longer term advantages for term infants whose cord was clamped more than 60 s after birth, ranging up to 12 months of life (Kc et al., 2017). Benefits of DCC include improved transitional circulation, better establishment of RBC volume, decreased need for blood transfusion, and lower incidence of necrotizing enterocolitis and intraventricular hemorrhage (Qian et al., 2019). Moreover, ACOG (2020) reported that in term infants, DCC increases Hgb levels at birth and improves iron stores in the first several months of life, which may have a favorable effect on developmental outcomes.

4. Methodology

The researcher used quasi-experimental design (pre-test, post-test) to assess the differences in CBC results of the infants. The study was conducted at Al Helal Al Emaraty Maternity Hospital in Rafah governorate in Gaza Strip. The study was conducted from Jan 2023 and completed in June, 2025.

The population of the study included all the newborns with gestational age 37 - 40 weeks, and delivered at Al-Emirate Maternity Hospital during 2023. The study sample consisted of 200 newborns (100 in the DCC group and 100 in the ECC group). The study participants were chosen using purposive method, from those who attended labor room at AL-Emirate Maternity Hospital from Jan. to July 2023.

4.1. Instrument of the study

After reviewing previous studies and literature, the researcher prepared a questionnaire to assess the effect of DCC versus ECC on newborns' hematology. The questionnaire consisted mainly from two parts:

- The first part included personal information of the newborns.
- The second part included CBC analysis (Hgb, HCT, RBC, MCV, WBC, Platelets count).

The researcher distributed the questionnaire to a group of experts to validate the contents of the questionnaire. Their comments were considered in modifying the questionnaire.

4.2. Study procedure

The research passed through the following stages:

- Stage 1: Identifying the eligible newborns who met the inclusion criteria and their mothers expressed their willingness to participate in the study.
- Stage 2: Filling the questionnaire with each mother after delivery.
- Stage 3: Intervention. Measuring the length and head circumference of each newborn and draw blood sample for CBC analysis (pre-test CBC).
- Stage 4: Contact the mothers after one year to check their CBC (post-test CBC).

Data was collected by the researcher using face-to-face interview with each mother after normal vaginal delivery (NVD) who met inclusion criteria, during their presence in the labor department at AL-Emirate hospital. Each questionnaire had a consent form on the first page and ask the participants to participate in the study.

The researcher entered the data of questionnaires using the Statistical Package for Social Sciences (SPSS version 25). Perform proper statistical procedures including: frequency tables, and cross tabulation. Also, (t) test and One way ANOVA test was used to compare results between variables.

5. Results

Table 1 Consumption of folic acid and iron supplement during pregnancy

Variable	DCC n(%)	ECC n(%)	Chi square (p-value)
Received folic acid during pregnancy?			
No	12 (12.0)	13 (13.0)	0.046(0.831)
Yes	88 (88.0)	87 (87.0)	
Total	100 (100.0)	100 (100.0)	
Received iron supplementation during pregnancy?			
No	10 (10.0)	19 (19.0)	3.267(0.071)
Yes	90 (90.0)	81 (81.0)	
Total	100 (100.0)	100 (100.0)	
Hemoglobin at time of delivery			
Group	Min-Max	Median	Mean (SD)
DCC group	8.0 – 12.0	10.20	10.21 (0.888)
ICC group	8.0 – 12.4	10.60	10.47 (0.994)

Table (1) showed that 88% of mothers from the DCC group and 87% of mothers from the ECC group received folic acid during pregnancy and 90% of mothers from the DCC group and 81% of mothers from the ECC group received iron supplement during pregnancy. The mean hemoglobin level at time of delivery was 10.21±0.888 g among mothers from the DCC group and 10.47±0.994g among mothers from the ECC group. Chi square test showed no significant differences in maternal information of mothers from the two groups.

Table 2 Summary of newborns' information

Variable	DCC n(%)	ECC n(%)	Chi square (p-value)
Gender			
Male	59 (59.0)	55 (55.0)	0.326(0.568)
Female	41 (41.0)	45 (45.0)	
Total	100 (100.0)	100 (100.0)	
APGAR score (1 minute)			
Less than 7	8 (8.0)	8 (8.0)	----
7 and more	92 (92.0)	92 (92.0)	
Total	100 (100.0)	100 (100.0)	
Head circumference			
Normal (35 – 38 cm)	95 (95.0)	97 (97.0)	0.521(0.470)

Small size (less than 35 cm)	5 (5.0)	3 (3.0)	
Total	100 (100.0)	100 (100.0)	
Length			
Normal (45 – 55 cm)	97 (97.0)	98 (98.0)	0.205(0.651)
Short (less than 45 cm)	3 (3.0)	2 (2.0)	
Total	100 (100.0)	100 (100.0)	
Admission to NICU			
No	92 (92.0)	90 (90.0)	0.244(0.621)
Yes	8 (8.0)	10 (10.0)	
Total	100 (100.0)	100 (100.0)	
Cause of admission to NICU			
RDS	6 (75.0)	8 (80.0)	0.308(0.959)
Pathological jaundice	1 (12.5)	1 (10.0)	
Physiological jaundice	1 (12.5)	1 (10.0)	
Total	8 (100.0)	10 (100.0)	
Birth weight (g)			
Mean	3157.0	3068.5	--
SD	268.461	211.494	--
Median	3200.000	3050.000	--

Table (2) showed that 59% of newborns from the DCC group and 55% of newborns from the ECC group were males, 41% of newborns from the DCC group and 45% of newborns from the ECC group were females. 8% of newborns from each group have a one-minute APGAR score less than 7, and the rest of the newborns have normal APGAR score (7 – 10). In addition, 95% of newborns from the DCC group and 97% of newborns from the ECC group have normal head circumference, 97% of newborns from the DCC group and 98% of newborns from the ECC group have normal length (45 – 55 cm), 8% of newborns from the DCC group and 10% of newborns from the ECC group have been admitted to NICU, mostly due to RDS. The mean birth weight of newborns from the DCC group was 3157±268.461 gram, and 3068.5±211.494 gram for newborns from the ECC group.

Table 3 Comparison of CBC results of newborns after delivery between the two groups

Parameter	Group	N	Mean	SD	t	P value
Hgb	DCC	100	15.064	2.343	2.240	0.026
	ECC	100	14.417	1.689		
HCT	DCC	100	45.222	7.077	0.249	0.804
	ECC	100	44.984	6.415		
RBC	DCC	100	3.886	0.717	6.468	0.000
	ECC	100	3.244	0.687		
MCV	DCC	100	100.730	8.145	1.109	0.269
	ECC	100	99.306	9.926		
WBC	DCC	100	12.088	8.085	-1.924	0.056
	ECC	100	14.063	6.330		

Platelet	DCC	100	282.010	103.977	1.966	0.051
	ECC	100	254.300	95.171		

Table (3) presented comparison of the results of initial CBC analysis after birth. The results showed that newborns from the DCC group have statistically significant higher Hgb after birth than newborns from the ECC group (t= 2.240, p-value 0.026). Also, newborns from the DCC group have statistically significant higher RBC compared to newborns from the ECC group (t= 6.468, p-value 0.000). Whereas, there were no significant differences in the other parameters between the two groups (HCT, MCV, WBC, and platelets).

Table 4 Comparison of CBC results of infants after one year between the two groups

Parameter	**Group**	**N**	**Mean**	**SD**	**t**	**P value**
Hgb	DCC	76	13.363	0.673	5.642	0.000
	ECC	83	12.681	0.845		
HCT	DCC	76	40.486	3.003	4.255	0.000
	ECC	83	38.257	3.548		
RBC	DCC	76	4.290	0.444	7.188	0.000
	ECC	82	3.752	0.492		
MCV	DCC	76	111.313	4.479	5.660	0.000
	ECC	82	103.761	10.800		
WBC	DCC	76	8.339	2.067	-3.184	0.002
	ECC	82	9.554	2.709		
Platelet	DCC	76	363.547	73.222	3.699	0.000
	ECC	82	317.222	83.354		

Table (4) presented comparison of the results of CBC analysis after one year. The results showed that newborns from the DCC group have statistically significant higher Hgb after one year than newborns from the ECC group (t= 5.642, p-value 0.000). Newborns from the DCC group have statistically significant higher HCT than newborns from the ECC group (t= 4.255, p-value 0.000). Newborns from the DCC group have statistically significant higher RBC than newborns from the ECC group (t= 7.188, p-value 0.000). Newborns from the DCC group have statistically significant higher MCV than newborns from the ICC group (t= 5.660, p-value 0.000). Newborns from the DCC group have statistically significant lower WBC than newborns from the ICC group (t= -3.184, p-value 0.002). Newborns from the DCC group have statistically significant higher platelets count than newborns from the ECC group (t= 3.699, p-value 0.000).

Table 5 Comparison of CBC results of DCC and ECC group

(after birth – after one year)						
Phase		Mean	N	SD	t	P value
Delayed cord clamping group						
Hgb	After one year	13.363	76	0.673	-11.287	0.000
	After birth	15.544	76	1.725		
HCT	After one year	40.486	76	3.003	-9.251	0.000
	After birth	46.640	76	5.357		
RBC	After one year	4.290	76	0.444	10.037	0.000
	After birth	3.857	76	0.660		

MCV	After one year	111.313	76	4.479	18.493	0.000
	After birth	101.526	76	7.328		
WBC	After one year	8.339	76	2.067	-3.686	0.000
	After birth	11.565	76	8.437		
Platelet	After one year	363.547	76	73.222	18.281	0.000
	After birth	268.236	76	93.746		
Early cord clamping group						
Hgb	After one year	12.681	83	0.845	-18.543	0.000
	After birth	14.936	83	1.044		
HCT	After one year	38.257	83	3.548	-19.954	0.000
	After birth	47.041	83	3.987		
RBC	After one year	3.752	83	0.492	-9.458	0.000
	After birth	3.380	83	0.635		
MCV	After one year	103.761	83	10.800	2.641	0.010
	After birth	100.081	83	9.030		
WBC	After one year	9.554	83	2.709	-7.685	0.000
	After birth	13.715	83	6.290		
Platelet	After one year	317.222	83	83.354	8.698	0.000
	After birth	253.768	83	96.693		

Table (5) presented a comparison of CBC results between the DCC and ECC groups at two time points: after birth and after one year. The statistical analysis (paired t-tests) evaluates changes in hematological parameters over time within each group.

5.1. Delayed cord clamping group

The mean level of Hgb after birth was 15.544 decreased to 13.363 after one year (t= -11.287, p-value 0.000). The mean level of HCT after birth was 46.640 decreased to 40.486 after one year (t= -9.251, p-value 0.000). The mean level of RBC after birth was 3.857 increased to 4.290 after one year (t= 10.037, p-value 0.000). The mean level of MCV after birth was 101.526 increased to 111.313 after one year (t= 18.493, p-value 0.000). The mean level of WBC after birth was 11.565 decreased to 8.339 after birth (t= -3.686, p-value 0.000). The mean level of platelets after birth was 268.236 increased to 363.547 after one year (t= 18.281, p-value 0.000).

5.2. Early cord clamping group

The mean level of Hgb after birth was 14.936 decreased to 12.681 after one year (t= -18.543, p-value 0.000). The mean level of HCT after birth was 47.041 decreased to 38.257 after one year (t= -19.954, p-value 0.000). The mean level of RBC after birth was 3.380 decreased to 3.752 after one year (t= -9.458, p-value 0.000). The mean level of MCV after birth was 100.081 increased to 103.761 after one year (t= 2.641, p-value 0.010). The mean level of WBC after birth was 13.715 decreased to 9.554 after birth (t= -7.685, p-value 0.000). The mean level of platelets after birth was 253.768 increased to 317.222 after one year (t= 8.698, p-value 0.000).

Overall, the results indicated that Hgb was within normal level in both groups, but Hgb was slightly higher in the DCC group. In addition, levels of MCV was clearly higher in the DCC group compared to ICC group, which reflected that delayed cord clamping was beneficial in improving iron storage.

Table 6 Differences in CBC results related to gender of infant(DCC group)

Parameter	Gender	N	Mean	SD	t	P value
Hgb after birth	Male	59	14.996	2.344	-0.343	0.732
	Female	41	15.161	2.367		
Hgb after one year	Male	47	13.266	0.632	-1.619	0.110
	Female	29	13.520	0.719		
HCT after birth	Male	59	45.364	7.166	0.240	0.811
	Female	41	45.017	7.029		
HCT after one year	Male	47	40.263	3.045	-1.105	0.822
	Female	29	40.848	2.951		
RBC after birth	Male	59	3.820	0.760	-1.105	0.272
	Female	41	3.982	0.648		
RBC after one year	Male	47	4.245	0.525	-1.117	0.268
	Female	29	4.362	0.260		
MCV after birth	Male	59	99.808	8.248	-1.363	0.176
	Female	41	102.056	7.905		
MCV after one year	Male	47	110.791	4.815	-1.298	0.198
	Female	29	112.158	3.800		
WBC after birth	Male	59	11.094	6.145	-1.484	0.141
	Female	41	13.518	10.172		
WBC after one year	Male	47	8.161	2.069	-0.954	0.344
	Female	29	8.627	2.066		
Platelet after birth	Male	59	265.728	104.590	-1.903	0.060
	Female	41	305.439	99.711		
Platelet after one year	Male	47	345.834	70.361	-2.805	0.006
	Female	29	392.255	69.625		

Table (6) showed that there were statistically no significant differences in Hgb level after birth and after one year related to gender of infant (p-value 0.732 and 0.110). There were statistically no significant differences in HCT levels after birth and after one year (p-value 0.811 and 0.822). There were statistically significant differences in RBC level after birth and after one year (p-value 0.272 and 0.268). There were statistically no significant differences in MCV level after birth and after one year (p- value 0.176 and 0.198). There were statistically no significant differences in WBC level after birth and after one year (p-value 0.141 and 0.344). There were statistically no significant differences in platelets count after birth (p-value 0.060) but there were significant differences after one year (p-value 0.006).

Table 7 Differences in CBC results related to gender of infant (ECC group)

Parameter	Gender	N	Mean	SD	t	P value
Hgb after birth	Male	55	14.465	1.855	0.316	0.753
	Female	45	14.357	1.479		
Hgb after one year	Male	47	12.787	0.797	1.302	0.196
	Female	36	12.544	0.895		
HCT after birth	Male	55	45.107	6.559	0.211	0.833
	Female	45	44.833	6.305		
HCT after one year	Male	47	38.521	3.063	0.771	0.443
	Female	36	37.913	4.117		
RBC after birth	Male	55	3.286	0.675	0.681	0.498
	Female	45	3.192	0.705		
RBC after one year	Male	47	3.805	0.474	1.135	0.260
	Female	35	3.680	0.512		
MCV after birth	Male	55	99.140	10.405	-0.184	0.854
	Female	45	99.508	9.421		
MCV after one year	Male	47	105.063	4.785	1.271	0.208
	Female	35	102.011	15.537		
WBC after birth	Male	55	13.710	6.488	-0.617	0.539
	Female	45	14.494	6.176		
WBC after one year	Male	47	9.397	2.801	-0.606	0.546
	Female	35	9.765	2.606		
Platelet after birth	Male	55	249.054	84.023	-0.607	0.545
	Female	45	260.711	107.882		
Platelet after one year	Male	47	319.744	90.022	0.316	0.753
	Female	35	313.834	74.617		

Table (7) showed that there were statistically no significant differences in Hgb level after birth and after one year related to gender of infant (p-value 0.753 and 0.196). There were statistically no significant differences in HCT levels after birth and after one year (p-value 0.833 and 0.443). There were statistically significant differences in RBC level after birth and after one year (p-value 0.498 and 0.260). There were statistically no significant differences in MCV level after birth and after one year (p- value 0.854 and 0.208). There were statistically no significant differences in WBC level after birth and after one year (p-value 0.539 and 0.546). There were statistically no significant differences in platelets count after birth and after one year (p-value 0.545 and 0.753).

Table 8 Differences in CBC results related to infant's APGAR score(DCC group)

Parameter	APGAR score	N	Mean	SD	t	P value
Hgb after birth	Less than 7	8	10.700	2.536	-6.553	0.000
	7-10	92	15.443	1.912		
Hgb after one year	Less than 7	4	13.175	0.320	-0.571	0.570
	7-10	72	13.373	0.687		
HCT after birth	Less than 7	8	32.600	8.516	-6.164	0.000
	7-10	92	46.319	5.804		
HCT after one year	Less than 7	4	40.550	3.984	0.043	0.966
	7-10	72	40.483	2.976		
RBC after birth	Less than 7	8	2.815	0.663	-4.887	0.000
	7-10	92	3.980	0.645		
RBC after one year	Less than 7	4	3.450	0.620	-4.311	0.000
	7-10	72	4.336	0.388		
MCV after birth	Less than 7	8	89.287	4.986	-4.533	0.000
	7-10	92	101.725	7.599		
MCV after one year	Less than 7	4	104.800	3.559	-3.162	0.002
	7-10	72	111.675	4.258		
WBC after birth	Less than 7	8	24.062	7.322	4.836	0.000
	7-10	92	11.047	7.300		
WBC after one year	Less than 7	4	8.600	4.511	0.257	0.798
	7-10	72	8.325	1.910		
Platelet after birth	Less than 7	8	172.125	50.061	-5.784	0.000
	7-10	92	291.565	102.054		
Platelet after one year	Less than 7	4	253.750	90.164	-3.275	0.002
	7-10	72	369.647	67.846		

Table (8) showed that there were statistically significant differences in Hgb level after birth related to APGAR score at one minute after birth (p-value 0.000) but there were no significant differences after one year (p-value 0.570). There were statistically significant differences in HCT levels after birth (p-value 0.000) but there were no significant differences after one year (p-value 0.966). There were statistically significant differences in RBC level after birth and after one year (p-value 0.000 and 0.000). There were statistically no significant differences in MCV level after birth and after one year (p- value 0.000 and 0.002). There were statistically no significant differences in WBC level after birth (p-value 0.000) but there were no significant differences after one year (p-value 0.798). There were statistically significant differences in platelets count after birth and after one year (p-value 0.000 and 0.002).

Table 9 Differences in CBC results related to infant's APGAR score(ECC group)

Parameter	APGAR score	N	Mean	SD	t	P value
Hgb after birth	Less than 7	8	12.312	2.303	-3.933	0.000
	7-10	92	14.600	1.507		
Hgb after one year	Less than 7	5	11.960	0.896	-2.006	0.048

	7-10	78	12.728	0.826		
HCT after birth	Less than 7	8	38.037	10.215	-3.354	0.001
	7-10	92	45.588	5.669		
HCT after one year	Less than 7	5	34.380	3.582	-2.608	0.011
	7-10	78	38.506	3.421		
RBC after birth	Less than 7	8	2.477	0.600	-3.470	0.001
	7-10	92	3.311	0.655		
RBC after one year	Less than 7	5	3.310	0.471	-2.118	0.037
	7-10	77	3.780	0.482		
MCV after birth	Less than 7	8	93.775	8.395	-1.657	0.101
	7-10	92	99.787	9.943		
MCV after one year	Less than 7	5	103.560	2.762	-0.043	0.966
	7-10	77	103.774	11.131		
WBC after birth	Less than 7	8	17.025	9.674	1.386	0.169
	7-10	92	13.805	5.963		
WBC after one year	Less than 7	5	9.200	2.323	-0.301	0.765
	7-10	77	9.577	2.744		
Platelet after birth	Less than 7	8	219.250	88.825	-1.087	0.280
	7-10	92	257.347	95.548		
Platelet after one year	Less than 7	5	281.400	63.468	-0.992	0.324
	7-10	77	319.548	84.280		

Table (9) showed that there were statistically significant differences in Hgb level related to APGAR score at one minute after birth and after one year (p-value 0.000 and 0.048). There were statistically significant differences in HCT levels after birth and after one year (p-value 0.001 and 0.011). There were statistically significant differences in RBC level after birth and after one year (p-value 0.001 and 0.037). There were statistically no significant differences in MCV level after birth and after one year (p- value 0.101 and 0.966). There were statistically no significant differences in WBC level after birth and after one year (p-value 0.169 and 0.765). There were statistically no significant differences in platelets count after birth and after one year (p-value 0.280 and 0.324).

Table 10 Differences in CBC results related to admission to NICU (DCC group)

Parameter	**Admission to NICU**	**N**	**Mean**	**SD**	**t**	**P value**
Hgb after birth	No	92	15.405	1.937	5.664	0.000
	Yes	8	11.137	3.114		
Hgb after one year	No	72	13.402	0.644	2.232	0.029
	Yes	4	12.650	0.888		
HCT after birth	No	92	46.239	5.923	5.562	0.000
	Yes	8	33.525	9.068		
HCT after one year	No	72	40.644	2.950	1.978	0.052
	Yes	4	37.650	2.867		
RBC after birth	No	92	3.985	0.638	5.272	0.000

	Yes	8	2.748	0.613		
RBC after one year	No	72	4.329	0.393	3.535	0.001
	Yes	4	3.577	0.757		
MCV after birth	No	92	101.750	7.634	4.672	0.000
	Yes	8	89.000	3.131		
MCV after one year	No	72	111.752	4.018	3.972	0.000
	Yes	4	103.400	5.590		
WBC after birth	No	92	11.289	7.430	-3.540	0.001
	Yes	8	21.275	10.095		
WBC after one year	No	72	8.372	2.020	0.583	0.561
	Yes	4	7.750	3.112		
Platelet after birth	No	92	290.510	102.996	4.725	0.001
	Yes	8	184.250	55.884		
Platelet after one year	No	72	369.730	69.258	3.326	0.001
	Yes	4	252.250	55.512		

Table (10) showed that there were statistically significant differences in Hgb level related to admission to NICU after birth and after one year (p-value 0.000 and 0.029). There were statistically significant differences in HCT levels after birth (p-value 0.000) but there were no significant differences after one year (p-value 0.052). There were statistically significant differences in RBC level after birth and after one year (p-value 0.000 and 0.001). There were statistically significant differences in MCV level after birth and after one year (p- value 0.000 and 0.000). There were statistically significant differences in WBC level after birth (p-value 0.001) but there were no significant differences after one year (p-value 0.561). There were statistically significant differences in platelets count after birth and after one year (p-value 0.001 and 0.001).

Table 11 Differences in CBC results related to admission to NICU (ECC group)

Parameter	**Admission to NICU**	**N**	**Mean**	**SD**	**t**	**P value**
Hgb after birth	No	90	14.728	1.308	6.634	0.000
	Yes	10	11.610	2.172		
Hgb after one year	No	80	12.710	0.818	1.577	0.119
	Yes	3	11.933	1.401		
HCT after birth	No	90	46.206	5.058	6.950	0.000
	Yes	10	33.980	7.090		
HCT after one year	No	80	38.355	3.498	1.293	0.200
	Yes	3	35.666	4.725		
RBC after birth	No	90	3.344	0.630	4.870	0.000
	Yes	10	2.339	0.501		
RBC after one year	No	79	3.773	0.479	2.069	0.042
	Yes	3	3.186	0.566		
MCV after birth	No	90	99.978	9.938	2.067	0.041
	Yes	10	93.250	7.867		

MCV after one year	No	79	104.926	5.018	6.002	0.000
	Yes	3	73.066	47.696		
WBC after birth	No	90	13.556	5.801	-2.466	0.015
	Yes	10	18.630	9.065		
WBC after one year	No	79	9.535	2.732	-0.332	0.741
	Yes	3	10.066	2.402		
Platelet after birth	No	90	259.555	94.522	1.672	0.098
	Yes	10	207.000	92.297		
Platelet after one year	No	79	318.584	84.125	0.758	0.451
	Yes	3	281.333	58.183		

Table (11) showed that there were statistically significant differences in Hgb level related to admission to NICU after birth (p-value 0.000) but there were no significant differences after one year (p-value 0.119). There were statistically significant differences in HCT levels after birth (p-value 0.000) but there were no significant differences after one year (p-value 0.200). There were statistically significant differences in RBC level after birth and after one year (p-value 0.000 and 0.042). There were statistically significant differences in MCV level after birth and after one year (p- value 0.041 and 0.000). There were statistically significant differences in WBC level after birth (p-value 0.015) but there were no significant differences after one year (p-value 0.741). There were statistically no significant differences in platelets count after birth and after one year (p-value 0.098 and 0.451).

6. Discussion

The study recruited initially 200 newborns (100 in the ECC group and 100 in the DCC group). After one year, there were 83 infants in the ECC group and 76 infants in the DCC group available for CBC analysis.

More than half of newborns from the two groups were males, the vast majority have APGAR score of 7 – 10, the majority of them have normal head circumference and normal length. Most of them were healthy and only 8% of newborns from the DCC group and 10% of newborns from the ECC group have been admitted to the NICU mostly due to RDS and jaundice. The mean birth weight of newborns from the DCC and ECC group was 3157.0g and 3068.5g respectively. There were no significant differences in birth weight between newborns from the two groups. These results were approximate with the results of Aboushady et al. (2023) which indicated that 53% of newborns were males and 47% were females, the control group's mean birth weight was 3188.61 g, whereas the study group's was 3077.10 g. Furthermore, the control group's mean gestational age for the neonates studied was 38.68 weeks, compared to 38.71 weeks for the study group. The mean APGAR score of newborns in the study group at 5 minutes was 9.05 ±0.51, whereas infants in the control group had 8.41 ± 1.02. Also, the results of Rashwan et al. (2022) showed that there were no significant difference regarding APGAR scores at the first minute and after 5 minutes (P=0.114), and the rate of NICU admission (P=0.671). However, Hgb and HCT values were significantly higher in the DCC group than in the ICC group (P<0.001).

Also, the results of Chidre and Chirumamilla's (2015) indicated that there was no significant differences in the newborns' APGAR scores in the two groups.

In addition, the results of Katheria et al. (2017) and Ashish et al. (2017) found that UC > 3 minutes was linked to lower APGAR scores at 5 and 10 minutes. The transition from fetal to newborn life was also positively impacted by DCC. Compared to babies with ICC, babies with DCC reach a plateau in oxygen saturation much earlier, at 85 - 90%. According to Lara-Cantón et al. (2022), DCC may also result in fewer occurrences of bradycardia or tachycardia in the first few minutes following birth.

This result was supported by the Royal College of Obstetricians and Gynecologists (2015), which reported that DCC makes it easier for oxygenated blood to be transferred from the placenta to the infant, promoting the seamless transition of cardiopulmonary functioning from intrauterine to extrauterine life.

6.1. CBC results of study participants

After birth, the newborns from the DCC group have statistically significant higher Hgb after birth than newborns from the ECC group (mean 15.064g vs. 14.417g). Also, newborns from the DCC group showed slight higher HCT, RBCs, MCV, and platelet count than newborns from the ICC group, but these differences were not statistically significant.

After one year, the infants from the DCC group have statistically significant higher Hgb than infants from the ECC group (p-value 0.000), significant higher HCT (p-value 0.000), significant higher RBC (p-value 0.000), significant higher MCV (p-value 0.000), significant lower WBC (p-value 0.002), and significant higher platelets count (p-value 0.000).

Several studies supported these results. These results are attributed to the fact that the placenta provides between 25% and 35% of the blood volume for term babies. DCC reduces iron insufficiency between three and eight months after birth (ACOG, 2020).

The results of Aboushady et al. (2023) indicated that 65% of neonates in the control group had Hgb levels between 14.5 to 22.5 g/dl after 24 hours after delivery, but all of the infants in the study group had the same level with a strong statistically significant difference at (p= 0.001). Only slightly more than half of the neonates in the study group (50.6%) had hematocrit levels between 45 and 65% after 24 hours after delivery, compared to 87% of the babies in the control group. Additionally, only 48% of neonates in the control group had ferritin levels between 15 and 150 ng/mL 24 hours after delivery, which was significantly lower than the 77% of the study group and highly statistically significant at (p = 0.001).

Also, the results agreed with the results of Ofojebe et al. (2021), who reported that the newborns in the DCC group had higher Hgb levels than the newborns in the ECC group. Moreover, the results of Mercer et al. (2017) found that there were statistically significant differences in levels of Hgb and HCT between infants who underwent DCC and ECC. Also, the results of Qian et al. (2019) showed that DCC had shown higher Hgb levels and iron storage, lesser anemia, and fewer transfusions, as well as the lower rates of lung disease. DCC was seldom associated with lower APGAR score, lower admission to NICU, and lower respiratory distress. Earlier study found that DCC of term newborn infants at one or three minutes improved venous HCT levels measured at six hours after birth within a physiologic range and decreased the prevalence of neonatal anemia without any harmful effect in newborns or mothers (Ceriani Cernadas et al., 2006).

A few studies on DCC were published in the literature with the different follow-up time ranged from 2 to 12 months, and their results were inconclusive. Delaying the clamping of the UC until it stopped pulsating improved the hematologic status of the infants at two months after delivery (Grajeda et al., 1997).

In addition, a 2-minutes delay in the clamping of the UC of normal-weight, full-term infants improved the MCV up to 6 months of age (Chaparro et al., 2006). A study done by Nesheli et al. (2014) showed that DCC increased the term infants' Hgb concentrations and HCT at 6 months of age. Furthermore, DCC was effective in improving the Hgb levels and in preventing the anemia in 8-month (Gyorkos et al., 2012) or in 8- and 12-months' infants (Kc et al., 2017).

Interestingly, Ertekin et al. (2016) found that DCC up to 90 - 120 seconds increased the Hgb, HCT, and iron levels of infants significantly at the second month, but not at birth. Inversely, in a cohort of newborns with an expected low birth weight in South Africa, Tiemersma et al. (2015) reported that the infant Hgb levels at 24 hours after birth were significantly higher in the DCC group versus ECC group, while the effects of DCC on the infant Hgb levels were not detectable anymore at two months after birth.

In conclusion, DCC was a cost free, safe, and effective intervention to improve neonatal hematology and reduce anemia and should be implemented in the term infants, especially in resource-poor settings and in developing countries, which might offer a sustainable strategy to reduce early infant anemia risk.

6.2. Differences in CBC results related to infants' factors

The results of DCC group showed no significant differences in all hematology parameters between male and female infants, but female infants showed significant lower platelets count than male infants.

The results of ICC group showed no significant differences in all hematology parameters between male and female infants.

Also, the results of DCC group showed that infants with low APGAR score (less than 7) expressed statistically significant lower Hgb, HCT, RBC after birth, and significant lower MCV, and platelets at birth and after one year.

The results of ICC group showed that infants with low APGAR score was associated with low Hgb, HCT, RBC at birth and after one year, but no significant differences in MCV, WBC, and platelets count.

In addition, the results of DCC group showed that infants who have been admitted to NICU have statistically significant lower Hgb, HCT, RBC, MCV, WBC, and platelets count at birth and after one year.

The results of ICC group showed that infants who have been admitted to NICU showed statistically lower Hgb, HCT at birth, while there were no significant differences after one year. Also, infants who have been admitted to NICU showed significant lower RBC, and MCV at birth and after one year.

These results suggests that sick infants who need admission to NICU are getting more benefits from ICC rather than DCC, which supports the idea that DCC is more suitable to healthy, term infants.

Other studies reflected different factors affecting cord clamping. The study of Strada et al. (2022) reported that associated factors were skin-to-skin contact in the delivery room ($p = 0.014$), position of the newborn below the vaginal canal ($p < 0.001$), position of the newborn at the vaginal level ($p < 0.001$), and need for newborn resuscitation in the delivery room ($p = 0.001$).

7. Conclusion and recommendations

The study concluded that infants from the DCC group showed better hematological results compared to infants from the ICC group, which reflected that DCC technique was effective in improving hematological parameters and iron storage in full term infants.

The study recommended the need to prepare guidelines and protocols to ensure that DCC is considered as it has showed a marked impact on newborns' hematology. Also, the study recommended to conduct similar research in other maternity hospitals (governmental and private) to enable generalization of the results.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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8. Appendix

Questionnaire of the effect of delayed versus early umbilical cord clamping

Serial number: ☐☐☐
Group: ☐ Delayed cord clamping ☐ Early cord clamping
Maternal information
Did you take folic acid during first trimester of pregnancy? ☐ Yes ☐ No
Did you take iron supplements during pregnancy: ☐ Yes ☐ No
Newborns' information
Gender of infant: ☐ Male ☐ Female
One minute Apgar score: ………………… (Rating 0-10)

Birth Head circumference: ………..…cm		
Birth weight: ………..kg		
Birth length: ……….cm		
Admission to the Neonatal Intensive Care Unit: ☐ Yes ☐ No		
If yes, what is the cause of admission to NICU: ☐ Respiratory distress ☐ Pathological jaundice ☐ Physiologic jaundice ☐ Others		
Newborns' lab results		
Parameter	**First result (after birth)**	**Second result (at one year)**
Hgb		
HCT		
RBC		
MCV		
WBC		
Platelet Count		