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Research Article

Timing of Umbilical Cord Clamping in Preterm Neonates: A Randomized Controlled Trial

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Abstract

Background: The optimal timing for clamping the umbilical cord remains controversial. This study aimed to assess the optimal timing of umbilical cord clamping and its effect on preterm neonates.

Methods: The study was a randomized controlled trial with the registration number: NCT06000800. It was conducted at Kasr Al Ainy Maternity Hospital, Cairo University Hospital, where a total of 80 pregnant women were randomly pooled and randomly divided into four groups with each group comprising 20 pregnant women. Umbilical cord clamping was performed in the first group immediately (5 sec after birth), after 30 sec in the second group, after 60 sec in the third group, and after 90 sec in the fourth group. After birth, clinical and laboratory parameters were assessed and recorded at the 1st, 6th, 12th, 24th, and 48th hours for all preterm neonates.

Results: Delayed cord clamping at 90 sec was linked to improved preterm neonatal outcomes including heart rate at the 1st and the 6th hours; respiratory rate at the 12th hour; oxygen saturation at the 1st hour; hemoglobin, hematocrit, and blood glucose levels at the 6th, 12th, 24th, and 48th hours; but also linked to increase in bilirubin levels at the 12th, 24th, and 48*th* hours ($P < 0.001$). There was no statistically significant difference concerning APGAR score; respiratory rate at the 12*th* hour, temperature at the 1st, 6th, 12th, 24th, and 48th hours; hemoglobin, hematocrit, and blood glucose at the 1st hour; and bilirubin at the 1st, 6th, and 12th hours in all groups (5, 30, 60, and 90 sec) ($P > 0.05$).

Conclusion: Better levels of blood glucose and hemoglobin were seen in preterm neonates whose cord clamping was delayed. Further studies should be carried out to determine the optimal timing of umbilical cord clamping with larger samples, for extended delay of clamping for more than 90 sec, and with recording of parameters for an extended period of follow-up even past the neonatal period.

Keywords: preterm neonates, umbilical cord clamping, randomized trial

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1. Introduction

Preterm birth is a significant contributor to long-term adverse neonatal health outcomes. Annually, almost 15 million neonates are born preterm worldwide [1]. The umbilical cord clamping (UCC) procedure is a recognized technique used by healthcare providers at childbirth. It is often performed following the second stage of labor; however, the exact timing has been a matter of personal preference [2]. Early cord clamping (ECC) is usually performed immediately after delivery whereas delayed cord clamping (DCC) involves UCC performed >30 sec after the birth or once the cord's pulsing has stopped [3]. While ECC has been routinely performed for decades as an unquestioned intervention, numerous studies suggested that DCC would allow oxygenated blood to passively enter the newborn through placental perfusion [4, 5]. Therefore, several studies were carried out to see whether DCC had any advantages for term and preterm infants. According to these studies, DCC decreased hospital mortality and improved hemodynamic neonatal parameters like cardiac output, heart rate, peripheral arterial oxygen saturation, and cerebral oxygenation. It also reduced the prevalence of low iron levels, early- and late-onset anemia, and decreased iron deficiency by >40% [6–9].

Furthermore, an increasing body of evidence started to point out that the neonate's health could be negatively impacted by immediate UCC [10–12]. Thus, at present, DCC has been recommended for full-term neonates, however, its effects on preterm neonates need further evaluation. Additionally, in Egypt, there is no clear definition of the timing of UCC in the policies and procedures used by the hospitals [13].

1.1. Significance of the study

Performing DCC in preterm neonates is restricted, and further proof is required before it can be formally advised [12]. Clinicians could push for the inclusion of DCC in the resuscitation procedure for preterm neonates proposing that this practice might decrease the rate of severe disturbances in preterm neonates and may be associated with reduced major morbidity and mortality [14]. Upcoming research with extended follow-up for preterm neonates is required for firm recommendations [15]. Also, there is scanty evidence to display what duration of DCC is best, and therefore the best time to clamp the umbilical cord remains ambiguous [9]. Previous studies recommended comparing different lengths of delay in UCC. Until then, a period of 30–180 sec seems justified or until the cord is collapsed and white [11]. Additionally, the American College of Obstetricians and Gynecologists (ACOG) established DCC for at least 30–60 sec after childbirth as the standard of intervention during childbirth room treatment for full-term and preterm neonates [14, 16].

To date, the timing for cord clamping in the Maternity Hospital of Cairo University is not standardized. The results of the current study will expand the body of knowledge and provide evidence-based practice regarding the effect and best timing of UCC in preterm neonates in the nursing specialty. Thus, this study aimed to assess the optimal timing of UCC and its effect on preterm neonates. The following hypothesis was formulated: "There is no effect of umbilical cord clamping timing on preterm neonates."

2. Methods

2.1. Research design

A randomized controlled trial was conducted, wherein participants were randomly assigned

one of the two groups—the experimental group receiving the intervention under test and the control group receiving standard hospital care [17].

2.1.1. Randomization and random assignment

To ensure the randomization, first, random recruitment of the pregnant women was done using computer-generated random numbers. Then, pregnant women who fit the inclusion criteria were assigned randomly to either a study or control group; because the study was not blinded, both the participants and the researchers knew which group each participant belonged to. Pregnant women were randomized into four groups (groups 1, 2, 3, and 4) using sealed envelopes (Figure **1**). Our trial has objective measures so this might be less at risk of bias from the lack of binding.

2.2. Outcome measures

Primary outcomes were hemoglobin, hematocrit, bilirubin, and blood glucose levels, while, secondary outcomes were APGAR score and neonatal vital signs.

2.3. Setting

The study was conducted in two settings, the first was the casualty department (section 10) at the obstetrics and gynecology hospital at Kasr El Ainy University Hospital which offers free obstetrics and gynecology health services to pregnant women and women in labor who are at low or high risk, including antepartum, intrapartum, postpartum, and neonatal care. Approximately 7760 deliveries annually are attended to according to its local statistics for the year 2021. The second setting was the neonatal intensive care unit that provides free, high-quality, well-equipped secondary and tertiary level of care for high-risk neonates with a total capacity of 50 incubators.

2.4. Sample

Using computer-generated random numbers, a total of 80 pregnant women and their preterm neonates were pooled out of 120 who met the eligibility criteria. Eligibility criteria included healthy pregnant women with singleton fetuses undergoing early or late preterm cesarean delivery from 29 gestational ages and primiparous and multiparous women with elective cesarean section. The exclusion criteria included asphyxiated preterm neonates who needed immediate resuscitation, twins, and women with any obstetrical or medical complications that arise during childbirth, such as eclampsia or hemorrhage.

2.4.1. Sample size calculation

Based on data from the literature [18], considering a significance level of <5% and power of study of 80%, the sample size was calculated using the following formula:

$$n = \frac{(Z\alpha/2 + Z\beta)\wedge 2\times 2(SD)\wedge 2}{d\wedge 2},$$

where, SD stands for standard deviation, which was derived from a prior study, Zα/2 for 5%, Zβ for 80%, and d for the predicted difference. Therefore,

$$n = \frac{(1.96 + 0.84)\wedge 2\times 2(0.77)\wedge 2}{(0.69)\wedge 2} = 19.5.$$

The sample size needed, according to the preceding formula, was 20 in each group, for a total sample of 80 pregnant women.

2.5. Data collection tools

Three tools were used for data collection:

Tool 1: A structured questionnaire including two parts: Part I comprising pregnant women's data such as age, place of residence, degree of education, employment, and obstetric history, while

Part II containing preterm neonates' data including gestational age, birth weight, and gender.

Tool 2: Preterm neonates' outcomes assessment sheet: A sheet was developed by the researchers after reviewing the relevant literature (21), which included preterm neonates' physiological statuses such as oxygen saturation and vital signs, blood glucose, hemoglobin, hematocrit, and serum bilirubin levels.

Tool 3: APGAR score: This tool was adopted by APGAR (1975) to assess the health of neonates immediately after birth. It is determined by allocating scores to five simple criteria – color, heart rate, breathing, muscle tone, and reflex irritability – with a total score between 0 and 10. A score of 0–3 is interpreted as severe neonatal asphyxia, 4–7 indicates moderate asphyxia, and 8–10 indicates absence of difficulty in adjusting to extrauterine life.

2.5.1. Validity and reliability

(i) Validity

To examine the content validity, sentence clarity, and appropriateness of the material, five academic nursing specialists in the domains of women's health and midwifery nursing, maternity and neonatal health nursing, and pediatric medicine were given unstandardized tools. Before requesting the ethical committee's permission, the modifications were made following the expert's advice.

(ii) Reliability

Cronbach's alpha (α), a measure of internal consistency that shows how closely linked a set of items are as a group, was used to assess the reliability of the questionnaire. For Tool 1, the Cronbach's α value was 0.75, and for Tool 2, it was 0.72.

2.6. Procedure

First, an official letter was sent to the administrative authorities of Obstetrics and Gynecological Hospital, Kasr El Ainy to grant approval for conducting the present research. Data were collected three days per week for 12 months, beginning the end of November 2021 to the end of November 2022. Data collection was carried out in four steps in each group: recruitment and randomization; interviewing; intervention; and evaluation.

- Interviewing: All pregnant women were interviewed using a structured interview questionnaire schedule (tool 1 part I) to obtain their demographic information, such as age, place of residence, degree of education, employment, and obstetric history, including gravidity and parity. The interview took place at the waiting room of the operation room. The interview lasted for about 15–20 min for each pregnant woman.
- Intervention: All groups of preterm neonates were held 20 cm below the level of the incision immediately after birth. The umbilical cord of preterm neonates in the first group was clamped and cut within 5 sec of delivery, whereas the umbilical cords of preterm neonates in the second group were clamped and cut 30 sec after birth. The umbilical cord was clamped and cut after 60 sec for the preterm neonates in the third group. The fourth group of preterm infants had their umbilical cords clamped and cut after 90 sec. After cord clamping, all preterm neonates received routine immediate post-delivery hospital care.

Information including gender, birth weight, and gestational age was gathered and documented; preterm neonates' condition was assessed and documented immediately after birth in the delivery room applying APGAR (Tool 3) score at the 1st, 5th, and 10th minutes of life. As soon as the baby was delivered, the birth scale was used to measure the weight. Then, the preterm neonates were transferred immediately to the neonatal

intensive care unit at the same hospital where their outcomes were measured (Tool 2). The physiological status such as vital signs (respiration, pulse, and temperature) were measured and documented at the first, sixth, twelve, twenty-fourth, and forty-eighth hours after the event for all preterm neonates. Additionally, the preterm neonatal laboratory investigations were measured when blood samples were collected for a therapeutic reason according to the routine of the unit and not just for the study. Bilirubin, hemoglobin, and hematocrit levels were measured at the 1st, 6th, 12th, 24th, and 48th hours after birth.

2.7. Data analysis

The collected data were coded and statistically analyzed using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). This allowed for the determination of the mean and standard deviation for quantitative variables, as well as frequencies (number of cases) and relative frequencies (percentages) for categorical variables. For non-normally distributed quantitative variables, the non-parametric Kruskal–Wallis test and the Mann–Whitney test were employed; for regularly distributed quantitative variables, analysis of variance (ANOVA) with multiple comparisons post-hoc test was used to compare the groups. To compare categorical data, a Chi-square (2) test analysis was performed. The exact test was used in its place when the expected frequency was <5.

3. Results

Table 1 illustrates no statistically significant differences between the total studied groups in relation to their, residence, educational level, occupation, gravidity, and parity ($P > 0.05$).

Table 2 shows that the mean gestational age was 31.21 weeks, while the mean birth weight was 1856.2 gr and the male-to-female ratio was 1.05:1. The ANOVA test revealed no statistically significant differences among preterm neonates in the four groups concerning birth weight and gestational age ($P > 0.05$).

After birth, immediate neonatal assessment by Apgar score displayed that ANOVA test revealed no statistically significant differences among preterm neonates in the four groups at the 5th and 10th minutes ($P > 0.05$), while, the 1st minute APGAR score showed statistically significant difference favoring the fourth group ($P = 0.015$) over the other three groups as shown in Figure **2**. However, this finding is of no actual relevance as the outcome preceded the studied intervention.

Table 3 shows that at the 1st and 6th hours after birth, ANOVA test revealed statistically significant difference regarding the total mean scores of preterm neonates' heart rate between the four groups ($P = 0.004$ and 0.002, respectively) with favoring stability of heart rate in the 2nd group at the 1st hour and the 1st group at the 6th hour (mean ± SD =135.90 ± 18.18 and 139.6 ± 23.7, respectively). This table also shows that at the 12th and 24th hours after birth, there was a statistically significant difference in the total mean scores of preterm neonates' respiratory rate between the four groups ($P = 0.002$ and 0.001, respectively) with favoring stability of it in the 3rd group at the both 12th and 24th hours (mean ± SD = 55.9 ± 8.4 and 51.5 ± 6.4, respectively). Otherwise there were no statistically significant differences regarding the total mean scores of preterm neonates' physiological status between the four groups at the 1st, 6th, 12th, 24th, and 48th hours after birth.

Table 4 shows that ANOVA test revealed a highly statistically significant difference in the total mean scores of preterm neonates' blood glucose level between the four groups at the 1st and 6th hours after birth ($P < 0.001$) with the highest total mean score in the 2nd group (mean ± SD = 100.65 ± 81.54

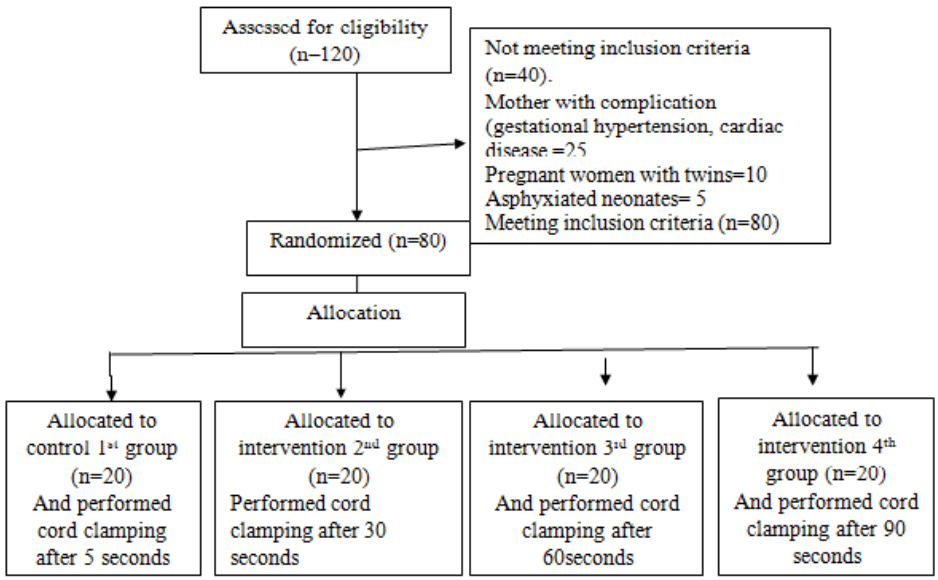

Figure 1: Flow diagram of group recruitment.

TABLE 1: Distribution of the participating pregnant women according to demographic characteristics and obstetric profile (*N* = 80).

		1st group (5 sec) (n = 20)		2nd group (30 sec) (n = 20)		3rd group (60 sec) (n = 20)		4th group (90 sec) (n = 20)		Chi-square test	P-value
		No	%	No	%	No	%	No	%		
Maternal age (mean ± SD)		28.40	5.52	26.55	6.82	27.75	6.76	26.30	5.05	*F* = 0.534	0.661
Residence	Rural	12	60	15	75	11	55	12	60	1.92	0.589
	Urban	8	40	5	25	9	45	8	40		
Level of education	Can't read & write	4	20	4	20	0	0.0	1	5	19.36	0.075
	Primary school	5	25	4	20	8	40	5	25		
	Preparatory	4	20	4	20	5	25	1	5		
	Secondary	4	20	6	30	7	35	6	30		
	University	3	15	2	10	0	0.0	7	35		
Occupation	Housewife	17	85	16	80	11	55	14	70	5.26	0.153
	Worker	3	15	4	20	9	45.0	6	30		
Gravidity	Primigravida	6	30	8	40	10	50	8	40	1.66	0.644
	Multigravida	14	70	12	60	10	50	12	60		
Parity	Primipara	7	35	9	45	10	50	10	50	1.21	0.750
	Multipara	13	65	11	55	10	50	10	50		

and 117.8 ± 60.1, respectively). At the 12th hour, there was a statistically significant difference in the total mean scores of preterm neonates' hemoglobin level between the four groups (*P* = 0.004) with the highest total mean score in the 4th group (mean ± SD = 17.9 ± 1.0). There was also a statistically significant difference in the total mean scores of preterm neonates' blood glucose level between the four groups (*P* = 0.002) with the highest total

TABLE 2: Percentage distribution of preterm neonates' characteristics in the four groups (N = 80).

		1st group (5 sec) (n = 20)		2nd group (30 sec) (n = 20)		3rd group (60 sec) (n = 20)		4th group (90 sec) (n = 20)		Chi square test/F	P-value
		No	%	No	%	No	%	No	%		
Gestational age (mean ± SD)		31.7	3.27	31.6	3.35	31.4	2.82	31.9	2.48	F = 1.12	0.118
Total mean gestational age = 31.21 ± 1.01 wk											
Birth wt in gr (mean ± SD)		2065.0	533.7	1984.7	1158.7	1682.5	495.0	1692.5	359.2	F = 1.56	0.206
Total mean birth weight = 01856.2 ± 1711											
Gender	Male	9	45	12	60	10	50	10	50	0.951	0.813
	Female	11	55	8	40	10	50	10	50		

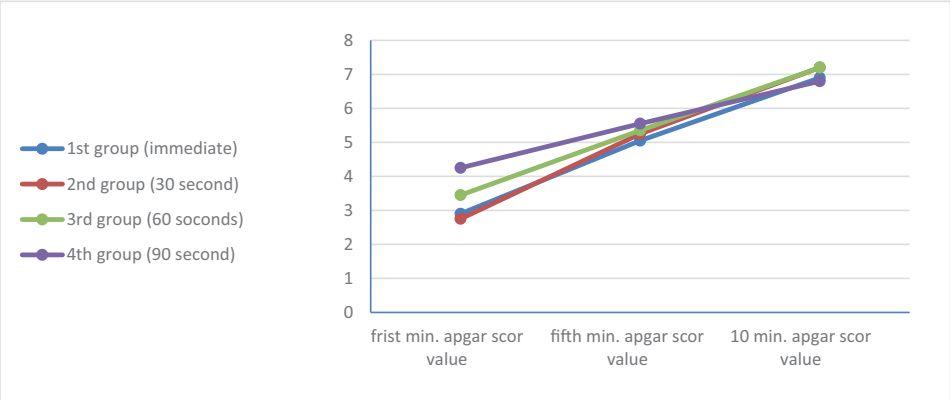

Figure 2: Description of the APGAR score at the 1st, 5th, 10th minutes among the preterm neonates.

mean score in the 2nd group (mean ± SD = 98.7 ± 37.9).

This table also shows that at the 24th and 48th hours, there were a highly statistical significant differences in the total mean scores of preterm neonates' hemoglobin, hematocrit, blood glucose, and bilirubin levels between the four groups (P = 0.001 and 0.001, respectively) with the highest hemoglobin, hematocrit, and bilirubin total means in the 4th group (mean ± SD = 17.9 ± 1.0, 49.4 ± 7.0, and11.2 ± 4.2 and mean ± SD = 18.4 ± 1.06, 50.9 ± 7.3, and 14.5 ± 4.5, respectively) and the highest level of blood glucose total means in the 2nd group (mean ± SD = 97.4 ± 32.2 and 101.7 ± 25.6, respectively). On the other hand, there was no statistically significant difference between the four groups in the total mean scores of preterm neonates' hemoglobin level at the 1st hour (P = 0.319), hematocrit at the 1st and 12th hours (P = 0.847 and 0.130, respectively), and bilirubin level at the 1st, 12th, and 24th hours (P = 0.628, 0.628, and 0.059, respectively) after birth.

4. Discussion

Professional recommendations for delaying cord clamping are updated frequently due to ongoing updates of body of evidence. While it has been proven that delaying the UCC is superior to immediate cord clamping regarding neonatal outcome in term neonates, the exact timing of cord clamping in preterm neonates is still under investigation.

Our study revealed that there are no statistically significant differences among preterm neonates in the four groups regarding the APGAR score at the 5th and 10th min, while the 1st min APGAR score showed statistically significant difference

Table 3: Comparison of the total mean scores of preterm neonates' physiological status in four groups at the 1st, 6th, 12th, 24th, and 48th hours after birth.

Physiological status	1st group (5 sec) (n = 20)	2nd group (30 sec) (n = 20)	3rd group (60 sec) (n = 20)	4th group (90 sec) (n = 20)	One-way ANOVA	
					F	P-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
At the 1st hour						
Heart rate	141.25 ± 27.12	135.90 ± 18.18	148.3 ± 21.72	159 ± 11.85	4.75	0.004*
Respiratory rate	73.50 ± 11.72	69.65 ± 15.14	66.15 ± 17.46	66.15 ± 8.80	1.31	0.277
Temperature	36.58 ± 0.61	36.42 ± 0.51	36.32 ± 0.26	36.26 ± 0.20	2.15	0.101
Oxygen saturation	82.9 ± 7.6	84.5 ± 5.2	88.6 ± 6.4	89.3 ± 6.4*	4.74	0.004*
At the 6th hour						
Heart rate	139.6 ± 23.7	143.7 ± 16.6	151.5 ± 12.3	158.5 ± 9.2	5.25	0.002*
Respiratory rate	70.5 ± 11.1	63.3 ± 12.5	61.9 ± 12.6	65.4 ± 9.5	2.11	0.106
Temperature	36.41 ± 0.72	36.48 ± 1.12	36.70 ± 0.31	36.41 ± 0.22	0.80	0.496
At the 12th hour						
Heart rate	146.5 ± 23.5	146.1 ± 15.8	149.7 ± 10.9	153.1 ± 14.9	0.74	0.531
Respiratory rate	66.7 ± 9.4	59.5 ± 10.6	55.9 ± 8.4	62.8 ± 5.8	5.12	0.002*
Temperature	36.45 ± 0.86	36.68 ± 0.58	36.84 ± 0.36	36.90 ± 0.31	2.53	0.063
At the 24th hour						
Heart rate	150.9 ± 20.7	138.7 ± 23.6	151.5 ± 12.9	149 ± 10.9	2.24	0.090
Respiratory rate	63.2 ± 9.4*	57.3 ± 11.5	51.5 ± 6.4	59.2 ± 4.1	6.77	0.001*
Temperature	36.43±0.87	36.39±1.63	37.02±0.30	37.05±0.20	2.97	0.057
Oxygen saturation	96.4±7.3	98.9±1.4	97.5±2.5	98.4±1.4	1.47	0.230
At the 48th hour						
Heart rate	149 ± 16.3	151.5 ± 19.9	152.4 ± 14.9	149.8 ± 11.5	0.18	0.908
Respiratory rate	58.1 ± 8.1	55.9 ± 10.3	51.7 ± 6.4	56.1 ± 5.3	2.38	0.076
Temperature	36.67 ± 0.53	36.82 ± 0.91	37.01 ± 0.32	37.08 ± 0.12	2.18	0.097

*A statistically significant variation at $P < 0.05$.

favoring the fourth group (90 sec). However, this finding is of no actual relevance as the outcome preceded the studied intervention. These findings are in line with the findings of a study [19] that examined the impact of postponed cord clamping on blood sugar levels in newborns aged three to six weeks who had been exposed to late preterm prenatal steroids. It discovered that no statistically significant distinctions exist between four groups in the 5th and10th min APGAR score. The current study's findings conflicted with those of a study [20] that assessed bilirubin levels in neonates ≥35 weeks of gestation receiving DCC for an extended time and reported statistically significant difference in the 5th- and 10th-min Apgar score after birth time to cord clamping ≤1 or ≥2 min.

Regarding vital signs, our study demonstrated that there are no statistically significant differences among preterm neonates in the four groups regarding temperature. The results of the current study showed that there was no statistically significant difference in the mean scores of temperature between the four groups. It means that the researchers were applying aggressive measures to prevent hypothermia in preterm newborns by preparing servo well, keeping a warm blanket

Table 4: Comparison between the total mean scores of preterm neonates' laboratory findings in the four groups at the 1st, 6th, 12th, 24th, and 48th hours after birth.

Laboratory findings	1st group (5 sec) (n = 20)	2nd group (30 sec) (n = 20)	3rd group (60 sec) (n = 20)	4th group (90 sec) (n = 20)	One-way ANOVA	
					F	P-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
At the 1st hour						
Hemoglobin	16.2 ± 2.8	16.3 ± 2.9	16.24 ± 2.5	17.4 ± 1.02	1.19	0.319
Hematocrit	47.3 ± 7.9	47.9 ± 9.9	46.6 ± 7.4	45.9 ± 2.9	0.27	0.847
Blood glucose	83.9 ± 27.5	100.65 ± 81.54	58.9 ± 8.6	55.4 ± 8.6	4.61	<0.001**
Bilirubin	6.5 ± 4.03	6.02 ± 4.8	6.05 ± 3.9	4.9 ± 2.6	0.582	0.628
At the 6th hour						
Blood glucose	80.3 ± 19.9	117.8 ± 60.1	91.3 ± 75.3	60.5 ± 9.1	4.67	<0.001**
Bilirubin	4.9 ± 2.6	6.02 ± 4.8	6.05 ± 3.9	6.5 ± 4.03	3.03	0.628
At the 12th hour						
Hemoglobin	15.2 ± 2.83	15 ± 2.95	16.4 ± 2.6	17.6 ± 0.96	4.90	0.004*
Hematocrit	43.6 ± 8.4	44.6 ± 10.1	47.9 ± 6.7	47.4 ± 2.9	1.94	0.130
Blood glucose	79 ± 28.1	98.7 ± 37.9	87 ± 31.5	65.7 ± 6.8	4.70	0.002*
Bilirubin	8.11 ± 4.08	7.4 ± 4.8	6.1 ± 3.8	4.68 ± 2.58	5.05	0.059
At the 24th hour						
Hemoglobin	13.2 ± 2.5	13.8 ± 3.1	16.8 ± 2.6	17.9 ± 1.0	17.8	<0.001**
Hematocrit	39.9 ± 7.2	41.4 ± 8.6	48.1 ± 2.9	49.4 ± 7.0	9.87	<0.001**
Blood glucose	93.4 ± 21.9	97.4 ± 32.2	84.9 ± 30.5	69.1 ± 7.8	5.01	<0.001**
Bilirubin	4.4 ± 2.6	6.2 ± 3.6	8.6 ± 4.5	11.2 ± 4.2	12.13	<0.001**
At the 48th hour						
Hemoglobin	11.5 ± 2.4	12.7 ± 3.5	17.3 ± 2.7	18.4 ± 1.06	34.8	<0.001**
Hematocrit	34.9 ± 6.5	38.2 ± 9.4	49.9 ± 2.9	50.9 ± 7.3	27.6	<0.001**
Blood glucose	93.3 ± 17.2	101.7 ± 25.6	81.1 ± 15.1	69.1 ± 7.02	13.2	<0.001**
Bilirubin	4.2 ± 2.6	5.2 ± 3.1	10.2 ± 4.7	14.5 ± 4.5	31.04	<0.001**

*Statistically significant difference at $P < 0.05$; **Extremely statistically significant at $P < 0.001$.

ready to cover the newborn, placing the preterm newborn skin-to-skin in the operating room, and covering the newborn well. In addition, preterm neonates were moved to the critical care unit after gaining stability in the delivery room and were treated according to hospital protocol. These results agreed with a study [21] that found no statistically significant difference in the mean scores of temperatures among the ECC and DCC groups.

Regarding heart rate, our study showed that there were statistically significant differences in the mean scores of heart rate in 2nd group at the 1st hour and in the 1st group after birth at the 6th hour. Furthermore, statistically significant differences were seen in the mean scores of respiratory rate among the 3rd group (60 sec) after the 12th and the 24th hours. DCC promotes preterm newborn recovery because it promotes arterial and venous umbilical blood flow increasing lung expansion and improving placental transfusion.

Our findings are in agreement with a study conducted [22] to ascertain how DCC affects respiration and oxygen saturation. The study found

that the DCC group needed less oxygen therapy, and when reviewing the impact of DCC on later biochemical changes, hypoglycemia, and anemia were notably lower in the DCC groups than in the group that immediately underwent cord clamping. According to the study's findings, there was no statistically significant variation in the mean hemoglobin (Hb) level scores, and hematocrit (Hct) level immediately after birth and at the 1st hour after birth among the four groups.

These results are consistent with a study that was aimed to assess the early versus delayed UCC on physiologic anemia of the term neonate [23]. The study found no statistically significant difference in the mean scores of the levels of HB and HCT on the 1*st* day of birth among DCC and immediate cord clamping groups.

Our study observed statistically significant differences in the mean scores of hemoglobin (Hb) level and hematocrit (Hct) level at the 24th and 48th hours after birth among the DCC group for 90 sec. DCC in preterm newborns improves circulation and increases red blood cell volume establishment, increases hemoglobin levels at birth, decreases the requirement for blood transfusions, and maintains iron stores in the initial several months of neonatal life.

These results are similar to those of a study which found that the mean levels of HB and HCT at childbirth and the 24th hours of childbirth among the DCC group were more than the immediate cord clamping group [24].

The results of this investigation showed that the mean blood glucose scores varied in a statistically significant way at the 1st, 6th, 12th, 24th, and 48thhours after birth among the 2nd group. These findings may be due to the ability to limit endogenous glucose synthesis, the insulin response to glucose, and the balance of glycogen and fat storage which might have improved blood glucose levels in the DCC group. These results are comparable with those of the study that found no significant differences at the 2nd, 3rd, and 4th hours after birth between groups in the occurrence of hypoglycemia [19].

Our study found that there was no statistically significant difference in the mean score of bilirubin level among the four groups after birth at the 1st, 6th, and 12th hours. Additionally, the researchers observed an increase in the serum bilirubin levels in the DCC (90 sec) group at the 24th and 48th hours after birth. These findings may be due to the samples being preterm neonates, delivered by cesarean section, having prematurity in liver function, and lacking in sucking. Our findings are supported by a study that discovered that the DCC group's serum bilirubin levels were higher than those of the ECC group [25]. Conversely, this study disagreed with the results of the study that found no relation between the time of UCC and higher bilirubin levels [20].

Also, these findings were not supported by a study which reported that regardless of the mode of delivery (vaginal or cesarean), DCC was not linked to elevations in severe hyperbilirubinemia and jaundice necessitating phototherapy in either term or preterm neonates. Thus, based on our study results, we may appear confident to say that the optimum timing of UCC in preterm neonates delivered by cesarean section is somewhere between 30 and 60 sec after birth. This conclusion is consistent with the ACOG recommendations advising that for preterm and term neonates, UCC should be delayed at least 30–60 sec after birth.

5. Conclusion

Better levels of blood glucose and hemoglobin were seen in preterm neonates whose cord clamping was delayed. However, a majority of them had higher bilirubin levels than those whose cord was clamped early.

Recommendations

A protocol should be implemented in every maternity unit with information about the benefits and risks of DCC to reduce variations in practice and improve the safety of care.

The current study must be replicated using a large sample from different regions of the country.

Limitations

We would have a wider impression of the impact of postponed cord clamping on preterm neonatal outcomes if we were able to extend the delay to >90 sec or extend the follow-up period for >48 hours to detect later effects.

The researchers were not able to examine the effect of DCC on preterm neonates >90 sec because of the policy of the study setting which may have impacted the findings of the study.

Ethical Considerations

The Faculty of Nursing, Cairo University, Egypt's research ethics committee granted approval (Code: 2021) with the final approval number RHDIRB2019041701 on 2021, November 18. The study was registered in the Cairo University Registry of Clinical Trials with the registration number:NCT06000800. Moreover, pregnant mothers of preterm newborns who met the inclusion criteria gave written informed consent after clear explanation of the aim, procedure, benefits, and the nature of the research. The pregnant women's ability to leave the trial at any moment had no impact on the care they provided for their premature neonates. The confidentiality and anonymity of the data were guaranteed.

Competing Interests

None declared.

Availability of Data and Material

All materials of this study are available from the corresponding author upon reasonable request.

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Abbreviations and Symbols

UCC: Umbilical cord clamping

ECC: Early cord clamping

DCC: Delayed cord clamping

ACOG: American College of Obstetricians and Gynecologists

SPSS: Statistical Package for Social Sciences

ANOVA: Analysis of variance

Hb: Hemoglobin

Hct: Hematocrit

References

[1] Cao, G., Liu, J., & Liu, M. (2022). Global, regional, and national incidence and mortality of neonatal preterm birth, 1990–2019. *JAMA Pediatrics, 176*(8), 787–796. https://doi.org/10.1001/jamapediatrics.2022.1622

[2] Joshi, N. S., Padua, K., Sherman, J., Schwandt, D., Sie, L., Gupta, A., Halamek, L. P., & Lee, H. C. (2021). A feasibility study of a novel delayed cord clamping cart. *Children (Basel, Switzerland), 8*(5), 357. https://doi.org/10.3390/children8050357

[3] Marzec, L., Zettler, E., Cua, C. L., Rivera, B. K., Pasquali, S., Katheria, A., & Backes, C. H. (2020). Timing of umbilical cord clamping among infants with congenital heart disease. *Progress in Pediatric Cardiology, 59*, 101318. https://doi.org/10.1016/j.ppedcard.2020.101318

[4] Katheria, A., Lee, H. C., Knol, R., Irvine, L., & Thomas, S. (2021). A review of different resuscitation platforms

during delayed cord clamping. *Journal of Perinatology, 41*(7), 1540–1548. https://doi.org/10.1038/s41372-021-01052-3

[5] Fogarty, M., Osborn, D. A., Askie, L., Seidler, A. L., Hunter, K., Lui, K., Simes, J., & Tarnow-Mordi, W. (2018). Delayed vs early umbilical cord clamping for preterm infants: A systematic review and meta-analysis. *American Journal of Obstetrics and Gynecology, 218*(1), 1–18. https://doi.org/10.1016/j.ajog.2017.10.231

[6] Yunis, M., Nour, I., Gibreel, A., Darwish, M., Sarhan, M., Shouman, B., & Nasef, N. (2021). Effect of delayed cord clamping on stem cell transfusion and hematological parameters in preterm infants with placental insufficiency: A pilot randomized trial. *European Journal of Pediatrics, 180*, 157–166. https://doi.org/10.1007/s00431-020-03730-4

[7] Ceriani Cernadas, J. M. (2021). Ligadura del cordón umbilical en recién nacidos prematuros. *Archivos Argentinos de Pediatria, 119*(4), 315–e321.

[8] Güner, S., & Saydam, B. K. (2021). The impact of umbilical cord clamping time on the infant anemia: A randomized controlled trial. *Iranian Journal of Public Health, 50*(5), 990–998. https://doi.org/10.18502/ijph.v50i5.6116

[9] Rabe, H., Gyte, G. M., Díaz-Rossello, J. L., & Duley, L. (2019). Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal and infant outcomes. *Cochrane Database of Systematic Reviews, 9*, CD003248. https://doi.org/10.1002/14651858.CD003248.pub4

[10] Li, J., Yang, S., Yang, F., Wu, J., & Xiong, F. (2021). Immediate vs delayed cord clamping in preterm infants: A systematic review and meta-analysis. *International Journal of Clinical Practice, 75*(11), e14709. https://doi.org/10.1111/ijcp.14709

[11] Seidler, A. L., Gyte, G. M. L., Rabe, H., Díaz-Rossello, J. L., Duley, L., Aziz, K., Testoni Costa-Nobre, D., Davis, P. G., Schmölzer, G. M., Ovelman, C., Askie, L. M., Soll, R., & The International Liaison Committee on Resuscitation Neonatal Life Support Task Force. (2021). Umbilical cord management for newborns< 34 weeks' gestation: A meta-analysis. *Pediatrics, 147*(3), e20200576. https://doi.org/10.1542/peds.2020-0576

[12] Brown, B. E., Shah, P. S., Afifi, J. K., Sherlock, R. L., Adie, M. A., Monterrosa, L. A., Crane, J. M., Ye, X. Y., El-Naggar, W. I., Beltempo, M., Kanungo, J., Ting, J., Cieslak, Z., Sherlock, R., Abou Mehrem, A., Toye, J., Aziz, K., Bodani, J., Strueby, L., . . . Allen, V., & the Canadian Neonatal Network, & the Canadian Preterm Birth Network Investigators. (2022). Delayed cord clamping in small for gestational age preterm infants. *American Journal of Obstetrics and Gynecology, 226*(2), 247.e1–247.e10. https://doi.org/10.1016/j.ajog.2021.08.003

[13] Fawzy, A. E. M. A., Moustafa, A. A., El-Kassar, Y. S., Swelem, M. S., El-Agwany, A. S., & Diab, D. A. (2015). Early versus delayed cord clamping of term births in Shatby Maternity University Hospital. *Progresos de Obstetricia y Ginecología, 58*(9), 389–392. https://doi.org/10.1016/j.pog.2015.05.001

[14] American College of Obstetricians and Gynecologists' Committee on Obstetric Practice. (2020). Delayed umbilical cord clamping after birth: ACOG committee opinion, number 814. *Obstetrics and Gynecology, 136*(6), e100–e106. https://doi.org/10.1097/AOG.0000000000004167

[15] Qian, Y., Ying, X., Wang, P., Lu, Z., & Hua, Y. (2019). Early versus delayed umbilical cord clamping on maternal and neonatal outcomes. *Archives of Gynecology and Obstetrics, 300*, 531–543. https://doi.org/10.1007/s00404-019-05215-8

[16] Bianchi, A., Jacobsson, B., Mol, B. W., & the FIGO Working Group for Preterm Birth. (2021). FIGO good practice recommendations on delayed umbilical cord clamping. *International Journal of Gynaecology and Obstetrics, 155*(1), 34–36. https://doi.org/10.1002/ijgo.13841

[17] Karanatsios, B., Prang, K. H., Verbunt, E., Yeung, J. M., Kelaher, M., & Gibbs, P. (2020). Defining key design elements of registry-based randomised controlled trials: A scoping review. *Trials, 21*, 552. https://doi.org/10.1186/s13063-020-04459-z

[18] Yan, J., Ren, J. D., Zhang, J., Li, J., Zhang, X., Ma, Y., & Gao, L. (2024). The short and long term consequences of delayed cord clamping on late pre-term infants. *International Journal of Women's Health, 15*, 361–368. https://doi.org/10.2147/IJWH.S385800

[19] Hitchings, L., Rodriguez, M., Persaud, R., & Gomez, L. (2022). The effect of delayed cord clamping on blood sugar levels on 34-36 week neonates exposed to late preterm antenatal steroids. *The Journal of Maternal-Fetal & Neonatal Medicine, 35*(18), 3587–3594. https://doi.org/10.1080/14767058.2020.1832074

[20] Wilander, M., Sandblom, J., Thies-Lagergren, L., Andersson, O., & Svedenkrans, J. (2024). Bilirubin levels in neonates ≥35 weeks of gestation receiving delayed cord clamping for an extended time – An observational study. *The Journal of Pediatrics, 257*, 113326. https://doi.org/10.1016/j.jpeds.2023.01.005

[21] Chantry, C. J., Blanton, A., Taché, V., Finta, L., & Tancredi, D. (2018). Delayed cord clamping during elective cesarean deliveries: Results of a pilot safety trial. *Maternal Health, Neonatology and Perinatology, 4*, 16. https://doi.org/10.1186/s40748-018-0083-3

[22] Mina, N. S., & Mohammed, A. K. (2024). Effects of delayed neonate cord clamping on oxygen saturation, Apgar Score, and respiratory distress syndrome at Maternity Teaching Hospital in Sulaimani City. *HIV Nursing, 23*(1), 962–968.

[23] Alzaree, F., Elbohoty, A., & Abdellatif, M. (2018). Early versus delayed umbilical cord clamping on physiologic anemia of the term newborn infant. *Open Access Macedonian Journal of Medical Sciences, 6*(8), 1399–1404. https://doi.org/10.3889/oamjms.2018.286

[24] Withanathantrige, M., & Goonewardene, I. M. R. (2017). Effects of early versus delayed umbilical cord clamping during antepartum lower segment caesarean section on placental delivery and postoperative haemorrhage: A randomised controlled trial. *Ceylon Medical Journal*, *62*(1), .1–5 https://doi.org/10.4038/cmj.v62i1.8425

[25] Fenton, C., McNinch, N. L., Bieda, A., Dowling, D., & Damato, E. (2018). Clinical outcomes in preterm infants following institution of a delayed umbilical cord clamping practice change. *Advances in Neonatal Care, 18*(3), 223–231. https://doi.org/10.1097/ANC.0000000000000492