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Research Article:

The Impact of Early Versus Delayed Cord Clamping on Neonatal outcomes: A comparative study

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Abstract

Background: The timing of umbilical cord clamping has been widely debated in obstetrics. An early cord clamping (ECC) was adopted widely since the 20th century; however, accumulating data over the past two decades has challenged this practice and considered delayed cord clamping (DCC) as the best practice with optimized neonatal outcomes.

Aims: To investigate the impact of ECC vs. DCC on APGAR score in neonates at one and 5-minutes after delivery and to investigate the relationship between the timing of cord clamping and the need for neonatal resuscitation or other immediate postnatal care.

Methodology: In this clinical comparative study, 500 participants were randomly and equally allocated into two groups at Erbil Maternity Teaching Hospital, Erbil, Kurdistan Region, Iraq, from May 2024 to January 2025. Group one (n=250), in which the ECC was performed within 30 seconds after birth without milking the umbilical cord, and Group two (n=250), in which the DCC was performed at 1.5 minute, with milking the umbilical cord once only. Then, patients sociodemographic and clinical data were obtained, and the APGAR score was assessed at one and 5-minutes post-delivery for both groups.

Results: The mean maternal age was 30.6 ± 3.5, while their mean gestational age was 37.6 ± 1.2 weeks. The mean neonates' BW was 3.14 ± 0.45 kg, with nearly equal gender distribution, and most of them (28.4%) had an APGAR score of 9 after one minute, while majority (29.4%) had APGAR score of 10 after 5-minutes. Also, most neonates had no SOB (59.2%), while 40.8% were admitted to Neonatal Intensive Care Unit (NICU) due to grunting (18.8%) and asphyxia (4.44%). No significant associations ($p>0.05$) were observed between neonatal/maternal factors and the time of clamping. APGAR score at one and 5-minutes also not significantly ($p>0.05$) correlated with the time of clamping. Regression analysis revealed that the DCC predict higher APGAR scores at one and 5-minutes. Also, neonates in the DCC group demonstrated 67% reduced odds of APGAR score of ≤7.

Conclusion: DCC improves neonatal adaption reflected by higher APGAR scores, that supports its adoption as routine practice during term deliveries.

Keywords: *APGAR scores, cord clamping time, resuscitation, maternal and neonatal factors*

1. Introduction

A significant evolution occurred in approaches to umbilical cord clamping shortly after birth over the past century, reflecting growing understandings of the newborn physiologic transition [1]. Early cord clamping (ECC) is the act of clamping the cord within 15-30 seconds of birth and was the accepted practice for much of the 20th century due to theoretical fears of postpartum hemorrhage, and neonatal problems, such as jaundice or respiratory distress [2]. Contemporary studies have disproven that cord clamping is a necessary intervention, and have supported that delayed cord clamping (DCC), usually performed at 30-90 seconds after birth, or when the cord pulsation ceases, serves an essential purpose of transfusing placental blood and nutrients that is essential to neonatal transition to extra-uterine life [3].

The physiology of DCC is based on placental transfusion, in which approximately 20 - 30 mL/kg of blood (80-100 mL in term infants) moves from the placenta to the neonate in the early minutes after birth [4]. This extra blood volume, which is rich in red blood cells, stem cells, and iron, improves oxygen delivery, increase cardiovascular stability, and enhance iron stores, especially important in reducing anemia in newborn infants [5]. Conversely, ECC violates this biological process immediately during the transition, and therefore potentially threatens subsequent hemodynamic transition of the newborn infant. The physiological benefits of DCC have led large health organizations, such as the World Health Organization (WHO) and the American College of Obstetricians and Gynecologists (ACOG) to endorse DCC as a standard care for both preterm and term births, except in urgent clinical scenarios that requiring immediate resuscitation of the neonate [2,6].

The APGAR scoring system is a quick the mainstay of immediate assessment of a newborn's health given at one and five minutes after birth, measuring five key areas, including neonates' Appearance (skin color), Pulse (heart rate), Grimace (reflex irritability), Activity (muscle tone), and Respiration (breathing effort) [7]. The system is used to score every healthy neonate at one and 5-minutes after birth. It is quick and useful in identifying those who suffer acute respiration dynamics and predicting short-term clinical outcomes that could denote idiosyncratic distress if the infant has a low score. Neonates with an APGAR score of less than seven should be considered distressed and likely to need some resuscitative measures [8].

The relationship between cord clamping time and APGAR scores presents a complex clinical picture. Physiologically, DCC's benefits for cardiovascular transition could theoretically improve APGAR components like heart rate (Pulse) and respiratory effort (Respiration) [9]. It was studied that DCC facilitates smoother cardiopulmonary transition by allowing gradual shift from placental to pulmonary respiration, which may positively influence these APGAR parameters [10]. Therefore, this study aimed to investigate the impact of ECC vs. DCC on APGAR scores in neonates at one and 5-minutes after delivery and to investigate the relationship between the timing of cord clamping and the need for neonatal resuscitation or other immediate postnatal care.

2. Methods and Materials

2.1. Study design and setting

This clinical comparative study recruited 500 pregnant women attending the hospital for labour, using a convenient consecutive sampling method. Participants were randomly and equally allocated into two groups at Erbil Maternity Teaching Hospital, Erbil, Kurdistan Region, Iraq, from May 2024 to January 2025.

2.2. Inclusion criteria

Healthy pregnant women aged ≥18 years without chronic illness or major health issues, had singleton term pregnancy (gestation age of 37-40 weeks), and planned vaginal delivery.

2.3. Exclusion criteria

Patients with fetal anomalies, placental pathology required emergency delivery (placenta previa with hemorrhage, suspected abruption), and amniotic fluid pathology (oligo-/polyhydramnios). Also, those with acute maternal pathology (eclampsia and significant hemorrhage), hemoglobinopathy (sickle cell and thalassemia), anemia (hemoglobin of <7.0 g/dL), or had Human Immunodeficiency Virus (HIV) or active hepatitis infection.

2.4. Study protocol

A self-developed validated (by 5 experts) questionnaire was used to collect sociodemographic and clinical information of pregnant women (age, gestational age, and parity) and their delivered neonates (BW, gender, and APGAR scores). Group one women's neonates (n=250) had ECC within 30 seconds after birth without milking the umbilical cord, and Group two women's neonates (n=250) had DCC at 1.5 minutes, with milking the umbilical cord once only to assist with placental transfusion. Trained medical staff documented the APGAR score at one and 5 minutes after birth in each group. A score of 0-2 means neonates required resuscitation, such as ventilation, oxygen, or Neonate Intensive Care Unit (NICU) admission.

2.5. Ethical considerations

Ethical approval was obtained from the Ethical Committee of College of Medicine, Hawler Medical University prior to study commencement (No. 7/21 on April 21, 2024). The data collection was authenticated by the Scientific Committee of the Erbil Maternity Teaching Hospital, Erbil,

Iraq. Participants were provided information about the study purpose, procedures as well as any risks or benefits to newborns. Participants provided written informed consent prior to enrollment and confidentiality of their information was assured.

2.6. Statistical analysis

Statistical analysis was conducted using Statistical Package for Social Sciences, version 25 (IBM, Chicago, USA). For descriptive statistics, continuous variables maternal, such as maternal age, parity, mode of delivery, gestational age, birth weight, and neonate gender were summarized using means and standard deviations (SD). Categorical variables were presented as frequency and percentage. Independent t-test for continuous variables, Chi-square test, or Fisher's exact test (for small cell counts) for categorical variables were used to compare the ECC and DCC groups at baseline to demonstrate successful randomization. A $p<0.05$ was used to indicate significant differences.

3. Results and Discussions

Following the establishment of the evidence of benefits of DCC in many randomized controlled trials[11], there has been a strong recommendation by the WHO for a shift in practice from immediate cord clamping to DCC, especially in low and middle-income countries (including Iraq), where the burden of anaemia is very high [12]. Accordingly, we tried to find the correlations between maternal/neonatal factors with the time of cord clamping after birth. The mean maternal age was 30.6 ± 3.5, while their mean gestational age was 37.6 ± 1.2 weeks, and most of them (n=237) were primiparous (116 in Group one and 121 in Group 2). The mean neonates' BW was 3.14 ± 0.45 kg (3.13 ± 1.0 kg in Group 1 and 3.15 ±1.2 kg in Group 2), with nearly equal gender distribution in both groups, and most of them (28.4%) had an APGAR score of 9 after one minute (29.2% in Group 1 and 27.6 in Group 2), while majority (29.4%) had APGAR score of 10 after 5-minutes (30.4% in Group 1 and 28.4% in Group 2). Also, majority had no SOB (59.2%); however, 40.8% were admitted to NICU due to grunting (18.8%) and asphyxia (4.44%) (Table 1).

Table 1. Demographic and clinical characteristics by cord clamping group.

Variable		Delayed Clamping (n=250)	Early Clamping (n=250)	Total (n=500)
			Frequency (%)	
Parity	0.0	23 (9.2)	31 (12.4)	54 (10.8)
	1.0	116 (46.4)	121 (48.4)	237 (47.4)
	2.0	85 (34)	79 (31.6)	164 (32.8)
	3.0	26 (10.4)	19 (7.6)	45 (9)
Gender	Female	126 (50.4)	125 (50)	251 (50.2)
	Male	124 (49.6)	125 (50)	249 (49.8)
APGAR at 1-minute	5.0	59 (23.6)	52 (20.8)	111 (22.2)
	6.0	41 (16.4)	52 (20.8)	93 (18.6)
	7.0	29 (11.6)	24 (9.6)	53 (10.6)
	8.0	45 (18)	51 (20.4)	96 (19.2)
	9.0	73 (29.2)	69 (27.6)	142 (28.4)
	10.0	3 (1.2)	2 (0.8)	5 (1)
APGAR at 5-minutes	6.0	58 (23.2)	52 (20.8)	110 (22)
	7.0	42 (16.8)	52 (20.8)	94 (18.8)
	8.0	29 (11.6)	24 (9.6)	53 (10.6)
	9.0	45 (18)	51 (20.4)	96 (19.2)
	10.0	76 (30.4)	71 (28.4)	147 (29.4)
SOB	No	150 (60)	146 (58.4)	296 (59.2)
	Yes	100 (40)	104 (41.6)	204 (40.8)
NICU Admission	No	150 (60)	146 (58.4)	296 (59.2)
	Yes	100 (40)	104 (41.6)	204 (40.8)
Cause	Asphyxia	59 (23.6)	52 (20.8)	111 (4.44)
	Grunting	41 (16.4)	52 (20.8)	93 (18.6)

NICU: Neonate Intensive Care Unit, SOB: Shortness of breath

Regarding the participants; demographic data, mean maternal age among both studied groups were uniform suggesting that risk factors associated with age were evenly distributed. Also, gestational age was uniform, suggesting matched neonatal maturity as evidenced at time of delivery. Neonatal gender is almost same among both groups and it was established that neonate gender was not a confounding factor in evaluating outcomes [13].

Moreover, there were no significant associations ($p>0.05$) between neonatal variables (BW, gender, NICU admission, and causes of admission) and maternal factors (age, parity, and gestational age) with the time of clamping in each group (delayed and early) (Table 2).

Table 2. Association between cord clamping time and maternal-neonatal characteristics.

Variable		Delayed Clamp		Early Clamp		Total Frequency (%)	p-value
		Frequency	%	Frequency	%		
Neonate Body Weight	Normal	245	98	245	98	490 (98)	p>0.05
	Over Weight	5	2	5	2	10 (2)	
Gender	Female	126	50	125	50	251 (50.2)	p>0.05
	Male	124	50	125	50	249 (49.8)	
Mother Age (Years)	<30	99	40	101	40.4	200 (40)	p>0.05
	≥30	151	60	149	59.6	300 (60)	
Parity	0.0	23	9	31	12.4	54 (1.08)	p>0.05
	1.0	116	46	121	48.4	237 (47.4)	
	2.0	85	34	79	31.6	164 (32.8)	
	3.0	26	10	19	7.6	45 (9)	
Gestational Age (Weeks)	<37	65	26	66	26.4	131 (26.2)	p>0.05
	≥37	185	74	184	73.6	369 (73.8)	
SOB	No	150	60	146	58.4	296 (59.2)	p>0.05
	Yes	100	40	104	41.6	204 (40.8)	
NICU	No	150	60	146	58.4	296 (59.2)	p>0.05
	Yes	100	40	104	41.6	204 (40.8)	
Cause of NICU Admission	Asphyxia	59	59	52	50	111 (22.2)	p>0.05
	Grunting	41	41	52	50	93 (18.6)	

NICU: Neonate Intensive Care Unit, SOB: Shortness of breath

Furthermore, APGAR score at one and 5-minutes not significantly correlated to the time of clamping. At one-minute, the delayed clamped group had moderately depressed scores of 40.0%, and normal scores of 60.0%, while the early clamped group showed moderately depressed scores of 41.6%, and normal scores of 58.4%. Notablly, improvements were seen at the 5-minutes for both groups. For the delayed clamped group, the moderately depressed scores dropped to 23.2%, and there were 76.8% with normal scores. In the early clamped group, the moderately depressed scores dropped to 20.8%, and the normal score were 79.2% (Table 3).

Table 3. Neonatal APGAR outcomes in relation to cord clamping timing.

APGAR Score Grade		Delayed Clamping Frequency	%	Early Clamping Frequency	%	Total Frequency(%)	p-value
At One Minute	Moderately Depressed	100	40.0	104	41.6	204 (40.8)	p>0.05
	Normal	150	60.0	146	58.4	296 (59.2))	
At 5-Minutes	Moderately Depressed	58	23.2	52	20.8	110 (22)	p>0.05
	Normal	192	76.8	198	79.2	390 (78)	

Generally, DCC allows blood flow between the placenta and neonate to continue, which may improve iron status in the infant for up to six months after birth. This may be particularly relevant for infants living in low-resource settings with reduced access to iron-rich foods. In this way, the current study offers substantial support for the hypothesis that DCC helped improve the condition of neonates compared to ECC, as measured with APGAR scores. The results indicated that infants with DCC had higher APGAR scores consistently at one and 5 minutes postpartum, with an average increase of one point at both time points. Furthermore, those who experienced DCC had a 67% decrease in the odds of low APGAR scores (≤7), which is clinically important given that this score is less than or equal to clinically concerning value of 7 and suggests potential for neonatal compromise. These improvements in APGAR score might positively affect the neonates' level of electrolytes, minerals, oxygenation, and immunity for next 6 months to one year. Zhao et al. who reported that being assigned to DCC was associated with better hemoglobin levels in infants at 24-48 hours after birth and improved iron stores at 3-6 months [11].

Additionally, a multivariate linear regression was conducted to identify independent predictors of neonatal APGAR scores at one and 5-minute post-delivery. The data shown that DCC was significantly associated with an increase in APGAR score at one minute ($\beta = +0.17$, $p=0.011$), which is in an adverse association to other clinical parameters. Gestational age also was a positive predictor ($\beta = +0.14$, $p=0.003$) that indicated more mature neonates scored higher at one minute. Neonates BW also contributed highly significantly ($\beta = +0.21$, $p<0.001$) as an expected association of physiological resilience in neonatal responsiveness (Figure 1).

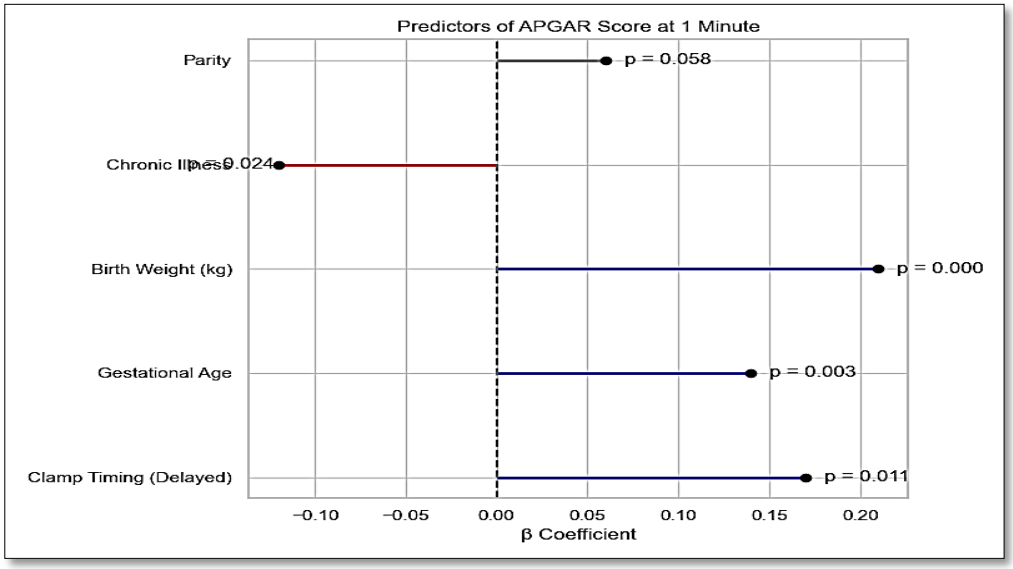

Figure 1. Predictors of neonatal APGAR scores at one minute, using a multivariate linear regression analysis.

Also, analyzed data realized that DCC was significantly associated with an increase in the APGAR score at 5-minutes (0.13 coefficient, p=0.017); thereby confirming its positive influence for neonatal stabilization during the immediate postpartum period. Gestational age and BW were positively associated with APGAR outcomes (0.11 coefficient, p=0.008 and 0.19 coefficient, p<0.001, respectively). These variables represent an important physiological marker of maturity; their influence underscores the significance of fetal growth and timing, in determining birth outcomes. Finally, parity had a small positive non-significant effect (+0.05, p=0.073) (Figure 2).

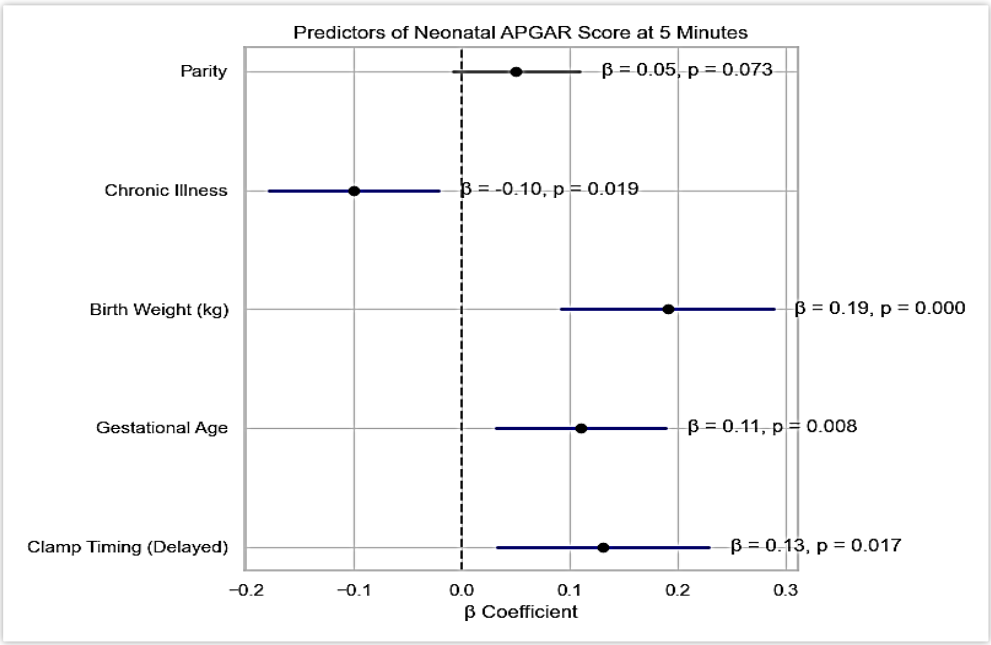

Figure 2. Predictors of neonatal APGAR scores at 5 minuteS, using a multivariate linear regression analysis.

The ACOG recommends DCC for at least 30-60 seconds in vigorous term infants, based on the evidence that DCC improves hemoglobin levels and iron stores in early infancy [10]. Accordingly, this study benefits in the context of neonatal transition, evidenced by better APGAR scores in DCC group. Seldomely, DCC was associated with lower Apgar scores, neonatal hypothermia of admission, respiratory distress, severe jaundice, increased risk of postpartum hemorrhage and maternal blood transfusion whether in cesarean section or vaginal delivery [14]. In agreement to this study, Rabe et al. in a randomized controlled trials examined the effect of DCC vs. ECC on APGAR scores in a group of preterm infants and found that delayed, rather than early, cord clamping may reduce the risk of NICU duration

and death before discharge [10]. However, their study was limited by investigation of preterm infants that may respond to DCC differently than term infants. DCC allows for ongoing placental transfusion, resulting in an increase of blood volume and red blood cell volume. This increase in volume increases cardiac output and oxygen delivery during the physiological transition to extra uterine life, which could be why the DCC infants had higher APGAR scores. In consistent with our APGAR scores, Mercer et al. showed that DCC results in a smoother transition in blood pressure and oxygenation within the first minutes of life [15]. The constant improvement in one-minute and 5-minutes APGAR scores for the DCC group suggests that placental transfusion confers an immediate and sustained advantage. Furthermore, the similar magnitude of improvements at both time points (1-point increase), suggests that DCC afforded a baseline advantage for neonatal adaptation rather than acceleration of recovery from any initial compromise. This is corroborated by the similar APGAR improvement (5-minute score minus one-minute score) between groups. In the regression analysis, we determined DCC to be the single most important predictor of APGAR score, after accounting for gestational age and BW, which are established determinants of neonatal condition [16]. Furthermore, this study found that DCC reduced the odds of low APGAR scores by 67%. This is clinically important, as low APGAR scores are associated with increased rates of complications during the neonatal period, such as hypoxic-ischemic encephalopathy and need for resuscitation [17]. The strong correlation between one-minute and 5-minutes APGAR scores (r=0.892) in this study supports APGAR's reliability of different measures of neonatal condition. While previous studies have also reported this correlation [18,19], the present study is unique in showing that DCC improved the APGAR scores without changing the relationship between the scores. Accordingly, these results have significant implications for clinical practice. The noticeable improvement in APGAR scores associated with DCC shows that this easy and inexpensive intervention can support a newborn's transition and potentially reduce resuscitation efforts, especially in resource challenged areas where advanced neonatal resuscitation may not be accessible. The current ACOG [6] and WHO [20] recommendations for DCC in term infants were already in place at the time this research was conducted; however, adhering to these guidelines is often not uniform. Our evidence can strengthen these recommendations and spark wider recognition of DCC as common practice. Our findings also indicated that DCC are independent of the other factors to be used for all term infants and not just high-risk infants. The consideration of DCC for all term infants could yield population level impacts by improving neonatal outcomes.

This study has some limitations that need to be considered, including unmeasured confounders, such as maternal nutrition, placental health, and intrapartum events that could have some influence on results. APGAR scores assess newborns' physiologic status at birth; however, they are subjective assessments that can differ between observers and therefore may represent measurement error. This study was single centered, which may limit generalizability to other settings. Finally, we assessed short term outcomes (APGAR scores at one and 5 minutes), and did not include any long-term outcomes (such as neurodevelopment).

4. Conclusion

There is strong evidence that DCC has a significant benefit to neonatal condition, evaluated by APGAR. These findings validate current recommendations for DCC in term infants and further emphasize that this simple intervention can make an important difference in neonatal transition. Future research should extend the findings in multiple directions, including determining the optimal exact duration of DCC in multiple hospitals, examining how APGAR scores can be more improved, looking at the long-term impact of an improved APGAR score with DCC, particularly neurodevelopmental outcomes, and trying to ascertain high-risk populations to get benefit from DCC, such as infants of diabetic mothers or children with intrauterine growth restriction.

4.1. Author Contributions

Z.W.J.: Study registration, methodology, data collection, data analysis, and writing of the original manuscript; R.K.J.: Conceptualization, study admission, validation, supervision, edition and revision of the drafted manuscript.

4.2. Conflict of interest

None

4.3. Acknowledgements

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