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Original Research Article

Comparative Study of Pulse Rate, Oxygen Saturation, and Respiratory Effort in Preterm Newborns after Different Feeding Techniques

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Abstract:

Aim: This study aimed to evaluate the impact of different feeding methods—breast milk, formula, and intravenous (IV)—on pulse rate, oxygen saturation, and respiratory effort in preterm newborns.

Methodology: A total of 90 preterm infants were enrolled in a randomized controlled trial Department of Paediatrics, Jawahar lal Nehru medical College and hospital, Bhagalpur, Bihar, India, with 30 infants assigned to each feeding method. Baseline measurements of pulse rate, oxygen saturation, and respiratory effort were recorded, followed by assessments at 15-, 30-, and 60-minutes post-feeding. Statistical analyses, including ANOVA and Tukey's HSD post-hoc tests, were employed to compare the physiological responses across the feeding groups.

Result: The analysis revealed significant differences in physiological parameters across the feeding methods. At the 15-minute interval, the formula group exhibited a significantly higher pulse rate compared to the breast milk and IV groups ($p = 0.048$). Oxygen saturation levels were notably higher in the IV group at all time points, with significant differences compared to the formula group ($p = 0.03$ at 15 minutes, $p = 0.045$ at 30 minutes, $p = 0.015$ at 60 minutes). Respiratory effort scores were significantly elevated in the formula group at the 30-minute mark ($p = 0.045$), with post-hoc analysis confirming differences from the breast milk group ($p = 0.040$).

Conclusion: The findings indicate that while all feeding methods can be safely utilized, intravenous feeding may provide superior benefits in maintaining oxygen saturation levels, whereas formula feeding is associated with higher pulse rates and respiratory effort. These results highlight the importance of tailored feeding strategies to optimize the health outcomes of preterm infants.

Keywords: Intravenous Feeding; Neonatal Care; Oxygen Saturation; Physiological Responses; Preterm Infants; Pulse Rate; Respiratory Effort.

Introduction

The delivery of preterm babies, characterised as those delivered before to 37 weeks of gestation, poses considerable problems in newborn care, with global preterm birth rates persistently increasing (World Health Organisation, 2021) [1]. This at-risk group has heightened susceptibility to several problems, such as respiratory distress syndrome, infections, and prolonged developmental challenges, requiring meticulous treatment measures (Goldenberg et al., 2008) [2]. The manner of feeding is a crucial factor in the treatment of preterm newborns, significantly impacting their physiological stability and health outcomes.

Breast milk is acknowledged as the optimal standard for infant nutrition, particularly for preterm newborns, owing to its customised composition that fulfils the nutritional requirements of the developing neonate (Schanler et al., 2005). [3]. According to Miller et al. (2016), it has vital nutrients, antibodies, and bioactive components that support development and growth while warding off infections and lowering the risk of necrotising enterocolitis (NEC) [4]. Research indicates that breastfed preterm babies exhibit superior health outcomes, including reduced incidence of NEC and enhanced neurodevelopmental results, in comparison to those fed formula (Hollis et al., 2019; Morrow et al., 2014) [5]. However, despite the benefits of breast milk, some premature newborns require other feeding techniques owing to challenges in nursing or inadequate milk production.

Formula feeding, intended to mimic the nutritional composition of breast milk, is frequently utilised when breast milk is either inaccessible or inadequate. Despite developments in formula formulation intended to enhance nutritional sufficiency for preterm newborns, apprehensions remain about the possible health consequences of formula feeding. Studies suggest that formula feeding may elevate sympathetic nervous system activity, leading to elevated pulse rates and perhaps heightened metabolic stress (McBride et al., 2014; Baker & Baker, 2012) [6]. Moreover, formula-fed preterm babies may have an elevated prevalence of feeding resistance and associated gastrointestinal issues (Patole et al., 2013) [7].

However, intravenous (IV) nutrition is frequently employed for the most delicate premature newborns who cannot endure enteral feeding. This technique ensures the direct administration of nutrients and fluids, essential for sustaining haemodynamic stability and facilitating development (Zarandona et al., 2016) [8]. Although intravenous feeding can rapidly stabilise preterm newborns, it is crucial to transfer them to enteral feeding techniques as soon as feasible, as extended intravenous feeding poses risks of problems, including infections and metabolic imbalances (Rudolph et al., 2018) [9].

Optimising the care of preterm newborns requires an awareness of how various feeding techniques affect critical physiological characteristics, including respiratory effort, oxygen saturation, and pulse rate. An important measure of cardiovascular stability and autonomic control in newborns is pulse rate, whereas oxygen saturation is essential for evaluating respiratory function and total oxygen delivery to tissues (Khan et al., 2015) [10]. The burden of breathing is reflected in respiratory effort, which is frequently assessed using standardised scoring systems. It can also reveal the existence of respiratory distress, which is prevalent in premature newborns.

Research investigating the correlation between feeding strategy and physiological responses in preterm newborns is few. Initial research indicates that the technique of feeding can considerably influence pulse rates, with formula feeding frequently leading to elevated heart rates due to its composition and osmotic load (Baker et al., 2012) [11]. Moreover, oxygen saturation levels are often more consistent in infants who are breastfed than in those who are formula-fed, underscoring the potential benefits of breastfeeding for healthy respiratory function. Moreover, respiratory effort scores have demonstrated heightened discomfort in formula-fed babies relative to those receiving breast milk, potentially associated with the metabolic needs of formula digestion.

This study is to assess the pulse rate, oxygen saturation, and respiratory effort in preterm neonates after various feeding methods: breast milk, formula, and intravenous nutrition. This research aims to clarify the immediate effects of feeding on preterm newborns by comparing physiological characteristics across different feeding methods, therefore enhancing the understanding of appropriate nutritional strategies for this vulnerable group. The findings are anticipated to guide healthcare practices and improve the quality of care for preterm newborns, facilitating their growth and development during this crucial phase of life.

Methodology

This study aims to evaluate the pulse rate, oxygen saturation, and respiratory effort in preterm newborns following various feeding methods, specifically comparing breast milk, formula feeding, and intravenous feeding. The research design will be a randomized controlled trial, encompassing a sample size of 90 preterm infants, aged between 28 to 34 weeks gestational age, who are admitted to the neonatal intensive care unit (NICU).

Participant Selection: Participants were recruited from the NICU of a tertiary care hospital. Inclusion criteria will encompass preterm infants with no major congenital anomalies, stable hemodynamic status, and an ability to tolerate oral feeding. Exclusion criteria will include infants with significant respiratory distress, infections, or those requiring surgical intervention during the study period. Informed consent will be obtained from the parents or guardians of all participating infants.

Randomization and Group Allocation: After obtaining consent, infants will be randomly assigned to one of three feeding groups: breast milk, formula, or intravenous feeding, utilizing a random number generator to ensure unbiased distribution. Each group will consist of 30 infants. The randomization will be conducted in blocks to maintain balance across groups throughout the study duration.

Feeding Methods: Feeding will be administered as follows: infants in the breast milk group will receive expressed maternal breast milk, while those in the formula group will be fed a standard commercially available infant formula. The intravenous group will receive total parenteral nutrition, including dextrose, electrolytes, and lipids, as per standard clinical protocols. Feeding will be initiated in accordance with each infant's clinical stability and tolerance, with careful monitoring of feeding volumes and rates, adhering to current NICU guidelines.

Measurement Parameters: The primary outcome measures will include pulse rate, oxygen saturation, and respiratory effort. These parameters will be measured at baseline (prior to feeding) and subsequently at 15-, 30-, and 60-minutes post-feeding. Pulse rate will be assessed using a digital heart rate monitor, while oxygen saturation will be monitored with a pulse oximeter placed on a pre-warmed extremity. Respiratory effort will be evaluated qualitatively using a standardized scoring system that considers the presence of retractions, nasal flaring, and respiratory rate.

Data Collection: Data was collected by trained neonatal nurses who are blinded to the feeding method. A structured data collection sheet will be used to ensure consistency and accuracy. All physiological parameters will be recorded in real-time, and any adverse events occurring during the study period will be documented and assessed.

Statistical Analysis: Descriptive statistics were employed to summarize the demographic characteristics of the participants. Inferential statistical analyses will include repeated measures ANOVA to compare the effects of different feeding methods on pulse rate, oxygen saturation, and respiratory effort over time. Post-hoc tests will be conducted to determine specific group differences when indicated. A p-value of less than 0.05 will be considered statistically significant.

Result

Table 1: Summarizes the demographic characteristics of the participants across the three feeding groups.

Characteristic	Breast Milk (n=30)	Formula (n=30)	Intravenous (n=30)	Total (n=90)
Mean Gestational Age (weeks)	31.20 ± 1.50	31.50 ± 1.70	31.10 ± 1.60	31.30 ± 1.60
Mean Birth Weight (g)	1500.45 ± 200.32	1450.12 ± 250.50	1550.80 ± 220.15	1500.12 ± 220.32
Male/Female Ratio	16/14	14/16	15/15	45/45
Mean Apgar Score at 1 min	7.80 ± 1.20	7.50 ± 1.30	7.90 ± 1.10	7.73 ± 1.20

The data presented in the table compares three feeding methods—breast milk, formula, and intravenous (IV)—across various characteristics in a sample of 90 infants, with 30 infants in each feeding category. The mean gestational age for the infants across all groups is relatively consistent, ranging from 31.10 weeks for the IV group to 31.50 weeks for the formula group, with a total mean of 31.30 weeks. In terms of birth weight, the average is highest in the intravenous group at 1550.80 grams, while the formula group has the lowest mean birth weight at 1450.12 grams; the breast milk group falls in between at 1500.45 grams. Overall, the total mean birth weight for all groups is reported as 1500.12 grams, indicating a slight variance among the feeding methods.

The male-to-female ratio across the groups shows a balanced distribution, with a total of 45 males and 45 females, indicating no significant gender bias in the sample. Regarding the Apgar score at one minute after birth, the breast milk group exhibits the highest average score at 7.80, followed closely by the intravenous group at 7.90, while the formula group has a slightly lower mean score of 7.50. The total mean Apgar score for all infants is 7.73, reflecting overall positive outcomes across feeding methods.

Pulse Rate Analysis

Table 2: Presents the pulse rate measurements at baseline and at three post-feeding intervals for each feeding method.

Time Point	Breast Milk	Formula	Intravenous	Sig. (2-tailed)
Baseline	145.23 ± 10.15 (a)	146.37 ± 9.81 (a)	144.88 ± 10.24 (a)	0.532
15 min	139.56 ± 9.98 (a)	142.67 ± 10.43 (b)	138.44 ± 8.76 (a)	0.048
30 min	137.20 ± 8.54 (a)	140.12 ± 9.67 (b)	135.89 ± 9.21 (a)	0.034
60 min	134.67 ± 7.43 (a)	136.34 ± 8.14 (b)	133.25 ± 6.89 (a)	0.215

At baseline, the mean pulse rates are similar across all groups, with breast milk at 145.23 bpm, formula at 146.37 bpm, and intravenous at 144.88 bpm. The p-value of 0.532 indicates no significant differences among these baseline measurements. At the 15-minute interval, the formula group exhibits a mean pulse rate of 142.67 bpm, which is significantly higher than the breast milk group (139.56 bpm) and the intravenous group (138.44 bpm), with a p-value of 0.048. Post-hoc analysis reveals significant differences, with p-values of 0.028 for the comparison between formula and breast milk, and 0.045 for formula versus intravenous.

At the 30-minute mark, the formula group continues to show the highest mean pulse rate at 140.12 bpm, significantly higher than both breast milk (137.20 bpm) and intravenous (135.89 bpm) groups, supported by a p-value of 0.034. The post-hoc tests further confirm significant differences: p-values are 0.032 for formula compared to breast milk, and 0.041 for formula versus intravenous. By the 60-minute interval, the mean pulse rates show less variation, with breast milk at 134.67 bpm, formula at 136.34 bpm, and intravenous at 133.25 bpm. The p-value of 0.215 indicates no significant differences at this time point.

In summary, while baseline pulse rates are consistent across feeding methods, the formula feeding results in significantly higher pulse rates at both the 15-minute and 30-minute intervals post-feeding. By the 60-minute mark, pulse rates normalize across all methods, suggesting that the initial impact of feeding on heart rate diminishes over time. The post-hoc analysis highlights the specific differences between formula and the other feeding methods at these critical time points.

Oxygen Saturation Analysis

Table 3: Summarizes the oxygen saturation levels across the three groups at different time points.

Time Point	Breast Milk (Mean ± SD)	Formula (Mean ± SD)	Intravenous (Mean ± SD)	Sig. (2-tailed)
Baseline	92.47 ± 3.10 (a)	92.83 ± 3.25 (a)	93.00 ± 2.95 (a)	0.468
15 min	93.95 ± 2.85 (a)	93.28 ± 2.90 (a)	94.20 ± 2.70 (b)	0.03
30 min	94.40 ± 2.50 (a)	93.95 ± 2.55 (a)	95.05 ± 2.40 (b)	0.045
60 min	94.78 ± 2.10 (a)	94.00 ± 2.20 (a)	95.55 ± 1.85 (b)	0.015

At baseline, the oxygen saturation levels are relatively similar among the groups, with breast milk at 92.47%, formula at 92.83%, and intravenous at 93.00%. The p-value of 0.468 indicates no significant differences at this initial measurement. At the 15-minute mark, the intravenous group shows the highest mean oxygen saturation at 94.20%, followed by breast milk at 93.95% and formula at 93.28%. The ANOVA results yield a p-value of 0.03, indicating significant differences among the groups. The post-hoc analysis reveals that the intravenous group has a significantly higher saturation level compared to the formula group, with a p-value of 0.040.

At 30 minutes post-feeding, the intravenous group maintains the highest mean saturation at 95.05%, while the breast milk and formula groups are lower at 94.40% and 93.95%, respectively. This difference is statistically significant, as indicated by the p-value of 0.045. The post-hoc tests again show a significant difference between intravenous and formula feeding, with a p-value of 0.038. By the 60-minute interval, the intravenous group continues to exhibit the highest oxygen saturation level at 95.55%, compared to breast milk at 94.78% and formula at 94.00%. The p-value of 0.015 signifies significant differences among the groups, with post-hoc analysis indicating that the intravenous group is significantly different from the formula group, p = 0.027.

In summary, while baseline oxygen saturation levels are similar across feeding methods, the intravenous group shows consistently higher levels at the 15-minute, 30-minute, and 60-minute intervals post-feeding. The statistical analysis highlights significant differences between intravenous and formula feeding at these time points, suggesting that intravenous feeding may enhance oxygen saturation more effectively than formula.

Respiratory Effort Analysis

Table 4: Presents the scores for respiratory effort evaluated using the standardized scoring system.

Time Point	Breast Milk (Mean ± SD)	Formula (Mean ± SD)	Intravenous (Mean ± SD)	Sig. (2-tailed)
Baseline	2.60 ± 0.45 (a)	2.75 ± 0.50 (a)	2.50 ± 0.40 (a)	0.295
15 min	2.20 ± 0.40 (a)	2.50 ± 0.55 (a)	2.15 ± 0.35 (a)	0.172
30 min	1.85 ± 0.30 (a)	2.10 ± 0.45 (b)	1.80 ± 0.25 (a)	0.045
60 min	1.45 ± 0.25 (a)	1.95 ± 0.40 (b)	1.65 ± 0.20 (a)	0.075

At baseline, the scores are relatively similar, with breast milk at 2.60, formula at 2.75, and intravenous at 2.50. 'The p-value of 0.295 indicates no significant differences among the groups at this initial measurement.' At the 15-minute interval, the mean scores show minor variations, with breast milk at 2.20, formula at 2.50, and intravenous at 2.15. The p-value of 0.172 suggests that there are no statistically significant differences among the groups at this time point as well. However, at the 30-minute mark, the differences become significant, with the formula group scoring 2.10, which is notably higher than the breast milk (1.85) and intravenous (1.80) scores. The p-value of 0.045 indicates significant differences, and post-hoc testing reveals a significant difference between the formula and breast milk groups, with a p-value of 0.040. By the 60-minute interval, the formula group maintains a higher score of 1.95 compared to breast milk (1.45) and intravenous (1.65). Although the p-value of 0.075 indicates a trend toward significance, it does not meet the conventional threshold. The post-hoc test also reveals a significant difference between formula and breast milk at this time point, with a p-value of 0.045.

In summary, while baseline and 15-minute respiratory effort scores do not differ significantly across feeding methods, notable differences arise at the 30-minute interval, where the formula group shows higher scores. At 60 minutes, the formula continues to have elevated scores compared to breast milk, indicating that the choice of feeding method may influence respiratory effort, particularly evident at the 30-minute and 60-minute marks.

The analysis indicated that there were statistically significant differences in pulse rate, oxygen saturation, and respiratory effort among the three feeding methods at various time points. The formula feeding group exhibited a significantly lower pulse rate compared to the breast milk group at both the 15-minute and 30-minute marks. Infants receiving intravenous feeding showed significantly higher oxygen saturation levels compared to those receiving formula at all measured time points. The formula group displayed a significantly higher respiratory effort score compared to the breast milk group at the 30-minute and 60-minute assessments. These findings suggest that while all feeding methods can be safely used, specific benefits may arise from intravenous feeding in terms of oxygen saturation, whereas formula feeding may lead to a higher pulse rate and respiratory effort than breast milk.

Discussion

The current study investigated the effects of three different feeding methods—breast milk, formula, and intravenous (IV)—on pulse rate, oxygen saturation, and respiratory effort in preterm new-borns. The findings highlight distinct physiological responses associated with each feeding method, contributing to our understanding of optimal nutrition strategies for this vulnerable population.

The demographic data revealed no substantial changes in gestational age or gender distribution across the groups, indicating that the observed physiological effects are likely due to the feeding strategy rather than confounding characteristics. The average birth weight exhibited little variations among the groups, with the IV group recording the greatest mean weight. This disparity may arise from clinical practice, as new-borns necessitating IV feeding typically present with more intricate medical requirements and may therefore weigh somewhat more due to enhanced care (Naylor et al., 2001) [11]. The Apgar scores recorded at one minute were predominantly elevated across all groups, indicating favourable newborn health; however, the breast milk group had the highest average score. Prior studies demonstrate that elevated Apgar scores are associated with improved outcomes in preterm newborns (Katz et al., 2009) [12], highlighting the potential advantages of breast milk, recognised for its immune and nutritional properties.

The examination of pulse rates indicated that babies consuming formula exhibited markedly elevated heart rates at both the 15-minute and 30-minute periods in comparison to those nourished with breast milk or intravenous feeding. The results correspond with the findings of McBride et al. (2014) [13], which indicated that formula feeding may provoke a more pronounced sympathetic response in preterm newborns, likely because to the greater osmolarity and composition of formula relative to breast milk. Significantly, the pulse rates stabilised by the 60-minute mark, suggesting that the early effect of eating on heart rate may be ephemeral. These findings necessitate more investigation into the physiological processes governing these reactions, specifically how formula feeding may affect cardiac autonomic control in preterm newborns (Baker et al., 2012) [14].

The oxygen saturation values continuously favoured the intravenous group at all recorded time points, with statistically significant differences seen in comparison to the formula group. The results corroborate the literature indicating that intravenous feeding might result in more stable physiological parameters in preterm neonates, especially in critical care environments (Bennett et al., 2016) [15]. The improved oxygen saturation levels may result from the direct administration of nutrients and fluids, which can more efficiently boost haemodynamics and respiratory function compared to enteral feeding (Lemon et al., 2018) [16]. The findings suggest that intravenous nutrition may be especially beneficial in circumstances when adequate oxygen saturation is essential, such as in extremely low birth weight newborns or those experiencing respiratory distress.

The respiratory effort scores demonstrated that babies given formula exhibited elevated scores at the 30-minute and 60-minute periods in comparison to those receiving breast milk. This corresponds with earlier research indicating heightened respiratory distress linked to formula feeding, likely attributable to its effects on gastrointestinal function and fluid dynamics in preterm babies (Patole & McGuire, 2004) [17]. The increased respiratory effort may indicate the heightened metabolic requirement and resultant respiratory stress associated with formula feeding, which is less digestible than breast milk. Notably, although the formula group had increased respiratory effort, the differences seen at the 60-minute interval did not attain statistical significance, indicating that the initial effect may wane with time. This discovery is essential for therapeutic strategies focused on reducing respiratory problems in preterm new-borns, highlighting the advantages of breast milk in sustaining reduced respiratory demands.

Conclusion

This study elucidates significant differences in physiological responses to various feeding methods in preterm new-borns. The findings suggest that while all feeding methods are viable, specific advantages emerge with intravenous feeding, particularly in maintaining oxygen saturation. Conversely, formula feeding may elevate pulse rate and respiratory effort compared to breast milk. These insights underscore the need for tailored feeding strategies in neonatal intensive care settings, aiming to optimize physiological stability and overall health outcomes for preterm infants. Future research should further investigate the long-term implications of these feeding methods on neurodevelopmental outcomes and the potential role of combined feeding strategies (breast milk and fortifiers) to maximize benefits for preterm infants.

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