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Kangaroo mother care enhances exclusive breastmilk feeding and shortens time to achieve full enteral feeding in extremely preterm infants requiring non-invasive assisted ventilation

Jiaxin Li[1], Huiyan Wang[2], Jiaming Yang[1], Xueyu Chen[2], Aifen Cao[2], Chuanzhong Yang[2] and Xiaoyun Xiong[2*]

Abstract

Background Extremely preterm infants (EPIs) frequently encounter challenges in feeding due to their underdeveloped digestive systems. Attaining full enteral feeding at the earliest possible stage can facilitate the removal of vascular catheters and decrease catheter-related complications.

Methods We performed a retrospective cohort study comprising 145 extremely preterm infants with a gestational age < 28 weeks who underwent non-invasive mechanical ventilation at Shenzhen Maternity & Child Healthcare Hospital between January 2019 and June 2020. The KMC group received standard nursing care along with KMC, while the control group received standard nursing care without KMC. KMC initiation took place three weeks after admission and continued for a period of two weeks or more while maintaining stable vital signs. We evaluated the rate of exclusive breastmilk feeding within 24 h prior to discharge and the time to full enteral feeding throughout hospitalization. Additionally, we conducted a multiple linear regression analysis to identify the independent factors associated with exclusive breastmilk feeding rates and the time to full enteral feeding.

Results The KMC group exhibited a significantly higher rate of exclusive breastmilk feeding in the 24 h before discharge in comparison to the Non-KMC group (52.8% vs. 31.5%, OR 2.43; 95% CI 1.24, 4.78). Moreover, the KMC group achieved full enteral feeding in a shorter duration than the Non-KMC group (43.1 ± 9.6 days vs. 48.7 ± 6.9 days, $p < 0.001$). Multiple linear regression analysis revealed that KMC was an independent protective factor associated with improved exclusive breastmilk feeding rates (OR 2.43; 95% CI 1.24, 4.78) and a reduction in the time to full enteral feeding (β -5.35, $p < 0.001$) in extremely preterm infants.

Conclusion Kangaroo Mother Care (KMC) can expedite the achievement of full enteral feeding and enhance exclusive breastmilk feeding rates in extremely preterm infants receiving non-invasive assisted ventilation. These

*Correspondence:
Xiaoyun Xiong
x.xyun@163.com

Full list of author information is available at the end of the article

findings highlight the beneficial effects of KMC on the feeding outcomes of this vulnerable population, underscoring the importance of implementing KMC as a part of comprehensive care for extremely preterm infants.

Keywords Extremely preterm infants, Full enteral feeding, Breastmilk feeding, Kangaroo mother care

Background

Complications arising from preterm birth pose a significant threat to the survival of neonates and children under the age of 5. In 2018, neonatal deaths accounted for 2.5 million cases, making up 50% of all deaths within the under-5 age group [1]. An estimated 13.4 million babies were born too early in 2020. That is more than 1 in 10 babies. Globally, approximately 560,000 newborns were born before 28 weeks of gestation in 2020 [2, 3]. As the global rate of preterm births continues to rise [4], it becomes crucial to identify strategies that can reduce the incidence of preterm birth and improve the survival rates of preterm infants.

One such intervention is Kangaroo Mother Care (KMC), which has proven to be effective in saving the lives of preterm infants [5]. KMC involves prolonged skin-to-skin contact between the mother and her hospitalized or early-discharged infant, continuing until the corrected gestational age reaches 40 weeks [6]. Extremely preterm infants (EPIs) are defined as those with a gestational age of fewer than 28 weeks [7], and they often experience various feeding difficulties due to their underdeveloped digestive systems. Achieving full enteral feeding at the earliest possible stage in EPIs can lead to the removal of vascular catheters and a reduction in catheter-related sepsis and other associated complications [8, 9]. Earlier achievement of full enteral feeding has been shown to reduce the incidence of necrotizing enterocolitis (NEC), a serious gastrointestinal complication in preterm infants [10].Although some studies suggest that KMC can enhance preterm infant intake and increase the rate of maternal milk feeding [11], there is a lack of information specifically pertaining to EPIs. Furthermore, the benefits of KMC in EPIs receiving non-invasive assisted ventilation remain largely unknown. Therefore, our study aims to investigate the advantages of KMC in promoting breastmilk feeding and shortening the time to achieve full enteral feeding in EPIs undergoing non-invasive mechanical ventilation.

Methods

Study design

A retrospective analysis was conducted on extremely preterm infants (EPI) admitted to Shenzhen Maternal and Child Health Hospital between January 2019 and June 2020. The study aimed to investigate the effects of KMC on EPI outcomes. The inclusion criteria for the study were gestational age < 28 weeks and parental agreement to participate in KMC. Infants who underwent non-invasive assisted ventilation were eligible, and KMC was initiated three weeks after admission. KMC was performed for a duration of two weeks or more with stable vital signs, including no fever, no recurrent apnea, and a stable heart rate. Exclusion criteria were infants with congenital inherited metabolic disease, congenital heart disease, digestive tract malformation, various surgical treatments in the neonatal period, intracranial hemorrhage grade 3 or above, or umbilical artery and umbilical vein catheters. The termination of KMC was considered in cases where maternal or family reasons, withdrawal from treatment, death, or transfer to another hospital were involved. This study was approved by the Ethics Committee of Shenzhen Maternity and Child Healthcare Hospital, and parental consent was obtained through signed informed consent forms (IEC No. [2019]-119).

Group assignment

All parents in both groups were provided with comprehensive training on neonatal care. The retrospective study participants were divided into two groups based on whether parents performed KMC: the KMC group and the control group. Parents were provided with KMC training and given tours of the neonatal intensive care unit. They were educated on how to perform KMC, observe symptoms, and assess the infant's physiological state. In the control group, infants received routine nursing care without KMC. Preferential application of KMC was given to the EPI's mother or father, except in cases where their health is poor. Three experienced senior nurses trained the mothers (fathers) of EPIs to implement KMC. Before the KMC procedure, the mother/father of the EPI performed a series of steps, including handwashing, disconnecting mobile phones, wearing a cardigan, adviseing not to eat or drink, and using the restroom, to avoid interruptions. They were advised to wear cotton and sweat-absorbing clothing and to avoid clothing with burrs, tightness, or made of synthetic fibers. The control group received standard care feeding training.

KMC implementation protocol

To facilitate KMC, one or two screens were placed next to the incubator. Before initiating KMC, the EPI's temperature, heart rate, respiration, and blood oxygen saturation were measured. The mother/father was comfortably seated in a recliner to ensure a satisfactory reclining angle. The EPI was then lifted out of the incubator and placed on the mother's (father's) chest, facilitating skin-to-skin contact. The EPI wore only diapers and

Table 1 Clinical characteristics of infants in two groups

	Control group	KMC group	t/X^2	*p*
N(%)	72 (49.7%)	73 (50.3%)		
Male	45 (62.50%)	35 (49.30%)	2.53	0.11
Gestational age(wk)	26.49 ± 0.92	26.31 ± 1.29	1.00	0.32
Birth age (min)	15 (12–20)	15 (13–20)	0.80	0.42
Cesarean Section(n%)	51 (70.83%)	47 (64.38%)	0.36	0.55
Assisted Reproductive Technology	18 (25.00%)	17 (23.94%)	0.02	0.88
Birth weight (g)	860 (807–951)	870 (730.00-970.00)	1.41	0.16
Birth length (cm)	34 ± 5	33 ± 3	1.09	0.28
Sufficient prenatal Steroids	40 (55.56%)	40 (56.34%)	0.009	0.93
1-minute Apgar	6.79 ± 2.28	6.94 ± 2.25	-0.40	0.69
5-minute Apgar	9.39 ± 1.39	9.39 ± 1.09	-0.03	0.98
Length of Hospital Stay(day)	84.97 ± 31.99	83.30 ± 15.54	0.39	0.03

Table 2 The feeding related indexes were compared between the two groups

	Control group	KMC group	Z	*P*-value
N(%)	72 (49.7%)	73 (50.3%)	-	-
Time to full enteral feeding (day)	48.7 ± 6.9	43.1 ± 9.6	4.06	< 0.001
Exclusive breastmilk feeding for 24 h prior to discharge (n%)	23 (31.5%)	38 (52.8%)	6.73	0.009

a cap, with the head slightly tilted upwards. The mother/father was instructed to gently support the child's buttocks and back with their arms, allowing the child's body to naturally flex and extend. To ensure stability, non-invasive ventilation nasal plugs and various tubes were securely fastened, a heated blanket was draped over the EPI, and the screen was closed. The monitor was placed outside the screen for observation by the nurses. The mother/father was provided with a mirror through which they could observe the EPI's facial color, and a nurse was always available to provide assistance. KMC was performed once a day for three hours each time, seven times a week, for a duration of two weeks.

Data collection

During the study, various characteristics of the EPIs were collected, including gender, gestational age, admission weight, admission length, intravenous fluids (IVF), Apgar score at birth, birth age (Birth age is defined as age at admission, which refers to the elapsed time from birth to the infant's admission to NICU, measured in minutes.)and other relevant parameters. Feeding-related indicators, such as the time taken to complete full enteral feeding, the type of food consumed in the 24 h before discharge (exclusive breastmilk feeding or not), and the time taken to complete full oral feeding, were also retrospectively gathered.

Statistical analysis methods

The statistical analysis was conducted using SPSS 24.0 software. Quantitative data with a normal distribution and homogeneity of variance between the two groups were compared using the t-test and Wilcoxon rank sum test. Categorical variables were compared using the $\chi 2$ test. In order to control for the effect of general information on study outcomes, stratified multivariate linear regression or stratified logistic regression analysis was employed to analyze the impact of kangaroo mother care on the time to full enteral feeding, the time to exclusive breastmilk feeding within 24 h before discharge, and the time to full oral feeding. The significance level for all tests was set at $\alpha = 0.05$.

Results

Population clinical characteristics

The study included a total of 145 infants with an average birth weight of 860 g and a gestational age at birth of 26.4 weeks. There were no significant differences in gender, gestational age, assisted reproductive technology, admission length, full course of prenatal hormone use, 1-minute Apgar score, and 5-minute Apgar score between the KMC group and the control group. The length of hospital stays tended to decrease. (Table 1).

Comparison of feeding-related indices between the two groups

In the KMC group, the time to achieve full enteral feeding in EPI was shorter compared to the control group, and the rate of exclusive breastmilk feeding 24 h before discharge was higher (Table 2).

Univariate analysis of EPI outcome indicators conducted by KMC

A single-factor analysis demonstrated that KMC had a statistically significant impact on outcome indicators related to EPI, such as the time to achieve full enteral feeding, the rate of exclusive breastmilk feeding within 24 h before discharge, and hospitalization costs (Table 3 is indicated the end of text).

Regression analysis of EPI feeding-related outcomes by KMC

Multiple regression analysis revealed that the KMC group required less time (β -5.358, $P=0.0002$) than the control group to achieve full enteral feeding, and their hospitalization costs were lower as well (β -23747.81, $P=0.001$). There was no significant difference observed in nosocomial infection and full oral feeding. Logistic regression analysis showed that KMC increased the rate of exclusive breastmilk feeding within 24 h before discharge (OR 2.43, $P=0.012$). These results remained consistent even after adjusting for relevant variables (Table 4).

Discussion

EPIs are highly prone to various feeding issues due to their underdeveloped digestive system, as well as other problems including insufficient suck reflex. Prompt achievement of full enteral feeding in EPIs can facilitate earlier removal of the vascular catheter, leading to a reduction in sepsis and other catheter-related complications [8].

Our findings indicate that KMC for extremely preterm infants requiring non-invasive assisted ventilation can shorten the time to achieve full enteral feeding and improve the rate of exclusive breastmilk feeding. These results may be closely related to the abundant presence of lactoferrin in breast milk, which contributes to intestinal maturation and immune regulation, thereby preventing severe complications like necrotizing enterocolitis [12]. Lactoferrin, the primary whey glycoprotein in mammalian milk and highly representative of colostrum, promotes intestinal maturation, differentiation of the newborn intestine, and immunomodulation in intestinal lymphoid tissues. Intestinal lactoferrin contains numerous active compounds with anti-infective, nutritive, and immunomodulatory properties, which help regulate excessive inflammatory and oxidative reactions in the intestines. These factors are crucial in preventing NEC [13–16].

During KMC, the infant is positioned in a prone position of more than 30 degrees, which promotes gastric emptying [17]. Additionally, KMC, through early and close skin-to-skin contact between mother and infant, triggers the release of oxytocin, regulates the mother-infant neurosystem, and may reduce the occurrence of feeding intolerance, thereby facilitating the achievement of full enteral feeding [18].Maternal heart sounds and rhythmic breathing during KMC provide gentle stimulation to the auditory, tactile, vestibular, and thermal sensory systems. These stimuli may have a soothing effect on infants. Infants fed in the KMC position exhibit lower heart rates, increased comfort, and reduced post-feeding discomfort compared to those fed in the prone position [12].

KMC not only has a positive impact on feeding but also plays a crucial role in newborn's health status. Data show that infants receiving KMC have a 2.43 times higher rate of exclusive breastmilk feeding in the 24 h before discharge compared to the control group (OR 2.40; 95% CI 1.21, 4.78), significantly improving the success rate of breastmilk feeding [19]. The significant effect of KMC may be attributed to its comprehensive effects on stabilizing body temperature, promoting immune function, and enhancing infant development [20].

However, challenges remain in implementing KMC and exclusive breastmilk feeding in EPIs. These challenges include postpartum isolation, mothers' lack of knowledge about feeding, maternal anxiety, and inadequate facilities in NICU [21]. Therefore, it is necessary to develop and implement effective KMC strategies to ensure the success of breastmilk feeding and promote the health of extremely preterm infants.

In this study, we reported the implementation of KMC in extremely preterm infants requiring non-invasive assisted ventilation. Our observations indicate that KMC can reduce the time needed for EPIs to achieve full enteral feeding and increase the rate of exclusive breastmilk feeding. These findings underscore the importance of KMC in promoting feeding practices for extremely preterm infants requiring non-invasive assisted ventilation.

Limitation

In our study, KMC sessions were restricted to 3 h per day, less than the 8 h per day recommended, due to practical issues. The delayed start of KMC, three weeks post-admission, was influenced by cultural practices and clinical assessments. Furthermore, the study's reliance on a single-institution cohort study is noted as a limitation, emphasizing the need for multicenter studies to enhance the external validity and generalizability of the findings.

Conclusion

Our study has concluded tha KMC has a significant impact on reducing the time required for achieving full enteral feeding and improving the rate of exclusive breastmilk feeding in extremely preterm infants who require non-invasive assisted ventilation. These findings

Table 3 Univariate analysis of EPI-related outcome indicators in the KMC Group

Variable of outcome	Variable of analysis	β/OR(95%CI)	SE	t/X^2	*P*
Time to full enteral feeding	KMC	-6.33 (-8.98,-3.68)	1.35	-4.68	0.001
	Gender	0.54 (-2.31,3.39)	1.46	0.37	0.71
	Gestational age(wk)	-2.47 (-4.05,-0.89)	0.81	-3.08	0.003
	Birth age (min)	-0.12 (-0.28,0.04)	0.08	-1.46	0.15
	Cesarean Section	1.36 (-1.67,4.39)	1.55	0.87	0.38
	Sufficient prenatal Steroids	-1.14 (-3.88,1.61)	1.40	-0.81	0.42
	Assisted Reproductive Technology	-0.38 (-3.60,2.85)	1.65	-0.23	0.82
	Birth weight(g)	0.001 (-0.01,0.01)	0.01	0.14	0.89
	Birth length(cm)	-0.41 (-0.79,-0.03)	0.19	-2.11	0.04
Time to full oral feeding	KMC	-1.63 (-6.66,3.41)	2.57	-0.63	0.53
	Gender	0.74 (-4.68,6.17)	2.77	0.27	0.79
	Gestational age(wk)	1.59 (-1.39,4.59)	1.53	1.04	0.29
	Birth age (min)	-0.23 (-0.53,0.07)	0.16	-1.45	0.15
	Cesarean Section	3.05 (-2.72,8.81)	2.94	1.04	0.30
	Sufficient prenatal Steroids	5.49 (0.28,10.71)	2.66	2.06	0.04
	Assisted Reproductive Technology	-1.71 (-7.83,4.42)	3.13	-0.55	0.58
	Birth weight(g)	-0.03 (-0.056,-0.006)	0.01	-2.44	0.02
	Birth length(cm)	0.05 (-0.68,0.78)	0.37	0.13	0.89
Exclusive breastmilk feeding for 24 h prior to discharge	KMC	2.43 (1.24, 4.78)	0.36	2.35	0.01
	Gender	1.68 (0.86, 3.27)	0.39	0.88	0.13
	Gestational age(wk)	0.92 (0.69, 1.24)	0.21	-0.21	0.59
	Birth age (min)	0.97 (0.92, 1.01)	0.03	-1.59	0.14
	Cesarean Section	0.88 (0.43, 1.81)	0.42	-0.19	0.74
	Sufficient prenatal Steroids	1.69 (0.86, 3.32)	0.37	1.23	0.13
	Assisted Reproductive Technology	1.42 (0.66, 3.04)	0.45	0.53	0.37
	Birth weight(g)	0.99 (0.99, 1.00)	0.002	-0.19	0.35
	Birth length(cm)	0.99 (0.91, 1.08)	0.05	0.93	0.84
Nosocomial Infection	KMC	0.005 (0.09,10.93)	1.22	0.004	0.99
	Gender	19.36651 (0,-)	-	0.007	0.99
	Gestational age(wk)	0.51 (0.29,9.52)	0.88	0.58	0.56
	Birth age (min)	-0.08 (0.73,1.17)	0.12	-0.65	0.51
	Cesarean Section	-0.28 (0.04,15.01)	1.53	-0.19	0.85
	Sufficient prenatal Steroids	0.08 (0.09,11.89)	1.22	0.067	0.95
	Assisted Reproductive Technology	-0.69 (0.02,16.58)	1.78	-0.39	0.69
	Birth weight(g)	0.003 (0.99,1.01)	0.01	0.54	0.59
	Birth length(cm)	0.15 (0.85,1.58)	0.16	0.97	0.33
Hospitalization expenses	KMC	-32832.48 (-51897.37,-13767.59)	9726.98	-3.37	0.001
	Gender	14101.79 (-6447.43,34651.01)	10484.3	1.34	0.18
	Gestational age(wk)	-19681.25 (-31026.83,-8335.65)	5788.57	-3.4	0.001
	Birth age (min)	-665.75 (-1823.21,491.73)	590.55	-1.13	0.26
	Cesarean Section	-11918.75 (-33750.45,9912.95)	11138.6	-1.07	0.29
	Sufficient prenatal Steroids	2910.52 (-16850.19,22671.23)	10,082	0.29	0.77
	Assisted Reproductive Technology	23800.32 (595.49,47005.15)	11839.2	2.01	0.05
	Birth weight(g)	16.18 (-78.55,110.96)	48.35	0.33	0.74
	Birth length(cm)	668.95 (-2095.67,3433.56)	1410.52	0.47	0.64

Table 4 KMC regression analysis of EPI feeding-related outcomes

	Model I			Model II		
	β/OR	95%CI	*P*	β/OR	95%CI	*P*
Nosocomial Infection	1.54	(0.25, 9.53)	0.64	1.57	(0.24, 10.10)	0.64
Hospitalization expenses	-23747.81	(-49703.01, 2207.39)	0.07	-31492.80	(-50112.72, -12872.88)	0.001
Time to full enteral feeding	-5.35	(-8.09, -2.63)	0.0002	-6.01	(-8.59, -3.42)	< 0.0001
Time to full oral feeding	-0.74	(-5.88, 4.41)	0.78	-1.24	(-6.21, 3.74)	0.63
Exclusive breastmilk feeding for 24 h prior to discharge	2.43	(1.24, 4.78)	0.01	2.40	(1.21, 4.78)	0.01

Model I: adjusted for gestational age and admission weight

Model II: adjusted for gender, gestational age, birth weight, birth age, cesarean section, sufficient prenatal steroids, and IVF

highlight the crucial role of incorporating KMC into the care regimen for EPIs.

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Author contributions
J.L wrote the main manuscript text.W analyzed the data. J.Y collected the data.X.C interpreted the data. A.C collected the message.C.Y interpretation of data. X.X substantively revised it. All authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved by the Ethics Committee of Shenzhen Maternal and Child Healthcare Hospital (Approval No. LLYJ2022-080-038). Consent for publication: Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]College of Nursing, Shanxi University of Chinese medicine, Jinzhong 030619, China
[2]Shenzhen Maternity & Child Healthcare Hospital, Shenzhen 518028, China

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