Reproductive Health

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Effect of early essential newborn care on breastfeeding and outcomes of mothers/newborns post-cesarean section: a randomized controlled trial in China

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Abstract

Background The implementation of early essential newborn care (EENC) is important to maternal and neonatal health. However, few studies have conducted a complete procedure of EENC in cesarean section. This study aimed to systematically evaluate the effects of EENC during and after cesarean section.

Methods A randomized controlled trial was conducted at a tertiary hospital in Wuhan, China. Full-term pregnant women who had no comorbidities and underwent elective cesarean section were recruited and received EENC intervention or routine health care. The Infant Breastfeeding Assessment Tool (IBFAT), the Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF), a questionnaire of the breastfeeding behavior, the Maternal Postnatal Attachment Scale (MPAS) and the Edinburgh Postnatal Depression Scale (EPDS) were used to collect data. The correlation between EENC implementation and breastfeeding, maternal-infant attachment, postpartum depression, and other maternal and neonatal outcomes was analyzed.

Results Mother-newborn pairs (N = 157) were enrolled in this study, 78 in the EENC group and 79 in the control group. A total of 155 (98.8%) were followed up at 14 days, 144 (91.7%) at 42 days, and 123 (78.3%) at 3 months. For the primary outcomes, generalized linear mixed model analysis showed that implementing EENC during cesarean section was beneficial for initiating breastfeeding (OR = 0.021), shortening the breastfeeding initiation time (β = −45.321), improving the IBFAT scores (β = 2.740), and enhancing breastfeeding self-efficacy (β = 4.880). These effects were not influenced by time interaction. However, no difference was observed in the rate of exclusive breastfeeding between these two groups (P > 0.05). Implementing EENC during cesarean section significantly improved maternal-infant attachment (β = 9.668). Moreover, univariate analysis showed benefits of EENC in improving postpartum depression (P < 0.001) and decreasing maternal perinatal blood loss (P < 0.05).

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Conclusions According to our small sample study, there is a trend of improvement in breastfeeding related behavior and maternal infant attachment in women who received EENC during cesarean deliveries. The effects of EENC on exclusive breastfeeding should be further explored in the future.

Trial registration: Chinese Clinical Trial Register at www.chictr.org.cn, ChiCTR2300074760, retrospectively registration. Registration Date: August 15, 2023.

Keywords Breastfeeding, Cesarean section, Early essential newborn care, Health outcomes, Randomized controlled trail

Plain English summary

EENC has been implemented in women who give birth vaginally and has been proven to have numerous benefits in aiding maternal postpartum recovery, increasing breastfeeding rates, and reducing admission rates to NICU. For a long time, China's cesarean section rate has remained high. While EENC has been well-promoted among women undergoing vaginal deliveries, its application in cesarean sections has been limited. Therefore, we conducted a randomized controlled trial, one group received EENC intervention and the other did not receive it. We collected data before and after the intervention to explore the safety and effectiveness of implementing EENC techniques in cesarean sections. The results indicate that the application of EENC in cesarean sections is safe and feasible. It can improve breastfeeding behaviors and mother-infant attachment. This intervention is recommended to be implemented on a larger scale.

Background

Maternal/neonatal health is the foundation of population health and national development, as well as a measurement of a social civilization. The Sustainable Development Goals (SDGs) of World Health Organization (WHO) [1], and the Program for the Development of Women and Children in China both put forward goals for reducing maternal and neonatal mortality [2]. Although there has been a global downward trend, these goals are unlikely to be achieved based on data from 2010 to 2016 [3, 4]. An accelerated application of essential perinatal health services is crucial for avoiding preventable deaths of women and newborns and helping to improve their long-term life quality [5, 6]. In 2005, the WHO proposed the concept of neonatal health care and pointed out its importance in improving neonatal outcomes [7]. In 2013, the West Pacific region of WHO recommended a series of evidence-based and actionable comprehensive intervention technologies for newborns, and named them "Early Essential Newborn Care (EENC)" [8]. The core measures of EENC include delayed cord clamping (DCC), skin to skin contact (SSC), and early breastfeeding initiation, among which SSC for at least 90 min is the key to raising breastfeeding rates. Currently, the EENC has been implemented in eight countries in the WHO West Pacific region, and its effectiveness in improving maternal recovery, breastfeeding and reducing neonatal intensive care unit (NICU) admissions has been proven in women with vaginal delivery [9].

For a long time, the rate of cesarean section has remained as high as 34.9% to 36.7% in China [10]. Although cesarean section is critical to save lives in special situations, it places women and their newborns at risk of short- and long-term health problems [11], including the potential for postpartum hemorrhage [12], slower recovery, delayed breastfeeding [13], and increased neonatal respiratory morbidity [14]. These adverse effects are particularly noteworthy in women undergoing cesarean section without medical indication [14]. The best chance of stimulating the sucking reflex after cesarean section may be impaired due to the separation of mother and newborn [12, 15]. Therefore, additional measures need to be taken to support breastfeeding in women with cesarean deliveries.

Although EENC has been well promoted among women with vaginal delivery, its application in cesarean section is controversial, and may be limited by aseptic requirements, anesthesia, and maternal position during surgery. Among 15 randomized trials involving nearly 4000 women and neonate pairs, only 3 trials involved a total of 87 cesarean deliveries, accounting for only 2.2% of the recommended population [16]. In 2022, the WHO updated the clinical practice pocket guide of EENC, which provided a detailed protocol of EENC in cesarean section [17, 18]. Existing evidence has verified the effectiveness of DCC and SSC during cesarean section in improving neonatal outcomes [19, 20]. One study from Italy has shown the benefits of SSC in raising exclusive breastfeeding rate [21]. However, existing studies have not conducted a complete procedure of EENC or emphasized on supportive method for initiate early breastfeeding. In view of this, this study conducted

a randomized controlled trial to explore operable EENC procedures during and after cesarean section, and systematically evaluated its safety and effectiveness. It was shown that the application of EENC in cesarean section is safe and feasible, and it improved breastfeeding behavior, postpartum depression and maternal infant attachment.

Methods

Study design

A randomized controlled trial was conducted in a tertiary hospital in Wuhan, a large city in central China, from January to May 2023. The Early Essential Newborn Care Guidelines were used to prepare this protocol [17, 23, 24]. The EENC had been introduced for vaginal deliveries in the hospital, which provided qualified faculties and technical support. The participants were randomly assigned to an EENC group or control group. Using the convenience sampling, 160 pairs of mothers and newborns undergoing cesarean delivery were recruited. Participants in the EENC group received EENC intervention and routine healthcare, while those in the control group only received routine healthcare. The study was approved by the Ethics Committee of Zhongnan Hospital of Wuhan University (2023143K) and registered on Chinese Clinical Trial Registry (http://www.chictr.org.cn), with the clinical registration number ChiCTR2300074760.

Participants

Inclusion and exclusion criteria

Inclusion criteria were: (1) pregnant women aged 18 to 45 planning selective cesarean section; (2) full term pregnancy (37 to 42 gestational weeks); (3) epidural anesthesia, or subarachnoid block anesthesia, or combined spinal-epidural anesthesia; (4) no serious pregnancy complications; and (5) agreed to receive EENC. Exclusion criteria were: (1) women who cannot breastfeed because of medical indications, such as AIDS, syphilis, or a history of breast surgery; (2) women having no intention to breastfeed; (3) serious maternal and neonatal complications occurring during surgery, which need urgent treatment; (4) neonatal malformations or newborns with congenital disease.

Sample size

The PASS 15 software (NCSS, Kaysville, UT, USA) was used to calculate the sample size with the α set as 0.05 and β as 0.2. According to the Global Breastfeeding Scorecard 2022, the 6-month exclusive breastfeeding rate in China was 34.1% [22], and it was estimated to increase to 60% after the implementation of EENC. Using these conditions and estimates, each group required 55 participants. Based on an estimated dropout rate of 20%, the final required number of cases was determined to be 69 per group.

Procedures

Recruitment

Women meeting criteria were invited and informed of the study purpose before cesarean section. The steps of EENC and the current situation of EENC application in cesarean section were introduced to them. Written informed consents were obtained from all women prior to their participation in the study. The participants were informed that they would be randomly given EENC intervention or not. They were assured that the participation was voluntary and routine healthcare would be provided for the safety of both mother and baby. They could withdraw from the study at any time without prejudice and will remain anonymous.

Randomization

The participants were randomly assigned to the EENC group and the control group. The researcher used a third-party organization (https://www.sealedenvelope.com/) to generate randomization sequences. Participants were identified according to their admission time and provided with a number based on the randomized code. According to the procedure of EENC, blinding participants, obstetricians, nurses/midwives, and researchers was not feasible.

Implementation of EENC

In June 2022, a team consisting of obstetricians, pediatricians, nurses, midwives, safety and quality management personnel, and infection control personnel was organized. According to the recommendations of the WHO [17, 23, 24], team members were assigned various works and received EENC training. Participants in the EENC group received a series of evidence-based interventions, including DCC, SSC for at least 90 min or until completion of first breastfeeding, initiation of breastfeeding during cesarean section, and other routine healthcare [17]. Participants in the control group received routine healthcare alone, including immediate drying, breastfeeding support, newborn eye care, Vitamin K1, immunizations, weighing and examinations. All participants have received breastfeeding educations during pregnancy, which is provided in the form of courses in the maternity clinics of baby-friendly hospital. The flow chart of EENC in cesarean section is shown in Fig. 1. The key procedures are as follows:

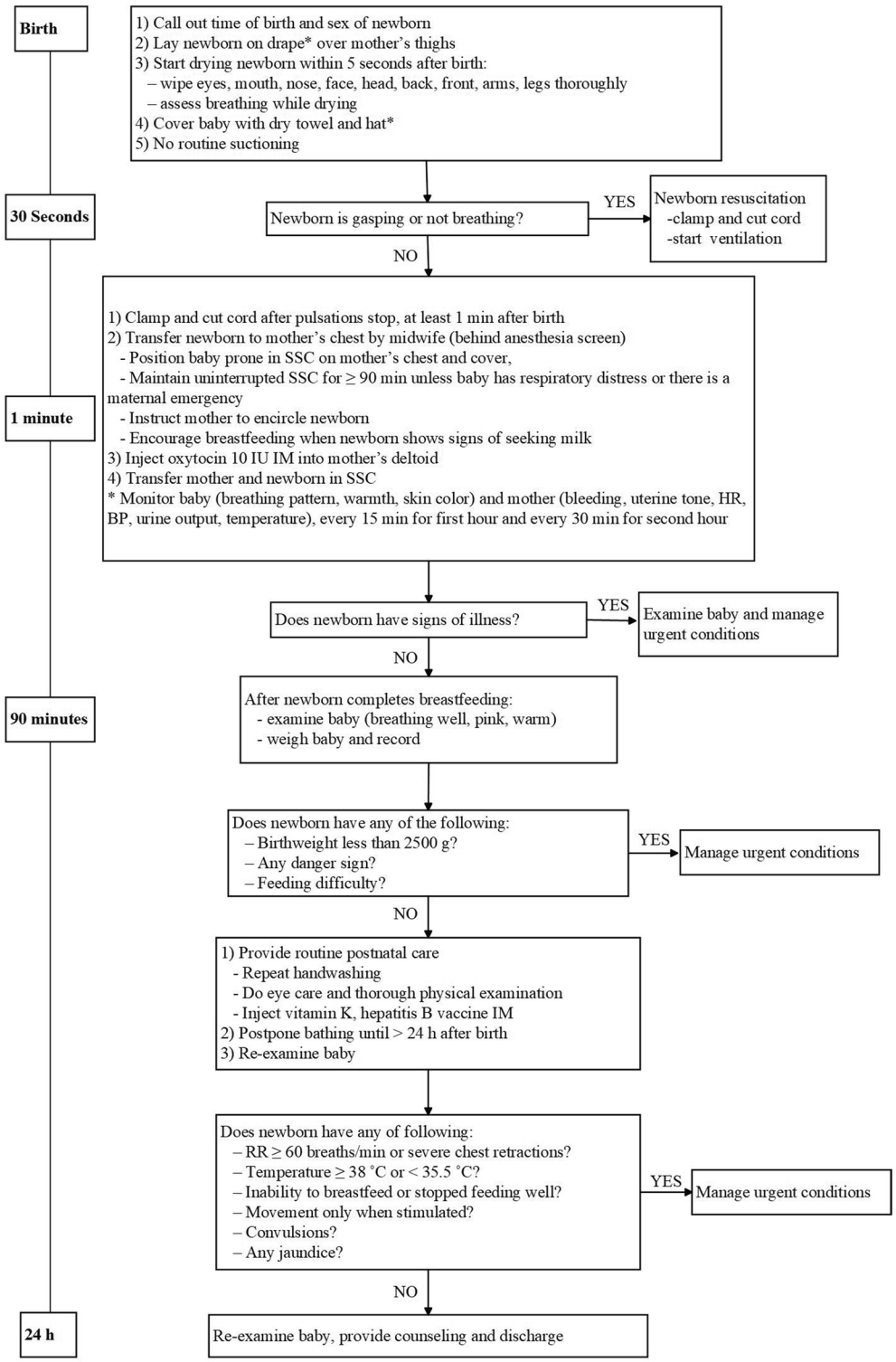

Fig. 1 Flow chart of EENC for cesarean delivery

Immediate health care after delivery of newborn

Dry the newborn and provide warmth: the operating room temperature was set at 24–26 °C. After birth, the newborn was immediately wiped dry with a sterile towel, and then wrapped in a preheated sterile towel within 20–30 s. A preheated hat is also placed on the newborn's head to provide warmth. If there are no abnormalities in mother and/or newborn, subsequent EENC measures will be implemented. Otherwise, EENC will be terminated to facilitate the rescue of mother or newborn.

DCC: During the neonatal drying process, an assistant palpates the umbilical artery and clamps the umbilical cord after the pulsation of umbilical artery stops or 1–3 min after birth.

Immediate SSC: After the umbilical cord is cut, the surgeon hands over the newborn to a midwife. The midwife places the newborn on the preheated neonatal radiation station with a temperature of 32–34 °C, ligates umbilical cord and covers the newborn with a second preheated thick sterile towel. Then, the newborn is placed in a prone position on the mother's exposed chest and begins SSC. The newborn's chest and abdominal skin should maintain close contact with the mother's skin, and the back and legs should be covered with warm sterile towel.

Early breastfeeding: When conducting SSC, midwives observe the newborn to ensure their safety and for signs of nipple searching. They help and encourage the mother to engage in nipple insertion and begin breastfeeding.

Follow-up health care after delivery of newborn

Prolonged SSC: After surgery, the newborn will be placed on the mother's chest to continue SSC during the process of transporting the mother to the ward. The SSC should be continued for at least 90 min, or until the first breastfeeding is completed.

Breastfeeding: Midwives encourage and assist mothers in breastfeeding. They also explain to the mothers and their families about appropriate precautions related to breastfeeding and newborn care.

Observation: Midwives pay continuous attention to the status of the mother and newborn. They assess and record the pulse, blood pressure, urine volume, blood loss, and other conditions of the mother every 15 min. Simultaneously, the newborn's breathing, skin color, and other vital signs are also assessed and recorded. If there are any abnormalities, SSC should be stopped for treatment.

Routine health care for newborn

The newborns were wiped dry and kept them warm after birth. A quick assessment was given to rule out situations that require neonatal resuscitation. Umbilical cord ligation was routinely performed. Umbilical artery blood is collected for testing the pH and hemoglobin. Physical examination of newborn will be performed as well giving a vitamin K injection. Other health care measures for the umbilical stump and eyes are carried out. Hepatitis B virus vaccine and Bacillus Calmette-Guerin (BCG) vaccine should be given in accordance with the regulations of the Chinese health administrative department.

Data collection

Socio-demographic variables of mothers were collected at baseline, including age, gestation weeks, gravidity and parity history. Newborn data including gender and birthweight were collected after birth.

Primary outcomes were indicators related to breastfeeding. (1) Successful initiation of breastfeeding is defined as completing the first breastfeeding within 60 min [25]. (2) Breastfeeding initiation time refers to as the time elapsed from fetal delivery to the successful completion of breastfeeding. (3) Infant Breastfeeding Assessment Tool (IBFAT) was used to assess behavioral performances associated with first breastfeeding including intention to breastfeed, initiative to suckle, newborn rooting and sucking reflex, sucking type [26]. Midwives observed the entire feeding process and gave scores according to the items of IBFAT. The Cronbach's alpha coefficient in similar studies is 0.83. (4) Exclusive breastfeeding is defined as feeding only breast milk without any other food or liquid [27]. A questionnaire 'How do you feed your baby?' was designed to evaluate the breastfeeding behavior at three days, 42 days and 3 months after delivery, respectively. (5) Breastfeeding self-efficacy was assessed by The Breastfeeding Self-Efficacy Scale-Short Form (BSES-SF) at three days, 42 days and 3 months after delivery, respectively [28]. Mothers identified their confidence level in 14 items related to breastfeeding. A Likert scale was used to rate the level of confidence in each item, ranging from 1 (completely unsure) to 5 (very confident). Scores were then summed to obtain a total score (ranging from 14 to 70). The Cronbach's α of the BSES-SF in this study was 0.86.

The secondary outcomes were as follows: (1) mother-infant attachment, evaluated by the Maternal Postnatal Attachment Scale (MPAS) at 42 days after delivery [29], using Likert 4-level scoring ranging from "rarely" to "always" to assess maternal-infant attachment levels (Cronbach's α of MPAS in this study was 0.94; (2) the hemoglobin level of cord blood and the abnormal rate of pH value, which was detected by blood gas analysis; (3) neonatal transcutaneous bilirubin levels within three days after birth, obtained from the participants' records; (4) maternal perinatal blood loss, which was assessed by the changes in hemoglobin level pre- and post- surgery;

(5) postpartum depression, which was evaluated by The Edinburgh Postnatal Depression Scale (EPDS) [30]. According to the severity of symptoms, each item of the EPDS is divided into four levels and assigned a score from zero to three. A total score of ≥ 12 indicates depression. Cronbach's α in this study was 0.89. During follow-ups, the connection with participants mainly by phone. Related tools were sent to the participants' mobile phone at the corresponding time point.

Statistical analyses

Statistical analysis was performed using IBM SPSS Statistics for Macintosh, Version 23.0. Armonk, NY: IBM Corp. Quantitative variables with normal distribution were described as mean ± standard deviance ($\overline{X}$±SD), while quantitative data with skewed distribution were described as median and inter-quartile range (IQR). T-test or Wilcoxon rank sum test was used to compare data between the two groups. Categorical variables were described as frequency and percentage, and analyzed by chi-square or Fisher exact test as appropriate. Analyses will primarily rely on generalized linear mixed modeling (GLMM) to evaluate the relationships between intervention and outcomes. This flexible approach allows modeling normally or non-normally distributed outcomes, longitudinal or multilevel data, continuous variable or categorical variable, and missing data. GLMM approach was used to examine the effects of EENC group compared to control group on the change of outcomes over time. Longitudinal analyses will model related outcomes as a function of the treatment group, time, and interaction between the group and time. Maternal age, parity, infant gender, and maternal hemoglobin level change were adjusted for these models. All tests were two-tailed, and $P < 0.05$ was considered statistically significant.

Quality control

Researchers meticulously documented any issues encountered during the study and promptly consulted with the project leader to resolve them.

Results

Socio-demographic characteristics of participants

In total, 160 mother-newborn pairs were recruited in this study, and they were randomly assigned to the EENC group (n = 80) and the control group (n = 80). However, three pairs (1.9%) were excluded from the subsequent study, including one from the EENC group because of discomfort during SSC and two from the control group due to the need for emergency intervention. Ultimately, 79 pairs in the EENC group and 78 pairs in the control group participated in the study. Among them, 155 (98.8%) participants received follow-up at 14 days with a loss rate of 1.2%, 144 (91.7%) at 42 days with a loss rate of 8.3% and 123 (78.3%) at 3 months with a loss rate of 21.7%. Figure 2 shows how participants were followed during the study. As shown in Table 1, there were no statistically significant differences in all socio-demographic characteristics of the two groups ($P > 0.05$).

Primary outcomes

As shown in Table 2, the rate of successful breastfeeding initiation in the EENC and control groups were 100% (79/79) and 46.15% (36/78), respectively. The breastfeeding initiation time of EENC group was earlier than that of control group (10 min vs. 63 min, $P < 0.001$). The scores of IBFAT of EENC group were significantly higher than that of control group (7.06 vs. 4.33, $P < 0.001$). However, there was no significant difference in the rate of exclusive breastfeeding between these two groups at three days postpartum (27.85% vs. 28.21%, P = 0.960), 42 days postpartum (34.85% vs. 26.92%, P = 0.304), and 3 months postpartum (29.41% vs. 33.33%, P = 0.301). In terms of breastfeeding self-efficacy, mothers in the EENC group had higher scores than those in the control group at three days postpartum (48.61 ± 11.22 vs. 42.92 ± 11.59, P = 0.002), 42 days postpartum (46.85 ± 12.31 vs.41.33 ± 9.67, P = 0.003), and 3 months postpartum (50.88 ± 13.21 vs. 43.98 ± 7.83, P = 0.002).

After adjusting for confounding variables such as mother's gender, parity, change in hemoglobin level before and after delivery, and infant's gender, the GLMM analysis indicates that implementing EENC during cesarean delivery would significantly increase the success rate of breastfeeding initiation (OR = 0.021, 95%CI 0.031, 0.100) as shown in Table 3. Additionally, the time for initiating breastfeeding was significantly shorter in the group that implemented EENC, with a reduction of 45.321 min compared to the control group (β = −45.321, $P < 0.001$, 95%CI −50.780, −39.862). Similarly, the IBFAT score was significantly higher in the group that implemented EENC, with an increase of 2.740 points compared to the control group (β = 2.740, $P < 0.001$, 95%CI 2.212, 3.267). The breastfeeding self-efficacy score was significantly higher in the group that implemented EENC, by 4.880 points (β = 4.880, P = 0.006, 95%CI 1.405, 8.355), without considering time factors. However, there was no significant difference in the rate of exclusive breastfeeding between the group that implemented EENC and the control group ($P > 0.05$).

Secondary outcomes

As shown in Table 4, the GLMM analysis showed that implementing EENC during cesarean section significantly improved maternal-infant attachment scores (β = 9.668, $P < 0.001$, 95% CI 6.401, 12.934). The results

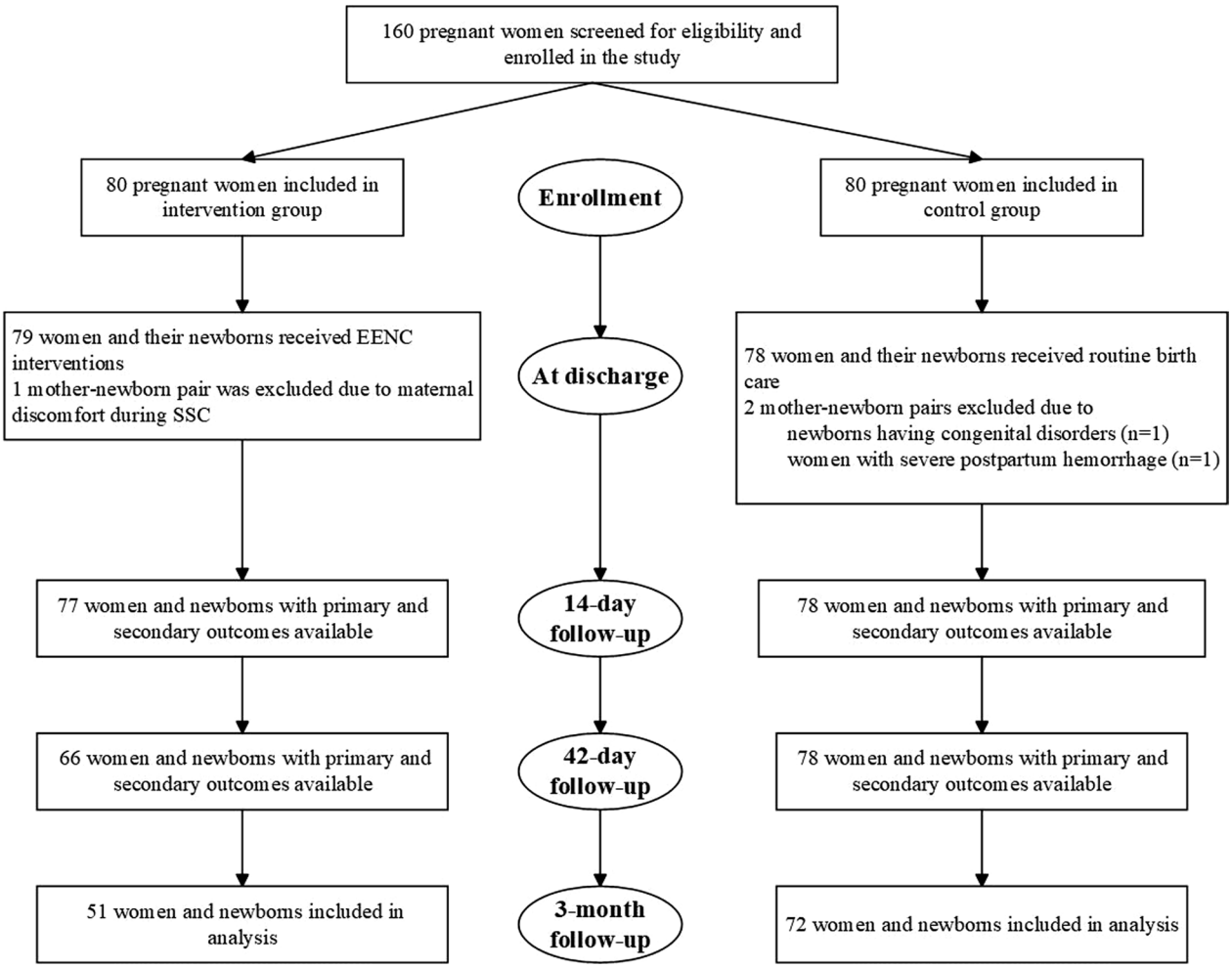

Fig. 2 Flow of participants through each stage of the study

from the GLMM model showed that the EENC intervention did not have a significant effect on postpartum depression based on EPDS scores. However, when considering the interaction between the intervention and time, it was found that the EPDS scores in the EENC intervention group significantly decreased at 42 days postpartum ($P < 0.001$), which is similarly with the result using univariate analysis in the Table S1. This result suggests that the EENC intervention may have improvement effect on maternal postpartum depression. In addition, there was no difference in the hemoglobin level of cord blood and the abnormal rate of pH value between EENC group and control group based on GLMM model ($P > 0.05$). As for the level of neonatal transcutaneous bilirubin, there was also no difference between the two groups ($P > 0.05$).

To evaluate the impact of EENC on maternal perinatal blood loss, the changes in hemoglobin level pre- and post- surgery were compared between the two groups. Univariate analysis showed that EENC group had a less decrease in hemoglobin level after cesarean section than that of control group (13.0 vs. 16.6, $P < 0.05$). Since the amount of intraoperative blood loss was subjectively estimated by the surgeon, the decrease in hemoglobin level could more accurately reflect the amount of maternal blood loss. Therefore, it can be assumed that participants receiving EENC will have less bleeding (Table S1). In addition, no other postoperative complications occurred in both groups.

Discussion

In China, more than 3.6 million infants were born by cesarean section every year [31]. Comprehensive promotion of EENC in cesarean deliveries may help to further improve maternal and neonatal health. In 2016, EENC was introduced to China and piloted in over 100 hospitals. A practice recommendation for EENC during

Table 1 Sociodemographic variables of participants

Variables	EENC group (n = 79)	Control group (n = 78)	P value
Maternal age (years), mean ± SD	31.06 ± 3.30	31.01 ± 3.98	0.097[a]
Gestational age (weeks), mean ± SD	38.61 ± 1.36	38.72 ± 0.91	0.024[a]
Gravidity history, n (%)			0.159[b]
Primi-gravida	59 (74.68%)	60 (76.92%)	
Multi-gravida	20 (25.32%)	18 (23.08%)	
Parity history, median (IQR)	1 (1, 1)	1 (1, 1)	0.559[d]
Prior breastfeeding rates in multi-gravida, n (%)			
< 3 months	9 (45%)	11 (61.11%)	0.321 [b]
3–6 months	2 (10%)	2 (11.11%)	0.911[c]
> 6 months	9 (45%)	5 (27.78%)	0.272 [b]
Cesarean section indication, n (%)			0.775[b]
Medical indication	57 (72.15%)	58 (74.36%)	
Maternal request	22 (27.85%)	20 (25.64%)	
Birthweight (g), mean ± SD	3306.84 ± 415.26	3239.58 ± 386.34	0.295[a]
Gender, n (%)			0.933[b]
Male	41 (51.9%)	41 (52.6%)	
Female	38 (48.1%)	37 (47.4%)	

IQR Interquartile range, *SD* Standard deviation

[a] Independent t-test

[b] Chi-square test

[c] Fisher's exact test

[d] Wilcoxon rank-sum test

Table 2 The comparison of breastfeeding indicators between the intervention and control groups

Variables	EENC group (n = 79)	Control group (n = 78)	t/Z/χ^2	P value
Breastfeeding initiation time (min), median (IQR)	10 (7.5, 15)	63 (46.25, 65.0)	9.829	< 0.001[c]
Initiation of first breastfeeding, n (%)	79 (100%)	36 (46.15%)	58.074	< 0.001[b]
IBFAT score, mean ± SD	7.06 ± 1.28	4.33 ± 1.84	− 10.73	< 0.001[a]
Exclusive breastfeeding rate, n (%)				
3 days	22 (27.85%)	22 (28.21%)	0.003	0.960[b]
42 days	23 (34.85%)	21 (26.92%)	0.093	0.304 [b]
3 months	15 (29.41%)	24 (33.33%)	2.918	0.301[b]
Breastfeeding self-efficacy, mean ± SD				
3 days	48.61 ± 11.22	42.92 ± 11.59	3.122	0.002[a]
42 days	46.85 ± 12.31	41.33 ± 9.67	3.010	0.003 [a]
3 months	50.88 ± 13.21	43.98 ± 7.83	3.284	0.002[a]

IQR Interquartile range, *SD* standard deviation, *IBFAT* infant breastfeeding assessment tool

[a] Independent t-test

[b] Chi-square test

[c] Wilcoxon rank-sum test

cesarean section was put forward by Women's and Children's Center of Peking University in 2022 [32]. Results of this study suggest that EENC can effectively establish earlier breastfeeding initiation, decrease postoperative blood loss, prevent maternal postpartum depression, and improve mother-infant attachment. However, this study did not find a significant improvement in exclusive breastfeeding rates in women received EENC, which requires further exploration.

Table 3 The effect of EENC on primary outcomes related to breastfeeding between the intervention and control groups using repeated measures by General liner mixed model analyses (GLMM)

Variables	Coefficients	Std. Error	t	P value	95% CI	
					Lower	Upper
Initiation of first breastfeeding	0.021 (OR)[a]	0.785	−4.910	< 0.001	0.031	0.100
Breastfeeding initiation time	−45.321 (β)	2.762	−16.406	< 0.001	−50.780	−39.862
IBFAT score	2.740 (β)	0.267	10.258	< 0.001	2.212	3.267
The rate of exclusive breastfeeding	OR					
Group						
EENC	0.925[b]	0.406	−0.191	0.849	0.417	2.056
Control	1					
Time						
Three-month follow-up	0.675	0.315	−1.247	0.213	0.363	1.254
Forty-two days follow-up	1.101	0.264	0.364	0.716	0.656	1.849
Three days follow-up	1					
Group*Time						
EENC*3-month	1.703	0.476	1.118	0.264	0.668	4.338
EENC*42 days	0.655	0.382	−1.107	0.269	0.309	1.388
EENC*3 days	1					
Breastfeeding self-efficacy	β					
Group						
EENC	4.880	1.768	2.760	0.006	1.405	8.355
Control	1					
Time						
Three-month follow-up	1.522	1.316	1.159	0.247	−1.059	4.104
Forty-two days follow-up	−1.590	1.183	−1.344	0.180	−3.915	0.736
Three days follow-up	1					
Group*Time						
EENC*3-month	0.773	1.939	0.399	0.690	−3.037	4.584
EENC*42 days	0.231	1.734	0.133	0.894	−3.177	3.638
EENC*3 days	1					

Models were adjusted for maternal age, parity, maternal hemoglobin level change and infant gender

CI confidence interval, *IBFAT* infant breastfeeding assessment tool

[a] If breastfeeding initiation was considered successful, binary outcome is assigned a value of 1

[b] Exclusive breast-feeding was assigned a value of 1 for the dichotomous outcome

Breastfeeding behavior

Early breastfeeding has been proven to reduce neonatal mortality and 6-month-old infant mortality by increasing the rate of exclusive breastfeeding [33]. Preexisting evidence has verified the effectiveness of SSC in promoting breastfeeding and extending breastfeeding time [34]. Women who experience SSC have the opportunity to begin breastfeeding as soon as possible within the first hour post-delivery [35]. Early SSC causes the secretion of oxytocin, which in turn promotes lactation and prolongs breastfeeding duration [36]. The findings of this study indicated that the pairs receiving EENC interventions had a higher incidence of early breastfeeding initiation which is similar to findings reported in previous studies [27, 31, 37]. Encouragement and assistance measures in breastfeeding during the SSC process are beneficial in establishing effective breastfeeding behaviors.

Previous studies have also validated the association between SSC and exclusive breastfeeding rates. Guala et al. showed that the rate of exclusive breastfeeding before discharge was significantly higher in cesarean section newborns who received SSC than those who did not, and it was still higher at 3 months after birth [21]. A recent multi-center study in China also reported similar results [38]. However, this study did not find the effectiveness of EENC in improving exclusive breastfeeding rate in the postpartum period. The reason for this

Table 4 The effect of EENC on the secondary outcomes between the intervention and control groups using repeated measures by General liner mixed model analyses (GLMM)

Variables	Coefficients	Std. Error	t	P value	95% CI	
					Lower	Upper
Mother-infant attachment	9.668 (β)	1.649	5.862	< 0.001	6.401	12.934
Maternal perinatal blood loss[a]	3.766 (β)	2.539	1.483	0.140	− 1.252	8.784
The pH of cord blood	0.563 (OR)[b]	0.381	− 1.506	0.135	0.265	1.198
Hemoglobin of cord blood	4.576 (β)	2.716	1.685	0.095	−0.805	9.958
Adverse neonatal outcomes	0.576 (OR)[c]	0.904	− 0.611	0.542	0.096	3.435
The rate of NICU admission	0.400 (OR)[d]	0.597	− 1.534	0.127	0.123	1.302
The scale of postpartum depression	β					
Group						
EENC	0.772	0.533	1.449	0.148	−0.275	1.819
Control	1					
Time						
Three-month follow-up	− 6.485	0.504	− 12.859	< 0.001	− 7.475	− 5.494
Forty-two days follow-up	2.273	0.468	4.862	< 0.001	1.355	3.191
Fourteen days follow-up	0.158	0.412	0.383	0.702	− 0.651	0.967
Three days follow-up	1					
Group*Time						
EENC*3-month	− 1.017	0.752	− 1.351	0.177	− 2.494	0.461
EENC*42 days	− 3.131	0.677	− 4.625	< 0.001	− 4.461	− 1.802
EENC* 14 days	− 1.070	0.581	− 1.841	0.066	− 2.211	0.071
EENC*3 days	1					
Neonatal transcutaneous bilirubin	β					
Group						
EENC	− 8.303	4.332	− 1.917	0.056	− 16.819	0.212
Control	1					
Time						
Three days follow-up	84.564	3.004	28.155	< 0.001	78.660	90.468
Two days follow-up	48.670	2.344	20.757	< 0.001	44.061	53.279
One day follow-up	1					
Group*Time						
EENC*3 days	1.553	4.241	0.366	0.714	− 6.783	9.888
EENC*2 days	3.619	3.289	1.100	0.272	− 2.848	10.085
EENC*1 day	1					

Models were adjusted for maternal age, parity, maternal hemoglobin level change and infant gender

CI confidence interval, *NICU* neonatal intensive care unit

[a] Models were adjusted for maternal age, parity, and infant gender

[b] The pH of cord bloods was set as 1 between 7.25 and 7.35, and 0 if it was less than 7.25 or more than 7.35

[c] Neonatal adverse outcomes were assigned a value of 1

[d] The neonatal admission to NICU was assigned a value of 1

difference may be that breastfeeding behavior is influenced by various factors such as personal cognition, family support and social culture. In fact, mixed feeding is quite common in China. We speculated these insufficiencies that EENC alone cannot solve may be compensated by continuous postpartum breastfeeding education.

Maternal breastfeeding self-efficacy is defined as the mother's confidence in her ability to breastfeed [39]. It is recognized to be a significant predictor of breastfeeding duration and level [40]. As a psychosocial factor related to breastfeeding behavior, maternal breastfeeding self-efficacy deserves more concern. In this study, the implementation of EENC can increase the BSES of women, which indicated that EENC intervention can help women build confidence in breastfeeding, which in turn encourage them to continue breastfeeding.

Maternal and newborn outcomes

The EENC has been reported to improve various maternal and newborn outcomes, including neonatal hypothermia, neonatal sepsis, neonatal anemia and the rate of NICU admission [19, 33, 41]. In addition, some medical institutions have reported the effectiveness of SSC during surgery in maintaining stable neonatal cardiopulmonary function, reducing the occurrence of neonatal hypothermia, and alleviating maternal pain or discomfort [42–44]. In the current study, no severe neonatal asphyxia and NICU admission due to neonatal complications was observed in newborns of both groups. This may be because the full-term pregnant women without any comorbidities were selected to enroll in the study, and any participants that required treatment due to abnormalities during EENC were excluded from the study.

It was reported that DCC can prolong blood transportation between newborn and placenta so as to decrease the need for blood transfusion, but it also correlated with higher bilirubin levels [45–47]. In this study, newborns in EENC group and control group had similar abnormal pH value rate and hemoglobin level of cord blood. The transcutaneous bilirubin level within three days after birth also showed no difference between these two groups. We conclude that EENC has neither improved these indicators nor had any adverse effects. This differs from the reports that DCC can help to increase the hemoglobin level of newborns [48]. Study with more cases with various conditions is needed to further clarify the effects of EENC on neonatal outcomes.

Long-term breastfeeding requires the establishment of a strong emotional bond between mother and child [49]. The SSC provide opportunities for establishing good maternal infant attachment and reducing the risk of postpartum depression. It was reported that women who had SSC during cesarean section had no or mild depression compared with a non- SSC group [50]. In this study, EENC group had better maternal infant attachment than control group. Moreover, participants in EENC group showed a trend towards lower rates of postpartum depression. The improvements of these indicators may facilitate establishing breastfeeding behaviors.

Strengths and limitations

This study systematically explored the effects of EENC on breastfeeding, maternal and neonatal outcomes. It provided evidence for the benefits of EENC in cesarean section related to breastfeeding, maternal infant attachment and maternal health postpartum. However, this study also has some limitations. Several important considerations should be taken into account when interpreting the findings. Firstly, it is a single center study conducted only at a tertiary hospital in China. The hospital feeding policies may have an impact on breastfeeding outcomes, so generalization of the results is limited. Secondly, the study sample size is limited. Moreover, follow-up in this study was for 3 months, and long-term effects of EENC were not evaluated. Thirdly, only healthy mothers and newborns were participants in this research. Results regarding results of self-efficacy, depression, and mother-infant attachment were self-reported variables, so self-report bias cannot be avoided. Due to the promising results from this study, large sample and multicenter studies are needed. The effect of EENC in women with various risks should be explored to further elucidate the role of EENC in cesarean section.

Conclusion

This study indicates that EENC is associated with better breastfeeding initiation, breastfeeding self-efficacy and maternal-infant attachment in women who received EENC during cesarean deliveries. Moreover, EENC may help in improving postpartum depression in the current study, but the effects of EENC on exclusive breastfeeding should be further explored. Although our conclusions are limited by the single center study and small sample sizes, we speculate the findings reported here may provide valuable information for extensively implementation of EENC in cesarean deliveries.

Abbreviations

EENC	Early essential newborn care
SDG	Sustainable development goal
WHO	World Health Organization
DCC	Delayed cord clamping
SSC	Skin to skin contact
BCG	Bacillus Calmette–Guerin
BSES-SF	Breastfeeding Self-Efficacy Scale-Short Form
MPAS	Maternal Postnatal Attachment Scale
EPDS	Edinburgh Postnatal Depression Scale
IBFAT	Infant Breastfeeding Assessment Tool
NICU	Neonatal Intensive Care Unit

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12978-024-01932-9.

Supplementary Material 1

Acknowledgements

Sincere thanks are given to Dr. Sharon R. Redding (RN, EdD, CNE) for assistance in editing.

Author contributions

The include MZ, JYG, and JZ who conceptualized and designed the study and drafted the initial manuscript; MZ and JYG were contributions to the conception and design of the study. CHZ, XQZ, and WW were responsible for the implementation of the intervention. TYL analyzed and interpreted the

maternal and infant data. YQOY, SRR and HJC substantively revised the manuscript. All authors will read and approve the final manuscript.

Funding
The study was funded by the General Program of National Natural Science Foundation of China (Grant No.82173909).

Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The original protocol of this research proposal has already obtained approval of the Wuhan University Zhongnan Hospital Medical Ethics Committee, under the number 2023143K (lcsy.znhospital.cn). The protocol also was published in the Chinese Clinical Trial Register under the number ChiCTR2300074760 (www.chictr.org.cn). Women will only be included if they agree to participate and sign the informed consent. All principles related to research in human beings established by the National Health Commission of the People's Republic of China according to the Declaration of Helsinki will be followed. The confidentiality on women's data and medical care will be ensured regardless of whether they participate in the study or not.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 30 November 2023 Accepted: 9 December 2024
Published online: 17 December 2024

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