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Original Article

Effects of early essential newborn care after elective caesarean section on maternal and neonatal outcomes: a retrospective study

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Abstract: Objective: Early essential newborn care (EENC) is a World Health Organization (WHO)-recommended package of evidence-based perinatal interventions, but evidence regarding its effects after elective caesarean section (CS) remains limited. We evaluated the effects of EENC on maternal and neonatal outcomes following elective CS. Methods: In this retrospective observational study, 590 patients who underwent CS from November 2021 to October 2022 were screened; after applying eligibility criteria, 282 were included for analysis: 125 in the EENC group (E group) and 157 in the routine care group (R group). Outcomes included intraoperative and 24-h postpartum blood loss, postoperative pain (visual analogue scale [VAS] at 2/24/48/72 h), exclusive breastfeeding rate, neonatal hospitalization, neonatal intensive care unit (NICU) admission and transcutaneous bilirubin (TcB). Continuous data were compared with the independent t-test or Mann-Whitney U test and categorical data with the chi-square or Fisher's exact test. Results: Intraoperative blood loss (239.20±74.21 vs. 259.87±85.37 mL, t=2.14, P=0.033) and 24-h postpartum blood loss (47.01±20.71 vs. 54.71±26.64 mL, t=2.66, P=0.008) were lower in the E group. The 2-h VAS score was lower in the E group (1.88 [1, 3] vs. 2.48 [1, 4], Z=3.32, P<0.001). The exclusive breastfeeding rate was higher (78.4% vs. 63.7%, χ^2=7.20, P=0.005) and neonatal hospitalization shorter (4.04 [3, 5] vs. 4.20 [3, 6] days, P=0.021) in the E group. NICU admission, TcB and VAS at 24-72 h did not differ. Conclusion: EENC after elective CS was associated with reduced intraoperative and 24-h postpartum blood loss, lower early postoperative pain, higher exclusive breastfeeding rates and shorter neonatal hospitalization, supporting broader implementation of EENC in CS deliveries.

Keywords: Early essential newborn care, caesarean section, maternal outcomes, neonatal outcomes, breastfeeding, skin-to-skin contact

Introduction

According to reports, in 2019, there were 5.30 million deaths among children younger than 5 years, primarily due to preterm birth complications, lower respiratory infections, intrapartum-related events, and diarrhoea, with 49.2% attributed to infectious causes [1]. Despite recent improvements in child survival, neonatal mortality continues to decline at a slower rate and currently accounts for 47% of under-five deaths globally [2]. Urgent measures remain necessary to further reduce mortality under-5 years of age. In fact, in the past decade, many international organizations have proposed numerous response measures to improve neonatal/child mortality rates, among which the World Health Organization (WHO)'s Early Essential Newborn Care (EENC) has had the broadest impact.

EENC comprises a set of evidence-based perinatal interventions, including standardised prenatal care, immediate drying and thermal care of the neonate after birth, skin contact between mothers and babies, the completion of the first breastfeeding session within 90 minutes at the latest, delayed umbilical cord clamping until 1-3

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minutes after birth, delayed bathing until 24 h after birth, and kangaroo-mother care for preterm infants requiring resuscitation for neonatal asphyxia, along with other related components [3]. EENC interventions provided during labour and the early neonatal period can improve maternal and neonatal outcomes [4]. EENC enhances breastfeeding initiation and increases exclusive breastfeeding at 6 months of age [5]. Victora CG et al. [6] estimated that increasing the global breastfeeding rate to 50% could prevent approximately 823,000 deaths annually among children under-5. The WHO also recommends skin-to-skin contact (SSC) between mothers and newborns immediately after birth and breastfeeding within the first hour after birth, which can improve exclusive breastfeeding rates and reduce neonatal mortality [7-9]. Many countries have clearly benefited from EENC since its promotion by the WHO. EENC was introduced in China in 2016 and was implemented in 112 medical institutions by 2017 [5].

The CS rate continues to increase worldwide. Projections have shown that by 2030, 28.5% of women worldwide will deliver by CS, ranging from 7.1% in sub-Saharan Africa to 63.4% in Eastern Asia [10]. A retrospective review of 28 hospitals in Beijing also revealed that the percentage of mothers aged ≥35 years more than doubled between 2012 and 2017 and the change in the maternal age distribution led to an increase in the CS rate, with 76.5% of CSs attributable to advanced maternal age [11]. The rising CS rate also poses new challenges for perinatal care. Guala A et al. [12] confirmed that babies delivered by CS have a lower rate of breastfeeding at hospital discharge than those delivered vaginally. Improving breastfeeding rates and overall outcomes for CS-delivered infants has thus become a priority. The proposal of EENC provides us with an authoritative direction.

However, there is a lack of relevant research on the impact of EENC on maternal and neonatal outcomes after CS. This study aimed to evaluate the effects of EENC on maternal and neonatal outcomes after elective CS, focusing on the following clinical outcomes: (1) maternal outcomes including intraoperative and 24-h postpartum blood loss measured by gravimetric method, postoperative pain severity assessed by the visual analogue scale (VAS) at 2, 24, 48, and 72 hours after CS; and (2) neonatal outcomes including NICU admission rate and specific reasons for admission, neonatal hospitalization duration, TcB levels at 24 h postpartum and at discharge, neonatal body temperature stability at 24 h postpartum, weight changes from birth to discharge, and feeding patterns including exclusive breastfeeding rates at discharge. We hypothesised that EENC would confer measurable benefits for both maternal and neonatal outcomes after elective CS. Clarifying these effects may provide evidence to support extending this low-cost, WHO-recommended intervention package from vaginal delivery to surgical births, and inform the design of future randomized controlled trials in this population.

Materials and methods

Study design and ethical approval

This retrospective observational study included patients who underwent elective CS at the Fourth Affiliated Hospital of Zhejiang University School of Medicine from November 2021 to October 2022. This study was performed in accordance with the Declaration of Helsinki (2013 revision) and was reviewed and approved by the Ethics Committee of the Fourth Affiliated Hospital of Zhejiang University School of Medicine (Chair: Prof. Weimin Fan; approval No. K2022201, 15 October 2022). The committee (11 members, covering clinical medicine, pharmacology, nursing, ethics and law) operates under China's Measures for Ethical Review of Biomedical Research Involving Humans. Given the retrospective nature of this study and the use of de-identified data from electronic medical records, the ethics committee granted a waiver of individual informed consent.

Study population and eligibility criteria

Patients who underwent CS from November 2021 to October 2022 were screened for eligibility. Maternal inclusion criteria were: (1) elective CS performed under neuraxial anaesthesia (epidural anaesthesia or combined spinal-epidural anaesthesia); (2) singleton pregnancy; (3) gestational age ≥37 weeks; and (4) complete medical records available. Neonatal inclusion criteria were: (5) liveborn singleton term neonate; and (6) a 5-min Apgar score ≥7 (indicating no severe birth asphyxia), thus considered clinically stable for skin-to-skin contact and early breastfeeding. Maternal/obstetric exclusion criteria were: (1) emergency CS; (2) placenta previa or placental implantation disorders; (3) eclampsia; (4) foetal distress requiring emergent delivery; (5) multiple pregnancies; and (6) CS under general anaesthesia. Neonatal exclusion criteria were: (1) major congenital malformation; (2) severe birth asphyxia (5-min Apgar <7) requiring immediate resuscitation and separation from the mother; (3) stillbirth or intrapartum death; and (4) any neonate requiring immediate NICU admission at birth that precluded skin-to-skin contact.

Implementation of newborn care

All neonatal care was carried out in the operating room and two obstetric wards of the Fourth Affiliated Hospital of Zhejiang University School of Medicine. EENC has been provided at this institution since 2018, and after a long period of research and training, it was clinically applied in designated wards. Group assignment was based on ward allocation (not patient or clinician choice): neonates in EENC-designated wards received EENC, while those in other wards received routine care.

Routine newborn care (R group): During routine newborn care after CS, the respiratory tract was cleaned in a timely manner, the umbilical cord was ligated and bandaged, the body was wiped dry, the length, head circumference, and body mass were measured, identification tags and wristbands were applied, footprints were taken, and warm and dry towels and blankets were used to wrap the newborn. Attention was given to newborn body temperature, eye and umbilical cord care, administration of vitamin K1 (1 mg intramuscularly), vaccination of neonates per national immunization schedule, and provision of appropriate breastfeeding guidance to mothers.

EENC group (E group): In addition to routine newborn care, the following standardized EENC interventions were performed: (i) immediately reporting sex and time of birth; (ii) drying the newborn within 5 s using pre-warmed sterile towels; (iii) delaying umbilical cord clamping at least 1 min after birth; (iv) closely monitoring the physical condition of the neonate, and immediately placing the neonate on the mother's chest to ensure SSC once clinical stability was confirmed (defined as spontaneous breathing, heart rate >100 beats/min, oxygen saturation >90%, and good muscle tone); (v) encouraging early breastfeeding during SSC when the neonate showed signs of milk seeking (rooting reflex, hand-to-mouth movements, sucking movements); (vi) maintaining SSC for at least 90 minutes, with continuous monitoring of neonatal heart rate, respiratory rate, oxygen saturation, and skin colour by a dedicated nurse every 15 minutes, and stopping SSC immediately and providing targeted treatment if any abnormal phenomena occurred; and (vii) delaying bathing until after 24 h.

Data collection and outcome measures

All baseline information, perioperative data, and maternal and neonatal outcome data were obtained from the electronic medical records of the Fourth Affiliated Hospital of Zhejiang University School of Medicine.

Maternal baseline variables: age, education level, occupation type, height, weight, body mass index (BMI), gestational age, parity, pregnancy-related comorbidities (pregnancy-induced hypertension [PIH], gestational diabetes mellitus [GDM], intrahepatic cholestasis of pregnancy [ICP], hypothyroidism, anaemia), and indications for CS. Neonatal baseline variables: neonatal sex, gestational age at birth, birth weight, and 1-min and 5-min Apgar scores.

Primary outcomes: (1) intraoperative blood loss measured by gravimetric method (weighing surgical sponges and measuring suction volume); (2) blood loss within 24 h postpartum; (3) exclusive breastfeeding rate at hospital discharge.

Secondary outcomes: (1) VAS pain scores at 2, 24, 48, and 72 h after CS (0 = no pain; 10 = worst imaginable pain); (2) NICU admission rate and specific indications; (3) neonatal hospitalization duration; (4) TcB at 24 h postpartum and at discharge; (5) neonatal body temperature at 24 h postpartum; (6) neonatal weight at birth, at discharge, and weight change; (7) feeding pattern at hospital discharge (exclusive breastfeeding, mixed feeding, or artificial feeding).

Sample size

As this was a retrospective study, no a priori sample size calculation was performed;

instead, all consecutive eligible patients during the 12-month period were included to maximise power and reduce selection bias. To evaluate the adequacy of the achieved sample (E group, n=125; R group, n=157), a post hoc power analysis was performed using G*Power 3.1 (α=0.05, two-sided). For the primary maternal outcomes, the achieved power was 58.3% for intraoperative blood loss (Cohen's d=0.26) and 76.1% for 24-h postpartum blood loss (d=0.32); for the primary feeding outcome, the achieved power for the exclusive breastfeeding rate (78.4% vs. 63.7%; effect size h=0.33) was 77.8%. The study was therefore adequately powered for the principal breastfeeding and 24-h blood-loss endpoints, but underpowered for low-frequency outcomes such as NICU admission (achieved power 8.2%), which is acknowledged in the Limitations.

Statistical analyses

Statistical testing was conducted with SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were first assessed for normality using the Shapiro-Wilk test. Normally distributed data are expressed as the mean ± standard deviation (SD), and the independent-samples t-test (reported as t) was used to identify between-group differences. Non-normally distributed data are presented as the median (interquartile range, IQR), and the Mann-Whitney U test (standardized as Z) was used to identify differences. Categorical data are presented as the number (n) and percentage (%), and the χ^2 test (or Fisher's exact test when the expected cell count was <5) was used to identify differences. Specifically, the t-test was applied to age, height, weight, BMI, gestational age, third-stage duration, surgical time, intraoperative and 24-h blood loss, VAS at 24/48/72 h, birth and discharge weight, weight change, TcB and body temperature; the Mann-Whitney U test was applied to the 2-h VAS score and hospitalization duration; and the χ^2/Fisher's exact test was applied to education, occupation, parity, comorbidities, indications for CS, NICU admission, and feeding patterns. Effect sizes were calculated using Cohen's d for continuous variables and Cramer's V for categorical variables to supplement *P*-value interpretation. A post hoc power analysis was performed using G*Power 3.1 to assess the adequacy of the sample size for detecting the observed differences. P<0.05 was considered to indicate statistical significance.

Results

Study population

A total of 590 patients who underwent CS from November 2021 to October 2022 were screened. Of these, 308 patients were excluded: 186 for emergency CS, 42 for placenta previa or placental implantation disorders, 18 for eclampsia, 31 for foetal distress, 22 for multiple pregnancies, and 9 for CS under general anaesthesia (**Figure 1**). Ultimately, 282 patients were included in the final analysis, including 125 in the EENC group (E group) and 157 in the routine newborn care group (R group). The detailed exclusion criteria are presented in **Figure 1**.

The baseline characteristics of the included patients are summarized in **Table 1**. No significant differences in age, education level, occupation type, height, weight, BMI, gestational age, number of pregnancies, number of deliveries, or medical comorbidities (including PIH, ICP, GDM, hypothyroidism, anaemia, and others) were observed between the two groups (all P>0.05; **Table 1**). There was also no significant difference in the indications for CS between the two groups (P>0.05; **Table 1**). Neonatal baseline characteristics (sex, gestational age, birth weight and Apgar scores) were also comparable between the two groups (all P>0.05; **Table 1**).

Maternal outcomes

The perioperative and maternal outcome data are presented in **Table 2**. There were no significant differences in the duration of the third stage of labour or surgical time between the two groups (P>0.05). Intraoperative blood loss in the E group was significantly lower than that in the R group (239.20±74.21 mL vs. 259.87±85.37 mL, t=2.14, P=0.033; Cohen's d=0.26, 95% CI: 1.63-39.71), as was blood loss within 24 h after birth (47.01±20.71 mL vs. 54.71±26.64 mL, t=2.66, P=0.008; Cohen's d=0.32, 95% CI: 2.04-13.36). The VAS score at 2 h after CS in the E group was lower than that in the R group (1.88 [1, 3] vs. 2.48 [1, 4], Z=3.32, P<0.001). However, there were no significant differences in the VAS scores at 24, 48, or 72 h

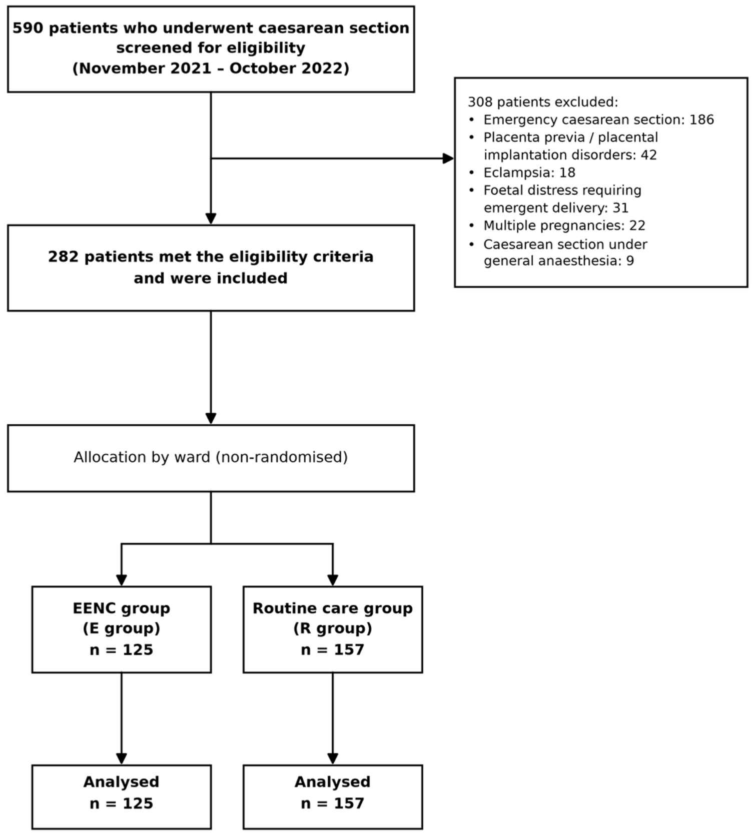

Figure 1. Flowchart of the study population. A total of 590 patients who underwent caesarean section were screened, and 308 were excluded for the specified reasons, itemized in detail in the figure (emergency CS, n=186; placenta previa/placental implantation disorders, n=42; eclampsia, n=18; foetal distress requiring emergent delivery, n=31; multiple pregnancies, n=22; CS under general anaesthesia, n=9). The final analysis included 282 patients: 125 in the EENC group and 157 in the routine care group. EENC, early essential newborn care; CS, caesarean section.

after CS between the two groups (all P>0.05; **Table 2**).

Neonatal outcomes

The neonatal outcome data are presented in **Table 3**. There were no significant differences in weight at birth, weight at discharge, or weight change between the two groups (all P>0.05). No significant differences were found in TcB at 24 h postpartum or at discharge, body temperature at 24 h postpartum, or NICU admission rate between the two groups (all P>0.05). The hospitalization time in the E group was significantly shorter than that in the R group (4.04 [3, 5] vs. 4.20 [3, 6] days, Z=2.31, P=0.021; Cohen's d=0.22).

Among the 282 patients, a total of 31 neonates were transferred to the NICU after birth, including 13 (10.4%) in the E group and 18 (11.5%) in the R group. The reasons for NICU admission are detailed in **Table 4**. There were no significant differences in hyperbilirubinemia, neonatal sepsis, neonatal wet lung, neonatal hypoglycaemia, or congenital diseases as reasons for NICU admission between the two groups (all P> 0.05; **Table 4**).

Breastfeeding outcomes

The feeding patterns before discharge are presented in **Table 5**. Among the 282 patients, 198 neonates were exclusively breastfed before discharge, including 98 (78.4%) in the E group and 100 (63.7%) in the R group. The overall feeding pattern distribution differed significantly between groups (exclusive/mixed/artificial: 98/14/13 vs. 100/33/24; χ^2=7.44, P=0.024). The exclusive breastfeeding rate of the E group was significantly greater than that of the R group (78.4% vs. 63.7%, χ^2=7.20, P=0.005; Cramer's V=0.17, OR=2.07, 95% CI: 1.22-3.52).

Discussion

Principal findings

This retrospective study evaluated the effects of EENC on maternal and neonatal outcomes after elective CS. To our knowledge, this is one of the first studies to comprehensively assess EENC's impact specifically in elective CS, rather than in vaginal or mixed CS populations. We found that EENC was associated with reduced maternal blood loss both intraoperatively and within 24 h postpartum, lower pain scores at 2 h postpartum, improved exclusive breastfeeding rates at discharge, and shorter neonatal hospitalization duration. The following sections interpret these findings in turn - first the maternal outcomes (blood loss and pain), then breastfeeding, and finally the neonatal out-

Table 1. Baseline characteristics of the included mothers and neonates (n=282)

Variable	E group (N=125)	R group (N=157)	Statistic (t/χ^2/Z)	*P* value
Age (years), mean ± SD	31.70±4.48	31.59±4.11	t=0.22	0.828
Education level, n (%)			χ^2=0.33	0.847
Undergraduate and above	43 (34.4)	59 (37.6)		
Junior college	42 (33.6)	49 (31.2)		
High school and below	40 (32.0)	49 (31.2)		
Occupation type, n (%)			χ^2=1.31	0.934
Public official	24 (19.2)	30 (19.1)		
Private enterprise	20 (16.0)	26 (16.6)		
Individual occupations	51 (40.8)	57 (36.3)		
Farmers	3 (2.4)	6 (3.8)		
Unemployed	24 (19.2)	32 (20.4)		
Other	3 (2.4)	6 (3.8)		
Height (cm), mean ± SD	160.04±4.46	159.34±4.49	t=1.30	0.200
Weight (kg), mean ± SD	70.32±10.22	70.48±9.61	t=0.13	0.893
BMI (kg/m^2), mean ± SD	27.43±3.65	27.72±3.38	t=0.69	0.491
Gestational age (weeks), mean ± SD	38.28±1.06	38.24±0.92	t=0.34	0.699
Number of pregnancies, n (%)			χ^2=2.29	0.683
One	32 (25.6)	35 (22.3)		
Two	36 (28.8)	40 (25.5)		
Three	27 (21.6)	32 (20.4)		
Four	18 (14.4)	32 (20.4)		
≥5	12 (9.6)	18 (11.4)		
Number of deliveries, n (%)			χ^2=1.08	0.783
One	45 (36.0)	48 (30.6)		
Two	60 (48.0)	79 (50.3)		
Three	18 (14.4)	27 (17.2)		
Four	2 (1.6)	3 (1.9)		
Comorbidities, n (%)				
PIH	15 (12.0)	19 (12.1)	χ^2<0.01	0.979
GDM	9 (7.2)	11 (7.0)	χ^2<0.01	0.950
ICP	6 (4.8)	9 (5.7)	χ^2=0.12	0.729
Hypothyroidism	7 (5.6)	9 (5.7)	χ^2<0.01	0.962
Anaemia	14 (11.2)	17 (10.8)	χ^2=0.01	0.921
Other	6 (4.8)	12 (7.6)	χ^2=0.94	0.332
Indications for CS, n (%)			χ^2=2.38	0.881
Scarred uterus	80 (64.0)	109 (69.4)		
Oligohydramnios	7 (5.6)	9 (5.7)		
Foetal distress	14 (11.2)	10 (6.4)		
Umbilical cord around neck	8 (6.4)	10 (6.4)		
Head-pelvis imbalance	6 (4.8)	8 (5.1)		
Macrosomia	6 (4.8)	6 (3.8)		
Other	4 (3.2)	5 (3.2)		
Neonatal characteristics				
Sex (male/female), n	66/59	81/76	χ^2=0.04	0.840
Birth weight (g), mean ± SD	3319.84±378.14	3294.52±427.50	t=0.52	0.604
Apgar score at 1 min, median (IQR)	9 [9, 10]§	9 [8, 9]§	Z=1.50	0.108
Apgar score at 5 min, median (IQR)	10 [9, 10]§	10 [9, 10]§	Z=0.55	0.534

BMI, body mass index; PIH, pregnancy-induced hypertension; GDM, gestational diabetes mellitus; ICP, intrahepatic cholestasis of pregnancy; CS, caesarean section; SD, standard deviation; IQR, interquartile range. E group, early essential newborn care (EENC) group; R group, routine birth care group. t, independent-samples t-test; χ^2, chi-square test; Z, Mann-Whitney U test (standardized). §The median (interquartile range, IQR) was used.

Table 2. Comparison of perioperative data and maternal outcomes between the two groups

Variable	E group (N=125)	R group (N=157)	Statistic ($t/\chi^2/Z$)	*P* value
Third stage duration (min), mean ± SD	6.38±2.08	6.49±2.26	t=0.42	0.685
Surgical time (min), mean ± SD	60.25±14.58	62.96±13.64	t=1.61	0.110
Blood loss (mL)				
Intraoperative, mean ± SD	239.20±74.21	259.87±85.37	t=2.14	0.033*
24 h postpartum, mean ± SD	47.01±20.71	54.71±26.64	t=2.66	0.008*
Pain score (VAS)				
2 h postpartum, median (IQR)	1.88 [1, 3]	2.48 [1, 4]	Z=3.32	<0.001*
24 h postpartum, mean ± SD	1.65±0.83	1.82±0.81	t=1.73	0.081
48 h postpartum, mean ± SD	1.58±0.78	1.72±0.73	t=1.55	0.120
72 h postpartum, mean ± SD	1.53±0.73	1.66±0.71	t=1.51	0.146

VAS, visual analogue scale; IQR, interquartile range; SD, standard deviation; t, independent-samples t-test; Z, Mann-Whitney U test (standardized). *Statistically significant (P<0.05).

Table 3. Comparison of neonatal outcomes between the two groups

Variable	E group (N=125)	R group (N=157)	Statistic ($t/\chi^2/Z$)	*P* value
Birth weight (g), mean ± SD	3319.84±378.14	3294.52±427.50	t=0.52	0.604
TcB 24 h postpartum, mean ± SD	4.63±1.29	4.78±1.21	t=1.00	0.316
Body temperature 24 h (°C), mean ± SD	36.64±0.14	36.67±0.13	t=1.86	0.125
Discharge weight (g), mean ± SD	3151.12±358.95	3116.30±408.55	t=0.75	0.449
Weight change (g), mean ± SD	168.72±112.70	178.21±100.76	t=0.75	0.456
NICU admission, n (%)	13 (10.4)	18 (11.5)	χ^2=0.08	0.466
TcB at discharge, mean ± SD	11.15±2.15	11.19±1.98	t=0.16	0.852
Hospitalization time (day), median (IQR)	4.04 [3, 5]	4.20 [3, 6]	Z=2.31	0.021*

TcB, transcutaneous bilirubin; NICU, neonatal intensive care unit; IQR, interquartile range; SD, standard deviation; t, independent-samples t-test; χ^2, chi-square test; Z, Mann-Whitney U test (standardized). *Statistically significant (P<0.05).

Table 4. Reasons for NICU admission in the two groups

Variable	E group (N=125)	R group (N=157)	Statistic ($t/\chi^2/Z$)	*P* value
Hyperbilirubinemia, n (%)	7 (5.6)	12 (7.6)	χ^2=0.46	0.333
Neonatal sepsis, n (%)	3 (2.4)	1 (0.6)	-†	0.231†
Neonatal wet lung, n (%)	3 (2.4)	1 (0.6)	-†	0.231†
Neonatal hypoglycaemia, n (%)	0 (0)	3 (1.9)	-†	0.171†
Congenital diseases, n (%)	0 (0)	1 (0.6)	-†	0.557†

NICU, neonatal intensive care unit; χ^2, chi-square test. †Fisher's exact test used due to expected cell count <5; no χ^2 statistic is reported for Fisher's exact test.

comes - before considering clinical implications and limitations.

Maternal outcomes: blood loss and pain

The finding of reduced blood loss in the EENC group is clinically significant and biologically plausible. SSC and early breastfeeding, which are core components of EENC, stimulate endogenous oxytocin release from the posterior pituitary through the Ferguson reflex [13-15]. Oxytocin acts on the myometrium through oxytocin receptors (OTR), promoting sustained uterine contraction and retraction, which is the primary physiological mechanism for achieving haemostasis after placental separation. Specifically, oxytocin binding to OTR activates the phospholipase C-inositol trisphosphate pathway, increasing intracellular calcium concentrations and triggering myometrial smooth muscle contraction [16]. Additionally, the tactile stimulation from SSC may activate the neuroendocrine axis through somatosensory afferent pathways, further augmenting oxytocin release [14]. Saxton A et al. [17] reported that immediate SSC and breastfeeding may reduce postpartum haemorrhage rates regardless of baseline risk. Our findings extend this evidence to the elective CS population, where the risk of haemorrhage may differ due to surgical factors

Table 5. Feeding patterns before discharge in the two groups

Variable	E group (N=125)	R group (N=157)	Statistic (t/χ^2/Z)	*P* value
Overall feeding pattern (EBF/MF/AF)	98/14/13	100/33/24	χ^2=7.44	0.024*
Exclusive breastfeeding, n (%)	98 (78.4)	100 (63.7)	χ^2=7.20	0.005*
Mixed feeding, n (%)	14 (11.2)	33 (21.0)	χ^2=4.83	0.020*
Artificial feeding, n (%)	13 (10.4)	24 (15.3)	χ^2=1.46	0.151

EBF, exclusive breastfeeding; MF, mixed feeding; AF, artificial feeding; χ^2, chi-square test. *Statistically significant (P<0.05).

and anaesthesia effects on uterine contractility.

Regarding pain outcomes, we observed lower VAS scores at 2 h postpartum in the EENC group, while no significant differences were detected at 24, 48, or 72 h. The early pain reduction can be attributed to the anxiolytic and analgesic effects of SSC-mediated oxytocin release. Oxytocin modulates pain perception through both central and peripheral mechanisms: centrally, oxytocin acts on the descending pain modulatory system in the periaqueductal grey and rostral ventromedial medulla, inhibiting nociceptive transmission at the spinal dorsal horn; peripherally, oxytocin has been shown to reduce inflammatory cytokine production, including interleukin-6 (IL-6) and tumour necrosis factor-alpha (TNF-α), thereby attenuating the peripheral inflammatory component of postoperative pain [14, 16]. Moreover, SSC has been shown to reduce maternal cortisol levels, which may contribute to decreased anxiety and improved pain tolerance in the immediate postpartum period [14, 16]. The absence of significant differences at later time points (24-72 h) is likely attributable to the application of multimodal postoperative analgesia (including patient-controlled intravenous analgesia with sufentanil, oral non-steroidal anti-inflammatory drugs, and wound infiltration with local anaesthetics), which may have masked any sustained analgesic effects of EENC.

Breastfeeding outcomes

Many previous studies have confirmed that EENC can effectively improve breastfeeding rates, but there is relatively little research on EENC after elective CS [2, 4, 5, 12, 13, 19]. The superior breastfeeding outcomes observed in the EENC group can be explained through multiple physiological pathways. First, uninterrupted SSC activates innate neonatal feeding reflexes, including the rooting reflex and stepping reflex, which facilitate self-attachment to the breast - a process that may be particularly important after CS, where the absence of vaginal delivery may delay neonatal neurobehavioural adaptation. Second, SSC-induced oxytocin release in the mother stimulates the letdown reflex by promoting contraction of myoepithelial cells surrounding the mammary alveoli, facilitating colostrum ejection. Third, early suckling stimulates prolactin secretion from the anterior pituitary, establishing the hormonal foundation for sustained lactogenesis II [20]. These mechanisms are particularly relevant in CS populations, where delayed lactogenesis II is a recognised challenge - studies report a 2- to 3-fold higher risk compared with vaginal delivery. Similar to the results of Stevens J et al. [18], our study confirmed that early breastfeeding after elective CS can improve feeding patterns at discharge and increase exclusive breastfeeding rates.

Neonatal outcomes

Previous studies have confirmed that EENC has many benefits in improving neonatal outcomes. Delayed cord clamping in term and preterm infants is associated with increased haemoglobin levels and iron storage, improved neurodevelopment, decreased anaemia, increased blood pressure and decreased transfusions, as well as decreased rates of intraventricular haemorrhage, chronic lung disease, necrotizing enterocolitis, and late-onset sepsis [21]. Immediate SSC during the first six postnatal hours improved cardiorespiratory stabilisation in very preterm infants [22]. EENC can decrease the incidence of hypothermia, promote the initiation of breathing, and improve the sleep quality of newborn infants [23]. The mechanism underlying the shorter hospitalization time observed in the EENC group may be multifactorial. Improved thermoregulation through SSC reduces metabolic demands and energy expenditure in neonates, thereby potentially accelerating metabolic stabilization and weight recovery. Furthermore, the higher exclusive breastfeeding rate in the EENC group may contribute to better neonatal nutritional status, immune protection through colostrum immunoglobulins (particularly secretory IgA), and reduced risk of complications that could prolong hospitalization. The gut microbiome colonization pattern may also differ, as early breastfeeding promotes colonization by beneficial Bifidobacterium and Lactobacillus species, potentially reducing the incidence of feeding intolerance and infection [20].

Tran HT et al. [24] reported that the EENC quality improvement approach for infants delivered by CS was associated with reduced NICU admissions and admissions due to hypothermia and sepsis. However, our study did not find similar results regarding NICU admission rates. Several factors may account for this discrepancy. First, the relatively small sample size (n=282) limited our statistical power to detect differences in a low-frequency outcome (overall NICU admission rate: 11.0%). Post hoc power analysis indicated that our study had only 8.2% power to detect the observed difference in NICU admission rates, suggesting that a larger sample size (estimated n≥2,400 per group) would be needed to adequately assess this outcome. Second, the indications for NICU admission in our study were predominantly medical conditions (hyperbilirubinemia, sepsis, wet lung) that may not be directly modifiable by EENC interventions. Third, the NICU admission threshold may vary between institutions, making cross-study comparisons challenging.

Clinical implications and translational significance

The translational significance of our findings warrants emphasis. Given the steadily increasing global CS rate, effective interventions that improve both maternal and neonatal outcomes following CS are urgently needed. Our results suggest that EENC, which is a low-cost, easily implementable, and evidence-based intervention package, can be safely and effectively extended from vaginal delivery settings to elective CS in the operating theatre. The reduced blood loss and improved breastfeeding rates observed in this study have important implications for healthcare resource utilization, as both outcomes are associated with shorter hospital stays, reduced readmission rates, and lower healthcare costs. Furthermore, the WHO has recommended EENC for all births, but implementation in CS settings has lagged behind that in vaginal delivery settings, partly due to perceived logistical challenges [25]. Our study provides evidence that these challenges can be overcome with appropriate staff training and interdisciplinary collaboration between obstetric, anaesthesiology, and nursing teams.

Limitations

Our study has certain limitations that should be acknowledged. First, this was a retrospective observational study, and despite comparable baseline characteristics between the two groups, residual confounding from unmeasured variables (such as maternal psychological status, previous breastfeeding experience, cultural attitudes toward breastfeeding, and family support) cannot be excluded. The non-random allocation of patients to EENC versus routine care groups introduces the possibility of selection bias, although this was partly mitigated by the fact that group assignment was determined by ward allocation rather than patient or clinician preference. Second, this study did not assess maternal anxiety and depression status (e.g., using validated instruments such as the Edinburgh Postnatal Depression Scale or the State-Trait Anxiety Inventory) before and after childbirth, which may represent a potential source of confounding, given that SSC has been shown to influence maternal psychological wellbeing. Third, although EENC has been implemented at our institution since 2018, standardised quality-control metrics for EENC fidelity - e.g., actual SSC duration, time to first breastfeed, and compliance with each component - were not systematically recorded, which may have introduced variability in EENC delivery and potentially attenuated the observed treatment effects. Fourth, the single-centre design at a tertiary university hospital may limit the generalizability of our findings to other settings, including community hospitals and resource-limited environments where EENC implementation may face different challenges. Fifth, no mid- to long-term outcomes were assessed, such as breastfeeding duration at 3 and 6 months, infant growth, maternal postpartum depression, or neurodevelopmental outcomes.

Conclusions

In this retrospective study, EENC after elective CS was associated with reduced intraoperative and 24-h postpartum blood loss, lower VAS pain scores at 2 h after surgery, higher exclusive breastfeeding rates at discharge, and shorter neonatal hospitalization duration, without significantly influencing NICU admission rates or neonatal jaundice. These benefits are likely mediated through oxytocin-dependent mechanisms triggered by SSC and early breastfeeding. Our findings support the extension of EENC implementation from vaginal delivery to elective CS settings and highlight the need for multi-centre randomized controlled trials to confirm these associations and establish optimal EENC protocols for CS deliveries.

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Disclosure of conflict of interest

None.

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