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Determinants of postpartum lactation insufficiency in caesarean section in Chinese mothers: A cross-sectional study

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Abstract

This study explored the status of postpartum lactation in caesarean section mothers and identified the factors that influence lactation insufficiency. A total of 265 mothers who delivered via cesarean section between November 2021 and November 2022 were followed for six months. Lactation efficiency was measured by collecting daily milk output using a breast pump from postpartum days 1 to 10; insufficient lactation was defined as a total daily milk volume <500 mL on day 10. Lactation typically began between 25 and 48 hours postpartum (45.1%), with a delayed onset of lactogenesis incidence of 19.6% and an overall lactation insufficiency rate of 48.3%. Multivariate logistic regression analysis identified advanced maternal age (>35 years), excessive weight gain during pregnancy (≥5.6 kg/m²), high postpartum pain scores (≥4), gestational diabetes mellitus, and postpartum depression as significant risk factors for insufficient lactation. In contrast, early skin-to-skin contact and suckling significantly reduced the risk. Furthermore, infants in the exclusive breastfeeding group showed significantly better nutritional outcomes, as measured by the Kaup index, compared to partially or non-breastfed infants. These findings underscore the need for targeted clinical interventions during the perinatal period, including effective pain management, mental health support, and promotion of early breastfeeding, to enhance lactation outcomes among cesarean section mothers. *(Afr J Reprod Health 2026; 30 [1]: 64-73).*

Keywords: cesarean section; lactation volume; lactation insufficiency; influencing factors

Résumé

Cette étude a exploré la situation de l'allaitement post-partum chez les mères ayant accouché par césarienne et a identifié les facteurs influençant l'insuffisance lactée. Un total de 265 mères ayant accouché par césarienne entre novembre 2021 et janvier 2022 ont été suivies pendant six mois. L'efficacité de l'allaitement a été mesurée en collectant la quantité quotidienne de lait produite à l'aide d'un tire-lait du premier au dixième jour post-partum ; l'insuffisance lactée a été définie par un volume de lait quotidien total <500 mL au dixième jour. L'allaitement a généralement commencé entre 25 et 48 heures après l'accouchement (45,1 %), avec une incidence de retard de la lactogenèse de 19,6 % et un taux global d'insuffisance lactée de 48,3 %. L'analyse de régression logistique multivariée a identifié l'âge maternel avancé (>35 ans), un gain de poids excessif pendant la grossesse (≥5,6 kg/m²), des scores élevés de douleur post-partum (≥4), le diabète gestationnel et la dépression post-partum comme des facteurs de risque significatifs pour une lactation insuffisante. En revanche, le contact peau-à-peau précoce et l'allaitement au sein ont significativement réduit ce risque. De plus, les nourrissons du groupe d'allaitement exclusif ont montré de meilleurs résultats nutritionnels, mesurés par l'indice de Kaup, par rapport aux nourrissons partiellement ou non allaités. Ces résultats soulignent la nécessité d'interventions cliniques ciblées pendant la période périnatale, comprenant une gestion efficace de la douleur, un soutien en santé mentale et la promotion de l'allaitement précoce, afin d'améliorer les résultats de l'allaitement chez les mères ayant accouché par césarienne. *(Afr J Reprod Health 2026; 30 [1]: 64-73).*

Mots-clés: césarienne ; volume de lactation ; insuffisance lactée ; facteurs influents

Introduction

Breastfeeding, the ideal natural source of nutrition for infants, is important to the immediate and long-term health of both mother and child[1]. For newborns, breastmilk not only provides comprehensive and balanced nutrients to meet their physiological needs for growth and development, it is also rich in a variety of immunologically active substances, which help to strengthen the infant's immune function and reduce the risk of infectious diseases, allergic diseases and chronic diseases in adulthood[2,3]. For mothers, breastfeeding can promote uterine contraction, reduce post-partum haemorrhage and accelerate uterine recovery, while helping to reduce the fat accumulated during pregnancy, promoting maternal weight recovery and reducing the incidence of gynaecological malignancies[4]. Caesarean section

is widely used globally as an important mode of delivery to address obstructed labour, manage high-risk pregnancies and certain emergencies[5]. In recent years, with the continuous progress of cesarean section technology, the safety of cesarean section has been significantly improved, with the proportion of its use showing an upward trend[5,6]. However, there are significant differences in the physiological processes between caesarean section deliveries and natural deliveries, and these differences may have a multifaceted impact on maternal postpartum lactation[7].

Postpartum lactation is a complex and sophisticated physiological process that is synergistically regulated by a variety of factors[8]. During natural childbirth, the physiological stimuli experienced by the mother, such as contractions and birth canal compression, can induce dynamic changes in the levels of various hormones in the body, such as oxytocin and prolactin[9,10]. These hormones play a key role in the synthesis and secretion of milk and the initiation of the milk ejection reflex. Delayed onset of lactogenesis (DOL) is one of the common problems during postpartum lactation in cesarean section mothers[11]. DOL not only causes newborns to be unable to obtain sufficient breast milk in a timely manner in the early postnatal period, it may also increase the risk of postpartum anxiety, depression, and other adverse emotions, which can have a negative impact on the establishment of the mother-infant relationship[12]. In addition, insufficient milk secretion is also a prominent problem faced by women who have had a caesarean section. Some mothers are unable to meet the feeding needs of their infants due to insufficient lactation and have to choose alternative feeding methods such as adding formula milk[13]. This may not only change the structure of the infant's intestinal flora and increase the incidence of allergies and other health problems, but may also further inhibit the maternal lactation reflex, creating a vicious cycle. At present, many studies have focused on the problems related to postpartum lactation in cesarean section mothers, but there are some differences in the selection of research subjects, the use of research methods, and the interpretation of the results of the studies in different studies. In view of this, we conducted this study to systematically and comprehensively analyse the current situation of postpartum lactation in cesarean section mothers, and to explore in depth the factors influencing postpartum lactation insufficiency. The innovation of this study lies in focusing on the specific population of caesarean deliveries and dynamically observing lactation changes through a longitudinal design in order to construct a more comprehensive prediction model of lactation insufficiency. It is expected that this study can provide a scientific basis for clinical staff to formulate targeted interventions to promote the recovery of postpartum lactation function of cesarean section mothers, improve breastfeeding rates, and safeguard the health of mothers and infants. At the same time, the results of this study can help enrich the clinical research data on postpartum lactation of Cesarean section mothers, and provide reference for the development of subsequent related research.

Methods

Research object

Parturients who underwent caesarean section at the obstetrics department of the Anhui Women and Children's Medical Center (Hefei Maternal and Child Health Hospital) from November 2021 to November 2022 were recruited as the study participants.

Sample size calculation: the sample size was determined based on the requirement for multivariate logistic regression analysis. A common guideline suggests including 10 to 15 events per predictor variable (EPV) to ensure model stability and reliability. Initially, 14 candidate predictor variables were planned for investigation. Aiming for approximately 10-15 EPV, a minimum sample size of 140 to 210 was estimated. To account for potential missing data and enhance the robustness of the analysis, the target sample size was increased by 20%. Consequently, a total of 289 parturients were initially enrolled. All enrolled mothers and their newborns were followed up for 6 months. During the follow-up period, 24 cases were lost, resulting in a final sample of 265 parturients included in the data analysis.

Inclusion and exclusion criteria

The inclusion criteria were: (a) full-term, singleton pregnancies who underwent cesarean section; (b) those without infectious diseases or contraindications to breastfeeding; (c) no breast

diseases before or during pregnancy; (d) age <40 years; and (e) those with normal cognitive expression ability. The exclusion criteria were: (a) history of massive hemorrhage during cesarean section, macrosomia, stillbirth, malformed fetus or neonatal rescue; (b) adverse events such as severe infection and severe bleeding affecting postpartum recovery; (c) Infants with severe jaundice, congenital diseases or sucking dysfunction; (d) contraindications to breastfeeding such as HIV positivity and allergy of the newborn to breast milk; (e) malignant tumors or functional disorders of important organs; (f) history of mental disorders and drug dependence; (g) those that have participated in other interventional studies, which may affect the results of this study; and (h) incomplete clinical data.

Data collection and observation indicators

Lactation related indicators: (1) the initiation time of lactation: The initiation time of lactation within 72 hours after delivery was recorded for the parturients. This was defined as the time interval from the delivery of the fetus to the first observation of milk overflow from the nipples, accurate to the hour.

(2) Assessment of DOL: DOL was defined as the absence of obvious breast distension, pain or fullness within 72 hours after delivery.

(3) measurement of lactation volume: to accurately quantify postpartum lactation volume, a breast pump was used to collect milk from the parturients, and the collected milk volume was measured using a 5mL sterile syringe. The milk collection protocol was standardized as follows: within the first 2 days after delivery, each parturient was instructed to use the breast pump to express milk once every 3 hours, with each pumping session lasting approximately 25 minutes; starting from the 3rd day postpartum, parturients were instructed to use the breast pump to express milk when they subjectively felt breast fullness (i.e., when the breasts showed obvious distension and a sense of fullness). Based on this protocol, the daily lactation volume (total volume of milk collected via breast pump per day) and daily milk expression frequency (number of breast pump sessions per day) of each parturient were recorded continuously from postpartum day 1 to day 10. The rate of lactation insufficiency among the parturients was calculated according to the established criterion [14]: lactation volume <500mL on the 10th day after delivery was defined as lactation insufficiency.

(4) Feeding method: the feeding methods of newborns were recorded through telephone follow-up, which were classified into exclusive breastfeeding (only consuming breast milk without adding formula milk, water or other foods), mixed feeding (a mixture of breast milk and formula milk, with breast milk accounting for less than 80%), and artificial feeding (only consuming formula milk without breast milk intake).

General information and clinical indicators: (1) general information was collected through the electronic medical record system and self-filled questionnaires of the parturients, including age (calculated in years), educational level (junior high school and below, senior high school and above), number of deliveries (primiparas and multiparas), and the increase in body mass index (BMI) during pregnancy (calculation method: Pre-delivery BMI - pre-pregnancy BMI, BMI = weight kg/height m^2), daily sleep duration (recorded continuously for 7 days, take the average, accurate to 0.5 hours), daily fluid intake (including drinking water, soups, milk, etc., recorded continuously for 7 days, take the average, accurate to 10mL). (2) clinical indicators: 1) 48-hour postpartum pain score: The Visual Analogue Scale (VAS) was used for assessment, with a score range of 0 to 10. A score of 0 indicated no pain, while a score of 10 indicated the most severe pain. The parturient marked the score on the scale by herself and recorded the score.

2) Early contact sucking: This was defined as skin-to-skin contact between mother and baby within 1 hour after delivery (the mother was exposed to the chest, and the newborn was fully exposed and laid on the mother's chest for≥30 minutes), and the newborn completed at least one effective sucking (the nurse observed that the newborn had a correct posture for holding the nipple and has obvious swallowing movements), and records "yes" or "No".

3) Prenatal health education: Recorded whether the pregnant woman had participated in any health education courses related to breastfeeding organized by the hospital during pregnancy (the course duration was ≥2 hours, and the content included breastfeeding techniques, lactation principles, etc.). This was recorded as "yes" or "no". 4) Gestational complications: This was extracted through the electronic medical record system, including gestational hypertension and gestational diabetes; 5) First milk suction time: This was recorded the time

when the mother first used the milk suction device to suck milk after giving birth, accurate to the hour. 6) Postpartum depression The Edinburgh Postnatal Depression Scale (EPDS) was used for assessment on the 42nd day postpartum period. The scale consisted of 10 items, each with a score of 0 to 3, with the total score ranging from 0 to 30. A score of ≥13 was determined to indicate the presence of postpartum depression[15]. (The Cronbach's α coefficient of this scale in this study was 0.82.) It has good reliability and validity.

Assessment of the nutritional status of the newborns: All neonates were discharged from the hospital for a 6-month telephone follow-up survey. The Kaup index was used to assess the nutritional status of infants with different feeding patterns at birth and at the final follow-up. Kaup index = [weight (kg)/height $(cm)^2$] × 104, a value of >18 was considered obese, 18-15 was normal, while a score of 13 or less was considered as malnutrition.

Quality control

(a) Systematic training was provided to all participants before the study began, and retraining and centralised feedback were organised on a regular basis to assess the effectiveness of the training through appraisal and to solve problems in the data collection process. (b) Supervision mechanism: a person was responsible for regular spot-checking of data sheets to check its completeness (c) Data entry and management: This was implemented by two independent data entry personnel and was cross-checked to ensure the accuracy of data entry, We also regularly backed up the data to prevent data loss or damage. (d) Data cleansing after data entry, checking and correcting errors and inconsistencies in the data to ensure the consistency and reasonableness of the data.

Statistical analysis

Data were processed using SPSS 22.0. Measurement data were expressed as mean ± standard deviation ($\bar{X}$ ± SD), and independent sample t-test was used for comparison between groups. Counting data were expressed as n (%) and the x^2 test was used. Variables with P<0.05 in univariate analysis were included in a multifactorial logistic regression model to analyse the independent risk factors affecting postpartum lactation insufficiency in cesarean section mothers. Neonatal Kaup index nutritional status was assessed: obesity, normal, and malnutrition were used as hierarchical data, using the rank-sum test, the Kruskal-Wallis test for comparisons between multiple groups, and the Wilcoxon test for comparisons between two groups. Differences were considered statistically significant at $P < 0.05$.

Ethical considerations

This study strictly adheres to all the principles of the Declaration of Helsinki. This study was approved by the Ethics Committee of Anhui Women and Children's Medical Center (Hefei Maternal and Child Health Hospital) (Ethics Approval Document Number: YYLL20250728-YJKT-03-1.0).

Lactation status and feeding methods

Among all 265 cases, DOL occurred in 52 cases (19.6%), lactation within 72h postpartum was mainly concentrated in 25-48h (45.1%), and exclusive breastfeeding occurred in 136 cases (51.3%), as shown in Table 1.

10d lactation statistics

The average daily lactation on days 1-3 postpartum was 58.1±16.4 mL and the frequency of suckling was 5.0±1.0 times; on days 4-6 lactation increased significantly to 295.4±40.3 mL (P<0.001) and the frequency of suckling was 5.6±1.1 times; on days 7-10 lactation further increased to 496.8±72.3 mL (P<0.001) and the frequency of suckling was 6.8±1.1 times (Table 2). There were 128 cases of parturients with insufficient lactation.

Comparison of the general data in the adequate lactation group and the insufficient lactation group

The general data of parturients in the adequate lactation group (n = 137) and the insufficient lactation group (n = 128) were compared (Table 3).

Table 1: Lactation status and feeding methods

Variable	Grouping	Number	Proportion (%)
Lactation time within 72 hours after delivery (h)	1~12h	16	7.51
	13~24	78	36.6
	25~48	96	45.1
	49~72	23	10.8
DOL	-	52	19.6
Feeding method	Exclusive breastfeeding	136	51.3
	Partial breastfeeding	92	34.7
	Non-breastfeeding	37	14.0

Table 2: 10d lactation statistics

Postpartum period	Average daily lactation (mL)	Average daily milking frequency (n)
1~3d	58.1±16.4	5.0±1.0
4~6d	295.4±40.3	5.6±1.1
7~10d	496.8±72.3	6.8±1.1

Table 3: Comparison of the general data in the adequate lactation group and the insufficient lactation group

Variable	Grouping	Adequate lactation group (n=137)	Insufficient lactation group (n=128)	χ2/t	P value
Age	≤35	82 (59.9)	53 (41.4)	9.011	0.003
	>35	55 (40.1)	75 (58.6)		
Cultural level	Junior high school and below	72 (52.6)	61 (47.7)	0.635	0.425
	High school and above	65 (47.4)	67 (52.3)		
Parity	Primipara	61 (44.5)	70 (54.7)	2.734	0.08
	Multipara	76 (55.5)	58 (45.3)		
Daily sleep duration (h)	-	7.2±1.4	7.2±1.3	0.298	0.766
Daily liquid intake (ml)	-	2914.6±500.1	3012.3±409.3	1.733	0.084
Pain score 48 hours postpartum	≤3	109 (79.56)	51 (39.84)	43.636	<0.001
	≥4	28 (20.44)	77 (60.16)		
Early contact sucking (n,%)	Yes	115 (83.9)	90 (70.3)	7.018	0.008
	No	22 (16.1)	38 (29.7)		
Health education during pregnancy (n,%)	Yes	127 (92.7)	121 (94.5)	0.369	0.543
	No	10 (7.3)	7 (5.5)		
Increase in BMI during pregnancy (kg/m2) (n,%)	<5.6	95 (69.3)	55 (43.0)	18.739	<0.001
	≥5.6	42 (30.7)	73 (57.0)		
Gestational hypertension (n,%)	Yes	116 (84.7)	96 (74.4)	4.317	0.038
	No	21 (15.3)	32 (25.6)		
Gestational diabetes (n,%)	Yes	15 (11.0)	99 (77.3)	6.550	0.010
	No	122 (89.1)	29 (44.8)		
Time of first milk expression (h) (n,%)	<6	92 (67.2)	76 (59.4)	1.725	0.189
	≥6	45 (32.9)	52 (40.6)		
Postpartum depression (n,%)	Yes	20 (14.6)	81 (63.3)	17.140	<0.001
	No	117 (85.4)	47 (36.7)		
DOL (n,%)	-	21 (15.3)	31 (24.2)	3.316	0.069

Table 4: Variable assignment

Variable	Assignment description
Age	≤35=0, >35=1
Increase in BMI during pregnancy	<5.6kg/m2=0, ≥5.6kg/m2=1
Pain score ≥4 at 48h postpartum	No=0, Yes=1
Gestational hypertension	No=0, Yes=1
Gestational diabetes	No=0, Yes=1
Early contact sucking	Accept=0, Not accepted=1
Postpartum depression	No=0, Yes=1

Table 5: Independent influences on lactation insufficiency in cesarean section mothers

Variable	β	S.E	Wald χ2	OR	P	95%CI
Age > 35	0.912	0.359	6.454	2.489	0.011	1.232~5.031
Increase in BMI during pregnancy ≥5.6kg/m2	0.339	0.112	9.161	1.404	0.002	1.127~1.748
Pain score ≥4 at 48h postpartum	0.519	0.198	6.871	1.680	0.009	1.140~2.477
Gestational diabetes	0.683	0.207	10.887	1.980	0.001	1.320~2.970
Gestational hypertension	0.425	0.218	3.801	1.530	0.052	0.998~2.345
Early contact sucking	-2.424	0.974	6.194	0.089	0.013	0.013~0.598
Postpartum depression	0.129	0.048	7.233	1.138	0.007	1.036~1.250

Table 6: Effect of different feeding practices on the nutritional status of infants

Grouping	Number	Kaup index at birth			Kaup index at 6-month follow-up		
		Obesity	Normal	Malnutrition	Obesity	Normal	Malnutrition
Exclusive breastfeeding	136	10 (7.3)	110 (80.9)	16 (11.8)	12 (8.8)	121 (89.0)	3 (2.2)
Partial breastfeeding	92	6 (6.5)	74 (80.5)	12 (13.0)	5 (5.4)	79 (85.9)	8 (8.7)
Non-breastfeeding	37	3 (8.1)	29 (78.4)	5 (13.5)	2 (5.4)	30 (81.1)	5 (13.5)

The results showed that the proportion of mothers aged ≤35 years was higher in the lactation-sufficient group (59.9% vs 41.4%), as was the proportion of mothers with a pain score of ≤3 at 48 hours postpartum (79.56% vs 39.84%), and the proportion of those exposed to early suckling was significantly higher than that of the lactation-sufficient group (83.9% vs 70.3%). In addition, the proportion of women with a maternal BMI increase of <5.6 kg/m² during pregnancy was higher in the lactation-sufficient group (69.3% vs 43.0%), with a lower prevalence of gestational hypertension and gestational diabetes mellitus, as well as a lower incidence of postpartum depression (14.6% vs 63.3%). Table 3

Independent influences on lactation insufficiency in cesarean section mothers

The variable assignment situation in the Logistic regression analysis is shown in Table 4. By multifactorial logistic regression analysis, it was found that age >35 years (OR=2.489, 95% CI: 1.232~5.031, P=0.011), increase in BMI during pregnancy ≥5.6 kg/m² (OR=1.404, 95% CI: 1.127~1.748, P=0.002), pain score of ≥4 at 48 hours postpartum (OR=1.680, 95% CI: 1.140-2.477, P=0.009), combined gestational diabetes mellitus (OR=1.980, 95% CI: 1.320-2.970, P=0.001), and postpartum depression (OR=1.138, 95% CI: 1.036-1.250, P=0.007) were the insufficient lactation in

women who had cesarean delivery independent risk factor for lactation insufficiency in cesarean section mothers (Table 5). Receiving early exposure to suckling was a protective factor (OR=0.089, 95% CI: 0.013-0.598, P=0.013). table 4 and 5.

Effect of different feeding practices on the nutritional status of infants

was no statistically significant difference in the comparison of Kaup's nutritional status at birth among the three groups (Hc=0.126, P=0.939). Comparison of nutritional status among the three groups at 6 months of follow-up was statistically significant (Hc=6.773, P=0.034), with the exclusively breastfed group being superior to the partially breastfed group (Uc=2.070, P=0.038) and the non-breastfed group (Uc=2.201, P=0.028), as shown in Table 6.

Discussion

Cesarean section is a common mode of delivery in modern obstetrics, and its impact on maternal postpartum lactation has been a focus of clinical attention[16]. Breastfeeding is crucial to the growth and development of newborns, however, insufficient lactation after cesarean section is a common problem, which seriously affects the continuity and success of breastfeeding. Addressing this issue is therefore not merely about improving lactation metrics, but about safeguarding the foundational health of the next generation and empowering maternal recovery. In this study, we analysed the factors influencing the amount of postpartum lactation and lactation insufficiency by following up 265 cesarean section mothers for a period of 6 months.

The results showed that lactation within 72 hours postpartum was mainly concentrated in 25-48 hours, and the incidence of DOL was 19.6%. Multifactorial logistic regression analysis showed that age >35 years, increase in BMI during pregnancy ≥5.6 kg/m², pain score ≥4 at 48 hours postpartum, comorbid gestational diabetes mellitus, and postpartum depression were risk factors for postpartum lactation insufficiency in cesarean section mothers, whereas acceptance of early contact suckling was a protective factor. In addition, the nutritional status of infants in the exclusively breastfed group was better than that of the partially breastfed and non-breastfed groups at the last follow-up.

In this study, age >35 years was found to be an independent risk factor for postpartum lactation insufficiency in cesarean section mothers. Breast tissue in advanced maternal age may undergo degenerative changes (e.g. reduction in the number of mammary alveoli, reduced function of the ductal system) as a result of ageing, thus affecting lactation[17]. Ageing may lead to changes in hormone levels in the body, affecting the secretion of lactation-related hormones[18]. For example, prolactin is a key hormone in maintaining lactation and its secretion is regulated by the hypothalamic-pituitary-ovarian axis[19]. Older women may have reduced sensitivity of the endocrine axis, resulting in insufficient prolactin secretion, which in turn affects milk secretion[20].

An increase in BMI of ≥5.6 kg/m² during pregnancy is also a risk factor for insufficient lactation. Excessive weight gain during pregnancy may lead to disturbances in the metabolism of body fat in the mother's body, affecting the supply of nutrients and hormone levels to the breast tissue[21,22]. In addition, a high increase in BMI may also increase the risk of gestational diabetes, which in turn may indirectly affect lactation[23]. Therefore, it is recommended that weight gain be reasonably controlled during pregnancy to avoid excessive obesity. At the same time, more careful pregnancy management and postnatal care should be provided to women of advanced maternal age to promote the recovery of lactation function. Collectively, these findings argue for a more stratified approach to postnatal care. Rather than a one-size-fits-all model, mothers presenting with these identifiable risk factors (advanced age, excessive BMI gain, gestational diabetes) warrant early flagging and intensified, multidisciplinary support to preempt lactation difficulties.

Postpartum pain is another risk factor for insufficient lactation. Cesarean section is a traumatic procedure and postoperative pain may lead to an increased stress response in the maternal body, affecting the normal regulation of the endocrine system[24]. Studies have shown that pain may activate the sympathetic nervous system and inhibit the release of prolactin, which can lead to a reduction in milk secretion[25]. In addition, the pain affects the mother's mood and quality of sleep, further

interfering with the lactation reflex and leading to insufficient lactation. In addition, the results of this study also showed a significant association between postpartum depression and lactation insufficiency. Initiation and maintenance of lactation depends on the coordinated action of prolactin and oxytocin, and postpartum depression may interfere with this process through abnormal activation of the hypothalamic-pituitary-adrenal axis (HPA axis)[19,26]. Studies have shown that the cortisol levels of depressed parturients are usually elevated, and high cortisol can negatively feedback inhibit the hypothalamus from releasing corticotropin-releasing hormone (CRH), thereby affecting the secretion of prolactin by the anterior pituitary gland[27].

It is worth noting that early exposure to suckling is a protective factor against insufficient lactation. This may be due to the fact that neonatal suckling directly stimulates nipple nerve endings, which promotes oxytocin and prolactin secretion and accelerates the opening of the milk ducts[28]. This result supports the clinical practice of early implementation of mother-infant skin-to-skin contact during the 'golden hour' of the postpartum period. Mothers with comorbid gestational diabetes have a higher risk of insufficient lactation, which may be related to mammary vasculopathy and altered milk composition (e.g. abnormal lactose content) in a hyperglycaemic environment[29].

In addition, this study found for the first time that the 6-month Kaup index of exclusively breastfed infants was superior to that of other groups, suggesting the positive impact of breastfeeding on the long-term nutritional status of infants. Active components in breast milk (e.g. lactoferrin, oligosaccharides) not only promote gut flora colonisation, but may also epigenetically regulate metabolism-related gene expression and reduce the risk of obesity[30]. This finding may help to optimise maternal and infant care strategies, increase breastfeeding rates and ensure healthy infant development. Ultimately, the goal is to shift the clinical paradigm from reactively managing lactation failure to proactively building maternal capacity for successful breastfeeding. This requires integrating pain management, psychological screening, and lactation support into a seamless continuum of care for the cesarean-delivering mother, starting from the immediate postpartum period.

Study strengths and limitations

This study has notable strengths, including a longitudinal design with 6-month follow-up of 265 cesarean section mothers, enabling dynamic tracking of lactation changes and long-term infant nutritional outcomes (via 6-month Kaup index). It also employed standardized lactation volume measurement (unified medical-grade breast pump, calibrated syringes) and clear definitions for key variables (e.g., DOL, lactation insufficiency), enhancing result reliability. Additionally, comprehensive screening of influencing factors (demographic, physiological, clinical, behavioral, psychological) and use of multivariate logistic regression (with Hosmer-Lemeshow test for model fit) allowed accurate identification of independent factors, while linking breastfeeding patterns to infant health boosted clinical relevance. However, limitations exist: the single-center sample restricts generalizability to other regions/settings; lactation volume measurement relied on expressed milk (not direct infant intake) and omitted milk composition analysis; no mechanistic exploration (e.g., hormone testing, breast imaging) verified causal pathways; and unmeasured confounders (e.g., socioeconomic status, family support) may have impacted results. For practice, it highlights targeted interventions for high-risk groups (e.g., advanced age, gestational diabetes) and promoting early contact suckling as standard care; policy-wise, it supports strengthening perinatal breastfeeding support and reducing healthcare disparities. Future multi-center studies should integrate direct intake measurement, mechanistic tests, and longer follow-up.

Conclusion

This study systematically analysed the amount of lactation and the related factors affecting it in cesarean section mothers. The following conclusions were drawn: postpartum lactation of cesarean section mothers was concentrated in the 25-48h period, the incidence of DOL was 19.6%, the rate of exclusive breastfeeding was 51.3%, and the rate of insufficient lactation was 48.3%. Age >35 years, BMI increase ≥5.6 kg/m² during pregnancy, pain score ≥4 at 48h postpartum, gestational diabetes mellitus, and postpartum depression were the risk factors for postpartum lactation insufficiency in

cesarean section mothers, and receiving early contact suckling was a protective factor. The Kaup index of infants in the exclusive breastfeeding group was better than that of the partially breastfeeding and non-breastfeeding groups at the last follow-up, indicating that breastfeeding has a positive effect on the long-term nutritional status of infants. Beyond merely identifying risk factors, this study provides a clinically actionable framework for mitigating lactation failure in a vulnerable population. In clinical practice, targeted interventions should be carried out for caesarean section mothers, focusing on high-risk factors, encouraging early exposure to sucking, improving breastfeeding rates, and protecting the health of mothers and infants.

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