The effects of Continuous quality improvement program on the incidence of nosocomial infection and complications in very preterm infants

Abstract

Purpose: By implementing continuous quality improvement in hospital infections, the incidence of complications in extremely preterm infants is reduced.

Methods: Extremely preterm infants admitted to the Neonatal Intensive Care Center of Gansu Maternal and Child Health Hospital from January 2021 to December 2022 were selected as the research subjects. The period before the implementation of quality improvement measures (from January 2021 to December 2021) was set as the control group, and the period after the implementation of quality improvement measures (from January 2022 to December 2022) was set as the intervention group. The admission baseline data were compared between the two groups. The incidences of complications in the two groups were also compared, and a multivariate logistic regression model was used to adjust for confounding factors.

Results:A total of 623 extremely preterm infants were included, with 295 in the control group and 328 in the intervention group. The TRIPS score and body temperature in the intervention group were higher than those in the control group, and the differences were statistically significant ($P < 0.05$). Multivariate logistic regression analysis showed that compared with the control group, the intervention group had a reduced risk of developing stage II or higher necrotizing enterocolitis (adjusted OR = 0.552, 95%CI 0.350 - 0.871, $P < 0.05$), moderate to severe bronchopulmonary dysplasia (adjusted OR = 0.523, 95%CI 0.326 - 0.839, $P < 0.05$), and retinopathy of prematurity (ROP) (adjusted OR = 0.566, 95%CI 0.330 - 0.973, $P < 0.05$).

Conclusion: The implementation of continuous quality improvement of nosocomial infections can effectively reduce the incidences of complications in extremely and extremely low birth weight preterm infants.

Keywords: Very preterm infant, Nosocomial infection, Quality improvement, Complications.

Introduction

Extremely preterm infants, defined as those with a gestational age of less than 32 weeks, are at high risk for nosocomial infections due to their immature development, low birth weight, and the need for respiratory support, invasive procedures, parenteral nutrition (PN), and antibiotic treatment. Nosocomial infections not only increase the mortality and morbidity of extremely preterm infants but also prolong hospital stays and lead to poor neurological outcomes. In recent years, the evidence-based practice

for improving quality (EPIQ) method developed by Professor Lee of the Canadian Neonatal Network has achieved significant results in reducing nosocomial infections and improving outcomes in preterm infants. Studies from Germany, Italy, and Spain have also shown that the use of neonatal network monitoring systems can reduce nosocomial infections and improve outcomes in preterm infants. This study references the EPIQ method, analyzes data from the China Neonatal Network (CHNN), and develops a continuous quality improvement strategy for nosocomial infections in extremely preterm infants to explore the impact of continuous quality improvement on nosocomial infections and complications in extremely preterm infants.

Materials and Methods

1. Study Subjects: Extremely preterm infants admitted to the Neonatal Intensive Care Unit (NICU) of Gansu Maternal and Child Health Hospital from January 2021 to December 2022 were selected as the study subjects. Inclusion criteria: (1) gestational age < 32 weeks; Exclusion criteria: (1) infants with intrauterine infections; (2) infants with congenital malformations; (3) infants who died within 72 hours of birth or whose parents signed a waiver of treatment. This study was approved by the hospital's ethics committee (GSFY Ethics Approval [2021] No. 63), and informed consent was obtained from the parents of the infants.

2. Research Methods:

-Study Type and Grouping: A prospective case-control study. Based on the implementation of quality improvement measures, the study subjects were divided into a control group (January 2021 to December 2021) and an intervention group (January 2022 to December 2022).

Data Collection: (1) Baseline data: ID, gender, gestational age, birth weight, 5-minute Apgar score, Transport Risk Index of Physiologic Stability (TRIPS) score, and body temperature. (2) Intervention measures: Hand hygiene compliance rate, invasive mechanical ventilation, central venous catheter use, PN, breastfeeding rate, and antibiotic use rate. (3) Nosocomial infection data: Sepsis (including confirmed sepsis and clinical sepsis), lower respiratory tract infections (excluding ventilator-associated pneumonia, VAP), catheter-related bloodstream infections (CRBSI), ventilator-associated pneumonia (VAP), purulent meningitis, urinary tract infections, and skin and mucosal infections. (4) Complications: Stage II or higher necrotizing enterocolitis (NEC), moderate to severe bronchopulmonary dysplasia (BPD), retinopathy of prematurity (ROP), grade III-IV intraventricular hemorrhage (IVH) or periventricular leukomalacia (PVL), and death. Severe neurological injury was defined as grade III-IV IVH or PVL. The diagnostic criteria for the above diseases were based on the fifth edition of "Practical Neonatology," the research protocol of the CHNN Quality Improvement Research Group, and the "Diagnostic Criteria for Nosocomial Infections (Trial)" issued by the Ministry of Health of the People's Republic of China.

3. Continuous Quality Improvement Measures:

-Hand Hygiene: To strengthen hand hygiene supervision, cameras were installed in

each room, and a specialist team reviewed 24-hour video footage daily for 1 hour and provided timely feedback for daily improvements.

Invasive Procedure Management: Disposable ventilator circuits and closed suction systems were used for ventilators. For central venous catheters, a bundle management strategy was adopted, using the Seldinger technique for catheter placement, switching from upper limb to lower limb puncture, removing umbilical venous catheters within 10 days, and removing central catheters immediately after enteral nutrition reached 120 mL/kg/day.

Antibiotic Management: The time for reviewing blood indicators for prophylactic antibiotic use was reduced from 72 hours to 48 hours, and antibiotics were discontinued promptly if no abnormalities were found.

Enteral Feeding Management:A breast milk express service was introduced to increase the breastfeeding rate. Pasteurization was discontinued for maternal breast milk, and all extremely preterm infants received fresh colostrum for "oral immune" therapy upon admission. For infants without maternal breast milk, the rate of donor breast milk feeding was increased.

Equipment Management: Disinfectant wipes were used to strengthen the disinfection of frequently touched surfaces. Surface wiping was increased from twice a day to three times a day, with dedicated personnel supervising the process.

4. Statistical Analysis:SPSS 26.0 software was used for data analysis. Non-normally distributed measurement data were expressed as M (Q1, Q3), and group comparisons were performed using the Mann-Whitney U test. Count data were expressed as cases (%), and group comparisons were performed using the chi-square test or Fisher's exact test. A multivariate logistic regression model was used to analyze the impact of continuous quality improvement on complications in extremely preterm infants, adjusting for baseline data such as gestational age, weight, gender, 5-minute Apgar score, TRIPS score, and body temperature. $P < 0.05$ was considered statistically significant.

Results

1. Baseline Data: From January 2021 to December 2022, a total of 669 extremely preterm infants were admitted to the NICU. After excluding 9 infants with congenital malformations, 37 infants who died within 72 hours of birth or whose parents signed a waiver of treatment, and 20 infants with intrauterine infections, a total of 623 infants were included in the analysis, with 295 in the control group and 328 in the intervention group. The TRIPS score and body temperature in the intervention group were higher than those in the control group, and the differences were statistically significant ($P < 0.05$). See Table 1.

Table 1. Comparison of Baseline Data Between the Two Groups

Group	Number	Male[a]	Birth Weifht(g)[b]	Gestational	5-minute Apgar	TRIPS Score[b]	BodyTemperature(℃)[b]

	r			Age(days)[b]	Score[b]			
Control	295	164(55.60)	1320(1100,1520)	210(200,217)	)	8(8,9 | 8)	22(19,2	36(35.5,36.3)
Intervention	328	187(57.01)	1295(1060,1490)	210(199,216)	)	9(8,9 | 0)	28(21,3	36.2(36,36.5)
χ^2/Z	-	0.127	-1.185	-0.795	3	-0.64		2.392	5.972
P	-	0.721	0.236	0.426		0.520		0.017	＜0.001

Note: TRIPS = Transport Risk Index of Physiologic Stability; ^a^ expressed as cases (%), statistical value = χ^2; ^b^ expressed as M (Q1, Q3), statistical value = U.

2. Mortality and Complications Before and After Quality Improvement: The incidence of stage II or higher NEC in the intervention group was significantly lower than that in the control group ($P < 0.05$). There were no significant differences in mortality, moderate to severe BPD, ROP, or severe neurological injury between the two groups ($P > 0.05$). After adjusting for confounding factors, the intervention group had a reduced risk of stage II or higher NEC, moderate to severe BPD, and ROP ($P < 0.05$). See Tables 2 and 3.

Table 2. Comparison of Mortality and Complications Between the Two Groups [Cases (%)]

Group	Number	Mortality[a]	StageIIor HigherNEC	Moderate to Severe BPD	ROP	Severe Neurological Injury
Control	295	35(11.86)	58(19.66)	78(26.44)	1)	54(18.3	47（15.93）
Intervention	328	36(10.98)	42(12.80)	65(19.82)	3)	47(14.3	41（12.5）
χ^2		0.12	5.42	3.85		1.81	1.51
P		0.727	0.02	0.05		0.179	0.219

Note: ^a^ Mortality refers to the total mortality of extremely preterm infants: (in-hospital deaths + palliative care + advanced life support) / total number of extremely preterm infants; NEC = necrotizing enterocolitis, BPD = bronchopulmonary dysplasia, ROP = retinopathy of prematurity, severe neurological injury = grade III-IV intraventricular hemorrhage (IVH) or periventricular leukomalacia (PVL).

Table 3. Logistic Regression Analysis of Mortality and Complications Between the Two Groups [Adjusted OR (95% CI)]^a^

Group	Mortality	StageIIor HigherNEC	Moderate to Severe BPD	ROP	Severe Neurological Injury
Control	OR＝1	OR＝1	OR＝1	OR＝1	OR＝1
Intervention	0.811(0.481,1.370)	0.552(0.350,0.871)[a]	0.523(0.326,0.839)[a]	0.566(0.330,0.973)[a]	0.411(0.359,1.042)

Note: ^a^ Adjusted for gestational age, weight, gender, 5-minute Apgar score, TRIPS score, and body temperature; ^b^ $P < 0.05$.

3. Discussion

3.1 Current situation of nosocomial infections in extremely preterm infants in our hospital

With the development of perinatal medicine in China, the treatment level for extremely preterm infants has significantly improved. However, the mortality and complications related to preterm birth are still higher than those in developed countries [10]. Nosocomial infection is one of the important causes of death and complications in extremely preterm infants [11, 12]. This study found that the TRIPS score and body temperature of the intervention group were higher than those of the control group, and the differences were statistically significant. The total nosocomial infection rate of extremely preterm infants in the control group was 38.98%, and the episode infection rate was 45.4%. This is similar to the research results of Zhang Deshuang, Ning Yanan and other domestic researchers, where the incidence of nosocomial infections in extremely preterm infants is 37.8% - 38.85% [13, 14]. The total nosocomial infection rate of the intervention group was 34.15%, and the episode infection rate was 36.9%, which is lower than the above levels, indicating that the incidence of nosocomial infections shows a downward trend through continuous quality improvement. Professor Lee from Canada [4] and other researchers showed that the incidence of nosocomial infections in extremely preterm infants was 24% - 32%, suggesting that the nosocomial infection rate of extremely preterm infants in our unit is still higher than the foreign level.

3.2 Incidence of nosocomial infection-related mortality and complications in extremely preterm infants

Continuous quality improvement can not only reduce the occurrence of nosocomial infections but also reduce the occurrence of complications in extremely preterm infants. Through continuous quality improvement, Professor Lee from Canada was able to reduce the nosocomial infection rate in preterm infants from 32% to 24%, the incidence of severe retinopathy of prematurity (ROP) from 17% to 13%, and necrotizing enterocolitis (NEC) from 10% to 8%, while there was no significant

change in bronchopulmonary dysplasia (BPD) and severe nervous system injury [4]. Wannasiri [15] and other researchers found that when the nosocomial infection rate decreased from 24.7% to 15%, the incidence of BPD in extremely preterm infants could decrease from 35% to 30%. This study showed that continuous quality improvement could reduce the incidences of NEC at stage II and above, moderate to severe BPD, and ROP, which is similar to the above results. However, there was no significant decrease in mortality or severe nervous system injury, which may be related to the fact that the level of purulent meningitis in this study did not decrease significantly. Yu Yonghui and others [11] conducted a multicenter prospective cohort study and found that in very low birth weight infants with late-onset sepsis and purulent meningitis, the mortality rate and the incidence of severe nervous system injury could be increased. This study showed that there was no significant decrease in the mortality rate, which was also reflected in the relatively large number of children who were discharged from the hospital after signing by their families. According to the data report of CHNN in 2021, the mortality rate of extremely preterm infants actively treated in our hospital was 0.60%, which was lower than the national average level (3.66%), while the mortality rate including the children whose families signed to give up treatment and were expected to die was 13.78%, which was significantly higher than the national average level (10.30%). The main reasons for signing and discharging the children from the hospital included that the condition of the children was stable and the families considered issues such as prognosis and costs, intracranial hemorrhage, or the children were seriously ill.

Although this study showed that there was no statistically significant difference in severe nervous system injury, the incidence of severe nervous system injury in the intervention group showed a downward trend, which still has clinical significance. Foreign studies have shown that nosocomial infections are not only related to short-term nervous system injury but also to long-term nervous system dysplasia. A study in France [16] found that infections in extremely and very preterm infants were related to the outcomes of neurodevelopmental impairment at the age of 5. A meta-analysis in Switzerland [17] also found that neonatal sepsis was related to long-term nervous system dysplasia and would increase the risk of cerebral palsy. Therefore, actively controlling nosocomial infections and reducing complications may bring long-term benefits.

Limitations: This study is a single-center study with a relatively small sample size, and its results need to be further verified in the process of continuous quality improvement. In this study, extremely and very preterm infants were included, and there was a relatively high rate of signing for discharge, which may underestimate the nosocomial infection rate and episode infection rate and overestimate the mortality rate.

There is a relatively high mortality rate and incidence of complications in extremely and very preterm infants in our hospital. Implementing continuous quality

improvement measures can effectively reduce the incidences of NEC at stage II and above, moderate to severe BPD, and ROP, but there is no significant decrease in the incidences of death and severe nervous system injury. In the later stage, our hospital will continue to improve the construction of the quality improvement team for nosocomial infections, rationally allocate human and material resources, and continuously promote the implementation of new measures, such as the use of minimally invasive pulmonary surfactant (PS), digitalized management of peripherally inserted central catheters (PICC), reducing the use of prophylactic antibacterial drugs, strengthening the monitoring of hand hygiene after contact with children, and increasing the breastfeeding rate.

Conflict of Interest: All authors declare that there is no conflict of interest.

Authors' Contributions Statement: Wang Min: Study design, paper writing; Shi Jingyun, Yi Bin: Study design, statistical analysis; Sun Qiangyong: Data collection and collation; Zhao Fangping: Study guidance, paper revision.

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