ORIGINAL ARTICLE

Prevention of Admission Hypothermia in Low-Birth-Weight Infants Through PDSA Cycle of Quality Improvement Initiative

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Background: Admission hypothermia (AH) is one of the key indicators in quality care of preterm infants. Unfortunately, AH rate in the authors' institution was high. Therefore, the authors had set up quality improvement initiatives (QI) to improve rate of AH in the authors' institution.

Objective: To assess the effectiveness of the authors' QI to reduce AH in infants less than 2,000 g.

Materials and Methods: The present study was a retrospective evaluation of the authors' QI program. The enrolled infants were inborn with birthweight less than 2,000 g, admitted in the NICU directly after birth. The QI consisted of increasing resuscitation area temperature (RT), use of heat protective measures, and transported with prewarmed transport incubator. Effectiveness, rate of admission hypothermia, and admission temperature (AT) were selected as QI outcomes. The outcomes were compared between pre-QI period and post-QI period.

Results: There were 117 and 133 infants in pre-QI and post-QI period, respectively. RT were 24.7±1.48°C and 24.8±1.04°C, AT increased from 36.4±0.85 °C to 36.7±0.60°C and incidence of hypothermia were decreased from 50.4% to 30.8%, in pre and post QI period ($p<0.05$).

Conclusion: The authors' QI effectively reduced AH in infants under 2,000 g.

Keywords: Preterm; Hypothermia; Quality improvement

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Admission hypothermia (AH) is one of the most serious problems in preterm newborn care[1,2]. Premature infants are susceptible to rapid heat loss because of their relatively large surface area, limited subcutaneous brown fat, thin epidermis, and inability to shiver[3]. Most premature infants need to be evaluated and resuscitated under a radiant warmer. As heat is lost through conduction, convection, radiation, and evaporation, ambient temperature plays an important role in controlling an infant's temperature.

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AH is strongly associated with mortality and late-onset sepsis, according to data since 2007 from the Neonatal Research Network, which has increased awareness of the importance of admission temperature (AT)[4-7]. Quality improvement initiatives (QI) to reduce AH, including warmer labor room temperatures, polyethylene wrap, prewarmed transport incubators, and heated humidified gas during resuscitation, have been implemented in various countries[8-10].

Even though the present study climate is tropical, AH in low-birth-weight infants occurs too frequently at the authors' institution. Therefore, the authors had established initiatives to improve ATs in infants under 2,000 g. The following was a description of the present study QI program between 2016 and 2018.

Materials and Methods

The present study was a retrospective review of the authors' QI to prevent AH. The present study hospital is a university-based hospital located in suburban Bangkok. The hospital had more than 3,000 deliveries per year. There are 70 to 80 infants

Figure 1. Customized polyethylene suit designed by the authors' NICU nurses.

weighing less than 2,000 g admitted in the authors' neonatal intensive care unit (NICU) each year. In the past, AH occurred in more than 50% of these infants. In 2014, the authors implemented measures, such as caps and plastic wraps, to prevent AH in low-birth-weight infants. However, the proportions of infants under 2,000 g having ATs below 36.5°C were 58.6% and 65.5% in 2015 and 2016, respectively. Therefore, in early 2016 the authors set up a working group consisting of an obstetric nurse, an operative room nurse, a neonatal nurse, and a neonatologist, to develop quality initiatives to reduce the rate of AH in infants weighing less than 2,000 g.

The present study was divided into two periods, pre-QI and post-QI period. Infants were included in the present study weighed less than 2,000 g, born in Thammasat University Hospital, and admitted to NICU. Still births and infants who died before admission were excluded. Informed consent was waived because only standard care was given, which did not endanger patients more than usual, and only anonymous data were analyzed. Infants' axillary temperature was measured by digital thermometer upon admission to NICU.

In pre-QI period, June 2016 to September 2017, a 16-months period, intervention consisted of maintaining the temperature of the resuscitation area at 24°C to 28°C by adjusting air flow in the area, using polyethylene wraps and wool caps, prewarming the radiant warmer with 100% power, in this period the radiant warmer was an old model that could adjust only the power of the warmer, and prewarming the transport incubator (double-wall) to 36.5°C. Feedback included unsteady room temperature and insufficient supply of wool caps. Another criticism was that personnel were unskilled at applying the plastic wrap, rendering it ineffective as insulation and causing delays.

In post-QI period, October 2017 to September 2019, a 24-months period, the authors used polyethylene bags instead of wrap and folded stocking caps instead of knit wool caps. The operating room temperature was preset to 25°C, adjusted the inlet of air conditioner to the resuscitating area and kept the door to the resuscitation area closed to maintain that temperature. The radiant warmer was replaced with a more modern model and prewarmed to 37°C. In the last two months of the post QI period, the newborn staffs developed a specialized polyethylene suit easier to apply and encouraged physician to perform resuscitation without breaking the suit (Figure 1). However, the effectiveness of the specialized suit had not been analyzed. In the present study institution, only dry gas was used to resuscitate infants.

Resuscitating area temperature was selected as a process measure. Outcome measures were incidence of AH and core body temperature on arrival in infants weighing less than 2,000 g when admitted in NICU. Hypothermia was defined as body temperature less than 36.5°C. For safety concern, the authors also monitored the incidence of fever during QI program. Fever was defined as a core body temperature of 37.8°C or higher.

To assess the effectiveness of the present study program, incidence of AH and AT were analyzed every quarter (3-month period).

Sample size and statistical analysis

Based on the authors unpublished institutional data, 58.6% of preterm newborn admissions had AH in 2015. To reduce AH to 45%, the study needed at least 98 subjects to achieve the level of significance of 0.05, power 0.8.

Patient characteristics and AT data were analyzed using Stata, version 14 (StataCorp LP, College Station, TX, USA). Independent t-test and chi-square test were used for analyzing continuous and categorical data, respectively. A p-value less than 0.05 was consider statistically significant.

Table 1. Patient characteristics

Variables	Period 1 (n=117)	Period 2 (n=133)	p-value
Birthweight (g); mean±SD	1,433±341	1,464±357	0.492
Male; n (%)	54 (46.1)	68 (51.1)	0.449
Hypothermia; n (%)	59 (50.4)	41 (30.8)	0.002
Fever; n (%)	6 (5.13)	4 (3.01)	0.522
Admission temperature (°C); mean±SD	36.4±0.85	36.7±0.6	0.008
Resuscitation area temperature (°C); mean±SD	24.7±1.48	24.8±1.04	0.387

SD=standard deviation

Ethical approval

The present study protocol was approved by the Human Research Ethics Committee of Thammasat University (Medicine), MTU-EC-PE-0-264/63.

Results

Two hundred fifty infants with birthweight less than 2,000 g were enrolled in the present study. One hundred twenty-two were male (48.8%), and mean birthweight was 1,450±349 g. There were 117 infants born in the pre-QI phase and 133 infants born in the post-QI phase. There was no significant difference between groups in terms of gender and birthweight. Resuscitating area temperature remained the same between periods. AT was increased from 36.4±0.85°C, in the pre-QI to 36.7±0.6°C in the post-QI period, p=0.008. In the pre-QI period, 59 infants (50.4%) had AH compared to 41 (30.8%) in the post-QI period (p=0.002). For safety concern, there was no difference in the incidence of fever between the two periods as shown in Table 1. AT and AH are shown in Figure 2 and 3, respectively.

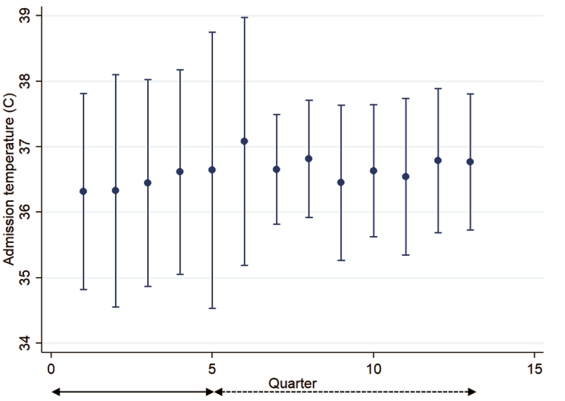

Figure 2. Mean admission temperature (°C) of participants with standard deviation errors bar.

Solid arrow represents pre-QI period, Dash arrow represents post-QI period

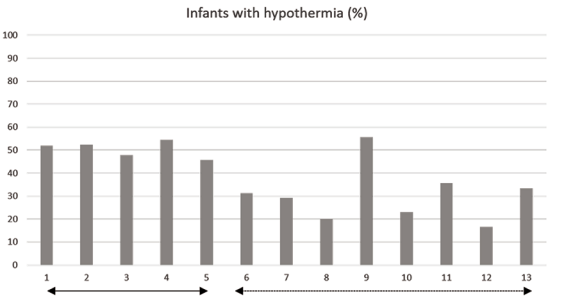

Figure 3. Proportion of infants with admission hypothermia in each quarter.

Bar graph show incidence of AH in each quarter, Solid arrow represents pre-QI period, Dash arrow represents post-QI period

Discussion

AH is one of the most adverse risk factors for very low birth weight (VLBW) infants[4-6,11,12]. In 2007, Laptook et al. reported an increase of mortality and late-onset sepsis in VLBW infants[4]. Since then, AT has become a major indicator of quality care in preterm infants.

Methods to reduce hypothermia in these infants include polyethylene wrap or bag, exothermal mattress, warmer delivery room temperature, and transport with prewarmed incubator[7,13,14]. Prevention of hypothermia in preterm infants requires collaboration between numerous medical specialists such as neonatologists, obstetricians, neonatal nurses, labor room nurses, and operating room nurses to implement and monitor improvements so that they are effective and sustainable.

These types of QI have been established in many parts of the world. The authors' study was consistent with similar studies from Europe[7], Brazil[8], USA[14,15], Singapore[16], and Korea[9], in that ATs were improved through a bundle of care and quality improvement methods.

The authors' early attempts to improve ATs focused on resuscitation area temperature, polyethylene wrap, and wool caps. These proved

insufficient. Then the authors set up a quality improvement program with a multidisciplinary care team including obstetricians, nurses from both neonatal and obstetric departments, and an operative room manager. Changes were gradually introduced through Plan-Do-Study-Act cycles. After using a single-sized polyethylene bag, the authors' nurses observed some difficulty when using the bag on different sized babies, so they developed a polyethylene suit that was custom-designed to be more practical for resuscitators.

In Figure 3, mean AT in each quarter gradually increased, but more importantly the range of AT was narrower, and fewer infants had fever or severe hypothermia. This clearly indicated that the authors' QI program was safe and effective.

There are limitations in the present study. First, because this was a quality improvement project from routine work, data collection was limited. Some of baseline characteristic of subjects were not collected such as maternal temperature and transport time from delivery area to NICU. As mentioned earlier, the authors have learnt that even if the authors had the recommended standard of care, without collaboration from all related disciplines, regular monitoring, and a care plan customized to the authors' own situation, outcomes might not be satisfactory.

In conclusion, the authors' quality improvement initiative effectively improved temperature care and reduced AH in their hospital.

What is already known on this topic?

Based on neonatal resuscitation guidelines, hypothermia in preterm infants must be prevented through a bundle of care such as use of a polyethylene bag, and a warm delivery room. However, the rate of AH is still high in parts of the world including Thailand.

What this study adds?

Effective prevention of AH needs a multi-disciplinary team, regular feedback and monitoring, and tailored guidelines based on local situation.

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Conflicts of interest

The authors declare no competing financial interests.

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