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Reducing hypothermia in preterm babies by usage of bubble wrap

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Objective: To determine if using bubble wrap in the routine care of preterm babies will reduce the incidence of hypothermia after transfer from the Neonatal Intensive Care Unit (NICU) to the High-Dependency Unit (HDU).

Materials and Methods: This is an interventional study conducted in a tertiary-level NICU (Bangalore, India) from April 2018 to September 2023. The study included 140 preterm babies with different gestational ages and birth weights who were shifted or admitted to the HDU during that period. The babies' vital parameters (heart rate, temperature, oxygen saturation, and respiratory rate) were monitored on a four-hourly basis for 2 days before and 2 days after intervention, and the results were recorded. Descriptive statistics were used for statistical analysis.

Results: The incidence of hypothermia before using bubble wrap was 44.3 %, while no cases of hypothermia were observed after its application. The mean temperature of the infants before using bubble wrap was 36.66 ± 0.06 °C, compared to 36.72 ± 0.06 °C afterward, with a p-value of 0.0001, indicating statistical significance.

Conclusion: Bubble wrap is a safe and cost-effective measure in preventing hypothermia in preterm infants.

Key words: INFANT, PREMATURE; HYPOTHERMIA; INTENSIVE CARE UNITS, NEONATAL; KANGAROO-MOTHER CARE METHOD

INTRODUCTION

An estimated 13.4 million babies were born preterm (before 37 completed weeks of gestation) in 2020 (1). Globally, prematurity is the leading cause of neonatal mortality, and hypothermia is one of its contributing factors. Overall, the prevalence of hypothermia in hospital-based studies ranges from 32 to 85 % (2). Preterm babies are vulnerable to heat loss due to immature thermoregulatory mechanisms and large surface area-to-body weight ratios (3). The World Health Organization (WHO) defines neonatal hypothermia as an axillary temperature below 36.5 °C among newborns aged below 28 days (4). Normal axillary temperature is 36.5 – 37.5 °C. Hypothermia has been classified based on severity as mild hypothermia/cold stress (36.0 - 36.4 °C), moderate hypothermia (32.0 - 35.9 °C), and severe hypothermia <32.0 °C. There are guidelines in place for managing each classified group of hypothermia. Every 1 °C drop in body temperature below

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36.5 °C has been found to increase the risk of mortality in low birthweight infants by 28 % (5). In addition, hypothermia at birth is associated with hypoglycemia, metabolic acidosis, sepsis, intraventricular hemorrhage, respiratory distress syndrome, necrotizing enterocolitis, and jaundice (6 - 8).

Newborns lose heat through radiation, evaporation, conduction, and convection, and it is vital to target these forms of heat loss to ensure they are kept warm (4). Thermal protection is recognized as a key component of essential newborn care. Hence, the WHO has established standard thermal guidelines, including the warm chain, which consists of a set of 10 procedures to reduce the likelihood of hypothermia in newborns at birth (4). The steps include warm delivery room, warm resuscitation, immediate drying, skin-to-skin contact, breastfeeding, postponed bathing and weighing, appropriate clothing and bedding, rooming in, warm transportation, and appropriate healthcare staff training.

For preterm infants, along with these guidelines, additional interventions like plastic polyethylene wraps, caps, and a thermal mattress (<32 weeks) and a prewarmed radiant warmer are recommended to be used at birth. To prevent heat loss and hypothermia during their Neonatal Intensive Care Unit (NICU) stay, preterm infants require a thermoneutral environment; therefore, several measures like single or double-walled incubators with humidifiers, servo-controlled radiant warmers, appropriate room temperatures, and proper handling are implemented. For stable preterm infants, warmth can be maintained through Kangaroo Mother Care (KMC) and cocoon warmers made from phase change materials.

To prevent hypothermia in preterm infants after NICU discharge, educating parents regarding maintaining a warm environment with room temperature of 24 - 25 °C, use of multiple layers of clothing, including caps and socks, to continue KMC, and to monitor the temperature of the baby using both the touch method and a digital thermometer is necessary. There are newer devices like the Hypothermia Alert Device (Bempu watch), which provides continuous real-time monitoring of the body temperature of newborns for early detection and intervention to prevent hypothermia (9). Despite existing measures, hypothermia continues to be a major concern for preterm and low birth weight infants, particularly in High-Dependency Unit (HDU), where continuous KMC is not possible, either because mothers are unable to stay in the hospital or they are unwell. In our study, we used plastic bubble wrap as an affordable alternative to help maintain normal body temperature and assess its effectiveness in preventing hypothermia in clinically stable preterm infants transferred to the HDU.

Plastic bubble wrap is a lightweight, flexible material made by bonding two layers of polyethylene film, creating rows of sealed air-filled pockets. These pocket straps act as an effective thermal barrier since air is a poor conductor of heat. This significantly reduces heat transfer through conduction. Additionally, the air pockets in bubble wrap prevent the movement of air, which helps minimize heat loss through convection, further boosting its insulating properties. This makes bubble wrap more efficient at maintaining temperature stability compared to standard plastic wrap, which lacks these air pockets.

OBJECTIVES OF THE STUDY

This study examined the effects of incorporating bubble wrap into the routine care of preterm neonates in reducing the incidence of hypothermia. We hypothesized that using bubble wrap would reduce the incidence of hypothermia in preterm babies, thus reducing the need for escalation of care or shifting to NICU.

MATERIALS AND METHODS

The study was conducted from April 2018 to September 2023 in a tertiary-level intensive care unit in Bangalore. This was a quasi-experimental study design with subjects serving as their own control. The Patient Intervention Comparison Outcome (PICO) model was used in the study. The study was designed and conducted by the authors, and the protocol was approved by the institutional ethical committee. Consent was taken from the parents or local guardians before recruitment.

Inclusion criteria were all clinically stable preterm babies (<37 weeks)with a weight of 1.5 - 2 kg admitted or shifted to HDU from NICU. All sick and

unstable newborns, premature infants with infections, respiratory distress, and congenital anomalies were excluded from the study. 142 preterm babies were included in the study after obtaining informed and written consent from their parents. Two babies were excluded as they had a fever during the study. The babies were studied at four-hourly intervals over different times of the day and night for four days, and the data were recorded. For the first 48 hours, babies were kept in the cradle wrapped with 2 layers of cotton cloth and a standard newborn blanket. Vitals were monitored every four hours. After 48 hours, babies were wrapped with an additional layer of plastic bubble wrap, and vitals were monitored for the next 2 days every four hours. The data were considered with and without intervention. The total study period for each baby was 96 hours. During the study period, if the temperature was less than 36.5 °C, protocols recommended repeating axillary temperature measurement immediately, followed by appropriate thermoregulatory interventions.

DATA COLLECTION

Data collected from medical record systems were recorded in Microsoft Excel sheets, including name, sex, gestational age, mode of delivery, birth weight, reason for NICU admission, age at enrolment, and weight. Four vital physiological parameters of the baby, namely temperature, respiratory rate, heart rate, and oxygen saturation, were recorded at four-hourly intervals. Axillary temperature was measured (in °C) by a digital thermometer. Respiratory rate was assessed by observing chest movements for a full minute. Heart rate and oxygen saturation were recorded with a pulse oximeter. Vitals were recorded at fourth-hourly intervals, and the data collection coincided with the routine nursing care. Vital parameters were monitored before and after the intervention.

STATISTICAL ANALYSIS

The collected data were entered into a Microsoft Excel spreadsheet and analyzed using Statistical Package for Social Sciences (SPSS 22). Descriptive data were presented in the form of percentages, frequencies, mean, and standard deviation (SD). The paired t-test was used to compare various study outcomes. P-value ≤ 0.05 was considered statistically significant.

RESULTS

In our study of 140 babies, 72 (51.4 %) were male and 68 (48.6 %) were female. Of these, 129 babies were delivered via Lower Segment Cesarean Section (LSCS), while 11 were born vaginally. The gestational ages (GA) of the babies ranged from 24 weeks + 4 days to 36 weeks + 6 days. Among them, there were 5 extreme preterm (<28 weeks of GA), 38 very preterm (28 - 32 weeks of GA), 46 moderate preterm (32 - <34 weeks of GA), and 51 late preterm (34 - <37 weeks of GA) infants. The birth weights varied from 0.66 kg to 1.96 kg, with a mean weight of 1.51 kg. Within this group, there were 12 extremely low birth weight (ELBW), 37 very low birth weight (VLBW), and 91 low birth weight (LBW) babies. The postnatal age of the infants at the time of enrolment in the study ranged from 4 to 134 days, with a mean age of 22.35 days. The postnatal weight of the infants ranged from 1.5 - 1.94 kg, with a mean weight of 1.61 kg.

The postnatal age at enrolment was 37 weeks for 35 infants, 38 to 40 weeks for 62 infants, 41 to 42 weeks for 34 infants, and more than 42 weeks for 9 infants (Table 1).

In our study of 140 babies, 78 were normothermic, while 62 were hypothermic before the intervention. The incidence of mild hypothermia was 27.9 %, and moderate hypothermia was 16.4 % (Table 2).

Graph 1 shows that the incidence of hypothermia before the intervention among LBW, VLBW, and ELBW babies was 40.7 %, 54.1 %, and 41.7 %, respectively. The highest incidence of mild hypothermia (28.6 %) was observed in LBW babies, while moderate hypothermia (27.0 %) was seen in VLBW babies. No baby developed severe hypothermia during the study.

Graph 2. illustrates that the highest incidence of mild hypothermia (29.6 %) and moderate hypothermia(21.3 %) was observed in babies weighing between 1.5 and 1.7 kg. There were cases of moderate hypothermia in the group weighing between 1.7 and <1.9 kg. There was no instance of hypothermia at all in babies weighing 1.9 to <2 kg.

Table 1. Baseline characteristics of the study group

Baseline characteristics	Baseline characteristics	Frequency (N=140)	Percent (%)
Sex	Male	72	51.4
	Female	68	48.6
Mode of delivery	LSCS	129	92.1
	NVD	11	7.9
Birth weight	ELBW (<1 kg)	12	8.6
	VLBW (1 - <1.5 kg)	37	26.4
	LBW (1.5 - <2.5 kg)	91	65.0
Gestational age at birth	Extreme preterm (<28 weeks)	5	3.6
	Very preterm (28 - <32weeks)	38	27.1
	Moderate Preterm (32 - <34 weeks)	46	32.9
	Late preterm (34 - <37 weeks)	51	36.4
Postnatal age at enrolment to study	< 7 days	16	11.4
	7 – 14 days	62	44.3
	15 – 30 days	31	22.1
	31 – 60 days	22	15.7
	>60 days	9	6.4
Postnatal weight at enrolment in the study	1.5 - <1.7 kg	108	77.1
	1.7 - <1.9 kg	30	21.4
	1.9 - <2 kg	2	1.4
Postnatal gestational age at enrolment in the study	>42 weeks	9	6.42
	41 - 42 weeks	34	24.2
	38 - 40 weeks	62	44.2
	37 weeks	35	25

Table 2. Incidence of hypothermia before intervention (bubble wrap)

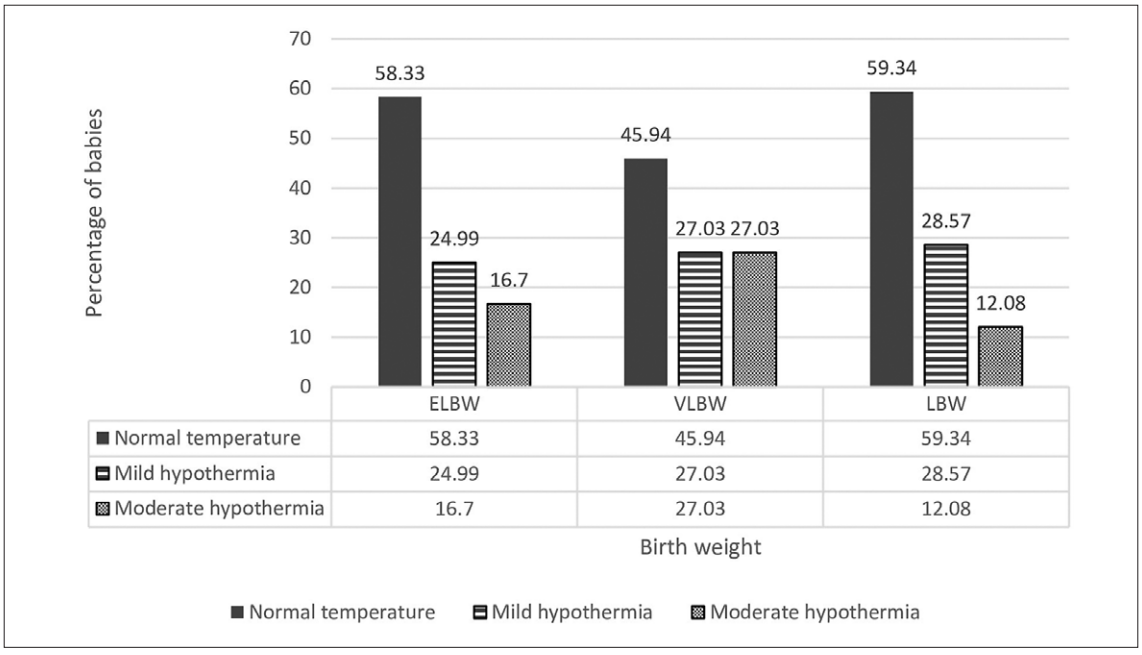
Temperature	Incidence of hypothermia before bubble wrap	
	Frequency (N=140)	Percent (%)
Normal (36.5 - 37.5 °C)	78	55.7
Mild Hypothermia (36 - 36.4 °C)	39	27.9
Moderate Hypothermia (32 - 35.9 °C)	23	16.4
Total	140	100

Graph 3. shows that the highest incidence of mild hypothermia (35.5 %) was found in the postnatal age group of 15-30 days, while the highest incidence of moderate hypothermia (22.2 %) was observed in babies older than 60 days.

As Table 3. illustrates, in our study, there were no instances of hypothermia following the use of bubble wrap in the study group.

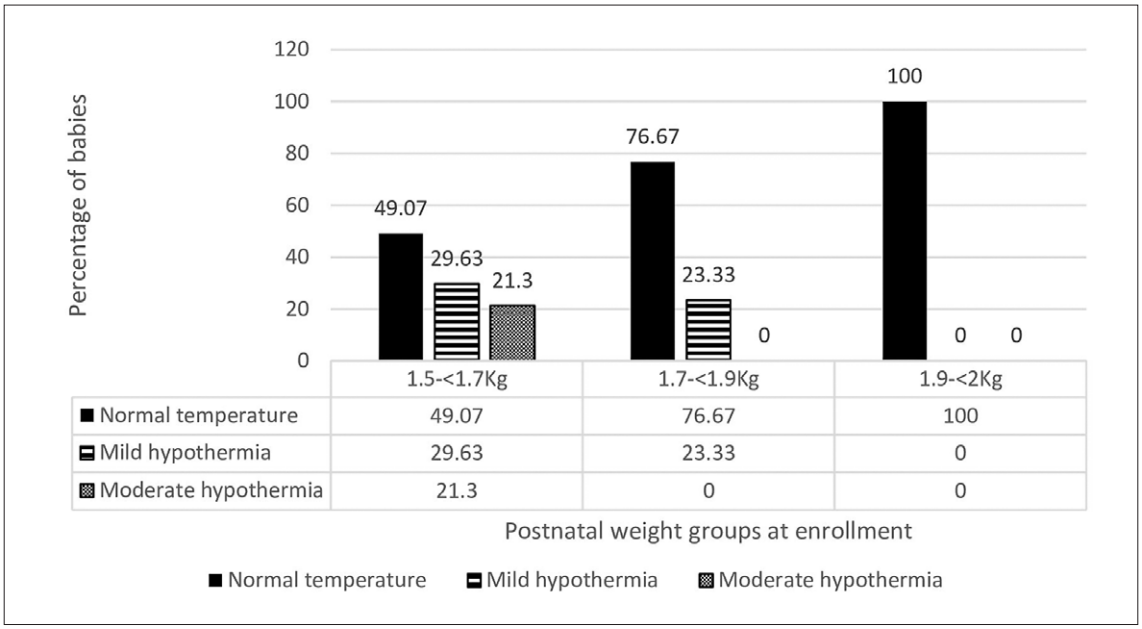
The incidence of hypothermia in babies in the group before using bubble wrap was 36.66 ± 0.06, while the mean temperature after using bubble wrap was 36.7 ± 0.06 °C, with a p-value of 0.0001, indicating statistical significance (Table 4).

The mean respiratory rate before bubble wrap was 42.52 ± 0.52, compared to 42.5 ± 0.51 after

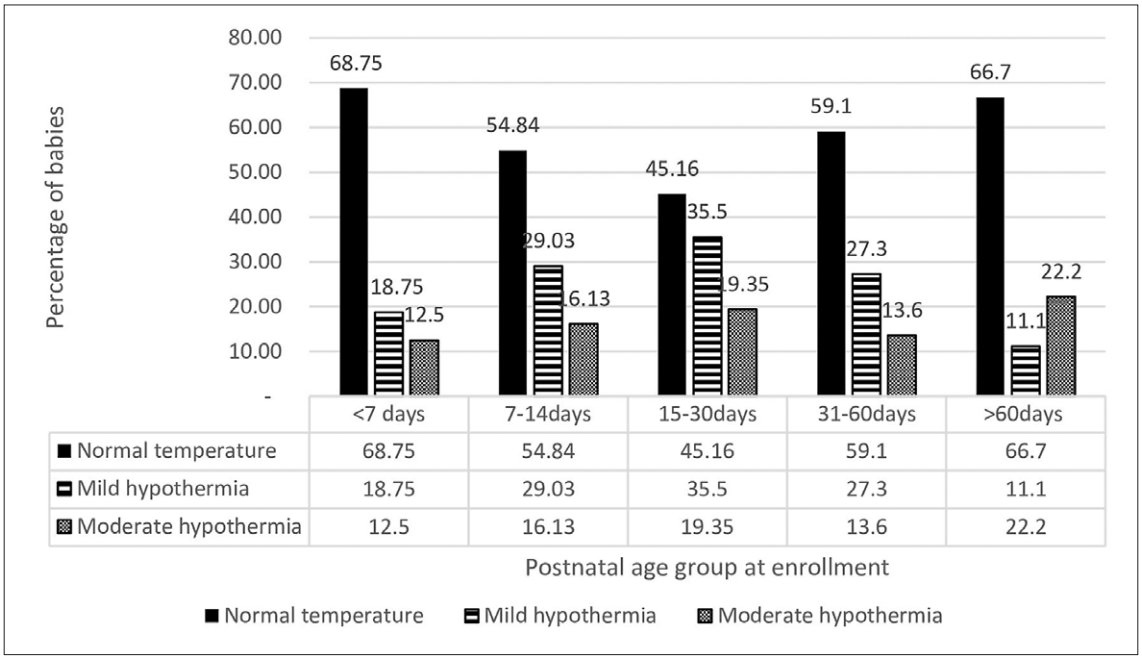


ELBW - Extreme Low birth weight; VLBW - Very low birth weight; LBW - Low birth weight

Graph 1. Incidence of hypothermia before intervention among different birth weight group



Graph 2. Incidence of hypothermia before intervention among different postnatal weight groups at enrollment in study



Graph 3. Incidence of hypothermia before intervention among different postnatal age groups at enrollment to study

using bubble wrap, which was also statistically significant with a p-value of 0.04. However, the differences in mean heart rate and mean oxygen saturation before and after using bubble wrap were not statistically significant.

DISCUSSION

Hypothermia, defined as core temperature below 36.5 °C by the WHO, is a serious and frequent problem that occurs in preterm babies due to their large body surface area, minimal subcutaneous fat, lesser brown adipose tissue, and skin immaturity. This causes increased risk of morbidity and mortality, poor weight gain, and long-term neurological impairment.

While several interventions are available to prevent hypothermia at birth and in NICU with the use of thermoregulation equipment such as

Table 3. Incidence of hypothermia after intervention (bubble wrap)

Temperature	Incidence of hypothermia after bubble wrap	
	Frequency (N=140)	Percent (%)
Normal (36.5 – 37.5 °C)	140	100
Mild hypothermia (36 – 36.4 °C)	0	0
Moderate hypothermia (32 – 35.9 °C)	0	0
Total	140	100

Table 4. Paired sample statistics of vital parameters before and after bubble wrap

Vital parameter	Before bubble wrap		After bubble Wrap		p value
	Mean	SD	Mean	SD	
Heart rate	142.81	5.04	142.78	5.01	0.38
Oxygen saturation	96.34	0.37	96.34	0.37	0.33
Temperature	36.66	0.06	36.72	0.06	0.0001
Respiratory rate	42.52	0.52	42.50	0.51	0.04

warmers and incubators, options become limited after the infants are transferred from NICU, with KMC and adequate clothing being the primary preventive measures. Only cloth wrapping without KMC in places where the environmental temperature is at a lower level is not adequate to maintain temperature in preterm babies with their limitations.

Our study aimed to evaluate the effectiveness of bubble wrap in reducing hypothermia among preterm infants in HDU.

The babies enrolled in this study did not have the option of KMC 24/7, which is proven to be of benefit to prevent hypothermia and is practiced worldwide. The reasons are that some babies were referred from tier 2 cities where parents lived, others who came for high-risk delivery to our center, but the mother went back to their hometown, thus unable to visit daily and provide KMC, and babies whose mothers were in the ICU or unwell. All these babies, once recovered from their primary illnesses, were off oxygen or any form of respiratory support, reached a gestational age above 37 weeks, weighed more than 1.5 kg, and established oral feeds were shifted from NICU to HDU care until optimal weight for discharge, which in our center is 1.8 kg, and temperature maintenance is achieved.

The incidence of hypothermia in these babies was noted to be high since they were not in warmers or incubators, and KMC was unavailable as a method of preventing hypothermia throughout the day. Hence, this method was studied as an alternative to prevent hypothermia in these babies.

Though hypothermia was expected to be more common in extremely low birth weight babies, in this study, it was not the case since these babies tended to stay in NICU under warmers and incubators for long due to their respiratory and other illnesses, and all were more than 42 weeks before meeting the discharge criteria to be shifted to HDU in this study. The incidence of hypothermia was noted to be higher in the very low birth weight infants than in the ELBW, as they went to HDU care earlier once the discharge criteria were met, but postnatal age-wise, they were still younger than their ELBW counterparts, who were more than 42 weeks of age. This study concentrated more on weight and hypothermia, as small for gestation age and preterm babies with a weight of less than 2 kg have less brown fat to tackle the cold stress. Plastic bags are used at birth to deliver babies under 32 weeks. There are a few reports about the use of bubble wrap for transporting preterm babies for procedures like CT/MRI, during transport from one center to another, but there are no studies for its use as a regular method of preventing hypothermia in stable babies post-discharge from NICU. This study aimed to address this population. There is no control group in this study; the standard incidence of hypothermia is used to compare the effectiveness.

The results were promising and aligned with the preventive practices mentioned earlier. No infants developed hypothermia after the application of bubble wrap, with a statistically significant increase in mean body temperature following its use. These results suggest that bubble wrap could serve as an effective, cost-efficient addition to existing hypothermia prevention practices.

This study introduces an affordable and effective method to prevent hypothermia in preterm infants in resource-limited settings and home care settings.

The incidence of hyperthermia or the baby remaining normothermic consistently for 3 days can be used as an endpoint for the use of bubble wrap. Nevertheless, in this study, reaching a weight of 2 kg was used as an endpoint.

Notably, this is the first study to examine the use of bubble wrap in the routine care of preterm infants as a method to reduce hypothermia, addressing a significant gap in the existing literature. This innovative approach has the potential to improve outcomes for this vulnerable population by offering a simple and accessible solution to a persistent clinical challenge. The future prospects are to extend this wrap for home care, resource-limited settings, and babies exposed to extreme cold in winters if a larger RCT trial proves its usefulness in preventing hypothermia.

However, considering that it is a quasi-experimental study, further research with randomized control trials, larger sample sizes, and control groups is needed to confirm the intervention's efficacy across different settings.

CONCLUSION

The adverse effects of hypothermia on preterm babies are well documented, emphasizing the importance of maintaining normal body temperature both in the NICU and after discharge to support optimal development. This study demonstrated that plastic bubble wrap is a cost-effective and safe intervention for preventing hypothermia in preterm infants, especially when KMC is not possible. In addition, its low cost, ease of use, and accessibility make bubble wrap an effective intervention, particularly in resource-limited settings, where it offers a practical approach for preterm care and can also play a crucial role in safe transport of preterm infants, during inter-facility transfers and within hospitals. However, additional research is needed to develop a standardized, widely applicable protocol for its use in home care.

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SAŽETAK

Smanjenje hipotermije kod prijevremeno rođene djece korištenjem mjehuraste folije

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Cilj: Utvrditi hoće li korištenje mjehuraste folije u rutinskoj njezi prijevremeno rođene djece smanjiti učestalost hipotermije nakon premještaja iz Jedinice intenzivne neonatalne skrbi u Jedinicu za neonatalnu skrb.

Materijali i metode: Ovo je intervencijska studija provedena na tercijarnoj Jedinici intenzivne neonatalne skrbi (Bangalore, Indija) od travnja 2018. do rujna 2023. Studija je obuhvatila 140 prijevremeno rođene djece različite gestacijske dobi i porođajne težine koja su premještena ili primljena na Jedinicu za neonatalnu skrb tijekom tog razdoblja. Vitalni parametri beba (otkucaji srca, temperatura, zasićenost krvi kisikom i frekvencija disanja) praćeni su svaka četiri sata tijekom 2 dana prije i 2 dana nakon intervencije, a rezultati su zabilježeni. Za statističku analizu korištena je deskriptivna statistika.

Rezultati: Učestalost hipotermije prije korištenja mjehuraste folije bila je 44,3 %, dok nakon njezine primjene nije uočen nijedan slučaj hipotermije. Prosječna temperatura dojenčadi prije korištenja mjehurićaste folije bila je 36,66 ± 0,06 °C, u usporedbi s 36,72 ± 0,06 °C nakon toga, s p-vrijednošću od 0,0001, što ukazuje na statističku značajnost.

Zaključak: Mjehurasta folija je sigurna i isplativa mjera u sprječavanju hipotermije kod prijevremeno rođene djece.

Ključne riječi: DOJENČE, PRIJEVREMENO ROĐENO; HIPOTERMIJA; JEDINICE INTENZIVNE NJEGE, NEONATALNE; METODA SKRBI KLOKAN-MAJKA