Original Article

Heat Loss Prevention for Preterm Infants in the Delivery Room

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OBJECTIVE:

Preterm infants are prone to hypothermia immediately following birth. Among other factors, excessive evaporative heat loss and the relatively cool ambient temperature of the delivery room may be important contributors. Most infants <29 weeks gestation had temperatures <36.4°C on admission to our neonatal unit (NICU). Therefore we conducted a randomized, controlled trial to evaluate the effect of placing these infants in polyurethane bags in the delivery room to prevent heat loss and reduce the occurrence of hypothermia on admission to the NICU.

METHODS:

After parental consent was obtained, infants expected to be <29 weeks gestation were randomized to intervention or control groups just prior to their birth. Infants randomized to the intervention group were placed in polyurethane bags up to their necks immediately after delivery before being dried. They were then resuscitated per NRP guidelines, covered with warm blankets, and transported to the NICU, where the bags were removed and rectal temperatures were recorded. Control infants were resuscitated, covered with warm blankets, and transported without being placed in polyurethane bags. Delivery room temperatures were recorded so this potentially confounding variable could be assessed.

RESULTS:

Intervention patients were less likely than control patients to have temperature < 36.4°C on admission , 44 vs 70% ($p<0.01$) and the intervention group had a higher mean admission temperature, 36.5°C vs 36.0°C ($p<0.003$). This effect remained significant ($p<0.0001$) when delivery room temperature was controlled in analysis. Warmer delivery room temperatures ($\geq$26°C) were associated with higher admission temperatures in both intervention and control infants, but only the subgroup of intervention patients born in warmer delivery rooms had a mean admission temperature >36.4°C.

CONCLUSIONS:

Placing infants <29 weeks gestation in polyurethane bags in the delivery room reduced the occurrence of hypothermia and increased their NICU admission temperatures. Maintaining warmer delivery rooms helped but was insufficient in preventing hypothermia in most of these vulnerable patients without the adjunctive use of the polyurethane bags.
Journal of Perinatology (2005) **25,** 304–308. doi:10.1038/sj.jp.7211289

INTRODUCTION

Optimal thermal management of preterm infants is a problematic but important aspect of care.[1–3] Cold stress is thought to contribute to increased rates of morbidity and mortality in low birth weight infants.[4,5] Low birth weight infants are vulnerable to hypothermia (temperature $\leq$36.4°C according to the previous definition by the AAP[6]) since they have impaired ability to prevent heat loss[1] and decreased heat production capability.[7,8] The risk of cold stress is greatest at birth during the transition from the warm, wet, well-insulated intrauterine environment to the cool, drafty delivery room. To reduce this risk, the Neonatal Resuscitation Program (NRP) has made the provision of warmth the first step in resuscitation of the newborn.[9]

Despite adherence to NRP recommendations and other attempts to minimize heat loss, many preterm infants have been hypothermic on admission in our neonatal intensive care unit (NICU). In a chart review of 100 patients we found 93% of those with birth weights less than 1000 g had rectal temperatures less than 36.4°C on admission. Other institutions have also reported low admission temperatures in premature infants.[10–13]

Previously reported efforts to reduce heat loss and therefore prevent hypothermia have included the use of various types of occlusive coverings.[10,13–16] These presumably work by reducing evaporation, which is a particularly important route of heat loss in the first few minutes after birth.[17] Such barriers may also reduce convective losses.

This study was designed to determine the effectiveness of placing infants less than 29 weeks gestation in polyurethane bags in the delivery room to reduce the occurrence of hypothermia on admission to the NICU. Additionally, the participants were followed until hospital discharge to determine any effects of this intervention

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This research was partially supported by National Institute for Nursing Research T32 NR07091 Interventions to Prevent and Manage Chronic Illness.

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on duration of oxygen therapy, incidence of major brain injury, duration of hospitalization and mortality.

METHODS

Study Design and Procedures

This prospective, randomized, controlled trial was conducted at Pitt County Memorial Hospital, Greenville, North Carolina, from November 2000 until July 2002 following approval by the Institutional Review Board. Parental consent was sought if the mother was expected to deliver before completing 29 weeks gestation. Randomization of consented infants was carried out in the delivery room by opening sealed, opaque envelopes just prior to birth. Infants were excluded if: (1) they had congenital anomalies with open lesions (e.g. gastroschisis, meningomyelocele), (2) resuscitation was not undertaken because of previability, (3) there was meconium staining of amniotic fluid, or (4) subsequent assessment indicated they were 29 weeks or greater gestational age.

A polyurethane bag (DeRoyal REF30-5510, sterile isolation transport bag $19'' \times 18''$) was placed on the radiant warmer bed prior to delivery for infants randomized to the intervention group. These infants were placed inside the bag immediately after birth (while still wet with amniotic fluid) and the bag was drawn in loosely around the neck using the drawstring, with the head protruding from the bag (Figure 1). The head and face were dried, after which NRP procedures were followed. The clear, pliable polyurethane bag did not interfere with either assessment (visualization, auscultation, palpation) or resuscitative interventions. Access to the infant's head permitted usual airway management. Further interventions, such as placement of monitors or establishment of vascular access, were deferred until after NICU admission (per our usual institutional practice). Infants randomized to the control group received usual care per NRP without being placed in the polyurethane bags. We attempted to prewarm the delivery rooms to approximately 26°C for all deliveries

Figure 1. Infant in polyurethane bag (parental consent obtained for use of photograph).

< 29 weeks, i.e. regardless of participation in the study. We anticipated however, that environmental temperatures in the delivery rooms would vary and that such variability should be controlled for in our data analysis. We therefore recorded delivery room environmental temperatures at the time of the infants' births as measured on mercury thermometers which were wall-mounted at eye level next to the delivery room doors specifically for the purpose of this study.

After initial stabilization, patients in both groups were covered with warm blankets and transferred to the NICU. On arrival in the NICU, the infants were placed under radiant warmers and the polyurethane bags were removed. Rectal temperatures were taken immediately on patients in both groups with a digital thermometer (IVAC Temp-Plus II Electronic Thermometer, Model 2080, Alaris Medical Systems). After removal of the bags, intervention group patients received similar care to the control patients, that is, according to usual NICU routines and attending staff preferences.

The primary outcome was measured in two ways: (1) the occurrence of hypothermia, defined as rectal temperature less than 36.4°C on NICU admission, in the intervention vs control groups, and (2) comparison of the mean admission temperatures for the two groups. Cranial ultrasound results, number of days requiring supplemental oxygen, and date of hospital discharge were recorded to assess secondary outcomes. A major brain injury was defined as sonographic evidence of intraventricular hemorrhage with ventricular dilatation, parenchymal hemorrhagic infarction, or periventricular leukomalacia. Mortality was defined as death prior to hospital discharge. In addition to the delivery room temperature at birth, we recorded time of birth and time of admission to the NICU.

Statistical Analysis

Power analysis indicated that 100 infants would provide 95% power to detect a postulated 30% reduction in the occurrence of hypothermia using a 0.05 level test of significance. In all, 12 infants were excluded due to previability or delivery prior to randomization. Mean admission temperatures in the two groups were compared using Student's *t*-test. A log transformation was conducted on two of the variables, days on oxygen and length of stay; these were then analyzed using Student's *t*-test. χ^2 analysis was used for categorical data, such as the occurrence of hypothermia, major brain injury, and mortality. Analysis of covariance was used to compare admission temperatures while controlling for variations in delivery room temperature.

RESULTS

The sample consisted of 88 infants, 41 in the intervention group and 47 in the control group. There were no significant differences between intervention and control groups in birth weight, gestational age, delivery room temperature, time from birth to

Table 1 Group Comparison

	Study ($n=41$)	Control ($n=47$)
Birth weight (g)	918±259	850±253
Gestational age (weeks)	26.5±1.4	26.1±1.4
Delivery room temperature (°C)	23.9±2.6	24.5±2.3
Delivery to admission time (min)	16.0±6.6	15.9±5.1
Modified SNAPPE II score	29.6±17.5	30.9±19.1

Values are mean±1SD.

Table 2 Secondary Outcomes (No Significant Differences)

	Study ($n=41$)	Control ($n=47$)
Duration of oxygen therapy (mean)	45.34 days, SD 40.626	51.85 days, SD 39.467
Major brain injury	5 (13%)	5 (11%)
Duration of hospitalization (mean)	70.53 days, SD 35.256	76.02 days, SD 33.561
Mortality	4 (10%)	6 (13%)

NICU admission, or severity of illness as measured by modified SNAPPE II score[18] (Table 1).

Infants placed in polyurethane bags were less likely to have temperature < 36.4°C on admission to the NICU than control infants, 44 vs 70%, χ^2 (1) = 6.22, $p<0.01$. The mean admission temperature in the intervention group (36.5°C, range 34.6 to 37.5°C, SD, 0.79) was 0.5°C higher than that of the control group (36.0°C, range 34.9 to 38.3°C, SD, 0.79), t (86) = 3.066, $p<0.003$. After controlling for delivery room temperature with an analysis of covariance, the adjusted mean admission temperature in the intervention group was 0.6°C higher than that for the controls, F (1,84) = 13.879, $p<0.0001$. No significant differences were noted between the intervention and control groups in the secondary outcomes measured: mortality, major brain injury, duration of oxygen therapy, or duration of hospitalization (Table 2).

Effect of Delivery Room Temperature — A Post Hoc Analysis

Higher delivery room environmental temperatures, that is, ≥26°C, were associated with higher admission temperatures in both control and the intervention infants. To separately assess the effects of the warmer delivery room environment and the polyurethane bag intervention, we performed a post hoc analysis. Intervention and control groups were subdivided into those who were born in "warm" (≥26°C) vs "cool"(<26°C) delivery rooms. Comparisons were then made between (1) control infants born in warm vs cool delivery rooms, (2) intervention infants born in warm vs cool delivery rooms, and (3) intervention infants born in warm delivery rooms vs control infants born in warm delivery rooms. The distribution of NICU admission temperatures in these four subgroups is shown in Figure 2.

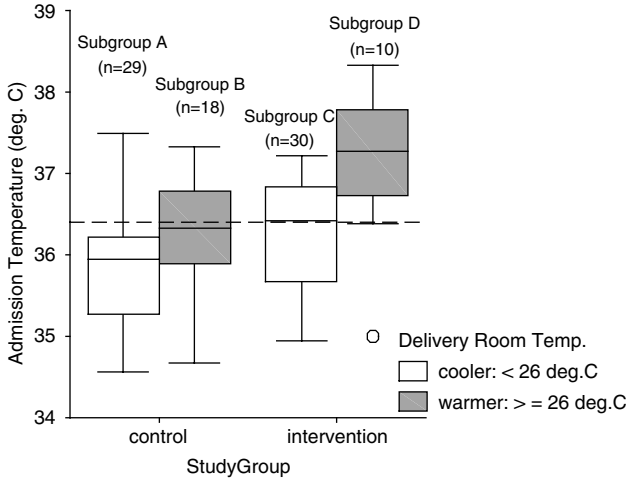

Figure 2. Distribution of NICU admission temperatures in control infants (subgroups A and B) and intervention infants (subgroups C and D) categorized by delivery room temperatures <26°C (clear boxes) vs ≥26°C (hatched boxes). Note: The solid horizontal lines through each box show the subgroup median temperatures, while the top and bottom of each box show the upper and lower quartiles, respectively, and whiskers show maximum and minimum values. There was one outlier in subgroup D, plotted separately with an open circle. The dotted horizontal reference line is at the AAP threshold for hypothermia, 36.4°C.

RESULTS

(1) Control infants born in warm delivery rooms had significantly higher admission temperatures ($n=18$, mean 36.3°C, range 34.7 to 37.3°C) than those born in cool delivery rooms ($n=29$, mean 35.8°C, range 34.6 to 37.5°C), $t=2.08$, $p<0.05$, but they were hypothermic according to the AAP definition (<36.4°C).

(2) Intervention infants born in warm delivery rooms had significantly higher admission temperatures ($n=10$, mean 37.1°C, range 35 to 38.3°C) than those born in cool delivery rooms ($n=30$, mean 36.3°C, range 34.9 to 37.2°C), $t=3.03$, $p<0.004$.

(3) Among infants born in warm delivery rooms, the intervention infants ($n=10$, mean 37.1°C, range 35 to 38.3°C) had significantly higher temperatures than control infants ($n=18$, mean 36.3°C, range 34.7 to 37.3°C), $t=2.78$, $p<0.01$. The mean admission temperatures of all subgroups were hypothermic except for the polyurethane bag intervention/warm delivery room subgroup.

Occurrence of hyperthermia

One study participant was hyperthermic with an admission temperature of 38.3°C. This 1112-g infant was in the intervention group; the delivery room environmental temperature was 26.7°C.

DISCUSSION

We found that the occurrence of NICU admission hypothermia in preterm infants <29 weeks gestation could be reduced by placing them in polyurethane bags immediately after birth. This finding supports that of Vohra et al.[10] who found higher admission temperatures in infants less than 28 weeks gestation who were wrapped in polyethylene immediately after delivery. In the Vohra study, all five of the infants who died were in the control (nonwrapped) group; the investigators postulated that reducing hypothermia might have reduced mortality. This study was small, with only 18 patients in the subgroup less than 28 weeks gestation, but it was provocative in its implications for the importance of thermal management.

The significance of evaporative water losses in newborn infants has been recognized for decades, and preterm infants are known to have increased insensible water loss. Hammarlund et al.[17] found evaporative heat loss is great during the first minutes of life. These authors suggested measures to reduce excessive evaporation should be taken when possible. Hammarlund has also shown that evaporative water loss is inversely related to gestational age.[19] Other investigators have observed increased insensible water loss in low birth weight and low gestational age infants.[20,21] Since evaporation is a major route of heat loss after delivery and preterm infants have increased evaporative water loss, measures to reduce evaporation would be expected to reduce heat loss in the delivery room. Reduction of evaporative heat loss is probably the primary mechanism of action of the occlusive covering, but there may also be an effect on convective heat loss. Convection is affected by the amount of skin surface exposed to ambient air, which is obviously significantly reduced by covering the infant. The thin layer of nonevaporated fluid on the infant's skin, after being entrapped by the occlusive barrier and warmed by the infant via conduction, may provide insulation analogous to that of a diver's wet suit.

Another finding of our study was the association between the environmental temperature in the delivery room and the infant's NICU admission temperature. This observation is not surprising, but there are no published data correlating delivery room environmental temperature with NICU admission temperature in preterm infants, nor are there published standards for optimal delivery room temperature. Recommendations are nonspecific, stating only ''the neonate should be put in a warm place'' immediately after delivery.[22] We attempted to maintain delivery room temperature at approximately 26°C for all preterm deliveries, but the actual temperatures recorded during this study ranged from 18.9°C to 31.1°C. We found that warmer delivery room temperatures were indeed associated with higher admission temperatures, but that only the subgroup of infants who were both delivered in warm delivery rooms and placed in polyurethane bags had a mean admission temperature >36.4°C. Hyperthermia was seen in only one patient and was not associated with any recognized adverse effects.

This study and others[10,13] have demonstrated that the occurrence of hypothermia in preterm infants immediately after birth can be significantly reduced by use of occlusive covering, a simple, noninvasive, inexpensive intervention. Our study also supports the intuitive assumption that warmer delivery room temperatures are helpful in preventing hypothermia in preterm infants, and suggests an environmental temperature of 26°C may be safe in this population. It indicates, however, that these most vulnerable patients should also be placed in occlusive covering to minimize the risk of hypothermia. Larger, multicenter studies could determine whether or not reduction of early hypothermia results in improved survival or other long-term benefits.

Acknowledgements

The authors would like to acknowledge the additional investigative team members, Carla Ahearn RNC, MSN, NNP and Marie Morton, RN. We would also like to acknowledge Diane Holditch-Davis, RN, PhD, and Alex Robertson, MD for their thoughtful review of the manuscript.

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