Original Article

Effect of Radiant Warmer on Transepidermal Water Loss (TEWL) and Skin Hydration in Preterm Infants

A. Maayan-Metzger
G. Yosipovitch
E. Hadad
L. Sirota

OBJECTIVE:
To evaluate the effect of radiant warmers on skin barrier function in preterm infants.

METHODOLOGY:
Transepidermal water loss (TEWL) and stratum corneum hydration were measured in 30 preterm infants (birth weight 825 to 2220 g) in seven body areas: forehead, upper back, cubital fossa, palms, soles, abdomen, and inguinal region. Measurements were performed under radiant warmer and incubator conditions. Each patient served as his/her control.

RESULTS:
TEWL was significantly higher in the radiant warmer compared to the incubator condition in only two areas: forehead and back. The overall mean difference in percentage TEWL between the conditions was 15%. Stratum corneum hydration was not affected by the radiant warmer.

CONCLUSIONS:
The use of radiant warmers does not significantly decrease barrier function in the preterm infant.
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INTRODUCTION

The stratum corneum (SC) plays a key role in maintaining life because it inhibits water loss from the tissues while preventing the entry of damaging microorganisms. In preterm infants, the SC layer is thinner and less well developed than in full-term infants and adults, leading to high water loss and cutaneous infections, with high morbidity and mortality.[1–3]

Radiant warmers are widely used for sick preterm and term newborns to effectively control body temperature and provide uniform heating over exposed body areas. However, several researchers have suggested that radiant warmers may affect insensible water loss.[4,5] Radiant warmers can also induce rapid drying of the skin surface.[6] In recent years, noninvasive techniques that can accurately measure the transepidermal water loss (TEWL) and skin hydration have been developed,[7–9] which also take environmental factors such as humidity and ambient temperature[9] into account.

The purpose of the present study was to evaluate the effect of radiant warmers on TEWL and SC hydration in preterm infants using noninvasive devices mentioned above.

MATERIALS AND METHODS

Patients

The study group included 30 preterm infants born at Schneider Children's Medical Center of Israel from January to June 1998. There were 13 male and 17 female infants, all appropriate for gestational age. The mean gestational age was 31.6 weeks (range 27 to 34 weeks), and mean birth weight was 1588 g (range: 825 to 2220 g). Infants with respiratory distress, low blood pressure or suspicion of sepsis, and infants who required ventilatory support were excluded from the study, although infants receiving antibiotic treatment were not. The study was approved by the Ethics Committee of the hospital, and informed consent was obtained from the patient's parents.

Instruments

To measure TEWL and SC hydration, we used a combined Tevameter and Corneometer (Courage and Khazaka, Köln, Germany). The Tevameter device, a cylindrical probe consisting of two hydrosensors, is designed to measure the rate of water evaporation from the skin surface. TEWL was calculated from the slope provided by the hydrosensors and was computed by averaging the data recorded every 2 seconds; starting 90 seconds from the time the probe was applied to the skin. The Corneometer measures the electrical capacitance at the skin surface, an indicator of SC hydration. Its operation is based on the high dielectric constant of water relative to other skin components. The results are expressed in arbitrary units.

Department of Neonatology (A.M-M., L.S.), Schneider Children's Medical Center of Israel, Israel; Department of Dermatology (G.Y., E.H.), Rabin Medical Center, Beilinson Campus, Petah Tiqva, Israel; and Sackler Faculty of Medicine (G.Y., E.H.), Tel Aviv University, Tel Aviv, Israel.

Address correspondence and reprint requests to A. Maayan-Metzger, MD, Department of Neonatology, Schneider Children's Medical Center of Israel, 14 Kaplan Street, Petah Tiqva 49 202, Israel.

Procedure

After birth, the infants were dried and dressed with only a diaper and then placed on a cloth-covered mattress under a radiant warmer (Infant Care System 90, Air Shields/Hill Rom, Hatboro, PA) with servo-controlled skin temperature. All infants received intravenous fluids with or without parenteral nutrition. TEWL and SC hydration were initially measured at least 4 hours after birth, while the patients were either sleeping or awake and quiet. This interval ensured that normal body temperature had been established and the infants had transitioned to extrauterine life. When the infants were stable, they were transferred to a nonhumidified incubator (Isolette—Infant Incubator C—100 Air Shields, Vickers Medical, Hatboro, PA) with a servo-controlled skin temperature. All neonates were dressed only with a diaper. A second set of TEWL and SC hydration measurements were performed between 4 and 12 hours after the first measurements. In both conditions, TEWL and SC hydration were measured in seven body areas: first in the supine position (forehead, cubital fossa, palms, soles, abdomen (above the umbilicus), and inguinal region. Then the child was turned to the prone position and, after 10 minutes of acclimatization, TEWL and SC hydration measurements were performed on the upper back (between the scapulas). Each patient served as his/her own control. Ambient temperature and humidity were measured throughout the study using a sensor placed 10 cm from the patient's body.

Statistical Methods

Simple statistics and frequencies were tabulated for the variables, and differences in percentage TEWL were calculated. For statistical analysis of differences between conditions and correlations among variables, paired *t*-test and Pearson's correlation coefficients were applied. A *p*-value less than 0.05 was considered significant.

RESULTS

The first measurement of TEWL and SC hydration was performed at the average postnatal age of 28 hours. Body temperature, measured by the servo-control probe, was kept within normal range (36 to 37°C) before and after the study measurements in both conditions. The mean ambient temperature was significantly lower in the radiant warmer than the incubator condition (30.5 vs 33.1°C), as was mean ambient humidity (34 vs 38%).

The overall mean difference for all seven body areas between the radiant warmer and incubator conditions was 15%. Among all patients, comparison of each body area yielded a significantly higher mean) TEWL value in the radiant warmer condition only for the forehead (14.0 ± 5.1 vs 12 ± 2.9 g/m^2/hour, ($p<0.05$)) and back (21.0 ± 8.3 vs 15.7 ± 5.3 g/m^2/hour ($p<0.0001$)). We also compared separately the TEWL and SC hydration in two subgroups of patients; those with birth weight (BW) lower than 1500 g ($N=12$ infants) and those with birth weight equal or higher than 1500 g ($N=18$ infants). Among the <1500 g premature infants, significant differences in TEWL on radiant therapy were recorded only for the back and abdomen (Table 1). Among the ≥ 1500 g infants, only TEWL on radiant therapy on the back was significantly elevated (Table 2). The highest TEWL measurements were noted in the cubital fossa and groin in both conditions (Tables 1 and 2). There were no gender differences for TEWL. A negative correlation was found between gestational age and BW and TEWL, both in the radiant warmer and incubator conditions.

Among the infants with BW<1500 g, the mean SC hydration was higher in incubator than radiant warmer only in the abdomen (Table 3). However, in the babies with BW$\geq$1500 g significant differences with higher SC hydration in incubator than the radiant warmer were noted in the cubital fossa, abdomen, and groin (Table 4). The highest SC hydration values were found in the groin and cubital fossa in both conditions, and the lowest in the forehead.

DISCUSSION

Body heat is exchanged by conduction, convection, evaporation, and radiation. The use of an external warming device helps to promote a natural thermal environment in order to maintain the

Table 1 Results of Measurements of TEWL under Radiant Warmer Compared with Incubator in Seven Body Areas in Preterm Infants with BW<1500 g ($N=12$)

Body area	Radiant warmer (g/m^2/hours) Mean±SD	Incubator (g/m^2/hours) Mean±SD	Average change %	*p*-value
Forehead	13±3.9	11.2±2.7	22.3	NS
Cubital fossa	31.4±7.5	29.8±14.7	17.5	NS
Palm	22.7±6.4	21.4±4.3	6.4	NS
Abdomen	22.4±6.9	19.2±5.5	18.3	0.03
Groin	27.6±6.8	27.9±9.1	1.6	NS
Back	21.8±5.3	16.3±3.7	35.2	<0.001
Sole	16±5.9	14.4±3.7	14.5	NS

NS = not significant.

Table 2 Results of Measurements of TEWL under Radiant Warmer Compared with Incubator in Seven Body Areas in Preterm Infants with BW $\geq$ 1500 g ($N = 18$)

Body area	Radiant warmer (g/m^2/hour) Mean ± SD	Incubator (g/m^2/hour) Mean ± SD	Average change %	p-value
Forehead	14.7 ± 5.7	12.6 ± 2.9	19.6	NS
Cubital fossa	34.6 ± 15.6	31.1 ± 14	16.3	NS
Palm	21.7 ± 8.7	20.8 ± 7.8	13.5	NS
Abdomen	17.2 ± 6	16.7 ± 5.5	5	NS
Groin	26.6 ± 8.2	26.3 ± 9.2	6.2	NS
Back	20.4 ± 9.9	15.2 ± 6.1	41.6	0.004
Sole	14.2 ± 3.8	13.6 ± 3.3	8.7	NS

NS = not significant.

Table 3 SC Hydration Measured by the Corneometer under Radiant Warmer Compared with Incubator in Seven Body Areas in Preterm Infants with BW < 1500 g ($N = 12$)

Body area	Radiant warmer (capacitance AU) Mean ± SD	Incubator (capacitance AU) Mean ± SD	p-value
Forehead	25.9 ± 6.8	25.2 ± 8.9	NS
Cubital fossa	77 ± 16.4	74.4 ± 12.9	NS
Palm	54.8 ± 19.7	49.7 ± 11.8	NS
Abdomen	48.1 ± 9.3	53.8 ± 8.8	0.03
Groin	60.5 ± 17	66.7 ± 14.6	NS
Back	44 ± 10.4	40.1 ± 7.6	NS
Sole	35.5 ± 11.2	35 ± 10.8	NS

NS = not significant.

Table 4 SC Hydration Measured by the Corneometer under Radiant Warmer Compared with Incubator in Seven Body Areas in Preterm Infants with BW $\geq$ 1500 g ($N = 8$)

Body area	Radiant warmer (capacitance AU) Mean ± SD	Incubator (capacitance AU) Mean ± SD	p-value
Forehead	32.3 ± 13	28.7 ± 14.7	NS
Cubital fossa	68.5 ± 17.6	80 ± 13.3	0.012
Palm	43.3 ± 15.8	54.6 ± 21.8	NS
Abdomen	43.5 ± 10.5	53 ± 15	0.001
Groin	56.3 ± 12.5	74.1 ± 16.6	< 0.001
Back	47 ± 10.5	43 ± 10.6	NS
Sole	30.4 ± 6.6	29.3 ± 8.1	NS

NS = not significant.

metabolic rate at a minimum.[10] This enables the body to preserve energy to overcome respiratory disease caused by lung immaturity, to prevent infection, and to grow and develop. Radiant warmers have the advantage of easy accessibility to the baby. However, unlike incubators, they do not enable good control of ambient humidity, increasing the risk of a higher TEWL due to convection, radiation and evaporation. Our findings show that TEWL and stratum corneum hydration did not differ markedly on radiant warmers versus nonhumidified incubators, and the temperature and humidity surrounding the baby was rather similar. Future studies that will compare radiant warmers and humidified incubators could demonstrate significant differences between these two treatments.

The early studies on radiant warmers did not differentiate TEWL from total insensible water loss (IWL), which was measured by weight loss.[4,5] These studies found that radiant warmers were

associated with a significant increase in IWL, which was attributed to either a higher skin-ambient temperature gradient or a higher skin-ambient vapor pressure gradient.

A more recent study by Visscher et al[6] demonstrated significantly lower SC hydration for radiant warmers compared to incubators, but the neonates in the treatment groups were of different racial backgrounds.

In our study, we measured both TEWL and SC hydration and found no significant effect of radiant warmers on TEWL. In contrast, Wu and Hodgman[4] have reported 50 to 90% differences in IWL under similar conditions. A possible explanation for the discrepancies in the results is that the high IWL reported in the latter study could be related to the other routes of IWL, such as respiratory tract and stool.

An additional finding of the present study is the significant differences in TEWL among the different body areas. This is in agreement with our previous study of full-term babies on the first and second days of life.[11] The SC hydration was significantly lower on radiant therapy in several sites in those infants with higher BW; these results are in agreement with the findings of Visscher et al.[10] in full-term infants. The effect of radiant warmer on SC hydration in preterm infants was minimal suggesting that radiant warmers have no significant adverse effect on biophysical properties of the SC in very low weight infants. The significantly higher TEWL and skin hydration found in the diaper area and cubital fossa is in agreement with results of previous studies[11,12] and is most probably related to an occlusion effect caused by limb flexion.

In conclusion, there is apparently no marked elevation in evaporation through the skin nor any skin dryness in preterm infants placed under a radiant warmer compared to a nonhumidified incubator. These results suggest that radiant warmers may not induce such a high increase in TEWL as previously estimated. Considering the advantages of radiant warmers, our findings justify their continuous use with no need for concern regarding their effect on barrier function.

References

1. Nachman RL, Esterly NB. Increased skin permeability in preterm infants. J Pediatr 1971;79:628–32.
2. Harpin VA, Rutter N. Barrier properties of the newborn infant's skin. J Pediatr 1983;102:419–25.
3. Fanaroff AA, Wald M, Gruber HS, Klaus MH. Insensible water loss in low birth weight infants. Pediatrics 1972;49:236–45.
4. Wu PY, Hodgman JE. Insensible water loss in preterm infants: changes with postnatal development and non-ionizing radiant energy. Pediatrics 1974;54:704.
5. Williams PR, Oh W. Effects of radiant warmer on insensible water loss in newborn infants. Am J Dis Child 1974;128:511–4.
6. Visscher MO, Srinath M, Munson K, Bare D, Hoath SB. Early adaptation of human skin following birth: a biophysical assessment. Skin Res Technol 1999;5:312–20.
7. Hammarlund K, Sedin G. Transepidermal water loss in newborn infants. Acta Paediatr Scand 1979;68:795–801.
8. Kalia YN, Nonato LB, Lund CH, Guy RH. Development of skin barrier function in premature infants. J Invest Dermatol 1998;111:320–6.
9. Hammarlund K, Nilsson GE, Oberg PA, Sedin G. Transepidermal water loss in newborn infants. Relation to ambient humidity and site of measurement and estimation of total transepidermal water loss. Acta Paediatr Scand 1979;68:371–6.
10. Avery BG, Fletcher AM, MacDonald GM. Neonatology. J.B. Lippincott Company: Philadelphia, 4th ed. 1994, 358–60.
11. Yosipovitch G, Maayan-Metzger A, Merlob P, Sirota L. Skin barrier properties in different body areas in neonates. Pediatrics 2000;106:105–8.
12. Visscher MO, Chatterjee R, Ebel J, et al. Biomedical assesemnt and instrumental evaluation of healthy infants skin. Pediatr Dermatol 2002;19:473–81.