Upsala J Med Sci 86: 27–31, 1981

Water Transport through the Skin of Newborn Infants

Gunnar Sedin, Karen Hammarlund, Gert E. Nilsson, P. Åke Öberg and Bo Strömberg

Department of Pediatrics, University Hospital, Uppsala and Department of Biomedical Engineering, University of Linköping, Linköping, Sweden

Dedicated to Torsten Teorell

ABSTRACT

Factors that may influence the water transport through the skin in infants on their first day of life were studied with a method based on determination of the vapour pressure gradient in the air layer close to the skin surface. The evaporation rate from the skin was found to vary with the site of measurement, ambient humidity, temperature, activity, gestational age and nutritional status at birth. Differences related to maturity were shown to decrease with postnatal age.

INTRODUCTION

Gestational-age-related differences in hydration and in the control of total body water have been described by Friis-Hansen (1956; 2) and MacLaurin (1966;8). During the development of neonatal intensive care, with the introduction of a large number of new methods (e.g. phototherapy, continuous positive airway pressure, intermittent positive pressure ventilation and parenteral nutrition), the survival rate of infants with a low birth weight has increased markedly.

Disturbances in water balance are often encountered in the care of these infants and the cause is not easily understood. As dehydration in preterm infants (1) can occur without noticeable profound losses of water in the stools or urine and with a supposedly adequate water supply, we focused interest on the insensible loss of water in newborn infants.

All previously used methods for measurement of insensible water loss have shortcomings, for instance in accuracy, and they are all difficult to use in preterm infants needing continuous or intermittent medical intervention.

METHODS AND MEASUREMENT PROCEDURE

With the method described earlier (9,3,11), the water transport through the skin of newborn infants was studied.

All measurements were made with the naked infant placed in an incubator. The inflow of air to the incubator was maintained at a constant, low level and the ambient humidity was kept at 50 % except when the effects of varying the ambient humidity were being investigated. By regulating the air temperature in the incubator, the body temperature was kept fairly constant and was always between 36.0 and 37.0°C except in studies of the effects of a higher body temperature. Thus there was only one variable that was allowed to change in each sequence of measurements. This was also true for activity, gestational age, nutritional status at birth, and postnatal age.

The maturity of all infants included in the study was carefully assessed. Infants whose birth weights were 2SD or more below the average for normal Swedish infants (7) were designated small for gestational age infants (SGA).

RESULTS

Evaporation rate at different ambient humidities

In all groups of infants a linear relationship was found between ambient humidity and evaporation rate (ER; g/m^2h), with higher ER values at a lower ambient humidity (Fig.1). In AGA preterm infants

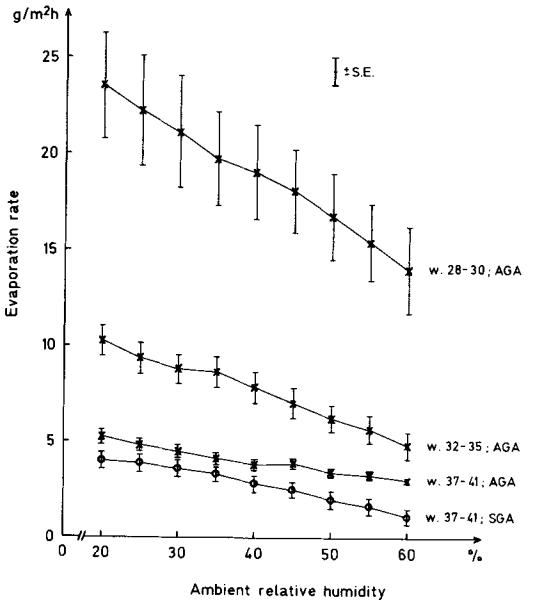

Fig.1
The relation between evaporation rate (ER) and ambient relative humidity (RH_{amb}) in preterm and full-term AGA infants and in full-term SGA infants on the first day after birth. SEE = standard error of the estimate. AGA = appropriate for gestational age. SGA = small for gestational age. W = completed weeks of gestation.

ER depended on the gestational age of the infant, with very high values in the most preterm infants. The susceptibility to changes in ambient humidity, as represented by the slope of the relationship, was also greater at lower gestational ages. Extremely high ER values were observed especially in the infants born after 25 to 26 weeks of gestation (5), with an ER of around 70 g/m^2h at an ambient humidity of 20 % and of around 35 g/m^2h at 60 %.

Lower ER values were noted in SGA infants than in AGA infants of the same gestational age.

Transepidermal water loss

Transepidermal water loss (TEWL; g/m^2h, cf. 11) showed an inverse exponential relationship to gestational age, TEWL being as much as fifteen times higher in the most preterm infants than in full-term infants.

When measurements were made on full-term infants during activity, 37 % higher values were obtained than during periods of rest before and after activity. At the same time the skin temperature was $0.2^{\circ}C$ higher, but no visible sweating occurred.

When the body temperature was allowed to rise in full-term infants, a marked increase in TEWL was observed when the body temperature exceeded $37.1^{\circ}C$.

All the above-mentioned results were obtained in infants on their first day after birth. In full-term infants transepidermal water loss did not alter appreciably during the first weeks of life. In preterm infants TEWL decreased and after some weeks approached the values found in full-term infants.

DISCUSSION

The results of this investigation show that there are great differences in the transport of water through the skin in different groups of newborn infants, and that environmental factors, body temperature, activity, nutritional status and postnatal age influence this transport.

The differences in ER and TEWL related to gestational age may be explained at least partly by differences in the epidermal layer, the vascularization of the skin, and the degree of development of sweat glands. It is also known that the state of hydration of the skin influences the transepidermal water diffusion (10).

During activity, a small rise in skin temperature was observed although higher ER values were recorded. This may mean that the lo-

cal perfusion of the skin had increased. The difference in temperature may to a minor degree have influenced the diffusion rate of water through the skin, but it is probable that the activation of sweat glands plays a much more important role in the increase in TEWL, even though no sweating was visible.

In the studies carried out hitherto (3,4,5,6) no attempts have been made to estimate the influence of local skin perfusion or of the chemical composition of body fluids. It is probable that both the blood flow and the oncotic pressure of interstitial fluid and blood have a substantial influence on the transepidermal transport of water. Both from a theoretical aspect and with a view to improving the care of newborn infants, further efforts should be made to examine the influence of these factors.

ACKNOWLEDGEMENTS

This study was supported financially by the Swedish Board for Technical Development (grants 74-3872 and 75-3615), the Swedish Medical Research Council (grant 19X-04998), the Samaritan Foundation and the Förenade Liv Mutual Life Insurance Company.

REFERENCES

1. Fanaroff, A.A., Wald, M., Gruber, H.S. & Klaus, M.H.: Insensible water loss in low birth weight infants. Paediatrics 50:236-245, 1972.
2. Friis-Hansen, B.: Changes in body water compartment during growth. Acta Paediatr Scand, Suppl.110, 1956.
3. Hammarlund, K., Nilsson, G.E., Öberg, P.Å. & Sedin, G.: Transepidermal water loss in newborn infants. I. Relation to ambient humidity and site of measurement and estimation of total transepidermal water loss. Acta Paediatr Scand 66:553-562, 1977.
4. Hammarlund, K., Nilsson, G.E., Öberg, P.Å. & Sedin, G.: Transepidermal water loss in newborn infants. II. Relation to activity and body temperature. Acta Paediatr Scand 68:371-376, 1979.
5. Hammarlund, K. & Sedin, G.: Transepidermal water loss in newborn infants. III. Relation to gestational age. Acta Paediatr Scand 68:795-801, 1979.
6. Hammarlund, K. & Sedin, G.: Transepidermal water loss in newborn infants. IV. Small for gestational age infants. Acta Paediatr Scand 69:377-383, 1980.
7. Karlberg, P. & Priolisi, A.: Clinical evaluation of similarities and dissimilarities between the two city surveys. In: Fundamentals of mortality risks during the perinatal period and infancy (ed. F.Falkner), Monogr Pediatr 9:165-192. Karger, Basel, 1977.
8. MacLaurin, J.C.: Changes in body water distribution during the first two weeks of life. Arch Dis Childh 41:286-291, 1966.
9. Nilsson, G.E.: Measurement of water exchange through skin. Med Biol Eng Comput 15:209-218, 1977.

10. Spruit, D. & Malten, K.E.: Humidity of the air and water vapor loss of the skin. Dermatologica 138:418-426, 1969.
11. Öberg, P.Å., Hammarlund, K., Nilsson, G.E., Nilsson, L. & Sedin, G.: Measurement of water transport through the skin. Upsala J Med Sci 86:000-000, 1981.

Received 1980-12-19

Address for reprints:
Gunnar Sedin, M.D.
Department of Paediatrics
University Hospital
S-750 14 Uppsala
Sweden