Temperature Regulation and Evaporative Water Loss

Marc, I. Rowe, M.D.*

*Division of Pediatric Surgery, University of Pittsburgh; Children's Hospital of Pittsburgh, U.S.A.

Budin in 1900 reported an increased mortality in preterm infants with low body temperature. Subsequent studies showed that mortality was also increased when ambient or skin temperature were low. Bruck in 1969 demonstrated that the newborn infant is thermogenically active, and doubles its metabolic activity when exposed to a cold, resulting in a marked increase in heat production. This thermogenesis is accomplished without shivering, and takes place in the highly metabolically active brown fat deposits. As ambient temperature drops, blood flow to the brown fat increases to 15% of the total cardiac output.

Individual infants have a specific thermoneutral ambient temperature zone at which energy expenditure for heat production is minimal. As the environmental temperature drops below this zone, metabolic activity increases to maintain normal body temperature. Thermoneutrality is highest during the newborn period; eg: adults 28°C.; term infants 34.4°C.; low birth weight infants 34.7°C.

Infants lose heat by radiation, convection, evaporation, and conduction. They are at a thermo-dynamic disadvantage because of their relatively large surface area, lack of insulating body fat, high thermoneutral temperature zone, and permeable skin. Exposure of the baby to environmental temperatures below thermoneutrality may be detrimental to the infant because, 1) vital energy stores are consumed, 2) metabolic breakdown products accumulate, 3) cardiac output is redistributed with possible reduced flow to important organs, and 4) if the hematocrit is high, the low body temperature will cause an increase in blood viscosity and a reduction in microcirculatory flow.

Cold stress can be reduced by a number of methods: 1) Maintain thermoneutrality. Incubator temperature can be set at thermoneutrality for the individual infant. The appropriate temperature is obtained from published tables that take into account weight, age and maturity. 2) Servo-control of skin temperature. By maintaining the surface temperature of the infant at a fixed level, the exposed surface is kept close to thermoneutrality. Skin temperature that represents approximate basal metabolic activity varies, but is approximately 36.2°C for the full-term, and 36.5°C for the low birth weight infant. 3) Reduce evaporative water loss. Since 0.58 calories of heat are lost per gram of water evaporated from the skin, evaporation can be significantly reduced by increasing the ambient relative humidity. 4) Head Covering. The head represents 20.8% of the body surface and the brain accounts for 36% of total heat production. Since the head is poorly insulated it represents an area of significant heat loss. By covering the
head with an insulated hat, head heat loss is reduced by 17% and total metabolic activity during cold stress by 15%.

Evaporation accounts for approximately 34—45% of the water loss in the newborn infant. The loss is principally from the skin. Water reaches the skin surface mainly by the trans-epithelial route rather than by sweating. There is a close relationship between transepithelial water loss (TEWL) and heat balance since 0.58 calories of heat are lost for every gram of water evaporated.

Factors governing TEWL are: 1) gestational age. TEWL averages 6 g/m /hr in the full term infant. However, due to increased permeability of the premature baby's skin, TEWL increases to volumes as high as 75 g/m /hr. 2) ambient relative humidity. This factor can be controlled by the physician. There is a linear relationship between evaporation water loss and the humidity of the environment; as humidity falls, TEWL increases. A major source of evaporative water loss in the newborn patient is intestinal exposure during operation. Typical values are 54.8 g/m /hr for water loss and 31.8 calories/m /hr for heat loss.

Methods of controlling evaporative water loss: 1) In the incubator. Relative humidity can be increased by adding water to the humidity chamber. Because of the increased risk of overgrowth of certain bacteria in the humid environment, we choose to humidify only the incubator of small pre-term infants. 2) Plastic bags and drapes. Placing the infant in a plastic bag, or lying him on a plastic sheet and covering him with a plastic drape, significantly reduces transepithelial water loss by increasing the ambient relative humidity directly about the baby. 3) Bowel bags. During operation, evaporative water loss from the bowel can be reduced to almost zero by enclosing the exposed intestine in a plastic bag. Once the intestine is in the bag, the humidity about the bowel is approximately 100%.