Heat shield reduces water loss

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SUMMARY A heat shield covered by polyvinyl chloride film greatly reduced insensible water loss and radiant energy requirements in 12 preterm infants on a radiant cradle. Measured transmittance of radiant energy emitted by the radiant heater was impeded minimally by various thin film plastics but was blocked significantly by Perspex.

The principal objective of a heat shield for infants on radiant warmer beds is reduction of insensible water loss, but a shield should neither impede transmittance of radiant energy appreciably nor impair patient visibility and accessibility. A shield used in our nursery fulfills these objectives. The effect on insensible water loss and radiant energy requirements was assessed by this study. We also measured transmittance of radiant energy through five common plastic materials.

Patients and methods

The shield is in two sections which telescope to adjust for length. The Perspex walls are 4 mm thick and measure 13 cm (high) × 22 cm (wide) × 35 cm (long) for each section; the top is covered by a thin film of polyvinyl chloride. Small semicircular openings along the bottom permit passage of apparatus (Figure).

Twelve well preterm infants were studied. Their birthweight was mean (SD) 1·33 (0·2) kg (range 0·92 to 1·65 kg) and their gestational age was mean (SD), 33 (1·3) weeks (range 30 to 34 weeks). At the time of the study their ages ranged from 8 to 76 days (mean 29·8 days) and weights from 1·38 to 1·72 kg (mean (SD), 1·51 (0·11) kg). Infants were studied on the same radiant warmer (Cavitron KDC Model IW-10A) placed away from outside walls and windows. Each infant was studied for two consecutive 90 minute intervals, one shielded (period I) and one unshielded (period II). The heat source, a metal clad quartz tube, emits radiant energy around a peak wave length of 3 μm. It was proportionally servocontrolled to maintain abdominal skin temperature at 36·0 to 36·5°C. Abdominal skin and rectal temperature and air temperatures inside and outside the shield were monitored continuously by thermis-
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tors (Yellow Springs Instrument Co) appropriately placed and shielded. Radiant energy was monitored by a thermopile (Model 21–330, Barnes Engineering Co). Temperatures and radiant energy were recorded graphically by a modified monitor (Model 512, Corometrics Medical Systems, Inc). Radiant energy was determined for each infant during each period by the average of three planimetric measurements of area beneath the recorded curve. Results were expressed as mw/cm²/hour, representing the mean radiant energy required to maintain skin temperature during the specified interval. In four infants, relative humidity was measured inside and outside the shield and vapour pressure calculated.

Change in weight was determined by an electronic scale (Potter Baby Scale, Model 62). Thermal stability, resolution, and repeatability of the scale under typical study conditions, with and without the shield in place, were evaluated carefully before in vivo measurements. Thus, we were aware of potential thermal effects on scale stability and for each study period allowed sufficient time for thermal equilibration and stabilisation of the scale. Calibration of the scale and other recording devices was verified at the beginning and end of each period.

Weight change and cardiorespiratory rates were recorded by a research nurse at 15 minute intervals. Data were discarded when, during any 15 minute interval, the baby voided or defecated. The baby was dried and a new 15 minute interval was initiated after resetting the scale to zero. In this manner, 90 minutes of observation were accumulated for each period. As reported by others, 1–3 weight loss (g) was equated with insensible water loss (ml/kg/hour). Statistical significance of differences between study environments was determined by paired Student’s t test.

Measurements of radiant transmittance through plastics were made with the thermopile placed in the centre of an empty radiant cradle, 5 cm above the mattress. The radiant source was the same tubular quartz heater described above. To ensure comparable measurements, constant peak radiant output was maintained. The unobstructed radiant energy received by the thermopile recorded a straight line representing 100% transmittance. Each plastic material was then interposed between the thermopile and heat source, immediately resulting in a steady lower level of radiant energy received by the thermopile; removal of the material produced a prompt return to the original line of maximal transmittance. The average decline (three measurements) in radiant energy induced by the interposed plastic was measured from recorded curves and expressed as per cent impedance for each material studied. Plastics tested were polyethylene, polyvinyl chloride-polyvinylidene, polyvinyl chloride, polyvinylidene, a double layered ‘bubbled’ material of polyethylene coated with polyvinylidene and 4 mm thick Perspex.

Results

Mean values of measurements for each study period are shown in the Table. Skin and rectal temperatures and cardiorespiratory rates were not influenced significantly by the presence or absence of shielding. Shielding, however, produced a warmer proximal ambience of higher vapour pressure; insensible water losses and radiant energy requirements were reduced significantly.

Measurements of radiant transmittance showed 85% blockage by Perspex, and an average of 14% blockage by single layer plastic films; the double layered ‘bubble blanket’ blocked approximately 32% of radiant emissions.

Discussion

In the group of infants studied, the shield reduced insensible water loss by 51% and radiant energy requirements by 59%. Baumgart et al 4 reported

<table>
<thead>
<tr>
<th>Study period</th>
<th>Temperature (°C)</th>
<th>Vapour pressure (mmHg)</th>
<th>Radiant energy (mw/cm²/h)</th>
<th>Insensible water loss (ml/kg/h)</th>
<th>Respiratory rate (per min)</th>
<th>Heart rate (per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skin (abd)</td>
<td>Rectal</td>
<td>Ambient in</td>
<td>Ambient out</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I, with shield</td>
<td>36-2 (0-3)</td>
<td>36-9 (0-3)</td>
<td>30-9 (1-1)</td>
<td>26-5 (0-9)</td>
<td>12-928 (2-185)</td>
<td>8-77 (2-97)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II, no shield</td>
<td>36-2 (0-3)</td>
<td>37-2 (0-2)</td>
<td>26-7 (1-7)</td>
<td>27-9 (1-1)</td>
<td>9-204 (1-072)</td>
<td>21-40 (5-58)</td>
</tr>
<tr>
<td>P value</td>
<td>≤0-001</td>
<td>≤0-001</td>
<td>≤0-05</td>
<td>≤0-001</td>
<td>≤0-001</td>
<td></td>
</tr>
</tbody>
</table>

abd = abdominal.
similar results using a blanket of plastic film placed directly upon the infant. They also measured a significant reduction in air turbulence near the baby. The rapidity with which radiant heat requirements diminished in response to the blanket suggested that the immediate and perhaps major effect of such shielding is abrupt reduction of air turbulence and resultant convective and evaporative heat losses. A greenhouse effect is unlikely because ambient temperature and radiant energy requirements would change more gradually. Air turbulence is greater over open radiant cradles than within incubators, and this may contribute to the greater insensible water loss associated with radiant heaters. We did not measure air velocity, but we assume a reduced turbulence because the shield provided virtually complete enclosure. Reduced turbulence and raised ambient vapour pressure under the shield should decrease convective and evaporative heat losses. By reducing insensible water loss to levels reported for incubators, the shield may eliminate a major objection to the protracted use of radiant warmers.

We used a plastic film cover (polyvinyl chloride) for the shield because Indyk suggested that polyvinyl chloride-polyvinylidene film did not block transmittance of radiant energy significantly while Perspex did. Our study of five plastic materials has confirmed and extended his observations. The thin film plastics that we tested should not interfere with warming.

We thank our dedicated research nurses and James E Wade, biomedical engineer, whose services were indispensable.

References


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Traumatic perforation of the hypopharynx—an unusual form of abuse

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**Summary** Two infants presented with extensive interstitial emphysema of the neck as a result of non-accidental trauma to the pharynx. The clinical presentation, diagnosis, and management of this unusual form of child abuse is discussed.

The variations in the clinical presentation of child abuse are legion. We describe two infants with erythematous swelling of the neck after non-accidental traumatic perforation of the hypopharynx complicated by haemorrhage, infection, and massive interstitial emphysema.

**Case reports**

**Case 1.** A 4 month old boy presented with a 24 hour history of feeding difficulty, coughing, and the production of bloodstained sputum. Examination showed respiratory distress, head retraction, pyrexia, and a rapidly progressing erythematous swelling of the anterolateral aspects of the neck over which crepitus could be felt. A linear abrasion was found on the soft palate; direct laryngoscopy showed fresh blood in the oropharynx and a haemorrhagic sloughing lesion on the posterior pharyngeal wall. Radiological examination showed extensive interstitial emphysema of the neck and three healing lower rib fractures, evidence of probable previous abuse.
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