Comparing results.

Senior Physician
Dr. Thomas Schaible,
cand. med. Frederik Loersch,
Pediatric Clinic,
University Hospital
of Mannheim, Germany

With and without heated mattress: comparing skin temperature profiles of newborns in open care therapy.

Sometimes, with all the attention focused on ventilation monitoring and cardiovascular management, neonatal intensive care patients do not receive the level of warming therapy they should, despite the fact that a steady supply of warmth is essential for every newborn. There are many different ways to achieve this, with solutions available from various manufacturers of incubators and heated cots. In the present trial, an infrared camera was used to record the surface temperature profiles of neonates in two different open care systems, both of which are popular among medical personnel because of the unrestricted access they offer to the patient. Both heated cots are fitted with a radiant heater to warm the baby from above, and one of the systems is additionally equipped with a heated mattress to warm the patient from below. The recorded images were used to gain an impression of how heat is distributed, absorbed and dissipated in the patient.

Patients and methods

Every year, around 100 patients with a variety of underlying diseases are treated in open care therapy at Mannheim Hospital's neonatal intensive care unit. The objective of our test was to establish whether children with similar rectal temperatures (36.6–37.4 °C) also show similar heat distribution patterns. Newborns weighing 2,540–3,980 g at birth were observed, none of the test subjects being older than 28 days. The measurements were always taken at the same time of day (approx. 9 p.m.) so as not to disrupt the circadian rhythm of the babies. The room temperature was kept constant at 26.0–28.0 °C. For the purposes of testing, a heated cot manufactured by Ameda (amenic) equipped only with a radiant heater, and a heated cot from Dräger Medical (Babytherm 8010) equipped additionally with a heated mattress were chosen. A thermal camera made by inframetrics (PM 280) was used to take still images of the surface temperatures in the 5 nm wave range; the images were subsequently analyzed on a PC. The images were all

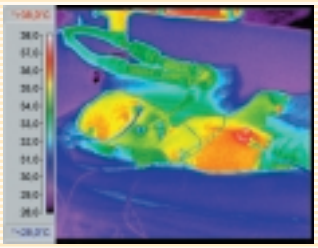

Figure 1 (child 1)
Newborn with bladder exstrophy, relaxed and ventilated. This patient is suffering from peripheral hypoperfusion. The head and abdomen are both warm and roughly the same temperature, but the extremeties are very cold (The double-lumen tube in the background is the ventilation hose. The scale to the left shows the temperature range and the temperatures that the colors correspond to)

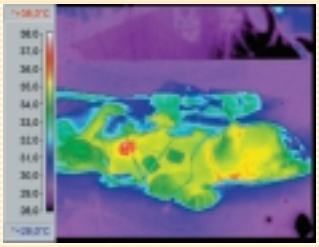

Figure 2 (child 2)
Newborn with sepsis. Catecholamine therapy is causing significant peripheral hypoperfusion in this patient. Gradients of over 3 Kelvin can be detected across the body. The increase in the central to peripheral gradient could be a sign of reduced thermal comfort. The surface skin temperature is low

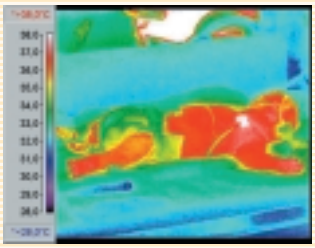

Figure 3 (child 3)
Ventilated newborn with wet lung syndrome. Newborn with insufficiently developed skin. Skin temperature generally too high, without gradients

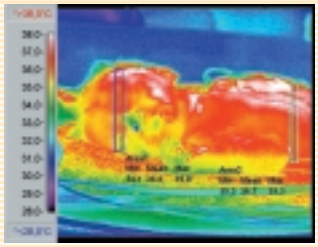

Figure 4 (child 4)
Neonatal infection and peripheral hypoperfusion. "Barbeque effect" with excessive temperatures on the exposed surface and significant cooling towards the underside (Example shows a marked reference area on the patient for measurement of the temperature gradients)

calibrated to a temperature range of 28.0–38.0 °C for ease of comparison. The skin temperature control was set to 35.0–37.0 °C. The maximum to minimum temperature gradient was recorded in the head and abdominal areas, in each case from the surface of the body to the underside, and expressed in Kelvin. On the basis of 300-500 individual temperatures, an analysis program calculated the temperature gradient across a marked reference area (see Figure 4) with maximum, minimum and mean temperature.

Results

The thermographic images of patients 1 to 4 (Ameda heated cot) and 5 to 8 (Dräger heated cot) can be described in relation to their different situations and interpreted as follows. Tables 1 and 2 present an overview of the various temperature gradients.

Discussion

In patients treated in an open care system with warmth provided by a radiant heater, we observed in some cases relatively high temperature gradients of up to 4.9 Kelvin on the surface of the skin. Such temperature gradients pose a considerable obstacle to the child's heat dissipation process and appear to be a particular problem in the head region. Overall, the patients showed very varying heat distribution, despite minimal differences in rectal temperature and virtually identical device settings. In the group with the additional heated mattress, the gradients were considerably lower. Typically, the underside of the patient was found to be warmer than the side turned toward the radiant heater. The heated mattress can also do nothing to counter the problem of peripheral hypoperfusion, but at least the patients are not exposed to any additional heat or cold stress from one-sided heating. A rectal temperature measurement and a temperature probe on the abdomen cannot possibly reproduce the complex heat balance of a child as can be observed using an infrared camera. It would appear that heating from both sides is preferable to a single radiant heater, though one disadvantage of the gel mattress is the lack of an X-ray drawer.

Conclusion

Infrared thermomonitoring gives a complex and rather general impression of surface temperatures. Furthermore, the images require a degree of interpretation to establish the actual core temperature. Such interpretation can be difficult, particularly under pathophysiological conditions like peripheral hypoperfusion. It would thus be useful to supplement the infrared monitoring with a non-invasive sensor able to reliably record the core temperature either directly or indirectly.

Patient	Age	Weight	Rectal Temperature	Skin Temperature Control	Gradient at Head (Forehead)	Gradient at Abdomen (Liver)	Maximum Temperature at Head	Maximum Temperature at Abdomen	Minimum Temperature at Extremity
1.	5. LT	3.980 g	36,8 °C	36,0 °C	1,1 K	0,6 K	35,5 °C	36,0 °C	32,5 °C
2.	4. LT	2.870 g	37,2 °C	35,0 °C	3,5 K	3,1 K	36,5 °C	35,2 °C	32,9 °C
3.	2. LT	3.320 g	37,0 °C	36,0 °C	2,2 K	1,5 K	36,6 °C	36,8 °C	35,0 °C
4.	7. LT	3.560 g	37,4 °C	36,5 °C	4,9 K	4,0 K	39,0 °C	39,3 °C	34,1 °C
Median	4,5. LT	3.440 g	37,1 °C	36,0 °C	2,85 K	2,3 K	36,55 °C	36,4 °C	33,5 °C

table 1: temperature data for the four patients in the heated cot with radiant heater

Patient	Age	Weight	Rectal Temperature	Skin Temperature Control	Skin Temperature Control (Mattress)	Gradient at Head (Forehead)	Gradient at Abdomen (Liver)	Maximum Temperature at Head	Maximum Temperature at Abdomen	Minimum Temperature at Extremity
5.	9. LT	3.360 g	37,1 °C	36,0 °C	35,0 °C	1,2 K	0,1 K	36,0 °C	36,4 °C	35,1 °C
6.	2. LT	3.470 g	36,8 °C	35,5 °C	36,5 °C	-0,2 K	-0,5 K	35,8 °C	35,9 °C	34,4 °C
7.	27. LT	3.900 g	36,5 °C	35,0 °C	34,0 °C	0,1 K	-0,3K	35,2 °C	35,3 °C	32,9 °C
8.	21. LT	2.650 g	36,7 °C	35,5 °C	34,5 °C	0,2 K	0,1 K	35,0 °C	36,2 °C	33,1 °C
Median	15. LT	3.415 g	36,75 °C	35,5 °C	34,75 °C	0,15 K	-0,1 K	35,5 °C	36,05 °C	33,75 °C

table 2: temperature data for the four patients in the heated cot with radiant heater and heated mattress

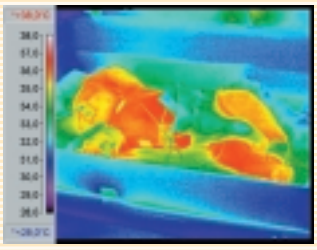

Figure 5 (child 5)
Newborn suffering from trisomy 21 and anal atresia. Heat distribution in this patient is fairly homogeneous and skin perfusion is normal. The gradients are good

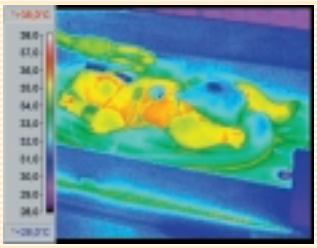

Figure 6 (child 6)
Newborn with ARDS-type respiratory disorder, ventilated, slight peripheral hypoperfusion. Low-dosage catecholamine therapy

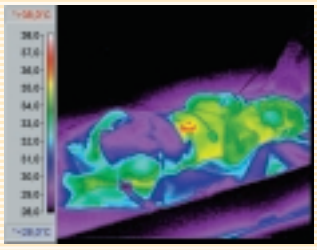

Figure 7 (child 7)
Newborn with serious sepsis, high-dosage catecholamine therapy. Peripheral hypoperfusion with low surface temperature. A relatively high core temperature of above 38.0 °C is likely. Several layers of material additionally shield the child from the heated mattress

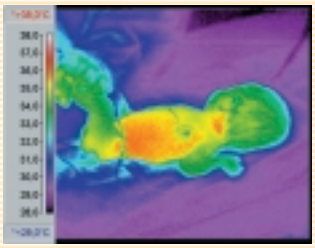

Figure 8 (child 8)
Newborn with suspected invagination. Peripheral hypoperfusion with cold extremeties. Central to peripheral gradient of above 2 Kelvin