ORIGINAL ARTICLE

Neonatal hypothermia detection by ThermoSpot in Indian urban slum dwellings

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Objective: To look at the performance of ThermoSpot liquid crystal thermometry in detecting neonatal hypothermia.

Design: A comparison was made between skin temperatures taken by ThermoSpot and axillary temperatures taken by digital electric thermometry. Non-medically trained local volunteers performed daily paired recordings on infants on days 1, 2, 3, 4, 5, 6, and 7 of life.

Setting: This is a non-hospital based study set in the homes of neonates in an underprivileged urban slum community in the developing world.

Subjects: Inclusion criteria: babies born at home. Exclusion criteria: hospital admission; parental refusal.

Interventions: The ThermoSpot was stuck to the neonate's abdomen over the liver area on day 1 and removed on day 7.

Main outcome measures: Fixed test properties of ThermoSpot.

Results: Over 180 paired observations, the fixed test properties of ThermoSpot in the detection of hypothermia were: sensitivity 88%; specificity 97%; positive likelihood ratio 29; negative likelihood ratio 0.13.

Conclusions: ThermoSpot performed well when used by non-medically trained volunteers for the detection of neonatal hypothermia in the homes of an urban slum community.

Neonatal hypothermia is a common problem in developing countries¹ but may be underestimated in the tropics.^{1, 2} The incidence in North Indian urban slums in winter has not been quantified, but a prospective year long observational study in Central Indian rural homes detected hypothermia (<35°C) in 17% of 763 neonates.³ There was a significant seasonal variation, and the same workers showed an incidence of 21.5% in 274 neonates during the winter.⁴ Hypothermia is associated with an increased risk of mortality in developing countries.⁵

In developing countries, if the temperature of a newborn infant is measured, a mercury in glass thermometer is generally used, but these are fragile and difficult to obtain in many parts of the developing world. Digital electric thermometers (DETs) are more robust but are relatively expensive. As an alternative, the use of the liquid crystal thermometer (LCT) has been suggested. Liquid crystals have the mechanical properties of a liquid but the optical properties of a single crystal. Long asymmetric molecules arrange themselves in orderly spirals in the liquid. When light strikes these spiral structures, some of it reflects. The reflection is strongest when the wavelength of the light is an integer or half integer multiple of the spiral's pitch—the distance between adjacent turns of the spiral. As the wavelength of light is related to its colour, the light reflected by these liquid crystals is coloured, and because the pitch changes with temperature, so does the colour. LCTs are cheap and have the additional advantage of being easily stuck on to the infant's skin, giving continuous non-invasive temperature monitoring. A study has favourably evaluated their use by medical staff in a hospital setting.⁶ However, such data may not be representative of the population in developing countries, as access to hospitals is generally limited, and most deliveries are conducted at home: in a North Indian study of home delivered newborns, 97.4% of babies were delivered by dais (traditional birth attendants).⁷

ThermoSpot is an LCT in the form of a sticky disc (12 mm in diameter) which can be applied to the skin. It is economical, costing about 10 p (7 Indian rupees) per spot at present.

This is a non-hospital based study set in the homes of neonates in an underprivileged urban slum community in the developing world. Measurements were not made by medically trained staff but by local non-medically trained volunteers.

The aim of the study was to compare the performance of ThermoSpot in the detection of neonatal hypothermia under these conditions with the gold standard of axillary DET.

METHODS

There are various sites for measuring temperature in neonates. Axillary temperature measurements have been recommended by the American Academy of Pediatrics.

There has been debate over the cut-off point for hypothermia. The World Health Organisation defines it in young infants as a rectal temperature below 36°C.⁸ Studies have shown that axillary temperature is lower than rectal temperature. A systematic review of studies comparing the two sites found a pooled mean temperature difference of 0.85°C for DETs.⁹ In neonates the limits of agreement were narrower. However, the review only included a single study of DETs in neonates.¹⁰ This was a hospital study where infants were nursed in controlled environments in incubators, under radiant warmers or swaddled in bassinets. Consequently no infant was included with a rectal temperature below 36.1°C. This would be expected to reduce core-surface temperature gradients. Our study focuses on hypothermia in neonates at home. In the absence of any published data directly applicable to our population, we have

Abbreviations: DET, digital electric thermometer; LCT, liquid crystal thermometer

arbitrarily defined hypothermia in this study as an axillary temperature below 35°C; this is the definition used (locally) by the National Neonatal Forum, India.¹¹ Other Indian workers have found that case fatality significantly increased below this.³ The manufacturers of ThermoSpot (TALC, St Albans, Hertfordshire, UK) state that its appearance changes from a bright green smiling face to a plain black disc when it cools to below 35.5°C. However, as with any test with a $\pm$ result, the selection of the cut-off point can be manipulated to change test performance: as we use ThermoSpot to signal progressively lower temperatures, there will be an increase in sensitivity (fewer false negatives) at the cost of a decrease in specificity (more false positives). The desired key test property in this context is a high sensitivity; false negatives are undesirable (they could falsely reassure the carers of a cold baby). The temperature cut-off point chosen should be clinically useful, and fixed test properties should be stated for this explicit cut-off value. This study therefore assesses the ability of ThermoSpot to signal hypothermia as defined by an axillary DET recording of 35°C.

This study took place during winter (January and February 2005) in Sunder Nagri, Delhi. This is an inner city slum area with a population of about 65 000. The Department of Community Health, St Stephens Hospital recruits volunteers from this community. "Community Health Volunteers" are local married women who make home visits to impart basic health education and improve accessibility to maternity services. "Friends of Children" are local adolescent girls who function as health educators to reduce childhood malnutrition as part of a project started in July 2003. Both groups are non-medically trained but underwent initial three day training programmes. They were employed in this study to perform ThermoSpot and digital electric thermometry in the homes of newborn infants.

All babies born at home were included. Exclusion criteria were admission to hospital and parental refusal.

The ThermoSpot was stuck to the infant's abdomen over the liver area. Temperature was measured on daily home visits on days 1, 2, 3, 4, 5, 6, and 7 of life. Temperature was first measured by ThermoSpot and then with a DET placed in the axilla. There was no formal blinding of the observer, but the DET reading is an electric digital reading, which cannot be biased by the observer.

The St Stephen's Hospital ethics committee approved the study.

RESULTS

Thirty two infants were recruited. Seventeen were boys (mean (SD) birth weight 3000 (340) g). Fifteen were girls (mean (SD) birth weight 3000 (380) g).

There were no reports of skin damage or discomfort reported from the use of ThermoSpot. It came unstuck and had to be reapplied in four cases.

Table 1 Performance of ThermoSpot compared with axillary digital electric thermometer (DET) in the detection of hypothermia (axillary temperature <35°C)

	DET: hypothermia	DET: normothermia	Total
ThermoSpot: hypothermia	7	5	12
ThermoSpot: normothermia	1	167	168
Total	8	172	180

Fixed test properties were: sensitivity 88%; specificity 97%; positive likelihood ratio (sensitivity/(1-specificity)) 29; negative likelihood ratio ((1-sensitivity)/specificity) 0.13.

What is already known on this topic

- Neonatal hypothermia is an important problem in the developing world
- The use of liquid crystal thermometers in the developing world has been suggested because they are cheap, relatively unbreakable, and give non-invasive and continuous monitoring

What this study adds

- ThermoSpot liquid crystal thermometers performed well when used by local non-medically trained volunteers in the homes of an underprivileged community in the developing world
- Their sensitivity for the detection of hypothermia (axillary temperature below 35°C) in this setting was 88%.

A total of 180 paired observations were made (on 36 occasions the scheduled visit was not possible; on two occasions no DET reading was recorded; on six occasions no LCT reading was recorded).

Hypothermia was recorded by axillary DET on eight (4%) occasions. These eight episodes occurred in eight different infants (25% of the infants studied). Each of these infants therefore had only one episode of hypothermia. Six (75%) of these episodes occurred on the first day of life. Table 1 summarises the performance of ThermoSpot.

The hypothermic recordings on DET ranged from 34.8 to 33.0 (mean (SD) 34.0 (0.68)°C). The temperature in the single case missed by ThermoSpot was 34.7°C.

In this population of urban slum dwellers (where the prevalence of hypothermia on daily home testing was 4%), the negative predictive value of ThermoSpot was 99% and the positive predictive value was 58%.

DISCUSSION

Most neonates in developing countries are born and cared for at home, but the available information is mostly hospital based. Previous studies have looked at the performance of LCT when used by medically trained staff in hospital settings.

The importance of using local community workers for health interventions has recently been highlighted by a large study in Bangladeshi urban slums, which showed that the use of local people, most of whom were not health professionals, dramatically increased child survival.¹² Home based neonatal care was shown to reduce infant mortality by nearly 50% in a malnourished, illiterate, rural Indian study population.¹³

ThermoSpot is a cheap device. There were no adverse effects when it was applied over one week. It came unstuck on only four occasions. In this context, it is relevant that most cases of hypothermia occurred on the first day of life. This is in agreement with Bang *et al*,⁴ who found that 70% of episodes of hypothermia in perinates in rural Indian homes occurred on day 1. There is no other information in the medical literature on how the incidence of hypothermia is distributed during different days of the perinatal period.

In this study the performance of ThermoSpot was satisfactory (sensitivity 88%) when used by non-medically trained local volunteers in the homes of an Indian urban slum.

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IMAGES IN NEONATAL MEDICINE.....

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A cloverleaf skull associated with Crouzon syndrome

A baby born to non-consanguineous parents presented with a cloverleaf skull and Crouzon syndrome. Computed tomography scans revealed a trilobed configuration of the skull with a characteristic honeycomb appearance of increased craniolacunae (fig 1). The limbs and extremities were normal. DNA studies showed a 1040C→G mutation in the *FGFR2* gene predicting a serine 347 to cysteine amino acid substitution. The mutation was not present in either parent.

A cloverleaf skull consists of a trilobular skull with craniosynostosis. The known aetiology includes Apert syndrome, Beare-Stevenson cutis gyrata syndrome, Boston type craniosynostosis, Carpenter syndrome, Crouzon syndrome, Cumming syndrome, *FGFR2* unusual phenotypes, Muenke syndrome, osteoglophonic dysplasia, type 2 Pfeiffer syndrome, Saethre-Chotzen syndrome, type 1 and type 2 thanatophoric dysplasia, chromosomal duplications of dup(4p), dup(13q), and dup(15q), amniotic bands, and bilateral subtemporal decompression procedures for hydrocephalus.¹ Crouzon syndrome (OMIM 123500) is an autosomal dominant disorder involving craniosynostosis and *FGFR2* mutations. A frank cloverleaf skull is present in only 7% of Crouzon syndrome.¹

Figure 1 Computed tomography scans showing a trilobed configuration of the skull with the honeycomb appearance of increased craniolacunae.

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