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Original Article

Liquid crystal thermometry for early detection of hypothermia in newborns in neonatology ward, Sardjito Hospital, Yogyakarta

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Abstract

Background Hypothermia in neonates increases the risk of mortality and morbidity such as infection, coagulation disorders, acidosis and hyaline membrane disease. Mercury thermometer is commonly used to detect hypothermia in newborns, but it has it is not ecological acceptable, difficult to be sterilized, easily broken, difficult to find in some developing countries and needs some training before use. A simple, effective and easily used tool for detection of hypothermia in newborns is needed.

Objective To evaluate the ability of liquid crystal thermometry (LCT) in early detection of newborn hypothermia.

Methods This study was conducted in the neonatology ward, Sardjito Hospital. The LCT was placed on the abdominal wall. Digital thermometer measurement and LCT observation were conducted three times in each patient. LCT's color and body temperature were documented by using a pre-coded questionnaire.

Results A total of 268 newborns met the inclusion and exclusion criteria. The pilot study showed that the inter-observer agreement of LCT was 0.75. Positive likelihood ratio during three measurements were 22.9 (95%CI 11.47;45.78), 18.97 (95%CI 9.43;38.16) and 22.8 (95%CI 11.34;45.83) respectively.

Conclusion LCT exhibits good accuracy and is safe to diagnose hypothermia in newborn. **[Paediatr Indones 2008;48:5-9]**.

Keywords: *liquid crystal thermometry, hypothermia, newborn, digital termometer*

Hypothermia in the newborn occurs throughout the world in all climates. In resource-poor countries, maintaining body temperature remains a major problem.[1] It has been well documented that hypothermia is associated with an increased risk of morbidity and mortality.[2-4] Newborns are at increased risk of heat loss because of certain characteristics such as large body surface area in relation to weight, large head in proportion to the body, and less subcutaneous fat. Heat loss usually occurs during the first few hours after birth, although the condition may occur later too, for example during bathing or on a cold night. During first 20 minutes after delivery, newborn's temperature may fall 2-4°C if there is no adequate drying and wrapping with head cover.[1,5] Some risk factors associated to hypothermia have been documented, such as lack of understanding of newborns' non-shivering thermogenesis among both mother and staff, prematurity, no proper drying and wrapping,

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unnecessary separation of babies from the mother soon after birth, no extra-provision of heat during resuscitation, home delivery, not exclusively breastfed and bathed within 24 hours after delivery.[5,6-10]

In developing countries a mercury-in-glass thermometer is usually used to measure temperature of newborn infants. More recently, World Health Organization has recommended the use of low-reading thermometer to detect hypothermia in newborn infants. Unfortunately, the low-reading variety is difficult to obtain in many parts of the developing countries. The other problems are this instrument is fragile, can not be sterilized and difficult to use without proper training.[3,11] Recently, a color contact liquid crystal thermometry (LCT) has been manufactured. In a liquid crystal, selective light scattering occurs at specific wave length. The wave length of maximum scattering changes inversely with temperature, thus, an appropriately calibrated strip liquid crystal appears to light up according to the temperature.[3,11] We evaluated the performance of LCT for early detection of hypothermia (body temperature 35.4 – 36.4°C) in newborn infants.

Methods

The study was conducted on newborn babies recruited from the neonatology ward at Department of Child Health, Sardjito Hospital, Yogjakarta, from July to September 2005. Informed consent was obtained from the parents. Babies with skin abnormalities in hepatic area, which made LCT attachment difficult, were excluded.

Axillary temperature measurement as a gold standard was done in all sample by trained health workers. This measurement was carried out three times after the babies were recruited within 8 hours interval, regardless whether the baby had already been bathed or not. A DT-1TB digital thermometer produced by Lotus was used to measure the axillary temperature. The measuring range of this thermometer was 32-42°C with ± 0.1°C accuracy. Thermometer was sterilized using 70% alcohol at its sensor before use. After the button power was activated, the digital thermometer was put under the baby's armpit after the symbol "°C" began to flash. When it stopped flashing and the buzzer sounded, the measurement was done and the score on the screen showed the measured body temperature. The symbol L°C will appear to show the measured temperature is below 32.2°C, where as H°C shows the measured temperature is over 42°C.

The color contact thermometer to be tested was ThermoSpot® which is manufactured by TALC (Teaching Aids at Low Cost, PO Box 49, St Albans, Herts, AL15TX, United Kingdom, Fax 441727846852). It is a 12 mm plastic disc, black in appearance with two white dots in the upper half and on the reverse side there is a self-adhesive facility. At 35.5°C the dark side begins to turn green and a smiling face will become visible. At 36.5–37.4°C a bright green face will be clearly seen. As the temperature drops below 35.5°C, the smiling face will fade away completely. ThermoSpot® discs were attached to the abdomen over the liver area (**Figure 1**) , because they were not easily removed and the measured temperature may represent the central temperature.[3] The area of skin, on which ThermoSpot® to be attached, has to be sterilized using 70% alcohol-soaked cotton before it was attached. Allow sometime to let the area dry. If the ThermoSpot® is accidentally removed before the examination is completed, it can be reattached using a peace of tape. The ThermoSpot® reading was done at the time when the digital thermometer showed the body temperature score. The health worker should notice whether the ThermoSpot® color was green with clear smiling face, pale green with unclear smiling face or dark without smiling face. Precoded questioners were used for documenting tempera-

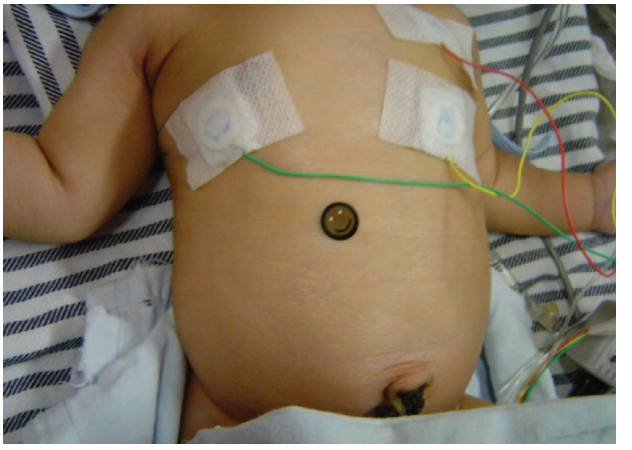

Figure1. The area to attach ThermoSpot's®

ture measurements, thermoSpot's® color and other following information for each infant: room temperature, gestational age, birth weight, apgar score and sex.

A pilot study to determine the inter-observer agreement on differentiated thermoSpot® color was conducted before the study started.

The calculation of minimal sample size requirement was based on the estimation of diagnosis accuracy, which was evaluated by sensitivity and specificity. Using formula for 40% sensitivity, 60% specificity with confidence interval 95%, a total of 92 newborn babies was needed if the absolute sampling error that could be tolerated was 10%. If the prevalence of hypothermia were assumed approximately 40% and an additional 10% of the sum, an amount of 230 newborns would be required.

Data were analyzed using Cat Maker and SPSS 10 for window. Sensitivity, specificity, positive and negative predictive values as well as positive and negative likelihood ratio were calculated to evaluate the performance of thermoSpot® for detection of hypothermia among newborn babies. Kappa was also calculated to examine the inter-observer agreement.

WHO puts hypothermia into 3 categories: babies suffer from mild hypothermia if their body temperature is 36–36.4°C, 32 – 35.9°C is moderate hypothermia and <32°C is severe hypothermia.[1] This Study was approved by Medical Ethics Committee of Faculty of Medicine Gadjah Mada University, Jogjakarta.

Prior to the study, a pilot study to test the inter-observer agreement after training was conducted. Kappa test was used to determine the inter-observer agreement. A good agreement was obtained among health workers in distinguishing thermoSpot's® color (Kappa=0.75).

Results

A total of 268 newborn infants were enrolled to this study; all of them completed the study protocol. All necessary data were completely recorded except the Apgar score which covered only 75% of the total respondents. The male and female ratio in this study was almost equal, as was the ratio for normal and low birth weight. On the other hand, most of the babies were term, showing that some of them were small for gestational age (**Table 1**).

ThermoSpot® observation and body temperature measurement were done every 8 hours, if the health worker noticed the ThermoSpot® color turned pale green or dark then thermometer measurement had to be done immediately.

The prevalence of hypothermia in 1st, 2nd, 3rd measurement were 18, 21 and 15% respectively (**Table 3**). The highest hypothermia prevalence was noted in the 2nd measurement. It showed that the false negative increased in the 2nd measurement as well (**Table 2**).

The performance of ThermoSpot's® for detection of body temperature ranging from 35.6 to 36.4°C among the newborns is shown in **Table 3**. Sensitivity and positive likelihood ratio were almost the same between 1st and 3rd measurement. This value slighthly decreased in the 2nd measurement.

If we assumed the prevalence of hypothermia in each measurement served as the pretest probability of hypothermia in this setting and were applied to the normogram for Bayes theorem based on the likelihood ratio in each measurement, the estimated post-test probability of detecting hypothermia would increase to 80 - 83% in all measurement (**Table 3**).

Discussion

Agreement test which was done before the study showed that there was a good inter-observer agreement to differentiate between pale green and bright green of the ThermoSpot®.

Table 1. Characteristics of the study sample

No	Characteristics	N
1.	Sex	
	Boys (%)	138 (51.5)
	Girls (%)	130 (48.5)
2.	Apgar score	
	1st minute (median)	6
	5th minute (median)	9
3.	Birth weight	
	normal (%)	130 (48.5)
	low* (%)	138 (51.5)
4.	Gestational age	
	Term (%)	164 (61.2)
	Premature (%)	104 (38.8)
5.	Room temperature (mean±SD)	27.5±1.2

*Low birth weight: birth weight less than 2500 g, regardless the gestational of age

Table 2. ThermoSpot® observation compared to axillary digital thermometer measurement

	Axillary digital thermometer measurement					
	1st measurement (°C)		2nd measurement (°C)		3rd measurement (°C)	
TC	35.4-36.4	≥36.5 or <35.5	35.4-36.4	≥36.5 or <35.5	35.4-36.4	≥36.5 or <35.5
HP	40	8	41	8	32	8
HT + Ht	8	212	16	203	8	220

TC : ThermoSpot's® color
HP : pale green with unclear smiling face
HT : green with clear smiling face
Ht : Dark

Table 3. ThermoSpot® performance for detection of hypothermia

	1st measurement (°C)		2nd measurement (°C)		3rd measurement (°C)	
	Value	95%CI	Value	95%CI	Value	95%CI
Sensitivity (%)	83	73-94	72	60-84	80	68-92
Specificity (%)	96	94-99	96	94-99	96	94-99
Positive predictive value (%)	83	73-94	84	73-94	80	68-92
Negative predictive value (%)	96	94-99	93	89-96	96	94-99
Positive likelihood ratio	22.92	11.47-45.78	18,97	9.43-38.16	22.8	11.34-45.83
Negative likelihood ratio	0.17	0.09-0.33	0.29	0.19-0.44	0.21	0.11-0.39
Prevalence (%)	18		21		15	
Post-test Probability (%)	83		83		80	

The prevalence of hypothermia in this study was not as high as that in the previous study. A study in Nepal reported a high prevalence of hypothermia in the population. During the first 36 hours, approximately 85% of 500 babies suffered from hypothermia.[9] In Zambia, a study showed that 44% babies experienced hypothermia during hospitalization.[9] A retrospective study in the United States found that the incidence of hypothermia among low birth weight babies was 45%.[12] One of the reasons for low prevalence of hypothermia in this population was the sample size calculation. In our study, the sample size was calculated for diagnostic test design, and not for a survey study. Thus the prevalence that was found in this study could over or under estimate for population.

In developing countries, hypothermia is identified only when it is already in extreme condition. Several conditions may contribute to this situation, such as lack of incubator with servo control, inadequate nursing staff, lack of awareness of the important of temperature control, shortage of clean/ warm linen, unavailability of affordable thermometers and frequent breakages of thermome-ters. Therefore, it is needed to find an alternative temperature detector which is simple, affordable and can be used by mothers and other caregivers.[4,11]

Our study has shown that ThermoSpot® is a valid method to diagnose hypothermia in the newborn infants. The results of this study provided convincing diagnostic evidence (positive likelihood ratio more than 10). From clinical standpoint, the use of ThermoSpot® to monitor newborns reliably identifies around 80 - 83% of hypothermic newborns, depending on the prevalence.[13] Some previous studies reported that ThermoSpot® was a valid method to detect hypothermia in newborn infant.[3,14-15] Another study conducted in Zimbabwe showed low sensitivity and specificity.[4]

In the serial measurements the value of positive likelihood ratio dropped in the 2nd measurement but was still more than 10. The possible explanation for the unstable result was inadequate attachment of the disc.

Several limitations of this study should be noted. Firstly, only 3 observations or temperature measurements were done during the study period. To know the performance of ThermoSpot® for early hypothermia detection, the observation should be done more frequently. Secondly, a second independent group of patients is needed to validate these results. The validation in the second independent group of patients aimed to distinguish the real diagnostic accuracy for the target disorders and to change associations due to idiosyncrasies in the initial (training or derivation) set of the patients. If, in the

second population, this instrument demons-trated similar level of accuracy, we may conclude that this instrument has a good accuracy.

We conclude that LCT exhibits good accuracy and is safe to diagnose hypothermia in newborn in the neonatology ward, Sardjito Hospital.

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