Effectiveness of a simple heated water-filled mattress for the prevention and treatment of neonatal hypothermia in the labour room

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ABSTRACT

Introduction: This study aimed to determine the proportions of normothermic infants who remained normothermic, and hypothermic infants who became normothermic following the use of a heated water-filled mattress (HWM) in the labour room.

Methods: A prospective observational study carried out in the labour room over a 2.5 month period on 228 well term infants delivered by lower segment caesarean section (LSCS) in the operating theatre (environmental temperature 18 degrees Celsius). Upon arrival in the labour room, the infants were placed on a HWM in a nursing cot. The axillary temperature was measured using a mercury thermometer for three minutes. Each infant was then wrapped with a large piece of linen, and covered with a blanket. Just before transfer to postnatal wards, the axillary temperature was re-measured.

Results: 52.2 percent (119/228) of infants were hypothermic (temperature less than 36.5 degrees Celsius) upon arrival in the labour room. Before leaving the labour room, the median increase in axillary temperature of the initially hypothermic infants was significantly higher (0.2 degrees Celsius, interquartile range 0.5) than those initially normothermic infants (0.0 degrees Celsius, interquartile range 0.3) (p-value is less than 0.00001). Among the initially hypothermic infants, 40.3 percent (48/119) became normothermic before transfer to postnatal wards. The significant independent risk factors associated with persistent hypothermia were lower birthweight (p-value equals 0.02), lower gestational age (p-value equals 0.02) and shorter duration on the warming mattress (p-value equals 0.08). Among 109 initially normothermic infants, 17.4 percent became mildly hypothermic (mean axillary temperature 36.2 degrees Celsius, standard deviation 0.2) before leaving the labour room.

Conclusion: The HWM is a reasonably effective simple device for the prevention and treatment of hypothermia in the labour room.

Keywords: heated water-filled mattress, labour room, neonatal disorders, neonatal hypothermia

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INTRODUCTION

Neonatal hypothermia remains a common problem in the labour room (LR) and operation theatre (OT), even in tropical countries like Malaysia. This is because, for optimal functioning of equipment and comfort of staff and mothers in labour, the environmental temperatures of these areas are maintained at lower levels by air-conditioning. Radiant warmers and, in some hospitals, closed incubators have been used to prevent neonatal hypothermia in these areas. However, both equipments are expensive.

A simple and relatively cheap heated water-filled mattress (HWM) (KanMed, Bromma, Sweden) has been used in many developed countries over the last one and a half decades for the prevention and treatment of hypothermia in pre-term infants[1,2]. It consists of a soft flame-resistant polyvinylchloride mattress which is filled with 4.5 litres of water and kept at a constant temperature by a thermostatically-controlled heating pad. When in use, the HWM is placed on top of the mattress of an ordinary baby cot and the infant lies on top of the HWM. This keeps the baby warm by heat conducted from the HWM.

Review (via Medline) of English language medical literature published between 1970 and 2002 showed that no study has been reported on the effectiveness of the HWM for the prevention and treatment of hypothermia in term infants in LRs. There have only been two articles published so far on the use of HWM for prevention and treatment of hypothermia in pre-term infants[1,2]. We hypothesised that the HWM could prevent and treat neonatal hypothermia in term infants born or managed in air-conditioned LRs. The

objectives of the present study were to determine the proportions of: (a) normothermic infants who remained normothermic, and (b) hypothermic infants who became normothermic, after being placed on the HWM during their transit through the LR from the OT.

METHODS

This was a prospective observational study carried out in the LR of the Hospital Universiti Kebangsaan Malaysia over a 2.5-month period between 1 October 2002 and 15 December 2002. The inclusion criteria were well infants of term gestation born by lower segment caesarean section (LSCS) in the OT, which had an average environmental temperature of 18ºC. Upon delivery, these infants were subsequently transferred to the LR, which had an average environmental temperature of 20ºC for routine procedures of anthropometric measurement, vitamin K injection, Hepatitis B vaccination, and checking of anal patency prior to admission to postnatal wards. The exclusion criteria were pre-term infants or ill term infants requiring direct admission to the neonatal intensive care unit, or maternal pyrexia prior to LSCS.

Upon arrival in the LR, infants were placed on the HWM covered with a piece of linen in a cot. Their axillary temperature was measured using a mercury thermometer for a duration of three minutes. The standard nursing procedure described above was carried out with the infants lying on the HWM. The scalp, neck and body of each infant were wrapped with a large piece of linen, and was then covered with a piece of blanket. The infants stayed in the LR and were nursed in this manner until they were ready for transfer to the postnatal wards. Just before transfer, their axillary temperatures were re-measured as described above. The nursing staff in the labour room were reminded to keep the heating pad of HWM on at all times so that the HWM was maintained at a constant temperature of 37ºC. They were also reminded to cover the infants securely as described above.

The unpaired Student's t-test was used for comparison of continuous variables with normal distribution while the Mann Whitney U test was used for variables with skewed distribution. Paired Student's t test (or Wilcoxon signed rank test for skewed distribution) was used for comparison of axillary temperature of infants before and at the end of the period they were on the HWM. The chi-square test (or Fisher exact test for expected values of less than 5) was used for analysis of categorical variables. Forward logistic regression analysis was carried out to determine the significant risk factors associated with persistent hypothermia in sub-group analysis. All statistical tests were 2-tailed and p-values of less than 0.05 were considered statistically significant.

RESULTS

228 infants were recruited into the study. Their mean birthweight was 3,085 (standard deviation (SD) = 572) g and median gestational age was 38.0 (interquartile range (IQR) = 2) weeks. 119 (52.2%) of them were hypothermic initially, with an axillary temperature of less than 36.5ºC when they arrived at the LR from OT. The median axillary temperature (36.0ºC, IQR 0.3) of these initially hypothermic infants was significantly lower than the remaining 109 infants whose median initial axillary temperature was 36.6ºC (IQR 0.3, p=0.0001).

Table I compares the clinical variables between infants who were initially normothermic (axillary temperature $\geq$36.5ºC) and those who were initially hypothermic (axillary temperature <36.5ºC). There was no significant difference in the ethnic distribution, gender distribution, mean birthweight and mean gestation age between these two groups. There was also no significant difference in the median age of infants when they were placed on the HWM between these two groups (p>0.05). Neither was there any significant difference in the median duration of infants lying on the HWM between these two groups (p>0.05). However, the median rise in axillary termperature during their stay on the HWM was significantly higher in the initially hypothermic infants than those initially normothermic infants (p<0.0001). Furthermore, the final axillary temperature of the initially hypothermic infants remained significantly lower than those who were initially normothermic before leaving the labour room (p<0.0001)

Among the 109 initially normothermic infants, 17.4% (19/109) of them became mildly hypothermic before leaving LR while the remaining 90 infants remained normothermic. The final axillary temperatures of these 19 infants (mean=36.2ºC, SD=0.2) were significantly lower than those who remained normothermic (mean=36.7ºC, SD=0.2, p<0.0001). There was no significant difference in the mean birthweight, mean gestational age, mean age when placed on the HWM, and median duration of remaining on the HWM between these two groups of infants (p>0.05) (Table II). The median increase in axillary temperature during their stay on the HWM was significantly lower in the hypothermic infants (p<0.0001).

Among the 119 initially hypothermic infants, 40.3% (48/119) of them became normothermic

Table I. Relationship between clinical variables of infants and their initial axillary temperature on arrival at the labour room from the operation theatre.

Clinical variables		Initial axillary temperature ≥36.5°C n=109	<36.5°C n=119	p-value
Sex	Male	53 (48.6)	60 (50.4)	0.8
	Female	56 (51.4)	59 (49.6)	
Race	Malay	68 (62.4)	71 (50.7)	0.9
	Chinese	31 (28.4)	36 (30.3)	
	Indian	6 (5.5)	9 (7.6)	
	Others	4 (3.7)	3 (2.5)	
Mean birth weight in g (SD)		3169 (568)	3008 (566)	0.03*
Mean gestation in weeks (SD)		38.5 (1.5)	38.2 (1.5)	0.2
Median age (in minutes) when placed on warmer (IQR)		27 (165)	26 (19)	0.7
Range		3-80	5-80	
Median duration (in minutes) on warmer (IQR)		25 (15)	25 (10)	0.9
Range		5-105	10-285	
Initial axillary temperature in °C				
Median (IQR)		36.6 (0.3)	36.0 (0.3)	<0.0001*
Range		36.5-37.5	35.5-36.4	
Final axillary temperature in °C				
Median (IQR)		36.7 (0.3)	36.4 (0.5)	<0.0001*
Range		36.0-37.5	34.6-37.2	
Median increase in temperature in °C (IQR)		0.0 (0.3)	0.2 (0.5)	<0.0001*

* denotes statistical significance. IQR = interquartile range; SD = standard deviation.

Table II. Relationship between clinical variables of initially normothermic (≥36.5°C) infants and their final axillary temperature before leaving the labour room.

Clinical variables	Final axillary temperature ≥36.5°C n=90	<36.5°C n=19	p-value
Mean birth weight in g (SD)	3199.7 (0.6)	3021.1 (0.5)	0.2
Median gestation in weeks (IQR)	38 (2)	38 (1-0)	0.9
Mean age (in minutes) when placed on warmer (SD)	28.5 (13.6)	25.9 (11.4)	0.4
Duration (in minutes) on warmer			
Median (IQR)	23.5 (10)	30 (15)	0.1
Range	5-80	15-105	
Final axillary temperature in °C			
Mean (SD)	36.7 (0.2)	36.2°C (0.2)	<0.0001*
Increase in axillary temperature during warming in °C			
Median (IQR)	0.0 (0.2)	-0.5 (0.2)	0.0001*
Range	-0.7, -0.5	-1.0, -0.1	

* Denotes statistical significance; IQR = interquartile range; SD = standard deviation.

Table III. Relationship between clinical variables of infants who were initially hypothermic (<36.5°C) and their final axillary temperature before leaving the labour room.

Clinical variables	Final axillary temperature ≥36.5°C n=48	<36.5°C n=71	p-value
Mean birth weight in g (SD)	3176 (550)	2894 (552)	0.007*
Mean gestation in weeks (SD)	38.8 (1.4)	37.9 (1.5)	0.002*
Final axillary temperature in °C			
Median (IQR)	36.5 (0.2)	36.2 (0.3)	<0.0001
Range	36.5-37.2	34.6-36.4	
Mean age (in minutes) when placed on warmer (SD)	28.4 (14.7)	29.4 (13.2)	0.7
Duration (in minutes) on warmer			
Median (IQR)	25 (18.8)	20 (15.0)	0.03*
Range	15-285	10-100	
Rise in axillary temperature in °C			
Median (IQR)	0.35 (0.3)	0.1 (0.2)	<0.0001*
Range	0.1-3.0	-0.8 to 2.0	

* denotes statistical significance; IQR= interquartile range; SD= standard deviation.

during their stay on the HWM, while the remaining 59.7% (71/119) infants remained hypothermic. The final axillary temperatures of the 48 infants who became normothermic were significantly higher than those who remained hypothermic (p<0.0001) (Table III). Both groups of infants showed a rise in axillary temperature. However, the median rise in axillary temperature of infants who became normothermic was significantly higher than those who remained hypothermic (p<0.0001). When compared with infants who became normothermic, the persistently hypothermic infants were of significantly lower mean birthweight and gestational age than those who became normothermic (p<0.001).

Although there was no significant difference in the age when these two groups of infants were placed on the HWM, the duration of stay on the HWM was significantly shorter among the persistently hypothermic infants than those who became normothermic before their transfer to the postnatal wards (p=0.03). Using their birthweight, gestation, their chronological age when placed on the HWM, and their duration of stay on the mattress as independent variables, forward logistic regression analysis showed that the significant independent risk factors associated with persistent neonatal hypothermia before transfer from the LR were: lower birthweight (odds ratio [OR] of persistent hypothermia for each extra gramme increase in birthweight = 0.999; 95% confidence interval (CI) = 0.998, 1.000; p=0.02), lower gestational age (OR of persistent hypothermia for each additional week increase in gestation = 0.7; 95% CI=0.5, 0.9; p=0.02), and shorter duration of stay on the HWM (OR of persistent hypothermia for each extra minute increase in duration of stay on the HWM=0.97; 95% CI=0.94, 0.99; p=0.008).

DISCUSSION

The present study showed that despite the use of radiant warmer for initial care of infants born by LSCS in the operation theatre (OT), the incidence of hypothermia, at 52.2%, was very high in this hospital. The low environmental temperature in the OT, failure of strict observation of standard operation procedure for prevention of hypothermia by staff, absence of a warming room in the OT and, at times, delay in transfer of infants rapidly out of the OT, were some of the contributing factors identified during quality improvement studies done in this hospital. The use of the HWM during this study helped to re-warm the initially hypothermic infants with resultant significant rise in their axillary temperature. However, despite this rise of axillary temperature, only 40.3% of the initially hypothermic infants became normothermic before being transferred to the postnatal wards.

The present study suggests that it is important to measure the body temperature of all infants born in a cold environment, such as the OT, before transferring them to postnatal wards. Our data also suggest that effort to prevent hypothermia in the OTs should be intensified. When hypothermia is detected, all newborn infants should be kept on the

HWM long enough until they become normothermic. This is because the present study shows that besides lower birthweight and lower gestational age, shorter duration of stay on the HWM is a significant independent risk factor associated with persistent hypothermia in the LR.

An issue of concern during the present study was the discovery that a certain proportion (17.4%) of the initially normothermic infants became mildly hypothermic when nursed on the HWM. This drop in body temperature did not appear to be associated with lower birthweight, lower gestational age, age of infants when placed on the HWM or their duration on the HWM when compared with the persistently normothermic infants (Table II). We speculated that the drop in body temperature in this sub-group of previously normothermic infants during their stay on the HWM could be due to violation of protocol by the staff during the study. This speculation was based on our observation of the activities of the staff after completion of the present study.

We observed that some of the initially normothermic infants born were only wrapped loosely with a thin piece of linen and not covered with a blanket as according to our protocol. The probable reason for the violation of protocol could be staff complacency towards the initially normothermic infants. Unfortunately, in a cold environment like the LR, this act of omission could cause heat loss from these infants via radiation, evaporation and convection with resultant development of mild hypothermia, despite the fact that they were placed on a HWM. However, to confirm this suspicion, a randomised controlled study should be carried out to determine the optimal number of linen and blankets required to maintain normothermia in these infants nursed on the HWM in such a cold environment. The main limitation of this study was that it was not a randomised control study comparing the effectiveness of the HWM with the more expensive radiant warmers or incubators. As a result we were not able to determine whether the use of the cheaper HWM was more cost-effective than the more expensive radiant warmers or incubators in the LRs.

In conclusion, this study showed that the simple and cheap HWM was a reasonably effective alternative method to the expensive radiant warmer for keeping term newborn infants warm in cold LRs, provided observation of the standard operating procedure of using the HWM was strictly adhered. However, further studies are required to determine the minimum number of linen and blankets required to be used in conjunction with the warming mattress to maintain normothermia in these newborn infants in such environment.

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