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Challenges of Minimizing Heat Loss at Birth: A Narrative Overview of Evidence-Based Thermal Care Interventions

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ABSTRACT

Evidence-based thermal care recommendations designed to minimize heat loss immediately at birth are readily available however, hypothermia still persists as a global challenge especially when caring for the most immature and smallest preterm infants. In this narrative overview we aim to provide the reader with a succinct summary of the causes and consequences of hypothermia, the extent of the problem (rates of hypothermia), principles of good thermal care, delivery room preventative measures, the research evidence underpinning existing interventions, current issues in practice, and the way forward. Due to the plethora of research literature available in this subject area, our article will focus primarily on evidence derived from systematic reviews and randomized or quasi-randomized controlled trials assessing the effectiveness of interventions to prevent hypothermia in the most vulnerable (preterm/low birth weight) infants where the intervention or combination of interventions is applied immediately at birth.

Providing warmth is well recognized as one of the basic needs for the well-being of all newborn infants.[1] In the first few minutes after birth, the newborn is most vulnerable to rapid heat loss[2] which, if extended, can result in adverse events and even death.[3,4] Activities and interventions from the minute of birth particularly within the "golden hour" can affect short- and long-term outcomes.[5,6] Thermal care recommendations designed to minimize heat loss immediately after birth have evolved over time, in line with emerging research evidence, and have been implemented in practice to varying degrees.[7,8] However, newborns still develop postnatal hypothermia in both resource-rich and resource-poor settings and across all climates.[9–11] Since hypothermia is potentially avoidable in almost all newborn infants,[12] this persistence poses a challenge for clinical teams particularly for the thermal management of the most immature and smallest infants.

How Is Hypothermia Defined and What Is the Extent of the Problem?

Healthy newborn temperature ranges vary and there are some differences of opinion regarding normothermia in the neonatal population.[13] Currently, the definition for "normal" preterm temperature, the accuracy and mode of measurement remain under discussion.[14] For the purposes of our review, hypothermia has been defined as a core body temperature below the normal range of (36.5 to 37.5 °C (skin temperature 0.5 to 1.0 °C lower).[15] Globally, newborn hypothermia continues to be a challenging matter. A recent review,[11] focusing on low-income and middle-income countries,[16] retrieved 32 relevant hospital ($n = 22$) and community-based ($n = 10$) studies reporting hypothermia prevalence rates. Hospital-based rates ranged from 8% within 12 hours of birth (<34.5 °C) in Guinea-Bissau (Africa) to 85% upon admission (<36 °C) in Harare, Zimbabwe (Africa) and Kathmandu, Nepal (Asia) 2 hours after delivery.[11] The rates of community-based hypothermia ranged from 11% (<36.5 °C) in a small study in Haryana, India (Asia) to a high rate of 92.3% (also <36.5 °C) in a large population of 23,240 newborns Sarlahi, Nepal on 10 days during the first month of life.[11] In resource-poor settings, additional barriers to effective thermal management include cultural, and socioeconomic factors such as follows: early bathing, the use of massage oils, lack of resources and understanding of the causes and/or effects of heat loss.[17]

Even in the best-resourced countries, hypothermia immediately after birth remains an issue particularly during resuscitation and stabilization for preterm or low-birth-weight infants. The recent 2012 data collected by the Vermont Oxford Network (VON) showed an unadjusted network rate of 19.5% for 55,956 infants (902 centers)

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with a birth weight 501 to 1500 g where core body temperature was <36 °C on admission to NICU.[9] The UK National Neonatal Audit Programme (NNAP) also reported that over 40% of 2697 infants <29 weeks' gestation from 97.2% (174 of 179) of English and Welsh neonatal units were hypothermic (core body temperature <36.5 °C) on admission to NICU during 2012.[10]

What Are the Causes and Consequences of Hypothermia?

The physiology of thermoregulation and hypothermia-associated morbidity and mortality are reviewed in detail in complementary articles in this special issue. Therefore, our discussion will be limited to the key issues. Risk factors for hypothermia include prematurity, decreasing birth weight,[4] intra-uterine growth restriction,[18,19] asphyxia, compromised central nervous system[20] and some congenital anomalies e.g. gastroschisis or exomplalos. During pregnancy the fetal temperature is sustained by maternal thermogenesis and the temperature of the uterus remains relatively stable at 37.9 °C.[21,22] The ability to maintain a core body temperature within the narrow limits previously discussed is restricted in healthy term infants within the first 12 hours of life.[20] The primary cause of the rapid heat loss immediately after birth is evaporation of the amniotic fluid[23] when the wet infant is exposed to the delivery or operating room environment,[24] which contrary to recommended guidelines,[15] is often cool and dry. At this time, if health professionals do not act quickly, core body temperature of the term infant can drop at a rate 0.1 °C per minute.[24] Preterm infants are at higher risk of hypothermia than term infants due to a number of physiological factors.[22] Thermoregulation mechanisms can quickly be over-extended, leading to direct or indirect mortality.[11,17] Hypothermia can adversely affect nearly all systems in the body.[25] Therefore, there is consensus agreement that long periods of cold stress should be prevented especially in preterm infants.[26]

What Are the Minimum Basic Thermal Care Strategies?

In 1997 the WHO[15] described a "warm chain" composed of 10 steps to minimize the risk of hypothermia and reduce heat loss by the four mechanisms of heat exchange: conduction, convection, radiation and evaporation.[27] Based on this "warm chain," basic preventative routine measures include providing a warm delivery room (although this is not widely adopted in practice), drying the infant thoroughly, particularly the head, removing wet blankets, wrapping in pre-warmed blankets, pre-warming contact surfaces, minimizing or avoiding draughts and staying away from cold outside walls. Routinely used pre-warmed radiant warmers also provide warmth (when the infant is thoroughly dried), and do not interfere with access during resuscitation.

Current Evidence-Base Underpinning Interventions to Minimize Heat Loss Immediately at Birth

We searched the following electronic databases: the Cochrane Library Issue 11 of 12, November 2013 (which also included the Cochrane Central Register of Controlled Trials (CENTRAL) and the Database of Abstracts of Reviews of Effects (DARE, 1994 to November 2013)), MEDLINE (1950 to November 2013), EMBASE (1974 to November 2013), CINAHL (1982 to November 2013), conference/symposia proceedings using ZETOC (1993 to November 2013) and Web of Knowledge (December 2013). We imposed no language restrictions. We used the key words and search strategies reported in a Cochrane Review on interventions to prevent hypothermia.[26]

Interventions to prevent hypothermia generally focus on providing warmth from external heat sources or by acting as a barrier to heat loss without hindering resuscitation and stabilization.[26] These interventions have been assessed individually or in combination and compared to both routine thermal care and in some studies to each other.

Delivery Room Ambient Temperature

The WHO[15] and the International Liaison Committee on Resuscitation (ILCOR) 2010 guidelines[28] state that ambient delivery room temperature should be increased to ≥25 °C and to ≥26 °C respectively for preterm deliveries of <28 weeks' gestation. Chitty and Wyllie[13] suggested that perinatal teams may find this recommendation to be one of the most difficult to accomplish in practice. Indeed this is reflected in a recent Canadian Web-based survey of 78 neonatologists across 23 tertiary NICUs with 40% of respondents having rarely or never adjusted the delivery room temperature to 25 °C or 26 °C as recommended by the Canadian Neonatal Resuscitation Program.[8] A small randomized controlled trial (RCT) conducted in eastern China[29] demonstrated significantly higher mean core body temperatures for infants ≤32 weeks' gestation who were born in warm rooms (mean (SD) ambient temperature 25.1 °C (0.6) when compared to regular rooms (mean (SD) ambient temperature 22.5 °C (0.6)) This increase was associated with a 0.5 °C higher mean NICU admission temperature and a reduction in the incidence of hypothermia from 66.8% to 34.9%. However, additional thermal care measures such as plastic wraps or caps were not used in this study and over a third of infants in the warm group had admission core body temperature <36 °C with a further three infants <35 °C.[29] Bhatt and colleagues[12] suggested that all delivery rooms should have individual thermostat and humidity controls to facilitate adjustment for preterm deliveries and supported the WHO[15] opinion that "adults should not determine the delivery room temperature according to their own comfort." Only 2 of the 22 randomized or quasi-randomized controlled trials comparing interventions to reduce heat loss applied immediately at birth in preterm infants identified in this review (Tables 1 and 2) attempted to keep the ambient delivery suite temperature at the recommended 26 °C.[30,31] The remaining studies reported a range from 20 °C–21 °C)[32] to 26 °C–28 °C.[33] This further illustrates the need to address barriers to implementation of warm delivery rooms for preterm infants.

Heated Humidified Gases

The recent 2013 update of the European Consensus Guidelines for the management of neonatal respiratory distress syndrome[34] states that using heated and humidified gases during the stabilization of infants <28 weeks' gestation may also help to maintain body temperature. In 2010, te Pas and colleagues[35] conducted a small prospective observational cohort study before and after the introduction of a policy change to commence using heated and humidified gases during respiratory support for infants ≤32 weeks' gestation. During this study all other standard thermal care and respiratory practices were unchanged. The study showed a reduction in postnatal fall in temperature in the heated cohort (cold: mean (SD) admission temperature 35.9 °C (0.6) versus heated: 36.4 °C (0.6) $P < 0.01$) with a significant decrease in moderate hypothermia (core body temperature <36 °C) from 53% in cold group to 19% in heated group, $P < 0.001$). Mild hyperthermia (core body temperature 37.6 °C to 38 °C) was reported for one infant in the cold group. There were no differences in any of the reported secondary outcome measures. However, of note a risk of selection bias cannot be ruled out since 26 infants were missed due to error or because the humidifier was not set up.[35] The authors highlighted the need for further RCTs assessing short- and long-term outcomes and a cost–benefit analysis before firm recommendations could be made.[35] This was supported by Shearman and co-workers[36] in a 2012 bench test study recommending more research into safety issues prior to