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Current Perspectives on Temperature Management and Hypothermia in Low Birth Weight Infants

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ABSTRACT

For more than a century, nurses and physicians have recognized the importance of maintaining the temperature of newborn infants, especially for premature and low birth weight infants. Research has confirmed and elucidated how infants lose heat and what is required to keep them warm. Adverse outcomes associated with hypothermia have been carefully documented. Variations in practice exist and fail to optimize infant outcomes. In this context, the Collaboration for Advancing Pediatric Quality Measures (CAPQuaM) was assigned the task of developing quality measures related to hypothermia and low birth weight infants. This paper integrates a literature review with the CAPQuaM measure development process, and includes original data (qualitative interviews). The authors call for the use of new CAPQuaM measures both to enhance accountability and to improve outcomes for these vulnerable low birth weight infants.

The story of temperature, hypothermia, and infants precedes what we think of as modern medicine. And yet, as we shall see, perspectives at the dawn of the twentieth century are all too modern. In 1901, an article published in the American Journal of the Medical Sciences began, "I have selected the subject of premature infants because it has been inadvertently neglected." Referring to an infant's temperature regulation, it goes on to state:

> "If hard upon the full-term infant, how much more difficult the effort for the prematurely born, all too soon thrust into an unsuitable environment where each undeveloped organ must be subjected to an unaccustomed strain… The greatest task undertaken by the premature infant is the maintenance of its body heat… the uneducated heat centre struggles to so control the manufacture and loss of heat that a normal temperature may be maintained… Unjust as it seems, then, the smaller and more premature the infant the greater is the task imposed. It is hardly to be expected that the uneducated heat centre can be forced to that nicety of control which exists after the mature training of adult life."[1]

Hypothermia in newborns, particularly low birth weight (LBW) infants has persisted as a problem and its relationship to morbidity and mortality became recognized. In classic work from midcentury, Silverman et al described that infants placed in incubators at 31.7 °C had lower mortality than controls who were in incubators maintained at 29.9 °C.[2] Yet now, more than one hundred years after the earliest publications and 60 years after Silverman's landmark work, hypothermia in LBW infants remains a problem.[3,4]

The national Pediatric Quality Measures Program (PQMP), funded by the Child Health Insurance Reauthorization Act (CHIPRA, 2009) and administered by the Agency for Healthcare Research and Quality (AHRQ) in collaboration with the Centers for Medicare & Medicaid Management (CMS) has developed a consortium of seven AHRQ-CMS CHIPRA Centers of Excellence across the country to develop measures of the quality of children's health care. The Mount Sinai Collaboration for Advancing Pediatric Quality Measures (CAPQuaM) is one of these centers and was asked to develop a measure of quality of care regarding hypothermia in low birth weight infants. Through implementation of a novel measure development process, CAPQuaM has proposed measures to assess both the timeliness of temperature assessment and the extent to which these children remain euthermic. The preliminary data analyzed on testing the proposed measures suggest there may be an opportunity to prevent adverse outcomes by better managing the core body temperature of premature infants in the delivery room and on transport to the NICU.

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Constructs and questions were developed to inform the measure development process. We structure this article to parallel the CAPQuaM thought process in its thorough approach to summarizing the literature.

Does Temperature Control Matter?

- *Is there evidence that body temperature in low birth weight infants is associated with outcomes?*

Newborn infants lose heat rapidly at birth and during the first half hour of life. Body temperature begins to fall immediately after birth, and can drop 2–3 °C in the first 30 minutes after delivery. Heat loss by convection, evaporation, and radiation usually far exceed heat production after birth. The typical delivery room temperature is considerably lower than that of amniotic fluid, the newborn is wet, and has a large surface relative to body weight.[5] These factors along with many other physiologic aspects such as the infant's inability to shiver, extremely thin insulation by subcutaneous fat, low levels of glycogen store, and inefficient vascular control for thermoregulation all contribute to the potential of hypothermia in the newborn.[6] Infants do not typically produce heat by shivering. The metabolism of brown adipose tissue, or brown fat is a critical heat-producing process for neonates. However, at birth premature infants lack a full complement of brown fat, seriously impairing their ability to create heat in cool environments.[7]

Cold stress increases oxygen demands and may compromise respiration and glycemic control.[8] Hypothermia can delay initiation of spontaneous breathing, cause respiratory distress and hypoxia, and disturb glucose and calcium metabolism.[9] Renal insufficiency with or without renal tubular necrosis, metabolic acidosis, and coagulopathy may be ominous complications.[10–12] LBW infants are more vulnerable to these consequences and early death.

In 2006, LBW infants (defined as less than 2500 grams) represented 8.2 percent of births in the US, a slight decline from the upward trend that had persisted since 1984 when the rate was 6.4 percent.[13] Twenty four percent of very low birth weight (VLBW) infants (less than 1500 grams) and 1.4 percent of moderately low birth weight (1500–2499 grams) compared with 0.2 percent of heavier infants did not survive the first year of life. Laptook et al confirmed the association of temperature loss with poor outcomes in 5,277 infants, 401–1499 grams, born at 15 academic medical centers participating in the National Institute of Child Health and Development (NICHD) Neonatal Research Network.[4] Their analysis showed that temperature on admission to the neonatal intensive care unit (NICU) was inversely related to both mortality (28% increase per 1 °C decrease) and late-onset sepsis (11% increase per 1 °C decrease).[4] They also suggested further study to determine if the admission temperature is part of the casual path or is a marker of mortality. CAPQuaM investigators as yet unpublished work confirms that the Laptook findings hold in three diverse urban settings. This work further suggests that hypothermia may be a continuous rather than a threshold phenomenon.

The World Health Organization (WHO) established criteria for assessing hypothermia associated with mortality and published a guidebook on the thermal protection of newborns in 1997, indicating that this issue is a worldwide problem even for term infants. They defined the normal temperature range for an infant as 36.5–37.5 °C, potential cold stress (cause for concern) as 36.0–36.5 °C, moderate hypothermia (danger warranting immediate warming) as 32.0–36 °C, and severe hypothermia (outlook grave; skilled care urgently needed) as <32 °C.[14] Using WHO temperature criteria, a population-based study of 8,782 VLBW infants born in California neonatal intensive care units in 2006 and 2007 was performed to assess the epidemiology of neonatal hypothermia in preterm infants. Their analysis showed hypothermia increased and mean temperature decreased with decreasing gestational age and birth weight. The study suggested that the WHO criteria could help to assess infants at greatest risk for low temperatures and poor outcomes due to hypothermia.[15]

Do Specific Interventions/Practices Succeed in Maintaining Appropriate Body Temperature?

- *What interventions in the delivery room or in the NICU are shown to be effective in controlling body temperature and reducing morbidity and mortality?*
- *Are there specific procedures that should be used for infants during transport to the NICU?*
- *Can we identify guidelines regarding how to keep a low birth weight baby warm?*
- *Are there barriers to thermal management?*

Methods to prevent hypothermia in LBW infants generally fall into two categories: barriers to heat loss, and external sources of heat. Over the years, many mechanisms of both high and low-technology have been developed, particularly for use with LBW infants. A 2008 review of interventions by the Cochrane Neonatal Group (updated since), suggests that keeping preterm babies warm is difficult, even when thermal care guidelines are followed.[3] Some interventions are considered to be standard care that should always be provided, though anecdotal stories suggest that they are not. Studies evaluating diverse approaches have been published: they vary in definitions of hypothermia and of "routine" care; by weight, gestational age and inclusion/exclusion criteria of the infants; and by other characteristics, making comparisons or summaries difficult. Yet the studies show a similar pattern: infants in the intervention group are warmer (often significantly) than infants receiving routine care. There is also a suggestion from these studies that the effect is greater in the lightest and least mature infants.

Knobel (2006) reported on direct clinical observations of 10 extremely LBW infants during their first 12 hours in the NICU: seven of 10 infants averaged hypothermic temperatures (going as low as 33.0 ° C) throughout the observation period.[16] Infant temperature dropped during a variety of caregiver procedures, including both invasive procedures such as umbilical line insertions and intubations and non-invasive activities such as chest x-rays, taking vital signs, repositioning, and suctioning. Cold accompanies many actions: opening isolette doors, using blankets that were not pre-warmed, and administering room temperature fluid boluses all lowered temperature. These precepts are well known in the field but variably applied. Attention to environmental conditions may wane during stabilization of airway, breathing, circulation and fluids.[17] Watkinson suggests that during resuscitation, one team member is assigned lead responsibility for thermal management.[6] WHO recommendations that delivery room temperature be 25 °C or higher are not typically followed.

The use of incubators dates back to the nineteenth century.[18] Incubators have evolved, and although single-walled incubators are still in use today, double-walled incubators have become the standard. Double-walled incubators circulate warmed air between two panes rather than around the infant, decreasing heat exchange. Modern designs include humidification modules, and the most sophisticated models are hybrid devices that can convert from radiant warmer mode to incubator mode without physical movement of the infant, reducing thermal insult and stress.[19]

Skin-to-skin contact (SSC), also known as kangaroo care, is defined as holding a naked infant against a parent's skin near the chest. The effect of SSC on thermal regulation in term and nearly term infants was assessed in a randomized controlled study aimed at establishing whether SSC influences neonatal recovery from hypothermia.[20] Results of this study showed that infants having SSC had a tendency towards greater recovery from hypothermia at 5 minutes, suggesting