

Chapter 5

Neonatal Infrared Thermography Monitoring

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ABSTRACT

For critically ill preterm infants, there is a clinical need for contact-free monitoring technologies, which would eliminate discomfort and potential harm (e.g., necrosis) due to adhesive electrodes, temperature and saturation sensors. Hence, this chapter focuses on non-contact physiological monitoring of infants based on infrared (IR) thermography. This technique has the potential to replace the conventional temperature sensing by detecting radiated thermal energy emitted from the baby's surface according to black-body radiation principle. This allows the application of a less invasive method giving more detailed information about the thermoregulation status of newborn infants. As an illustrative example, an investigation into thermoregulation physiology during kangaroo care method has been chosen to illustrate the benefit of this method for standardized neonatal intensive care unit (NICU) procedures. Furthermore, this technique may have a large impact on non-contact respiratory monitoring, as it allows quantitative evaluation of the heat transfer processes over nostrils region. Moreover, the ability to detect infrared respiration (IRTR) signature with thermography imaging, will pave the road toward a non-contact breathing monitoring. This in turn will influence the development efforts for wireless and smart incubator solutions.

1. INTRODUCTION

Despite the incapacity of the preterm neonate to adequately control body core temperature and to compensate large temperature gradients, he/she can adapt to minor changes in the environmental temperature if they are incubated inside a thermoregulated micro-climatic zone. Hence, one major point in preterm infant care is to avoid cold stress and to keep the neonate's body within the still small thermoneutral zone without affecting other physiological functions.

Clinically, neonates require a typical skin temperature within the range of 35.5 °C ... 37.2 °C and a core temperature of approximately 37 °C (Asakura, 2004). Therefore, the maintenance of this temperature zone is a highly differentiated process, involving lipolysis and gluconeogenesis. This is associated with consumption of energy, oxygen and glucose. The more energy is needed for maintaining a constant body temperature, the less energy is available for other proceedings such as growth, brain development, or lung maturation. Basically, hypothermia causes high oxygen consumption with a left shift of the oxygen dissociation curve, resulting in acidosis, less oxygen supply in tissues, and vasoconstriction (Bissinger & Annibale, 2010). For neonates, especially if they are preterm, this implicates two consequences: The urgent need for analyzing body temperature constantly, and the provision of a thermoneutral zone, accomplished by an incubator with a proper temperature and humidity. Basically, the thermoneutral zone is defined as the area of surrounding temperature in which lowest energy exchanges and therewith minimal oxygen consumption takes place.

Clinically, the standards to measure central and peripheral temperature are by cable-bound temperature sensors which are placed either into the rectum or are attached to the skin of the infant, respectively. However, as adhesive connections cause mechanical stress to the very sensitive skin of the infant and lying on cables may ultimately

cause ulcers, there is a growing demand to install cable-free monitoring techniques into incubators or generally within the intensive care stations.

Such a contact-free monitoring modality is infrared (IR) imaging. The first documented application of infrared imaging in medicine was in 1956 (Bissinger & Annibale, 2010; Flenday, 2003) when female breast cancer patients were examined for asymmetric hot spots and vascularity in IR images of their breasts. Since then, several research findings have been published and the 1960s witnessed the first surge of medical application of the IR technology with breast cancer detection as the primary practice (Flenday, 2003; Bohnhorst, 2010). However, IR imaging has not been widely recognized in medicine yet largely due to high costs and the premature use of the technology. In neonatal care, Clark and Stothers (Clark, 1980) were the first to work on mapping temperature distribution of neonatal skin surface, which can be considered as the first trial of neonatal infrared thermography imaging.

An interesting study investigating non-invasive temperature monitoring based on IR imaging in neonates was performed by Kimberly and Horns (2003). In this work, skin surface temperature gradients using infrared thermography were recorded. In fact, the authors investigated the instability of neonatal temperature as main index for morbidity in Very Low Birth Weight (VLBW) infants using IR thermography for detecting cold stress and other related physiological parameters as changes in peripheral perfusion. Possibly, this pilot project will eventually provide a description of existing patterns for thermoregulatory control in the first day of life, substantiate for non-invasive technologies, and explores the feasibility of infrared thermographs in infants who are care for in a special environment (Horns, 2003; Clark, 1980). Hence, these findings may serve as data for future research in predicting early signs of infection and impending shock before serious blood pressure changes are demonstrated on the bed-side monitors.

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