

Chapter 45

Neonatal Monitoring: Current Practice and Future Trends

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ABSTRACT

This chapter focuses on monitoring vital health parameters for a particular group of patients - critically ill newborn infants in neonatal intensive care units (NICU) at hospitals. These neonates are extremely tiny and vulnerable. Thus, health monitoring for the neonates provides crucial parameters for urgent diagnoses and corresponding medical procedures, subsequently increasing the survival rates. Neonatal monitoring is a multidisciplinary area which involves a unique integration of knowledge from medical science, design, technology and social study. In this chapter, the authors introduce current status and new developments in neonatal monitoring. They present some ongoing research examples of non-invasive neonatal monitoring designed and developed at the department of Industrial Design and the department of Electrical Engineering, Eindhoven University of Technology (TU/e) in collaboration with the department of neonatology, Máxima Medical Center (MMC), Veldhoven, in the Netherlands, including the first prototype smart jacket, a wireless power supply and video signal processing for neonatal monitoring. Challenges and social impacts of non-invasive neonatal monitoring will be discussed.

INTRODUCTION

The word “neonate” refers to the infant’s first four weeks after birth (Thomas, 1980). Neonatology is a subspecialty of Pediatrics that cares for newborn infants, especially the ill or premature newborn infants. Neonatal monitoring refers to monitor vital

physiological parameters of neonates. Monitoring of the newborn is an old biological phenomenon. All species of the animal kingdom monitor their offspring from birth, using the sense organs for smelling, tasting, feeling, seeing and hearing (Smith, 1980). Critically ill neonates are a special group of patients that consists of premature infants and full term infants that became severely ill during or immediately after birth. Premature infants are

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babies that are born after a pregnancy lasting 37 weeks or less. Critically ill preterm neonates can weigh as little as 500 g with a size of our palm and are highly vulnerable to external disturbances. Premature neonates are normally admitted to neonatal incubators in Neonatal Intensive Care Units (NICU). Neonatal medicine has progressed strongly in the past decades. Continuous health monitoring for the neonates provides crucial parameters for urgent diagnoses so that adequate medical treatment can be instituted. Recent advances over the last decades in medical treatments resulted in a significant increase of survival. As a result, neonates born after 25 weeks of pregnancy can survive with appropriate medical care in NICU (Costeloe, 2000). Therefore, incubators are populated by steadily younger neonates, whose survival and long-term health prospects depend strongly on reliable and comfortable health-status monitoring systems.

The Eindhoven University of Technology (TU/e) in the Netherlands has started a 10-year project on non-invasive perinatal monitoring in cooperation with the Máxima Medical Centre (MMC) in Veldhoven, the Netherlands. The goal of this project is to improve the healthcare of the pregnant woman, and her child before, during and after delivery.

In this chapter, we focus on the current practice and future trends of neonatal monitoring. The NICU environment, the technologies for physiological measurements, and the different users all contribute to the current practice of neonatal monitoring. Understanding the current practice is important for the future development of this multi-disciplinary area. As the existing neonatal monitoring systems meet the pressing needs of users and society at best partly, innovations will be needed to achieve the required degrees of functionality, reliability, robustness, comfort, and ease of use. These innovations aim to strongly improve comfort and reliability of neonatal monitoring systems, so as to improve the neonates' comfort and quality of life later on, to enhance the parent-

child interaction, and to alleviate workload of clinical staff.

In order to understand the nature of the innovations which arise now and which can be expected and created in the future, we propose the following innovation model (see Figure 1). The model contains ten types of professional activities, all of which are happening in parallel. These are shown as rounded boxes. Moreover the model contains several interactions between the activities. The interactions include information flow as well as transfer of working prototypes and products. The interactions can be understood as feed forward and feedback. The innovation model thus becomes a closed system. The four leftmost activities represent four major areas of research and development (R&D). It is essential to appreciate the fact that these are conducted not just for the sake of neonatal monitoring only. They are driven by technological roadmaps, some of which are self-propelling, and all of which assume huge emerging consumer markets for embedded systems, wearable electronics and ambient intelligence. Neonatal monitoring is just one of these markets, at best. More realistically is to assume that it represents an interesting niche and a forerunner for larger markets, eventually targeting older and less critically ill children. In other words, there is a technology push of which the development of neonatal monitoring can take great advantage. The latter development is represented by the middle area with three activities which speak for themselves. Next to the above-mentioned feed forwards there is also an input from clinical neonatal practice, viz. the explicitly formulated needs which arise in clinical practice. The major output of the integration and prototyping activity inside the development for neonatal monitoring consists of working prototypes which, when approved by the ethical committee, can be put to the test (clinical validation). The neonatal development informs the technological R&D of its needs and experiences, as shown by the dotted curved arrows.

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