

Neonatal Monitoring System

L. Suresh¹, N. Anju Latha², B. Rama Murthy², K. Tanveer Alam¹, K. Jyothi Babu¹

¹ Department of Electronics, Sri Krishnadevaraya University, Anantapuramu, Andhra Pradesh, India

² Department of Instrumentation, Sri Krishnadevaraya University, Anantapuramu, Andhra Pradesh, India

ABSTRACT

Childbirth is generally time of joy for parents and families. As per the medical reports each year 4 million newborns die within 28 days of birth and more suffer from disability, disease, infection and injury. The enabling environment for safe childbirth depends on the care and attention required to newborns by health personnel and the availability of adequate health-care facilities, equipment, and medicines and emergency care when needed. Neonatal monitoring refers to the monitoring of vital physiological parameters of premature infants. Continuous health monitoring of the neonates provides crucial parameters for early detection of adverse events. Health monitoring for the neonates provides crucial parameters for urgent diagnoses and corresponding medical procedures, subsequently increasing the survival rates. In the present paper, we propose a proto type design of a neonatal monitoring system. The system is designed and integrated with different health measurement and display devices. The prototype design is very much useful for monitor the physiological parameters of infants.

Keywords: Neonatology, Neonatal Intensive Care Unit, Health parameters

I. INTRODUCTION

Neonatal monitoring refers to the monitoring of vital physiological parameters of premature infants. Babies that are born after a pregnancy lasting 37 weeks or less are considered as premature. Premature infants may suffer from diseases that are mainly caused by immaturity of their organs, Infants can weigh as less as 500g with a size of a palm. Critically ill newborn infants are normally admitted to a Neonatal Intensive Care Unit (NICU) [1] for treatment by neonatologists.

Neonatology is a subspecialty of pediatrics that started to develop in the 1940s. After the World War II the specific needs of sick newborn infants were recognized and new premature nurseries were built. The term "Neonatology" was first used by Alexander Schaffer in 1960 in the introduction of the first edition of his book. The miniaturization of samples for blood tests, needed for clinical management including electrolytes, bilirubin and blood gases was one of the major advances in the development of Neonatology. In the following decades important progress was achieved in thermoregulation, nutrition, growth, respiratory support, cardiopulmonary support and infection control.

Continuous health monitoring for neonates provides crucial parameters such as cessation of breathing, heart rhythm disturbances and drop in blood oxygen saturation...etc. more than 50% premature infants show deficits in their further developments such as developmental delay, speech and language delay, behavioral, attention and learning problems. Medical conditions including

chronic lung disease, apnea and bradycardia, transient thyroid dysfunction, jaundice and nutritional deficiencies are potential contributing factors [2][3].

Newborn babies who need intensive medical attention are often admitted into the Neonatal Intensive Care Unit. The NICU combines advanced technology and trained healthcare professionals to provide specialized care for the tiniest patients. NICUs may also have intermediate or continuing care areas for babies who are not as sick, but do need specialized nursing care. About 10% of all newborn babies require care in a NICU.

Vital parameters of clinical relevance for neonatal monitoring include body temperature, electrocardiogram (ECG), respiration, and blood oxygen saturation [4]. Body temperature is monitored with adhesive thermistors; ECG and respiration are obtained by adhesive skin electrodes. The oxygen saturation of the blood is monitored by a pulse oximeter with the sensor applied on the foot or palm of the neonate [5][6].

The objective of the present work is to develop a prototype of multifunctional user –friendly biomedical measurement device of an of integrated neonatal monitoring system, which provide a complete health status of a infants. The following parameters are required in neonatal intensive care unit such as electrocardiogram, blood oxygen saturation, Body temperature, Radiant warmers, Phototherapy lamps...etc.,. The module devices are connected to central processing unit, the data acquired from each system is then displayed on the Monitor and store data in health report.

II. GENERAL SPECIFICATIONS

Monitoring the status of preterm infants in the Neonatal Intensive Care Unit (NICU) provides a unique and challenging environment for the design, function and use of sensor-based monitoring equipment [7]. In the Neonatal Intensive Care Unit, monitoring is an integral part of the care process together with the administration of therapy. Monitoring is therefore a tool that provides early indication of changing patient status, and allows for early intervention, but is also a means by which the effect of interventions and therapies may be recorded, evaluated and controlled.

III. SYSTEM DESCRIPTION- NICU BLOCK DIAGRM

The Neonatal intensive care unit monitoring system block diagram is as shown in figure 1. The primary function of the device is to operate as a medical pre-screening/diagnostic device. The first stage lists the different types of medical data to be measured by the device. Electrocardiogram, blood oxygen saturation, Body temperature, Radiant warmers, Phototherapy lamps...etc. in the second stage of the system a central processing unit reads data from these medical devices and display in the monitor and stores it in memory. Figure 2 shows the snapshot of a Neonatal intensive care unit

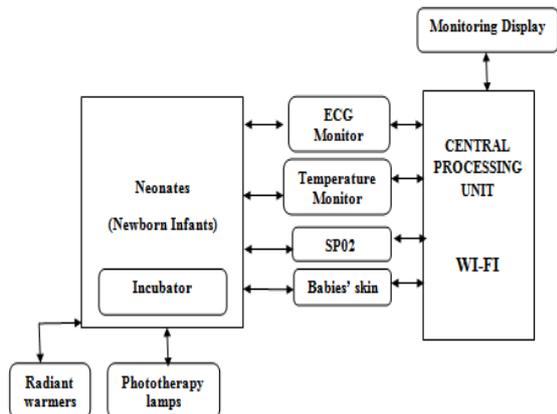


Figure 1: Block diagram of Neonatal Intensive Care Unit (NICU)

Most babies who need special care are admitted into the NICU are premature (born before 37 weeks of pregnancy), have low birth weight (less than 2.5 Kg or 5.5 pounds), or have a medical condition that requires special care. Twins, triplets, and other multiples are often admitted to the NICU, as they tend to be born earlier and smaller than single birth babies. Babies with medical conditions such as heart problems, infections, or birth defects are also cared for in the NICU.

In hospitals, babies in the NICU are monitored with the infrared monitor on the extremities for measuring oxygen saturation in the blood and heart rate, using ECG electrodes only in the most critical situations. The time for monitoring varies and depends on the patient's condition: some babies may be monitored for one day or two, some may require continuous monitoring for weeks or even months.



Figure 2: snapshot of a Neonatal Intensive Care Unit

Three electrodes are placed on the babies chest for ECG continuous monitoring. The same electrodes that are used for ECG monitoring are also used for respiration monitoring, since the equipment can measure and display both the ECG and the respiration rate.

Body temperature is one of the key parameters for health monitoring of premature infants at the neonatal intensive care unit (NICU). Body temperature [8] is monitored with adhesive thermistors with a non-invasive neonatal temperature monitoring with wearable sensors. A negative temperature coefficient resistor is applied as the temperature sensor due to its accuracy and small size.

Blood oxygen saturation [9] is also a one of the key parameters for health monitoring of premature infants. Reflectance pulse oxymeter based on Near Infrared Spectroscopy (NIRS) techniques are applied for enhancing the flexibility of measurements at different locations on the body of the neonates and the compatibility to be integrated into a non-invasive monitoring platform, such as a neonatal smart jacket. The oxygen saturation of the blood is monitored by a pulse oximeter with the sensor applied on the foot or palm of the neonate

Radiant warmers are used when a baby is very unstable or extremely premature. Small babies have a large surface area compared to their volume, and little body fat, and cannot maintain their own temperature. The overhead arm contains electric heating elements that are directed down toward the infant. A thermostat is hooked up to a sensor on the baby's abdomen and adjusts the power of the warmer up and down dynamically so that it delivers whatever

heat is necessary to keep the baby at the desired normal temperature. The open nature of the radiant warmer allows physicians and nurses to have easy access to the baby from all sides during the most critical periods.

Phototherapy lights are used when babies are jaundiced (yellow). Some degree of jaundice, which is caused by the presence of a molecule called bilirubin in the blood, is common and even normal in newborns. However, in sick infants, jaundice can result from a variety of problems, and when jaundice is extreme it can cause brain damage. Certain wavelengths of light (in the blue part of the spectrum) can cause a chemical reaction that converts bilirubin into a harmless form as blood passes through the skin.

When a baby is relatively stable but still premature, requiring intravenous fluids or other special attention, he/she is cared for in an "incubator." The incubator keeps the baby warm with moistened air in a clean environment, and helps to protect the baby from noise, drafts, infection, and excess handling. Temperatures range around 30 to 37°C, humidity levels range from 50 to 90%, depending on the babies size and age.

Premature infants' skin has fewer layers of stratum corneum, it is very permeable. Babies's skin may have oedema: excess accumulation of fluids. It has less collagen and fewer elastic fibres in the dermis, little subcutaneous fat. The babies skin does not sweat, it is non-keratinised. There is a risk of injuries and infection.

Kangaroo care is used in the NICU to help aid in an infant's recovery and comfort parents during a stressful time. Kangaroo care is a form of skin-to-skin contact between a parent and their baby. The baby is held in an upright position against a parent's bare chest for 20 minutes to four hours a day. Benefits of this method of care include: bonding between the parent and child, and calming of the infant as he/she responds to the parent's heartbeat and enjoys deeper levels of sleep.

The monitoring display is attached to sensors through the central processing unit on the baby and provides a constant read-out of the baby's heart rate and ECG, breathing rate, arterial or central venous pressure, oxygen saturation, temperature..etc., and other useful information.

IV. STATUS REPORT

Neonatal monitoring system can be considered as a powerful health care system with integration of health parameter measurement devices. The NICU collect and record the health information with continuous monitoring of infants. The collection, analysis and dissemination of health data and information were designed to support in decision making for further care taken in the hospitals. The

maternal information to prioritize, plan implement and sustain effective intervention strategies can be produced. This information is useful for health planning and policy development at national level and that the information produced complies with WHO standards. The implementation of information systems at population level could be a factor in decreasing health inequalities in countries. The conclusion of the neonatal monitoring system is about 10% of all newborn babies require care in a NICU. The size of patients is very variable, as well as their length of stay in the NICU. Most babies admitted into the NICU are premature, have low birth weight, or have a medical condition that requires special care. For ECG monitoring, 3 electrodes are placed on the babies chest. The same electrodes that are used for ECG monitoring are also used for respiration monitoring. Premature babies' skin is very delicate and sensitive. Equipment used in NICU that is related to electrodes performance includes: Radiant warmers, incubators, monitors and phototherapy lamps.

V. FUTURE PLANS

Continuous health monitoring is crucial for the survival of the ill and fragile infants admitted at neonatal intensive care units in hospitals [10]. Vital signs for neonatal monitoring include body temperature, Electrocardiogram, respiration, and blood oxygen saturation [11]. Presently, adhesive wired sensors are used for monitoring the physiological signals of neonates. Placement of these adhesive sensors and the presence of all the wires lead to discomfort and even painful stimuli. The disturbance, interruption of sleep, and lack of natural communication with parents all interfere with the babies' normal growth and development [12]. Recent advances in sensor technologies and wireless communication technologies enable the creation of a new generation of healthcare monitoring systems with wearable electronics and photonics.

Design a Smart Jacket [13] is a wearable unobtrusive continuous monitoring system realized by body sensor networks (BSN) and wireless communication. The smart jacket aims for providing reliable health monitoring as well as a comfortable clinical environment for neonatal care and parent-child interaction. The jacket is expandable with new wearable technologies and has aesthetics that appeal to parents and medical staff.

REFERENCES

- [1] *The EPICure study: Outcome to discharge from hospital for infants born at the threshold of viability.* Costeloe, K.; Hennessy, E.; Gibson, A. T.; Marlow, N. & Wilkinson, A. R. *Pediatrics*, Vol. 106, No. 4, 2000, pp. 659-671.

- [2] *Neurobehavioral deficits in premature graduates of intensive care -Potential medical and environmental risks factors.* Perlman, J. M. *Pediatrics*, Vol. 108, No. 6, 2001,pp. 1339-1348. Society Washington, Pages 162-167, ISBN: 978-0-7695-3644-6, 2009
- [3] *The genesis of cognitive and behavioural deficits in premature graduates of intensive care.* Perlman, J. M. *Minerva Pediatr.*, Vol. 55, 2003, pp. 89-101.
- [4] *Fetal and Neonatal Physiology*, W. B. Saunders Company, Polin, R. A. & Fox, W. W. (Eds.). 1992
- [5] *Sensors in neonatal monitoring: Current practice and future trends. Technology and Health Care*, Murković, I.; Steinberg, M. D. & Murković, B. Vol. 11, IOS Press, 2003, pp. 399–412.
- [6] *Neonatal Monitoring: Current Practice and Future Trends*, Wei Chen, Sidarto Bambang Oetomo, Loe Feijs.
- [7] *Sensors in neonatal monitoring: current practice and future trends.* Murković I, Steinberg MD, Murković B
- [8] *Monitoring body temperature of newborn infants at neonatal intensive care units using wearable sensors*, Wei Chen, Sietse Dols, Sidarto Bambang Oetomo, Loe Feijs
- [9] *Non-invasive blood oxygen saturation monitoring for neonates using reflectance pulse oximeter.* Wei Chen, Idowu Ayoola, Sidarto Bambang Oetomo, Loe Feijs
- [10] *The EPICure study: outcomes to discharge from hospital for infants born at the threshold of viability*, K. Costeloe, E. Hennessy, A. Gibson, N. Marlow, and A. Wilkinson, *Pediatrics*, vol. 106, pp. 659-671, 2000
- [11] *Fetal and Neonatal Physiology* R. A. Polin and W. W. Fox, W. B. Saunders Company, 1992.
- [12] *A three-center, randomized, controlled trial of individualized developmental care for very low birth weight preterm infants: medical, neurodevelopmental, parenting, and caregiving effects*, H. Als, L. Gilkerson, F. Duffy, G. Mcanulty, D. Buehler, K. Vandenberg, N. Sweet, E. Sell, R. Parad, and S. Ringer, *Journal of Developmental & Behavioral Pediatrics*, vol. 24, pp. 399-408, 2003
- [13] *Smart Jacket Design for Neonatal Monitoring with Wearable Sensors*, Sibrecht Bouwstra, Wei Chen, Loe Feijs, Sidarto Bambang Oetomo, BSN '09 Proceedings of the 2009 Sixth International Workshop on Wearable and Implantable Body Sensor Networks, IEEE Computer