MEASUREMENT OF BODY TEMPERATURE IN INFANTS

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Abstract: The measurement of body (core) temperature is well established in clinical care. However, there are still numerous challenges especially in mature and premature infants including the lack of a reliable, non-invasive and fast measurement method for body core temperature. The current standard of care, technological challenges and limitations, as well as current and future research needs will be discussed in this contribution.

Keywords: Temperature Measurement; Patient Monitoring; Body Core Temperature; Infant; Neonate

Introduction

Measurement of body temperature has been ubiquitously established in medical practice for many years. Measurement of body core temperature plays an important role in physiologic monitoring. Change of body temperature can be indicative of illness. Also, the effectiveness of a specific therapy can be assessed by body temperature monitoring. However, especially in mature and premature infants temperature measurement can still pose many challenges.

Clinical Requirements

A continuous, accurate and precise measurement of the body temperature is critical in neonates and small infants. Several systems exist which allow the measurement of body core temperature. The most common measurement sites – irrespective of patient age – are: pulmonary artery, tympanic membrane, oesophagus, bladder, rectum, oral and nasopharynx and temporal artery. Several systems exist which allow the measurement of temperature in different applications with specific properties, e.g., tympanic or oral probes for instantaneous measurements, or telemetry pills and oesophageal probes for continuous measurements of body core temperature. However, some of these monitoring systems are invasive and others lack accuracy. And while most of them are in clinical use in adults, only few lend themselves for use in neonates and small infants. Until now, there is no ideal system for measurement of body core temperature that is small, easy to use, comfortable, fast (for spot checks), continuous, accurate, precise, non-invasive, low in energy consumption, and affordable.

For any measurement method four basic requirements should be considered:

Accuracy and precision: The acceptable measurement error, i.e. the bias ± 2 standard deviations (SD), depends on the specific clinical question. The standard EN 12470-4 states, that the error of a complete thermometer shall be ± 0.2 °C in the temperature range from 25 °C to 40 °C.

Time Response: In clinical practice the user may prefer a faster measurement at the cost of accuracy and precision. This explains the common use of the infrared ear thermometer which has wide limits of agreement [1][2].

Measurement range: The norm defines a temperature measurement range between 25 to 45°C. This seems to be sufficient in neonatal and paediatric practice.

Handling: Easy handling is a key to user acceptance and assures reliability of measurements in daily practice. In continuous monitoring adequate safeguards against sensor dislocation, e.g., during positioning of the patient, should be implemented. Patient comfort and safety against injury must also be considered.

Methods of Measurement

A comprehensive technical overview is given in the book by Michalski et al. [3].

Current Practice: Many physical principles exist to measure temperature based on temperature-sensitive effects such as changes of volume or resistance, detection of heat flow and radiation. These methods are further divided into non-electrical or electrical. Radiation-based sensors advantageously allow for contact-less measurement, whereas most of the sensors have to be brought into direct contact with the tissue of interest. However, not only physical principles but also the physiological status (peripheral perfusion, heat redistribution under various conditions) play an important role for the performance of a thermometer.

In clinical practice embodiments with thermistors (semiconductors) and thermocouples are often used. Contactless methods are mainly based on the detection of infrared-radiation emitted by the body or tissue. This approach can measure skin or surface temperature and body core temperature may be estimated, such as in IR ear thermometers [4].

Research Methods: Two methods from research and development with immediate relevance for neonatal and pediatric settings shall be mentioned here.

The zero-heat flux approach is based on a perfect thermal insulation of a small skin area from the surrounding so that in thermal equilibrium the skin reaches the same
temperature as the deeper tissue. Zero-heat-flux can be achieved passively with a perfect thermal insulation or by active heating in order to compensate the heat loss of the surface [5][6].

A second approach analyses the temperature gradient of a well-defined thermal bridge, called Double Sensor, placed on a skin area without active heating. Body core temperature is inferred from the acquired temperatures based on a mathematical model. This approach has shown sufficient accuracy in clinical trials [7][8]. Drawbacks are initial response time of several minutes and relatively large sizes [8].

**Specific Challenges in Neonatology and Pediatrics**

In case of newborns and premature babies, several effects need to be considered. Often, a migration of temperature patterns from the periphery to the core can be observed which may be explained by the fact that the metabolic rate of the baby responds to the external thermal stress or the mother interaction [9]. Premature babies have only a very narrow temperature range in which they can maintain normothermia. Outside this range they should - from a control theory point of view – show a passive behavior as their actuator is saturated. However, local temperature oscillations can be observed in thermograms, which indicate that the premature thermoregulation is not a passive process. The underlying nature of these thermal skin effects of premature babies could be due to the autonomous nervous function. Also unknown are the effects of body contact between mother and child during so called “kangaroo mother care”. Here, the naked infant is placed in the naked chest of the mother (skin-to-skin contact). For the calculation of the total heat balance, convective effects at the backside of the baby and conductive effects between mother and baby have to be accounted for. It is believed that the conductive heat transfer route becomes the primary heat balance for neonates. Tachypnea and apnea as vegetative effects are caused by thermal stress [10][11][12].

**Discussion and Conclusions**

Temperature is an important vital sign and diagnostic tool, as the core temperature needs to be controlled in a narrow normothermic region. Independent of the different measurement sites, some overall requirements can be stated. The sensor response should be sufficiently fast, the measurement error (bias plus two SD) should be 0.5°C or less within a measurement range of 25°C to 45°C and it should be easy to use. Ideally it is comfortable for the patient, noninvasive and inexpensive. Additionally, the system should also be able to measure peripheral temperatures to calculate heat flows and temperature gradients as additional parameters. These parameters might allow to predict the temperature or to extract further information.

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**Bibliography**


