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Skin conductance measurements as pain assessment in newborn infants born at 22–27 weeks gestational age at different postnatal age

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ABSTRACT

Background: To assess pain or stress in newborn infants submitted to intensive care is important but difficult, as different observational pain scales are not always reliable in premature infants. As an indicator of pain, skin conductance (SC) measurements have detected increased sweating in newborn infants >28 gestational age (GA) submitted to heel lancing.
Objective: To measure SC during heel lancing and routine care in newborn infants, born at 22 to 27 GA, with special relation to postnatal age (PNA).
Methods: In six infants <28 + 0 GA and 4 infants ≥28 + 0 GA spontaneous SC activity and behavioural state (Neonatal Pain Agitation and Sedation Scale (N-PASS)) was measured before, during and after each intervention. Measurements were repeated in each patient at different PNA.
Results: Baseline SC prior to intervention took longer time to stabilise and was higher in <28 than in ≥28 + 0 PNA. The combination of heel lancing and squeezing gave an increased SC in <28 PNA, whereas heel lancing alone gave the same SC response in ≥28 + 0 PNA. A possibly continued immature response in SC measurements was not observed. Oral glucose admission prior to heel lancing increased SC. Routine care did not give any changes in SC. Except during orogastric tube placement no signs of discomfort or pain could be detected by the neonatal pain, agitation and sedation scale (N-PASS) in <28 PNA.
Conclusion: Changes in SC could be detected in infants at <28 + 0 PNA and related to the combination of heel lancing and squeezing. A maturational development of the SC was observed in infants born <28 GA. SC seems to be able to differentiate between pain and discomfort.

1. Introduction

Extremely preterm infants are subjected to an intensive care that is characterised by many painful procedures and environmental disturbances. To assess pain or stress in newborn infants submitted to intensive care is important in order to evaluate effective pain management and thereby reduce harmful short and long term effects of pain; specifically brain development [1]. Many studies have been performed to assess pain in preterm infants, but it has been difficult to find a "golden standard" to measure the pain or discomfort they might experience during potentially painful procedures in the intensive care unit [1,2]. As both physiological and observational pain scores developed for more mature infants have been shown to have their limits in scoring pain in premature infants, efforts have been made to develop new method for pain assessment [2–7].

Emotional sweating is a physical reaction to emotive stimuli like stress, anxiety, fear and pain that can occur over the whole body surface, but is most evident on palms, soles and in the axillary region [8]. Unlike thermoregulatory sweating, it arises independently of ambient temperature and decreases during sleep and relaxation [8]. Emotional sweating of palms and soles occurs already in newborn infants [9].

A sensitive method of measuring skin conductance (SC) has been developed, based on stress induced sweating. SC is determined by the number and the activity of sweat glands, and their activity is stimulated by the sympathetic nervous system [10–14]. When pain is experienced, sweat glands are stimulated by sympathetic excitatory efferent neurons and sweat is released within 1–2 s whereby SC increases due to skin resistance reduction [10,15]. When the painful stimulus is taken away, sympathetic activity decreases and the sweat is reabsorbed and evaporated, followed by a decrease in skin conductance. The sympathetic neural firing resulting in excretion of the sweat gland can be depicted as one skin conductance peak [10,16]. The number of skin conductance peaks correlates directly to the firing rate in the sympathetic nerves of the skin [17]. Previous studies in

Abbreviations: GA, gestational age; SC, skin conductance; PNA, postnatal age; N-PASS, neonatal pain agitation and sedation scale; TEWL, transepidermal water loss.

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infants born at >28 GA have shown that skin conductance increased with the level of behavioural state [18]. To our knowledge no SC studies have been performed in premature infants born at <28 GA.

The aim of this study was to find out at which GA preterm newborn infants start to react to potential painful or discomforting procedures by emotional sweating and how this response changes with different PNA.

2. Methods

2.1. General

The study was performed at the neonatal care unit, Uppsala University Children's Hospital in Uppsala, Sweden. SC was measured when infants were exposed to heel lancing for routine blood sampling, feeding, orogastric tube placement and routine care. Observing the infants with N-PASS, an observational scale used as routine assessment of pain in this neonatal unit, included behavioural changes associated with pain perception [19].

2.2. Patients

Ten preterm infants were recruited from the neonatal care unit, Uppsala University Children's Hospital during a period of 3 months. Infants who were in a haemodynamically stable condition and did not receive any anaesthetics that might have interfered with their pain response to planned clinically indicated heel lancing were eligible for participation. No patients recruited were excluded.

In total there were six girls and four boys. The infants were born between 22 + 4 and 34 + 3 weeks (median: 28 + 1 weeks) GA and at the time of the study they were between 1 and 47 days PNA (median: 15 days).

Patients were divided into 2 groups: <28 weeks GA and >28 weeks GA. These two groups were analysed in four different ways: <28 weeks GA, >28 weeks GA, <28 weeks PNA and >28 weeks PNA.

Median weight at birth was 633 g (range: 437 g–920 g) <28 weeks GA and 2191 g (range: 1727 g–2910 g) ≥28 weeks GA. At the time of participation in the study the median weight <28 weeks PNA was 548 g (range: 522 g–580 g). Mean APGAR-scores were 4, 6 and 8 (respectively after 1, 5 and 10 min) in infants <28 weeks, and 7, 9 and 9 in infants >28 weeks.

All the patients <28 weeks GA were artificially ventilated. None of the patients >28 weeks GA needed respiratory assistance. The study was approved by the Ethics Committee of the Medical Faculty at Uppsala University. Parental consent was obtained before the infant was included in the study and reconfirmed before each subsequent measurement.

2.3. Methods and measurements

In this longitudinal cohort study SC was measured with the Med-Storm Pain Monitor (Medstorm Innovations, Oslo, Norway) [9]. Three electrodes were applied on the infant's foot and measurements of SC, number of fluctuations within the mean SC per second (NFSC) and amplitude of NFSC were analysed. The counter current electrode was placed on the medial right side of the foot, the measuring electrode was placed midway between the first phalanx and a point directly beneath the ankle and the reference voltage electrode was placed on the dorsal side of the foot (Fig. 1). The analysed values are peaks/s (the rate of firing in the sympathetic nerves), average amplitude (mean peaks) and area under curve (forcefulness of sympathetic nerve firing). The N-PASS was used to analyse behavioural state, irritability, facial expression, tone and vital signs in preterm infants, and performed simultaneously by a care giving nurse and the researcher [19]. The N-PASS was specifically chosen as an observational assessment tool because it is the most commonly used tool in our neonatal ward. Transepidermal water loss (TEWL) was measured in three patients at <28 weeks GA in order to define the maturational status of the skin, a factor that might interfere with the emotional sweating [20].

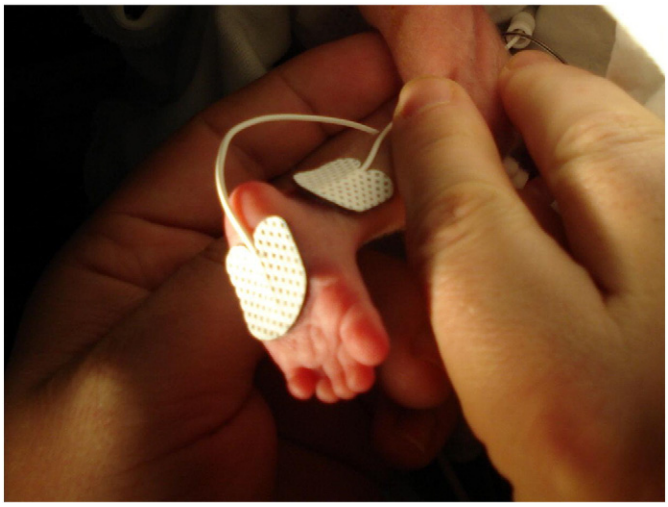

Fig. 1. Application of skin conductance measurement electrodes on the foot of a 26 PNA weeks infant.

Heart rate and saturation were measured in patients <28 GA and PNA before, during and after each registration period.

2.4. Study design

Measurements were performed during heel lancing for routine blood collection and during feeding, orogastric tube placement and routine care such as diaper change, feeding and auscultation.

Electrodes were applied to the infants' foot 5 min before the intervention.

All heel lancing was scheduled at least 1 h after feeding. All infants received 0.5 ml 30% oral glucose before heel lancing according to established unit policy, except for one extremely preterm boy with insulin infusion due to hyperglycaemia. Behavioural state (N-PASS) and skin conductance activity were measured for 2 min before, during, and for 2 min after the intervention.

During heel lance electrodes were attached to the opposite foot to prevent any artefacts by touching the measurement electrode. Measurements started at least 1 min before the glucose was given. After the heel lance and the squeezing period the measurement continued for at least 2 min.

Orogastric tube placement was performed within a minute. Measurement of SC and of N-PASS continued for a couple of minutes. Feeding was done with a syringe and in very small portions, during at least five and at most 30 min. After feeding the measurement continued for at least 3 min.

Skin conductance registrations were made for approximately 10 min. Auscultation with a stethoscope was also measured, as was the effect of tactile stimuli (such as caressing the child and kangaroo mother care), sounds (in the ward) and warm versus cold (water bags on the infants' feet before heel lancing and application of a cold stethoscope).

The groups were analysed in four different ways: <28 weeks GA and >28 weeks GA independent of PNA; <28 PNA and >28 weeks PNA independent of GA. The means for each analysis were put into tables and figures.

2.5. Method of analysis

Measurements of SC were analysed by taking thirty-second intervals of which the mean peaks/s and average peak were calculated. The thirty