

## REGULAR ARTICLE

# Skin-to-skin contact reduces near-infrared spectroscopy pain responses in premature infants during blood sampling

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## ABSTRACT

**Aim:** This study investigated if skin-to-skin contact could provide pain relief, measured with near-infrared spectroscopy (NIRS), during venepuncture in premature infants.

**Methods:** Ten infants born at 26–35 weeks of gestation were examined during a blood-sampling procedure with venepuncture under two different conditions: in skin-to-skin contact with their mother or lying in their incubator or crib. A double-channel NIRS device was used, and oxygen saturation and heart rate were measured using pulse oximetry. The infant's face and the pulse oximetry values were videotaped throughout the procedures, so that we could carry out a pain assessment using the Premature Infant Pain Profile-Revised (PIPP-R).

**Results:** We found a significantly smaller increase in oxygenated haemoglobin on the contralateral side during venepuncture when the infants were in skin-to-skin contact with their mothers, compared to when they were laying in their incubator or crib. When venepuncture was compared with a sham procedure, oxygenated haemoglobin increased significantly more with the infant in the incubator or crib than held skin-to-skin, but no significant differences could be seen in the PIPP-R results between the two groups.

**Conclusion:** This study showed that skin-to-skin contact between premature infants and their mothers during venepuncture had a pain-relieving effect.

## INTRODUCTION

The use of skin-to-skin contact, also referred to as Kangaroo mother care (KMC), is an established method in neonatal units in major parts of the world. Skin-to-skin care is defined as the infant, dressed only in a diaper and possibly a cap, lying on the parent's bare chest for short or longer periods (1).

The benefits of skin-to-skin care have been demonstrated through research over the past few decades. Among the positive effects of skin-to-skin contact are better temperature regulation and better weight gain in the infant. It also increases the mothers' breast milk production and is beneficial for the attachment between the infant and the parents (2). Finally, some studies have suggested that skin-to-skin contact has a pain-relieving effect for the infants (3,4).

Premature infants have a highly developed ability to transmit and process pain signals, but their inhibitory

functions are poor (5). Untreated pain in infancy has numerous negative short-term and long-term consequences. Caution must therefore be taken to prevent and treat the pain, which can be caused by both the infant's medical condition and by medical and caring procedures (6). Pain management should include both pharmacological and behavioural interventions (6,7). Examples of behavioural interventions that have been shown to have a pain-relieving effect are non-nutritive sucking, facilitated tucking and

## Key notes

- We investigated if skin-to-skin contact could act as pain relief during venepunctures in premature infants.
- Double-channel near-infrared spectroscopy showed a significantly smaller increase in oxygenated haemoglobin on the contralateral side during venepuncture when the infants were in skin-to-skin contact with their mothers than when they were laying in their incubator or crib.
- This showed that skin-to-skin contact between premature infants and their mothers during venepuncture had a pain-relieving effect.

## Abbreviations

HbO<sub>2</sub>, Oxygenated haemoglobin; HHb, Deoxygenated haemoglobin; KMC, Kangaroo mother care; NIRS, Near-infrared spectroscopy; PIPP-R, Premature Infant Pain Profile-Revised.

breastfeeding (8,9). Research has also focused on the pain-relieving effects of skin-to-skin contact during painful procedures (10). These studies have mostly used different physiological outcome measures such as heart frequency (11), oxygen saturation (3) and salivary cortisol (12) or behavioural measures such as crying time (13) or facial grimacing (4).

Premature infants lack the ability to verbally express pain, and it is therefore important that clinically active healthcare professionals and researchers have access to validated and reliable pain assessment tools.

One of the scales that has been thoroughly tested is the Premature Infant Pain Profile (PIPP) (14), which has been revised to enhance validity and feasibility (15,16). The Premature Infant Pain Profile-revised (PIPP-R) is a multi-dimensional pain assessment scale that consists of three behavioural factors (brow bulge, eye squeeze and nasolabial furrow), two physiological factors (heart rate and oxygen saturation) and two contextual (gestational age and behavioural state) factors. The maximum PIPP-R score is 21 for the premature infant and 18 for the full-term infant. A higher PIPP-R score indicates a higher rated intensity of pain (15).

Near-infrared spectroscopy (NIRS) is a non-invasive technique that reflects haemodynamic changes in regional parts of the brain. Near-infrared light, which ranges in wavelengths from 700 to 1000 nm, passes through skin, soft tissue and bone. The amount of light absorbed is dependent upon how much oxygen that is bound to the haemoglobin molecule. During activation in the tissue, there is typically an increase in oxygenated haemoglobin (HbO<sub>2</sub>) and a slight decrease in deoxygenated haemoglobin (HHb) (17).

NIRS has been used in some studies in painful procedures on premature infants, and the results indicate activation in the somatosensory cortical areas following the painful event. This increased cortical activity leads to an increase in HbO<sub>2</sub>, which can be recorded with the NIRS optode (18,19).

The aim of this study was to investigate whether skin-to-skin contact could provide pain relief during venepuncture procedures carried out on premature infants and measured with NIRS. Our hypothesis was that the increase in HbO<sub>2</sub> on the contralateral side of the somatosensory cortex during the venepuncture would be smaller when the infant was held skin-to-skin, compared to when the infant was in the incubator or crib.

## METHODS

### Patients

The study was carried out at a level three neonatal intensive care unit. Written consent was obtained from the parents, and the study was approved by the regional ethical review board (2011/341).

Ten infants born at 26–35 weeks of gestation were included and examined during a blood-sampling procedure with venepuncture in two different conditions. In one, the infant was held with skin-to-skin contact with his or her

mother, and in the other, the infant was in his or her incubator or crib, which was the standard practice for blood sampling at the unit and thus served as the control situation. A crossover design was used, and the infants were their own controls. The exclusion criteria were infants with an Apgar score of less than six at five minutes of age, a confirmed brain injury, infants receiving mechanical ventilation and infants who had received sedation or pain-relieving medicine within 24 hours prior to the procedure. One of the infants was treated with continuous airway positive pressure, but was in a stable condition. Based on published research, the number of infants to include in the study was calculated to be 90% power to enable us to detect statistically significant differences at a *p* level of 0.05.

The order in which the skin-to-skin and standard situations were chosen depended on whether the mother was in the unit when the first blood test was ordered or not. All the venepuncture procedures were performed by the same nurse to make the research situation as standardised as possible. The venepunctures were performed when blood tests were ordered for clinical reasons, which means that the time period between the two situations differed between patients.

### Data collection

A double-channel NIRS (NIRO 200NX, Hamamatsu Photonics, Shizuoka, Japan) was used, and the optodes were fastened bilaterally with an adhesive dark bandage over the somatosensory cortex in a standardised way (18) at least 10 minutes prior to the examination to stabilise the signals and get baseline data. Oxygen saturation and heart rate were also measured using pulse oximetry (OxyTrend, Dräger Mecal, Lubeck, Germany). The infant's face, as well as the pulse oximetry values, were videotaped throughout the procedures so that we could carry out a pain assessment using PIPP-R afterwards. The coding was carried out by the first author (EO). To ensure the quality of the PIPP-R coding, two video recordings from each test condition were also coded by the last author (ME), which gave an intercoder reliability with a Chronbach's alpha of 0.835.

All the infants received oral glucose prior to the venepuncture as stated in the pain management guidelines of the unit. A soft cotton band was used as a tourniquet, the hand was wiped with a disinfection solution, and the skin was punctured with a standard needle size (21 gauge, 0.8 inches). Before the actual venepuncture was performed, a simulated sham procedure was acted out, where all preparations were made with the tourniquet placement and the disinfection of the skin, but the needle was only held against the skin without penetrating it. There were at least five minutes separating the sham procedure and the venepuncture.

During the procedures, all steps were marked on the NIRS recordings to make it possible to analyse the different events. The primary outcome was the maximum change in HbO<sub>2</sub> within 30 seconds of the needle penetrating the skin

or the needle held against the skin during the sham procedure.

### Statistical analysis

For verification of the hypothesis, we calculated the changes in HbO<sub>2</sub> from baseline, that is the 10-second period before handling, to the maximum value within 30 seconds of the skin puncture, in the skin-to-skin and incubator or crib situation. Descriptive data are presented with the mean or median and standard deviation or range. Differences in NIRS and PIPP-R outcomes were analysed with the Student's *t*-test. A *p* value of below 0.05 was considered to be statistically significant.

## RESULTS

The 10 infants who were included in the study had a mean gestational age of 30 + 5 weeks (Table 1). Four of the infants experienced the skin-to-skin procedure first, and consequently, the remaining six infants experienced the standard procedure first. There was an average of 52 hours between the two procedures (range 6–202 hours). On average, the infants had experienced 5.8 painful procedures before their first study procedure.

The increase in HbO<sub>2</sub> was significantly higher during the venepuncture performed with the infant in the incubator or crib compared to the venepuncture performed with the infant skin-to-skin (*p* = 0.016), which confirmed the hypothesis of the study. Figure 1 shows the changes from baseline for all four conditions.

When we analysed the sham procedure compared to the skin-breaking procedure, HbO<sub>2</sub> increased more when the infant was in the incubator or crib (*p* = 0.044). There was, however, no significant difference between the sham procedure and the skin-breaking procedure when the infant was held skin-to-skin.

When we analysed the PIPP-R scores, an obvious outlier was discovered. The infant that was on continuous airway

positive pressure had a PIPP-R score of 10 and was in an agitated state during the sham procedure. Because we did not feel that this was pain-related, we decided to remove this value from the analysis.

The mean PIPP-R score increased from 4.3 (range 0–9, SD 2.8) during the sham procedure to 5.0 (0–10, SD 3.2) during the venepuncture with the infant in the incubator or crib and from 5.0 (0–8, SD 2.2) to 5.7 (0–11, SD 3.5) when the infant had skin-to-skin contact. There was no significant difference between the two conditions. The heart rate and oxygen saturation of the infants were registered as part of the PIPP-R. The heart rate increased with 8.4 beats per minute (range minus 26 to plus 25, SD 8.0) from baseline before the procedure to the maximum value the first 30 seconds after the procedure in all patients. There was no significant difference between any of the test conditions. Likewise, oxygen saturation decreased by 1.3%, with a maximum decrease of 6% and maximum increase of 5% (SD 2.7 not significant).

## DISCUSSION

To our knowledge, this is the first study that has used NIRS to assess the pain-relieving effect of skin-to-skin contact in premature infants. Our results support and strengthen those obtained from other studies, using other outcome measures (10).

We found a significantly smaller increase in HbO<sub>2</sub> on the contralateral side during venepuncture when the infants were held skin-to-skin with their mothers, compared to when they were laying in their crib or incubator. There was, however, no significant difference in the HbO<sub>2</sub> on the ipsilateral side, which is in accordance with the results of Slater et al. (19).

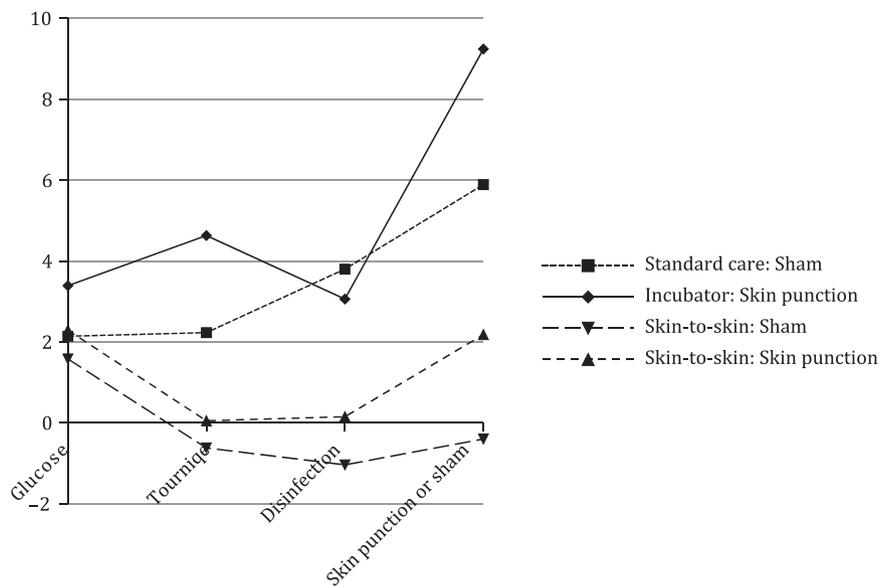
The lack of significant difference in HbO<sub>2</sub> between the sham procedure and the skin-breaking procedure when the infant was held skin-to-skin could indicate that the infant actually experienced less pain in this situation, and therefore, the differences between the reactions to the nonpainful and the painful stimuli were smaller.

We found no significant difference in the PIPP-R score between the skin-to-skin and incubator or crib conditions, which could be an indication that pain is processed on the cortical level even when there are no behavioural signs (20).

It is likely that the use of oral glucose also contributed to reducing the pain reactions; however, as the infants received glucose in all the situations, this effect would have been the same. A limitation of the study was the obvious problem with blinding when the infant was held skin-to-skin or laying in the incubator or crib, for the researcher performing the PIPP-R scoring from the video recordings. Although efforts were made to hide the surroundings, it was possible to see which situation the infant was in. There was, however, no possibility of knowing if it was a venepuncture or a sham procedure during the coding of the video recordings, because all the procedures were coded using randomly assigned numbers. While reading and

**Table 1** Data on included infants

	Min-max	Mean	SD
Gestational age, weeks and days	26 + 4–33 + 6	30 + 5	
Birth weight, g	875–2395	1707	416.3
Apgar, 1 minute	4–10	9 (median)	
Apgar, 5 minutes	6–10	10 (median)	
Apgar, 10 minutes	8–10	10 (median)	
CRIB score	0–2	0.2	0.6
Previous painful procedures, number	2–10	5.8	2.5
Post-natal age first procedure	1–18	6.6	4.7
PIPP-R	0–11	5.0	2.9
Maximum heart rate after procedure	145–192	165.4	13.1
Minimum oxygen saturation after procedure	78–99	94.2	4.7



**Figure 1** Changes from baseline in HbO<sub>2</sub> on the contralateral side during administration of glucose, tourniquet placement, disinfection and venepuncture or sham procedure with the infant in incubator or crib or held skin-to-skin.

analysing the NIRS values, the researcher was blind to the intervention. This was a small sample, and future studies may consider including more infants and also infants that are of an earlier and, or, later gestational age, and possibly also include infants on ventilators. If we had used more than two optodes, we could have obtained a more complete picture. However, due to the small head size of the infants we wanted to include, we decided to use two optodes with an optimum placement. It might also be of value to confirm if there is a difference in the pain-relieving effect between mothers and fathers sitting skin-to-skin with their infant (21).

Although there are a number of pain assessment instruments available, there is always a matter of subjectivity when rating another person's pain. Self-reporting is the most desirable way to rate a pain experience, which is obviously not possible in this vulnerable nonverbal patient population. The possibility of monitoring pain in a similar way to other vital signs such as heart rate or oxygen saturation is desirable, and NIRS might be one such method and feasible in clinical care.

This study adds another element to the support of skin-to-skin contact as part of the pain management of this vulnerable, nonverbal population. Skin-to-skin contact is an easy, inexpensive method that also could make parents more involved in their infants' care and pain management (22).

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