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AACN Clin Issues. Author manuscript; available in PMC 2007 June 8.

Published in final edited form as:
AACN Clin Issues. 2005 ; 16(3): 373–387.

Skin-to-Skin Contact Analgesia for Preterm Infant Heel Stick.

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Abstract

Objectives—The purpose of the study was to compare a heel stick conducted during skin-to-skin contact with the mother to a heel stick in an incubator in reducing premature infant physiologic and behavioral pain responses.

Study Design—24 premature infants in a University-based NICU were recruited and randomized to two sequences: Sequence A group received three hours of skin-to-skin contact with a heel stick in skin-to-skin followed by three hours in an incubator with a heel stick in the incubator. Sequence B group had incubator care and heel stick before skin contact care and heel stick. Heart rate, respiratory rate, oxygen saturation, crying time and behavioral state were measured before, during, and after heel stick. Repeated measures ANOVA and Mann Whitney U statistics were performed.

Results—Heart rate and crying responses to pain were significantly reduced during the skin-to-skin contact and skin contact heel stick as compared to incubator care and incubator heel stick. Three infants did not cry at all during the skin contact heel stick. Infants slept more during skin-to-skin contact than in the incubator.

Conclusion—Skin-to-skin positioning before and during a heel stick is a simple and inexpensive intervention to ameliorate pain in medically stable premature infants.

Keywords

Pain; premature infant; skin-to-skin contact; heel stick; analgesia

Introduction

Although much consideration has been given to non-pharmacologic interventions to manage heel stick related pain in preterm infants (Stevens et al., 2001;Grunau et al., 2004), little attention has been given to the use of skin-to-skin contact (SSC), with only one trial focused on skin-to-skin contact's effects on premature infants' pain (Johnston et al., 2003). Skin-to-skin contact provides the infant with physical boundaries (containment), maternal heart beat sounds, rhythmic movement with maternal breathing, warmth, and a prone position (Ludington-Hoe & Swinth, 1996 or 94?) –all simultaneous gentle stimulation across the proprioceptive, auditory, vestibular, thermal, and tactile sensory systems which may modify gate control and neuromatrix mechanisms thereby altering pain transmission (Melzack, 1999;Melzack, 2001). Recognizing that pain can produce physiologic disruption and that skin-to-skin positioning might be a simple and inexpensive intervention to ameliorate pain during procedures, an experimental study was conducted to measure the effect of skin-to-skin contact on physiologic (heart rate, respiratory rate, oxygen saturation) and behavioral (crying time and

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Financial Assistance: This study was supported in part by NIH-NR RO1-02251-04 and NIH-NR RO3-NR008587 to the first author.

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behavioral state) measures of pain before, during, and after a heel stick occurring in the incubator as compared to a heel stick occurring in skin-to-skin contact. A randomized, cross-over trial of three hours of skin-to-skin contact between the medically stable premature infant and his/her mother and three hours of incubator care before a heel stick was conducted.

Methods

All premature infants of less than 37 weeks postconceptional age according to the Ballard assessment who were no longer receiving oxygen support and were being cared-for in Montgomery warmers in the neonatal intensive care unit at the Hospital de Maternidad of San Salvador were eligible for the study.

Exclusion criteria were infants who had a five-minute APGAR <6, any congenital or neurologic anomaly, need for oxygen support in the 4 days prior to study, active sepsis, grade III or IV intraventricular hemorrhage, dysmorphic features, maternal substance abuse, intravenous line, continuous feeding, and need for analgesia or sedation in the 24 hours prior to study.

The University of California at Los Angeles Human Subjects review committee and the neonatal board of the El Salvador Hospital de Maternidad approved the study. Written informed consent was obtained from the mother of the infant.

Consenting mother-infant pairs were randomized by sealed envelope (Zellen, 1974) technique into two groups. Group A received three hours of skin-to-skin contact during the first interfeeding interval before having a heel stick for dextrostick analysis performed with the infant remaining skin-to-skin. The infant's routine vital signs were taken after the stick of a staff nurse and a human milk feeding at breast followed. At the end of the feed, the infant was placed prone and nested in a Montgomery warmer for the next interfeeding interval of three hours before a second heel stick for dextrostick analysis was performed on the infant as he/she remained in the warmer. Group B received three hours of warmer care for the first interfeeding interval and then spent three hours in skin-to-skin contact for the second interfeeding interval. Each infant was tested on one day using this cross-over design that controlled for intra- and inter-subject variability and provided the highest possible equivalence among subjects exposed to both conditions. The cross-over design controlled for all threats to internal validity except the interaction of selection and treatment, but assignment to group A or B independently and randomly by the Zellen technique insured balanced representation in both treatment sequences. This randomization removes the selection/treatment interaction source of both main and interaction effects, at least to the extent of sampling error. Carry-over effects from one condition to the next is a concern with any cross-over design. Previous research with KC has shown that physiological and behavioral state effects of KC are not sustained once KC is discontinued (Bohnhorst et al., 2001;Bosque et al, 1995;Constantinou et al., 1999;de Leeuw et al., 1991;Gray et al., 2000;Ludington-Hoe et al., 1998;Ludington-Hoe et al., 2000;Modi and Glover, 1998)

For skin-to-skin contact the infant wore only a diaper and was placed prone and upright between maternal breasts as the mother sat in a stationary chair at the infant's beside. A standard receiving blanket folded in fourths was placed across the infant's back and the mother's blouse closed over that. When the infant was in the warmer, he/she wore only a diaper and laid prone between two rolled up blankets that formed a nesting boundary on each side of the infant. The infant was covered by a receiving blanket folded in half and the lid of the warmer was closed. One experienced neonatal nurse conducted all the heel sticks and another manually recorded infant physiologic data every 30 seconds (using a Lorus timer that beeped every 30 seconds) as it was displayed on the Corometrics 515A cardiorespiratory monitor for heart rate and respiratory rate based on three lead impedance plethysmography. Oxygen saturation level was

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displayed on the Nellcor 200 (Mallinkrodt, Hazelwood, Missouri) Cardiolock pulse oximeter in Mode 1 (displaying data averaged over 2–5 seconds) and recorded every 30 seconds. The infant's cry was recorded on a Radio Shack (Model 2100, Tandy Corp) voice-activated recorder secured two inches from the infant's mouth on the incubator mattress and the mother's breast. If the infant turned his/her head away from the recorder, his/her head was turned toward the recorder by the neonatal nurse who was performing the heel sticks. Because behavioral state affects pain responses, the Al's (1984) system was used by the same consistent observer during all testing to rate behavioral state. The states are: 1 = deep sleep, 2 = active sleep, 3 = drowsy, 4 = quiet alert, 5 = active alert, and 6 = crying. All physiologic parameters, crying, and behavioral state were recorded for 15 minutes prior to the heel stick (pre-stick), throughout the heel stick (foot extracted from blouse, alcohol swipe, Tenderfoot ^{TM} lance and two squeezes and holding the foot in the hand) which required 2 minutes (heel stick), and for 5 minutes after a band aid was applied to the heel stick site (post-stick) as the infant remained in skin-to-skin contact or the warmer.

Crying was defined as audible vocalization of a whimper, cry, or hard cry as detected by a voice-activated recorder. Cry length was timed by the Lorus stopwatch to the nearest tenth of a second and defined as onset of a vocalization to cessation of vocalization for five seconds or more. Mean crying length was calculated from all crying bouts; crying bouts were from the beginning of crying vocalization to the end of crying for five seconds or more.

Data were entered and statistics calculated with SPSS 10.0 A repeated measures ANOVA using time (first vs. second interfeeding interval) and treatment (SSC vs. warmer) as the variables was performed on continuous measures as is common and appropriate (Grunau et al., 2004;Johnston et al., 2003;Ward-Larson et al.,2004), and was followed by Tukey post-hoc testing. Sleep/wake states were analyzed using the Mann Whitney U test to compare the skin-to-skin and warmer conditions during each event. Significance level was set at $p \leq 0.05$.

Results

Twenty-four subjects were recruited but one was discharged before the study could be completed. The data are from 23 infants, 13 male and 10 female, 12 Group A and 11 group B. Sample size was determined using a power analysis for repeated measures so that a medium effect size on heart rate of 0.56 could be detected with a power of 0.8 and alpha of 0.05, yielding 12 subjects per group. Eighteen were middle-Americans of Hispanic origin and five were Afro-Caribbean. The mean (SD) gestational age at birth was 31.4 (2.7) weeks, mean (SD) postnatal age on day of testing was 22 (11.4) days, mean (SD) five-minute APGAR was 7.8 (1.2). Eight infants had received oxygen support, three by ventilator and five by cannula, and all were still being cared for in Montgomery warmers in the one room NICU that housed all infants, regardless of severity of illness. Because severity of illness can affect the infant's ability to mount a response to pain, affecting cry duration (Johnston et al., 1999), the Score for Neonatal Acute Physiology II (SNAP-II) (Richardson et al., 2001) was used to measure severity of illness on the day of study. The mean (SD) number of previous heel sticks and venepunctures, according to the nursery flow sheets, was 10.2 (4.3) for Group A and 8.8 (5.2) for Group B. Comparisons between the demographic characteristics of the groups were made using an independent samples t- test for continuous data and Chi-square tests for categorical data. There were no significant differences between the groups in any of these characteristics.

Cardiorespiratory and crying data for each period under both SSC and warmer conditions are shown in Table 1. Significant main effects were found for heart rate ($F[1,32] = 3.54$, $p = 0.042$) and cry length ($F[1,32] = 5.20$; p 0.01. Mean rise in heart rate from baseline to heel stick was less in the SSC condition than in the warmer condition ($F[1,32] = 3.01$, $p = 0.047$. Crying length

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during the SSC heel stick was significantly less than during the warmer heel stick ($F[1,32] = 7.38$, $p = 0.003$) and post-stick period ($p = 0.02$).

The mean percent time spent in each behavioral state when infants were in the SSC and warmer conditions is in Table 2. Behavioral state differed significantly during baseline (Mann Whitney $U = 2.89$, $p \leq 0.04$), and during post-stick (Mann Whitney $U = 1.73$; $p \leq 0.05$) with infants being calm and quiet more often during skin-to-skin periods than warmer periods. The predominant state of infants during skin-to-skin care baseline was deep sleep, whereas in the warmer active sleep occurred most frequently. Three infants did not cry at all during the skin-to-skin heel stick; two aroused to the drowsy state and one to the active awake state instead. Post-heel stick, infants quickly resumed deep sleep in skin-to-skin, but remained awake and active or drowsy in the warmer.

The difficulty and duration of the heel stick was subjectively appraised as being similar between the two conditions because the heel stick was conducted by the same person using the same technique to draw the same amount of blood.

Discussion

The results show that heart rate and crying responses to pain were significantly reduced during skin-to-skin contact and skin contact heel stick as compared to incubator care and incubator heel stick. Unexpectedly, three infants who had been in deep sleep during baseline did not cry at all during the skin-to-skin heel stick, suggesting that the sleep they were in provided the ultimate respite from the noxious NICU environment. These results are similar to those of (Gray et al., 2002) who found that 11/15 full term infants who were in the KC position and breastfeeding during a heel lance did not cry or grimace at all. These results augment the Premature Infant Pain Profile findings of the only other study of skin-to-skin contact to reduce premature infant heel stick pain [3](Johnston et al., 2003). In that investigation, skin-to-skin contact was given for 30 minutes and effectively reduced the pain score by 2 points, a value that reached statistical and clinical significance. The study reported here incorporated a cross-over design that more fully accounts for the variability that exists in individual pain experiences than other designs. In addition, the number of previous heel sticks experienced by the infants was measured and did not differ between the groups prior to testing, minimizing the possible influence of previous painful experiences on pain response (Grunau et al., 2001;Johnston et al., 1996;Johnston et al., 1999). The more the number of previous painful experiences, the more likely the infant is to have hypersensitization to pain (Andrews and Fitzgerald, 1994;Fitzgerald and de Lima, 2001). Hypersensitivity to pain is an inability to implement inhibitory mechanisms, thus the infant demonstrates an exaggerated pain response to subsequent pain experiences. Another contribution of this study is that the cross-over design removed the effect of any prior conditioning acquired during the time in intensive care.

Though this study was not designed to address mechanisms contributing to a reduction in pain response, two other studies, each using the same methodology but differing in their outcomes, provide a possible explanation. Mooncey and associates (1997) gave 15 preterm infants (similar in gestational age and postnatal age to those tested in this study) 40 minutes of rest in an incubator before twenty minutes of skin-to-skin contact. Then infants were returned to the incubator for a heel stick. Both serum cortisol and serum β-endorphin fell significantly (cortisol by 66%; β-endorphin by 74%) after skin-to-skin contact. No drop in cortisol nor beta-endorphin occurred a day later when infants were kept only in the incubator prior to the heel stick. Modi & Glover (1998) replicated Mooncey's study and extended it by adding a group of infants who received massage prior to the heel stick. Salivary cortisol and β-endorphin fell a similar amount in the skin-to-skin group, but did not decrease at all in the massage group (Modi and Glover, 1998). SSC appears to deactivate the hypothalamic-pituitary-adrenal axis, and may

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consequently alter pain responses. SSC has been suggested by some to be form of touch that promotes the infant's ability to moderate the effects of painful factors because SSC increases opioid peptide secretion (Weller and Feldman, 2003;Weller et al., 2002). In animals, non-noxious stimulation such as stroking, skin-to-skin contact, massage, and pleasant warm temperature causes a release in oxytocin which enhances the antinociceptive effects of these treatments (Uvnas-Moberg et al., 1993).

The data presented here should be viewed with caution as manual recording of data is subject to error. Further, the observers were not blind to treatment and group, a condition that is being corrected by having all data videotaped and computer-stored for scoring outside the clinical area in an on-going study (Ludington, 2003). The clinical usefulness of three hours of skin-to-skin contact needs to be addressed in future studies too, given that only 20 minutes of SSC has been effective in deactivating the HPA axis (Modi and Glover, 1998) and 30 minutes of SSC has been shown to reduce facial grimacing and Premature Infant Pain Profile scores (Johnston et al., 2003). Fifteen minutes of SSC was effective in reducing crying time by 82% and minimizing heart rate increase (8–10 bpm during an SSC heel stick versus 36–38 bpm during an incubator heel stick) in thirty fullterm infants (Gray et al., 2000).

Repeated use of SSC to modify infant pain may result in the infant making associations between SSC and a painful experience, though this concern has not been substantiated in studies of older children being held by their mothers for surgical procedures (Kain et al., 2002). Precautions taken to prevent the association in older children, such as long periods of maternal-child contact prior to the painful procedure and intensification of maternal-infant contact by holding the infant more firmly and adding soothing vocalizations and stroking after the procedure, may be useful with premature infants too. Premature infant tolerance of simultaneous multisensory input without physiologic compromise will need to be monitored.

In conclusion, this study adds one more piece of evidence that pain, as measured by physiologic and behavioral responses, is significantly reduced in preterm infants undergoing heel stick when they are given three hours of SSC before the heel stick and have the heel stick performed in SSC.

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Table 1

Mean (SD) values for outcome measures

Variable	SSC Baseline	SSC Stick	SSC Post- stick	Warmer Baseline	Warmer Stick	Warmer Post-stick
Grp A HR (beats/min)	158.20 (6.15)	171.43 (12.17)	161.14 (7.33)	147.21 (14.93)	170.86 (9.24)	166.35 (8.96)
Grp B HR (beats/min)	157.80 (10.22)	160.53 (9.64)	159.78 (5.76)	151.85 (10, 77)	159.42 (11.21)	160.44 (5.64)
Grp A RR (breaths/min)	53.73 (7.49)	50.25 (10.71)	58.76 (8.04)	49.19 (8.34)	48.97 (10.05)	52.06 (11.23)
Grp B RR (Breaths/min)	58.29 (8.81)	52.69 (12.52)	50.43 (8.39)	52.43 (9.35)	49.68 (9.63)	50.01 (7.95)
Grp A SaO_2 (%)	98.26 (0.69)	96.55 (3.65)	97.03 (2.87)	94.62 (2.13)	92.55 (4.88)	92.89 (3.21)
Grp B SaO_2 (%)	97.89 (1.31)	94.94 (4.02)	95.61 (3.41)	97.74 (2.43)	92.84 (5.74)	96.95 (5.76)
Grp A Cry length (secs)	None	5.09 (3.21)	2.03 (1.85)	2.44 (2.20)	45.69 (13.77)	4.01 (2.86)
Grp B Cry length (secs)	2.33 (1.24)	4.98 (4.67)	3.84 (1.76)	2.00 (2.43)	39.25 (14.47)	3.22 (2.85)

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Table 2

Behavioral States in SSC and Warmer Conditions during Baseline, Heel Stick and Post-Stick with Group A and Group B Data Combined

Sleep-wake State	SSC Baseline %	SSC Heel stick %	SSC Post-stick %	Warmer Baseline %	Warmer Heel stick %	Warmer Post-stick %
Deep Sleep	88.54	5.92	42.88	58.26	1.33	27.85
Active Sleep	5.39	0.20	31.00	20.43	1.40	31.19
Drowsy	None −0.00	10.48	0.84	0.00	0.00	3.66
Quiet Alert	2.43	None	2.26	5.44	0.00	3.85
Active Awake	2.14	18.48	15.31	15.14	5.27	21.45
Crying	1.5	64.95	7.71	0.73	92.00	12.00