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Skin-to-Skin Contact Is Analgesic in Healthy Newborns

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ABSTRACT. ***Objectives.*** **To determine whether skin-to-skin contact between mothers and their newborns will reduce the pain experienced by the infant during heel lance.**

Design. **A prospective, randomized, controlled trial.**

Setting. **Boston Medical Center, Boston, Massachusetts.**

Participants. **A total of 30 newborn infants were studied.**

Interventions. **Infants were assigned randomly to either being held by their mothers in whole body, skin-to-skin contact or to no intervention (swaddled in crib) during a standard heel lance procedure.**

Outcome Measures. **The effectiveness of the intervention was determined by comparing crying, grimacing, and heart rate differences between contact and control infants during and after blood collection.**

Results. **Crying and grimacing were reduced by 82% and 65%, respectively, from control infant levels during the heel lance procedure. Heart rate also was reduced substantially by contact.**

Conclusion. **Skin-to-skin contact is a remarkably potent intervention against the pain experienced during heel stick in newborns.** ***Pediatrics*** **2000;105(1). URL: http://www.pediatrics.org/cgi/content/full/105/1/e14;** ***human newborns, pain, heel lance, skin-to-skin contact, kangaroo care, crying, grimacing, heart rate.***

ABBREVIATION. bpm, beats per minute.

Pain experienced by infants during and after common hospital procedures that cause tissue damage—heel stick, for example—can be palliated by some components of the nursing–suckling complex.[1–5] Nonnutritive sucking during heel lance substantially reduces crying and grimacing[6,7] and blunts heart rate increases.[7] In addition, various tastes and flavors cause analgesia. Sweet solutions,[7–24] milk,[25,26] protein,[25] and fat[25] reduce crying, grimacing, heart rate, oxygen saturation, and other physiologic pain indices in premature and term infants, who are crying during heel stick or circumcision. A little is known about these pain-relieving mechanisms. Sweet taste, milk, and fat flavor-induced analgesias in rats have been blocked by low doses of naltrexone, suggesting opioid involvement.[27–29] In contrast, suckling-induced analgesia is not blocked by the opioid antagonist in rats, nor is the analgesia caused by whole body contact, suggesting different pathways, at least in part.[30,31]

The ease with which analgesia has been induced through such behavioral interventions in human newborns has heightened interest in the function of mother–infant interactions as a means of preventing or reducing pain and stress.[1–5] An integral aspect of nursing–suckling exchanges and other social interactions that has received virtually no attention in either animal or human newborn pain literatures, however, is the influence of whole body contact on pain amelioration. The 2 reports in the animal literature on this issue have shown that whole body contact between 10-day-old rats and their mothers caused analgesia, judged by a doubling of withdrawal latencies from a noxious heat probe.[30,31]

A few studies in human infants have assessed contact-induced analgesia and have obtained decidedly mixed results. For example, Campos[6] allowed infants either to suck a pacifier or to be held and rocked after completion of blood collection via heel stick. Infants who sucked a pacifier after heel stick cried less than control infants and had lower heart rates. In contrast, holding and rocking had a more modest quieting effect and did not reduce heart rate relative to control infants. In fact, crying cessation was more apparent than real. Infants who had been held or who sucked a pacifier during the 8-minute intervention immediately attained and maintained control levels of crying when the intervention was terminated. In earlier reports, Korner and colleagues[33,34] were not able to reduce crying through contact alone; holding infants in the upright position only modestly reduced crying. According to Hallstrom,[35] holding infants during immunization, reduced crying by 17% compared with control infants, who received their immunizations while being restrained on the examination table. The modest reductions in crying were surprising in light of the parental and clinical impressions that holding is soothing and animal reports of very potent comforting through contact.[30,31,36,37] Accordingly, the present study revisits the issue of skin-to-skin contact as a potential source of analgesia in human newborns.

In planning the current study, we were impressed by recent advances in the clinical care of premature infants in developing countries who had been discharged from neonatal intensive care units because of the shortage of incubators and other resources. In these settings, long-term mother–infant skin-to-skin contact (kangaroo care) has improved survival, in-

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creased breastfeeding, caused better respiratory control and temperature regulation, and has enhanced maternal bonding.[38–46] The present study evaluates the short-term effects of mother–infant full-body skin-to-skin contact in a quiet setting on reactivity to a painful stimulus.

METHODS

Subjects

The study subjects were 30 healthy full-term newborns delivered at Boston Medical Center, Boston, Massachusetts, between March and October 1998. They were assigned randomly the morning of the study to 1 of 2 study groups: skin-to-skin contact (n = 15) and no-contact controls (n = 15). Five infants were delivered via cesarean section; 11 subjects were males; 16 were black, 4 white, 6 Hispanic, and 1 American Indian. Three infants were not classified racially. Birth weights ranged from 2.6 through 3.7 kg (mean birth weight: 3.3 kg). All Apgar scores were ≥8 at 5 minutes. All infants had been delivered at or beyond 37 completed weeks of gestation and were between 33 and 55 hours old at the time of testing, which generally began between 7 and 8 AM. Infants had been fed in their usual manner between 30 minutes and 4 hours before the start of the study. Of the infants, 16 were breastfed, and 4 had been circumcised on the previous day. All these characteristics were distributed equally between the 2 groups. No infant presented any evidence of congenital abnormalities, medical complications, or drug exposure. No infant required either oxygen administration or ventilatory support. This was the initial heel stick for all infants. A single physician (L.G.) performed all the heel sticks, thereby minimizing variability. As an additional precaution against procedural variability, blood collection time was capped at 3 minutes. The infant then entered the recovery phase of the study, which lasted an additional 3 minutes. In point of fact, for 27 of 30 infants, blood collection was completed in advance of the 3-minute cutoff. Blood collection was terminated for the remaining 3 infants at 3 minutes, and these infants entered the recovery phase. All 3 of these infants were in the experimental group. After the recovery period ended, blood harvesting was completed without additional data collection.

Based on our previous studies, to achieve a clinically significant reduction in grimacing and crying, with a power of 80% and a P value <.05, we estimated a sample size of 15 infants in each group.

The protocol governing these studies had been approved by the institutional review boards of the Boston Medical Center, Boston University School of Medicine, and the University of Massachusetts at Amherst. Mothers were approached, and informed written consent was obtained on the afternoon before the study. Of the mothers approached, 88% gave their consent.

Data Collection

Fifteen minutes before blood collection, the infant's shirt was opened and 3 safety electrodes (Klear Trace 2000-S; CAS Medical Systems, Branford, CT) were placed on the thoracic region for heart rate recording. A warming pad was wrapped around the assigned foot. Control infants were then wrapped in their receiving blanket and placed on their side in their respective bassinets.

Mothers, whose infants had been assigned to receive contact, changed into a hospital gown that buttoned in the front and returned to their beds that had been adjusted to a 45° angle to provide a comfortable reclined position. Their infant, wearing only a diaper, then was positioned on the mother so that skin-to-skin contact was maintained through her open gown. This arrangement left the infant's face visible for filming from the side of the bed. Two receiving blankets were placed over the infant's back, allowing access to the heel. This also insured that the mother was covered, so that her ventral area would not be video recorded. Mothers then were asked to lock their fingers, place their hands over the blankets and apply a slight pressure on their infant's back to stabilize the infant for both procedural ease and to facilitate video recording. The mothers were requested not to rub their infant's head, because we found during pilot studies that head stroking actually seemed to irritate the newborns. At this point, the experimenters left the room for 10 to 15 minutes, so that mother and infant could settle into a relaxed contact position. In preliminary studies, this period of time proved to be necessary for the mother–infant couple to relax. Initiating the heel stick before this time period mitigated the effectiveness of kangaroo contact. On return, we found infants in both groups to be in a relaxed and quiet state. At this point, the electrocardiogram electrodes were connected to the monitor, and the experiment proper began.

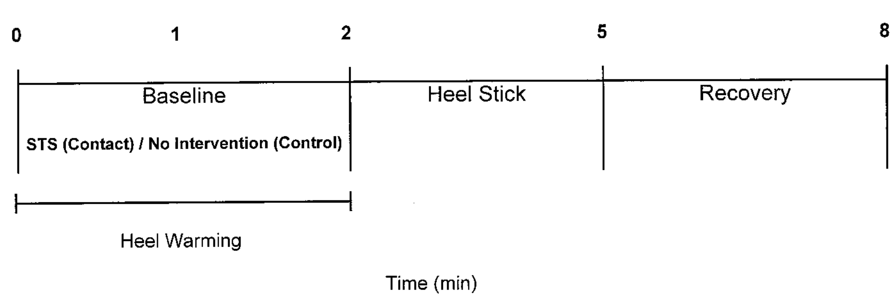
After a 2-minute baseline period (Fig 1), during which the infant's face was filmed (Sony Model CCD-TRV32) and heart rates were announced every 10 seconds from the monitor, the heel warmer was removed, and the heel was swabbed with alcohol. Blood then was drawn for the standard newborn-screening test (by L.G.) using a spring-loaded lancing device (Tenderfoot; International Technidyne Corporation, Edison, NJ) to reduce variability. Mean blood collection times were 159 and 155 seconds for experiment and control infants, respectively (not significant). After blood collection was completed, or 3 minutes had elapsed from the start of collection, a Band-Aid was applied to the heel, and the infant entered into the 3-minute recovery period. Filming continued uninterrupted through the procedure until the end of recovery. Considerable care was taken not to capture the mother's face at any time during filming. The entire study from the beginning of the baseline period took 7 to 8 minutes to complete.

Since L.G. conducted all heel sticks because of scheduling difficulties with the phlebotomists, a potential bias of differential treatment has been introduced. We are not concerned about this potential bias for a number of reasons. First, the duration of the procedure and apparent discomfort that it caused in control infants, expressed in crying, for example, was of the same order of magnitude as that caused by the phlebotomist in other studies conducted in our laboratory. Second, as indicated, mean blood collection times for both groups were not statistically different. Third, we went through a number of iterations as documented above before a successful set of parameters was attained. It would seem to us that any systematic bias on the part of L.G. would have become manifest from the outset and not after a number of procedural changes.

Pain Assessment/Outcome Measures

Videotape evaluations of infant pain reactions were conducted by research assistants who were not aware of either the purpose of the study or the number of different groups. Scorers were trained (by L.W.) to record grimace as brow bulge, eye squeeze, and nasolabial furrowing. These facial actions have been reported in 99% of neonates within 6 seconds of heel stick; they are believed to be very sensitive indices of infant pain.[47,48] Scorers were uninformed as to experimental condition when scoring heart rate and cry, both from the auditory portion of the tape. For grimacing, of course, knowledge of group assignment was unavoidable. The data obtained in these analyses were reliable among scorers (95% agreement).

Fig 1. Time line of the experimental procedure. Note that the foot warmer was placed on the infant before the mother and infant were placed in skin-to-skin contact.



Duration of crying and grimacing during the blood collection and recovery phases were the behavioral measures of pain. Crying was scored as the presence of an audible crying sound. Grimacing was determined as above. On occasion, grimacing was sometimes impossible to score owing to the unavailability of the infant's face, when turned from the camera or burrowed into the mother. In these circumstances ($n = 3$), the infants were not included in the grimace data analyses. Those portions of the film that we were able to evaluate, however, indicated that the treatment was as effective in these infants as in the others. Finally, heart rate was scored every 10 seconds and averaged separately for the baseline, heel stick, and recovery segments. Heart rate data for the recovery period were evaluated further at 30-second intervals for individual infants. Crying and grimacing during heel lance are reported as a percentage of procedural time, owing to variability in the duration of blood collection. They are reported in real time, over 30-second intervals, during recovery.

Statistical Evaluations

Simple t tests were performed on the mean percent cry and grimace measures during heel lance. Changes in mean heart rate values were determined via separate analysis of variances for each phase of the study. As will be seen, there was essentially no crying or grimacing during recovery in the contact infants.

RESULTS

The outcome of this study is clear: kangaroo care, as practiced here, markedly reduced crying and grimacing by 82% and 65%, respectively, from control infant values. It also prevented the explosive rise in heart rate that normally accompanies heel lance.

Figure 2 demonstrates the reduction for both crying and grimacing, during the procedure, expressed as the percentage of blood collection time. The reduction is striking and extremely robust statistically ($P < .0001$). There was virtually no overlap in the distribution of either crying or grimacing between the 2 groups. Moreover, pain-related differences extended into the 3-minute recovery period as well. As shown in Fig 3, infants, who were held by their mother in skin-to-skin contact, cried and grimaced for an average of 1 and 2 seconds, respectively, for the entire recovery period. No crying occurred in any contact infant after the first 30 seconds of recovery and grimacing in only 5 of the contact infants after the first recovery minute. In contrast, control infants cried for a mean of 32 seconds and grimaced for a mean of 30 seconds of the 3-minute recovery period. Analysis of crying and/or grimacing extended into the second recovery minute for 11 control infants, and into the third minute for 8 of the 15 newborns. Data collection was terminated for 4 control infants during the second minute and for 7 control infants during the third minute because of excessive crying.

Fig 2. Mean (±) standard error of the mean percentage occurrence of grimacing and crying during the heel stick procedure for control newborns and newborns who were in skin-to-skin contact with their mothers before and during the procedure ($n = 15$/group for crying and grimacing, except $n = 12$ for grimacing in contact group).

Skin-to-skin contact also prevented the marked rise in heart rate that occurred in control infants as shown in Fig 4. Heart rate of infants in the contact group was stable throughout the study, increasing by about 8 to 10 beats per minute (bpm) during the course of blood collection (not significant). This stability was maintained during the recovery period. In contrast, heart rate of control infants rose linearly by 36 to 38 bpm to an asymptote of 160 bpm. This plateau was sustained during the first minute of the recovery period. This pattern of heart rate activity is reflected in repeated measures analysis of variance, which revealed a significant effect of time and highly reliable interaction between treatment and time ($P < .0001$). As would be anticipated by looking at Fig 4, the overall difference between contact and control infants was not statistically reliable.

Comforting activities were variable among the mothers in this study. Some were content to remain in relaxed contact, holding their infants firmly against their bodies with both hands. Others, in addition to securing contact, spoke gently to their infants or made clicking sounds. There were a number of combinations. We thought it important not to interfere with these natural comforting expressions, because we wanted the mothers to be relaxed and not transfer discontent or tension to the infant.

DISCUSSION

These findings are of theoretical and clinical interest. From the perspective of understanding how the nursing–suckling relationship contributes to analgesia, we now know that all 3 components, contact, suckling per se, and taste/flavor are antinociceptive and calming in newborn rats and humans.[30,31] Each component uses different neural and neurotransmitter pathways[27–31] to reduce pain and enhance energy conservation.[49]

There is now a substantial literature on the quieting and analgesic properties of sweet taste and milk flavor in newborn rats and term and premature humans.[1–26] As judged by the effectiveness of sweet taste on pain reactivity in premature infants, it is reasonable to suggest that these mechanisms are available well before term and do not require suckling experience for their manifestation. This also is supported by elevated pain threshold in rats, delivered by cesarean section, that had never suckled or tasted milk before the study.[50] Taste/flavor induced analgesia is opioid-mediated[11,27–29] and endures well past the time of tasting in rat and human neonates.[12–14,51]

Nonnutritive sucking is also analgesic in rats[30,31] and humans[6–8,52,53] as judged by markedly increased escape latencies in rats and reduced crying and grimacing in humans undergoing heel stick or circum-

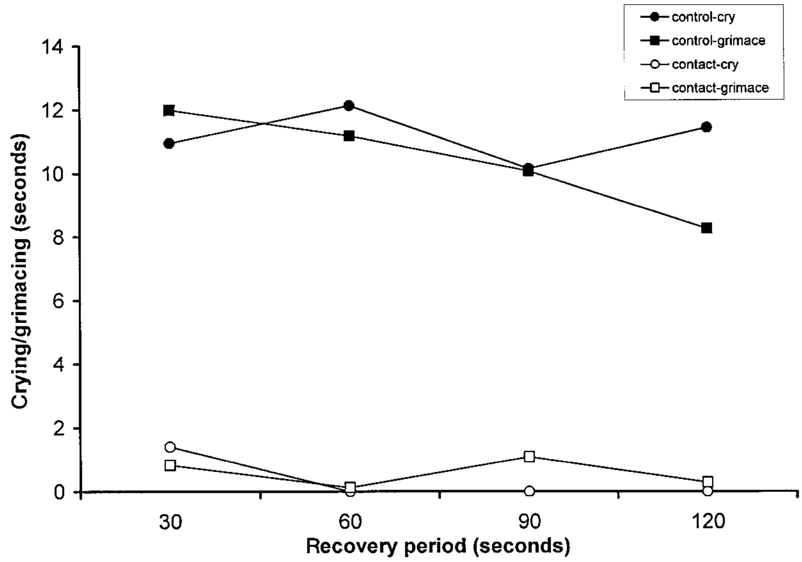


Fig 3. Amount of crying (circles) and grimacing (squares) in real time, for contact (open symbols) and control (filled symbols) groups of newborns during the first 2 minutes of recovery. Data presentation is limited to the first 2 minutes of recovery because 7 of the control infants had to be removed from the study at that point for excessive crying.

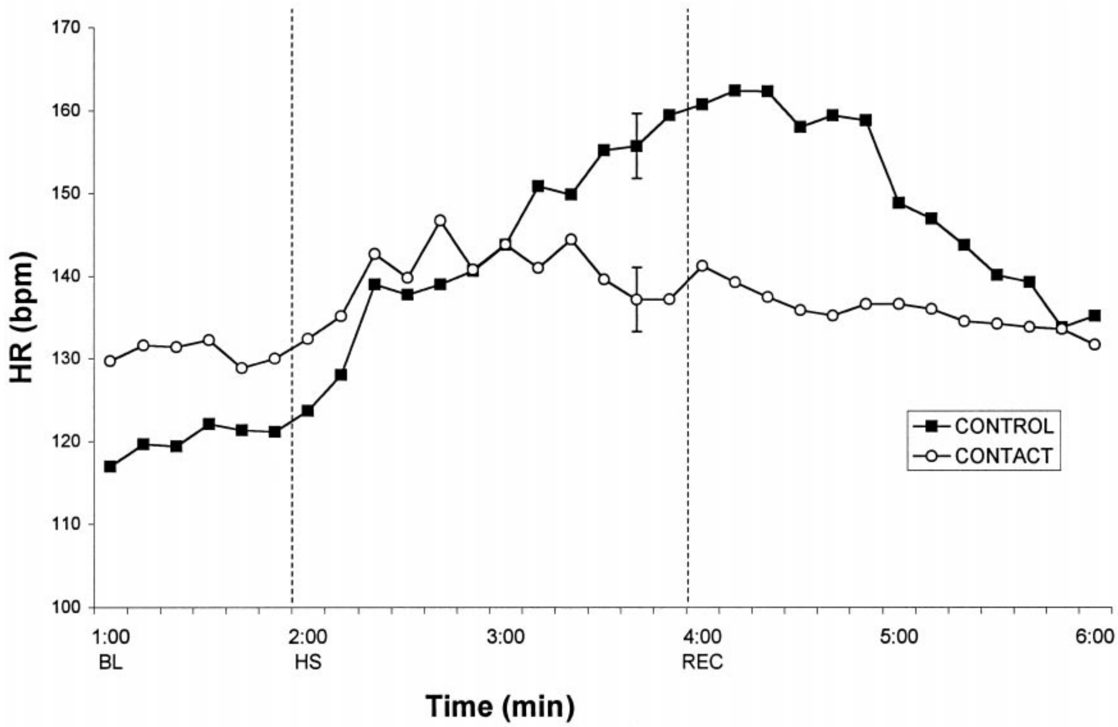


Fig 4. Mean heart rate (bpm) at 10-second intervals for the entire study for both control and contact infants. At each data point, $n = 15$ infants. Representative standard errors of the mean are placed at 3 minutes 40 seconds.

cision. The system differs from the orogustatory one in its neural mediation, it is not opioid-mediated,[30,31] and in its time course, which is rapid in onset and offset.[11,14] The 2 systems are additive.[7,12] Infants sucking a sweet pacifier cry considerably less than those who suck an unflavored pacifier during circumcision.[12] The combination is also more effective in combating pain in rats than is either component alone.[32]

The present study reveals that the third component of the natural nursing–suckling interaction, namely, skin-to-skin contact, is also markedly analgesic under our procedure, reducing crying by 82% and grimacing by 65%. For this procedure to be effective, the mother must be relaxed when holding her infant and must hold her close applying a light, but firm, pressure to the infant's back. In our experience, the key to insuring success was the 10 to 15 minutes of privacy with the infant in the ventral–ventral position. We should note, however, that we have not explored the range of time or the intensity of the mother's grasp on the infant. During this time, the mothers decided on the arrangements for the test setting. Some opted to watch television, others for drawn shades and a quieter ambience. Nonetheless, it is not the quiet or the lack of intervention per se that caused analgesia, because control infants who had been resting undisturbed did not benefit from the interlude.

In this regard, kangaroo care differs from how sweet taste or sucking relieves pain in newborns. It is context dependent. The influence of taste or sucking seems to be context independent. Sucrose delivered via syringe by a stranger to infants who are not being held markedly reduces crying and grimacing to heel stick, as does sucking a pacifier in the same circumstances. In contrast, contact effectiveness is very much dependent on the contact source being a relaxed individual, who is holding the infant comfortably, yet firmly, against her skin. An additional difference between contact-based analgesia and those induced by oral stimulation is the time course of induction. Both sucking and taste-induced analgesias are of rapid onset. In contrast, contact-induced analgesia is of a gradual onset: 10 to 15 minutes of contact were required to prevent excessive crying and grimacing.

These contextual considerations are important in our view because holding as a source of analgesia persists well into childhood[35] and is a source of comfort for adults as well. Sucking is certainly not used as a source of analgesia beyond weaning, so we can not comment on its behavioral efficacy. Fat flavor may reduce pain perception in adults and this requires additional exploration to determine which of the effective infant antinociceptive manipulations continue into the postweaning period.[55,56]

Contact-induced analgesia is consonant with the idea that a major direct and indirect benefit of pain and stress reduction by any of the components of suckling is energy conservation.[49] This is especially true for skin-to-skin contact because of the substantial change in surface to mass ratio. For example, when a 7-pound infant is placed in full ventral contact with her 135-pound mother, the surface: mass ratio is reduced fourfold from .11 m^2/kg to .03 m^2/kg with its attendant decrease of heat loss transfer. This protracted contact is of obvious advantage to both mother and infant in the evolutionary sense and is common in a number of nonwestern societies that live in more temperate climates.

These findings are of clinical relevance because they offer an alternative to parents who are reluctant to have their infants suck a pacifier or taste a sweet solution to combat pain without pharmacological intervention. Because enrollment was high in the present study (88%), although parents did not know whether their infants would be assigned to the control or contact group, it is reasonable to assume that a high level of cooperation would be the rule for prevention of routine pain in the hospital. It does not require additional effort on the part of nursing or medical staff or the phlebotomist responsible for the blood draw.

CONCLUSION

In summary, skin-to-skin contact is an effective, easily implemented, and safe intervention against pain in human newborns. The high rate of cooperation from the mothers in this study suggests that this procedure can be implemented readily in standard hospital settings.

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