Effects of Breastfeeding on Pain Relief in Full-term Newborns

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Aim: Breastfeeding may be useful for relieving procedural pain experienced by neonates. Researchers have compared breastfeeding against other pain relieving approaches in several studies, presenting marked methodologic heterogeneity.

Objective: To investigate the effectiveness of breastfeeding in reducing pain in newborns undergoing blood collection for newborn screening.

Method: The sample of this randomized clinical trial study consisted of 60 full-term newborns: 31 in the experimental group and 29 in the control group. The experimental group was breastfed 5 minutes before, during, and for 5 minutes after the blood collection procedure. Neonates in the control group were held in mothers' arms but not fed or given a soother. The duration of breastfeeding was prolonged in comparison to previous studies.

Results: The primary outcomes were Neonatal Facial Actions (Neonatal Facial Activity Coding System-upper face), sleep-wake state. Heart rate was considered as an index of arousal. Sucking frequency was only evaluated in the experimental group. Compared with the control group, the experimental group had significantly lower, Neonatal Facial Activity Coding System and sleep-wake state scores and heart rates changes. In the experimental group sucking frequency was highest during the first 5 minutes of breastfeeding before the procedure.

Discussion: This study innovates from earlier studies in 4 respects: the different phases of the procedure were evaluated separately; the breastfeeding intervention covered the period from 5 minutes before the blood collection until the end of recovery; sleep-wake state was fully assessed (not merely crying) and the sucking frequency in the experimental group was assessed during the procedure. The conclusion was that breastfeeding was effective in reducing pain caused by blood collection for newborn screening.

Key Words: pain, newborn, breastfeeding, screening, neonatal nursing

(*Clin J Pain* 2009;25:827–832)

Acute painful procedures are the most common source of pain experienced by the newborn. Within the first week of life, the normal newborn will experience 2 needle puncture procedures: intramuscular injection[1] and heel lance to draw blood for newborn screening.[2] Although the procedures are of short duration, they may cause the neonate much distress.

Researchers and clinicians have looked for ways to reduce pain and promote comfort during invasive procedures. These include methods such as the ingestion of sucrose[3–5] or glucose,[6] skin-to-skin between parent and infant,[7,8] non-nutritive suckling,[9] positioning,[10] and holding.[11] Breastfeeding has also been thought to be useful for relieving pain in neonates.[2,12–14]

Breastfeeding joins 4 aspects: maternal odor,[15] antinociceptive mechanism of milk and non-nutritive suckling,[16,17] and mother-child contact comfort.[18,19] The effects of each of these as nonpharmacologic interventions for pain relief during painful procedures have been documented in previous studies.

Researchers have compared various combinations of the above interventions for reducing needle puncture pain in newborns, but the results are not consistent. One study found that the benefits of glucose followed by pacifier during venepuncture did not differ from breastfeeding,[13] whereas another found that sucrose was superior to breastfeeding. One issue that has been raised relates to adequacy of the duration and timing of breastfeeding.[14]

There are 2 systematic reviews about the effectiveness of breastfeeding and breast-milk.[12,20] The most recent review identified only 5 studies about breastfeeding, which included term newborns.[20] The authors concluded that breastfeeding was associated with less changes in physiologic [heart rate (HR)] and behavioral [cry, grimace and Neonatal Facial Activity Coding System (NFCS), Premature Infant Pain Profile (PIPP), Douleur Aiguë Nouveau-né (DAN) scores] indicators when compared with placebo, no intervention, positioning, pacifier, holding, and swaddling, but it was similarly effective as higher concentrations of glucose and sucrose.[14] No study has evaluated effectiveness of repeated administration of breastfeeding or supplemental breast milk for pain relief.[12,20]

As far, we know in most research, breastfeeding started 2 minutes before the procedure and was carried on throughout the procedure, but not afterward. It may be that a longer duration of breastfeeding before the intervention would be more effective. Besides, researchers did not assess whether or not neonates were sucking, and sucking adequately, so that the intervention may not have been delivered to all study participants.

We hypothesized that newborns receiving breastfeeding 5 minutes before, during, and 5 minutes after heel lance to draw blood for newborn screening will experience less pain during the painful procedure (antisepsis, heel lance, squeezing, and wound compression) and will have better bio-behavioral recovery in comparison with nonbreastfed

Received for publication March 10, 2008; revised May 7, 2009; accepted May 11, 2009.

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Funded by the Brazilian National Council for Scientific and Technological Development (CNPq).

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newborns. The aim of this study was to investigate the effectiveness of breastfeeding in reducing pain in newborns undergoing blood collection for newborn screening.

MATERIALS AND METHODS

Participants

This study consisted of 60 full-term newborns. The sample represented the entire number of available eligible newborn who were scheduled to have blood collection for the newborn screening in the Clinics Hospital at Ribeirão Preto School of Medicine, University of São Paulo (Brazil) between October 2004 and January 2005.

In Brazil, neonatal screening for phenylketonuria (PKU) and congenital hypothyroidism (CH) has been mandatory since 1990. In 2001, the Newborn Screening National Program was implemented as a public health program. The Brazilian Health Ministry proposed to implement National Screening in phases according to the level of organization in each state: phase 1, diagnosis of PKU and CH; phase 2, diagnosis of phase 1 disorders and hemoglobinopathies (Hb); and phase 3, diagnosis of phase 2 disorders and cystic fibrosis (CF).[21] When data collection was performed in the present study, infants were screened for phase 2.

The inclusion criteria were: being exclusively breastfed; gestational age at least 37 weeks; Apgar ≥ 7 at 5 minutes after birth; and postnatal age not more than 7 days. The following exclusion criteria were adopted: congenital diseases of the nervous system, malformation, or neurologic damage; stomatognathic disorders that would interfere with sucking mechanics; use of analgesics interfering in nociceptive responses in infants; use postdelivery analgesics for the mothers, and newborns being admitted to the neonatal intensive care unit (NICU).

Of the 64 mothers initially approached, 4 infants were not entered into the study because their mothers declined participation. The 60 infants who met the inclusion criteria and whose mother agreed to their infant's participation were randomly assigned into 2 study groups: breastfeeding during blood collection (n = 31) and held in mother's arms without breastfeeding during procedure (n = 29). Randomization was achieved using a sequence of random numbers from a computer-generated sequence.[22]

Procedures

Ethical approval to conduct this study was obtained from the Hospital Ethics Committee and all 60 mothers signed an Informed Consent term before their infant's blood collection.

The painful procedure used for this study was the heel lance to obtain blood for the newborn screening. The 5 phases of the study are depicted in Table 1: baseline; intervention (breastfeeding/held in mother's arms without breastfeeding); blood collection; compression; and recovery. The technique used in the blood collection procedure consisted of 3 subphases: antisepsis, heel lance, and heel squeeze. After the procedure, pressure is applied to the heel to stop bleeding. Because heel compression can be a source of discomfort, it was analyzed as a separate phase.

The only difference in procedure for the 2 groups was in breastfeeding. In the experimental group, the newborn was placed on the mother's lap and breastfed 5 minutes before the procedure, during the entire blood collection, wound compression, and for 5 minutes after the procedure was completed. In the experimental group mothers were free to choose what breast would be used. The choice of breast determined whether the heel lance procedure was carried out on the neonate's right or left heel (if the right breast was sucked, the right heel was used for the blood collection, and vice versa).

The study did not start until the infant was observed to be sucking at the breast. Effective sucking movements were defined as movements in which the sucking sufficiently moved the temporomandibular joints to allow the infant to obtain maternal milk and eventually swallow it.

The control group newborns were not breastfed but held by the mother for the same length of time as the experimental group. Maternal holding is the standard care for blood collection for newborn screening at the clinic. We considered holding an effective intervention to compare with breastfeeding because its effectiveness to reduce acute pain in term newborns has been proved.[11,23,24] If the infant's head rested on the mother's left arm, the puncture was made on the infant's left heel. If the infant's head rested on the mother's right arm, the puncture was made on the right heel.

The remaining procedure was identical for both groups. None of the infants had been breastfed for at least 30 minutes before the study procedures commenced. Infants in both groups were kept in a semielevated position in the mother's arms, turned toward her, with the bottom supported by one of her arms and the infant's head by the other.

To facilitate observation, all newborns wore only an undershirt, room temperature was at least 27°C, to make sure that the infants would not be stressed by cold.[25]

TABLE 1. Phases of the Study

Phase	Duration (seconds)	Data Collected	Description
1. Baseline	120	HR	Held by mother arms
2. Intervention	300		Breastfeeding vs. held without breastfeeding
3. Antisepsis plus blood collection	Mean = 250	HR, sleep-wake state	Antisepsis = cleanse skin with cotton and alcohol Blood collection = heel lance followed by squeeze
4. Blood collection	Mean = 223	NFCS	
5. Compression	Mean = 41	HR, NFCS, sleep-wake state	Compressing puncture wound to stop bleeding
6. Recovery	300	HR, NFCS, sleep-wake state	Up to 5 min after end of compression

HR indicates heart rate; NFCS, Neonatal Facial Activity Coding System.

Eighty-three percent of newborn screening was carried out by one nurse. A second nurse substituted during a holiday period. Both had received the same technical training and used the same collection procedure.

Two digital cameras were used to record the newborn's behavior.[26] One camera focused on the newborn's face and continuously recorded the facial action, whereas the second camera was placed to film the infant's entire body. Video data were used to assess sucking frequency, sleep-wake state and facial actions.

Analysis of facial actions was carried out by a coder who was blind to the phase of the procedure. This was possible because the procedure was not recorded on the face video. It was not possible to create a blind condition for the group assignment as the information about breastfeeding was easily determined in both body and face videos.

Measures

Facial Actions

The NFCS was used to assess facial actions. The use of breastfeeding as an intervention in the experimental group affected some oral activities included in the NFCS, which required scale adaptations using the approach taken by others.[27–29] Three signs were considered in this study: brow bulge, eye squeeze, and nasolabial furrow (upper face).

Three upper facial actions were scored by a trained coder as present or absent for 2-second intervals of data in 3 phases. The first 20 seconds of the compression and recovery phases were coded at 2-second intervals, producing 10 scores for each phase. The maximum score for each of these 2 phases was 30 (that is, 3 facial actions $\times 10$ two-second intervals). The coder was blinded regarding the assessment phases, medical information, and the characteristics of infants.

To best capture the moment of pain associated with the blood collection, facial actions were only coded in the heel lance-squeezing (blood collection) portion of the antisepsis-heel lance-squeezing subphases.

The first 4 seconds, during which antisepsis occurred, were discarded, only considering the next 16 seconds for this phase. Thus, scores are presented as percentage values, as the puncture/squeezing period (blood colletion) was evaluated for 16 seconds, against 20 seconds for the others phases (compression and recovery).

For the sake of data comparability, NFCS scores were displayed in terms of the maximum number of activities possible in each period. The denominator for the blood collection phase was 24 (8 intervals of $2\,s \times 3$ possible face actions) $\times 10$; for the other phases, the denominator was 30 (10 intervals of $2\,s \times 3$ possible face actions) $\times 10$.

A different number of neonates was included for analysis in each study phase, given the difficulty of videotaping an infant being breastfed or held in the mother's arms. Missing data were considered when the recorded newborn's face was blocked for more than half of the time of each phase. The percents of missing data were 9.7%, 6.5%, 13.0% and 6.9%, 27.6%, 13.8% in the blood collection, compression, and recovery processes for experimental and control groups, respectively. Mean substitution for imputation missing data was used.

Sleep-Wake State

The infant's sleep-wake state was categorized on the basis of Precthel's method[30] by scoring deep sleep, active sleep, drowsy, quiet alert, active alert, and cry. Sleep-wake state was evaluated, first using facial videos and consulting body videos for confirmation. These different states were analyzed in terms of frequency and duration for 30 seconds every 2 minutes in the antisepsis plus blood collection, compression, and recovery phases. Sleep-wake state was treated as a quantitative variable in data analysis, as it represents an ordinal scale with states of increasing consciousness. The states were scored as follows: deep sleep = 1; active sleep = 2; drowsy = 3; quiet alert = 4; active alert = 5; and cry = 6.

Heart Rate

HR was measured using a heart monitor. One research assistant observed the monitor and recorded the reading on a data sheet each minute from baseline to recovery. It should be highlighted that HR was considered as an index of arousal, not pain.

Suckling

Suckling was only evaluated in the experimental group. Alterations were also evaluated in the different phases. On the basis of the recordings, we counted the number of suckles every 30 seconds, finally obtaining frequencies per minute.

Data Analysis

The reliability of the ratings of NFCS and the sleep-wake states were determined by means of percentage agreement between the 2 coders. A random sample of 33% of the recordings was used, involving 20 newborns (10 from each group). Agreement levels of at least 80% or higher between the 2 coders were achieved for all cases.

All data collected through the different instruments were typed in 3 Excel worksheets and later processed using Statistical Package for Social Sciences (SPSS), version 10.1, for descriptive (frequency) and comparative statistics (intergroup and intragroup comparisons). Infant characteristics were analyzed by using Student t test and Mann-Whitney's nonparametric test for 2 independent variables or χ^2 test and Fisher exact test for qualitative (or categorical) variables.

The Mann-Whitney statistical test was used to compare NFCS scores for each of 3 phases (heel lance-squeezing sub-phases of the antisepsis plus blood collection phase; compression and recovery). Using the results of the receiver operating characteristic (ROC) curve, a score of 3 was chosen as the best cutoff value.[24,25] The groups were dichotomized according to NFCS scores < 3 or NFCS scores ≥ 3 and compared in the 3 distinct phases, using Fisher exact test. When the cutoff point was used, for the heel lance phase, expected values of 95%, 63.3%, and 46.7% were used for the blood collection, squeezing, and recovery phases, respectively.

As to the sleep-wake state the Mann-Whitney statistical test was also used to compare the 2 groups in 3 phases: antisepsis plus blood collection, compression, and recovery. Using a repeated-measures analysis of variance, HR was assessed for the 2 groups and 4 phases (baseline, antisepsis plus blood collection, compression, and recovery).

A significance level of alpha ≤ 0.05 was adopted for all main analyses. For parametric post-hoc comparisons, the

significance level was set as alpha divided by the number of post-hoc comparisons to off-set type I error associated with multiple comparisons.

In the experimental group, sucking covered the period between the start of breastfeeding (5 minutes before antisepsis plus blood collection phase) and the fifth minute of the recovery phase. It was analyzed using Friedman's nonparametric test.

RESULTS

Infant Characteristics

Characteristics of the sample are presented in Table 2. There were no significant differences between groups in terms of age of mother, sex of infant, delivery type, hospitalization on day of newborn screening, birth weight, Apgar at 1 minute, Apgar at 5 minutes, time (seconds) to carry out the newborn screening, time (seconds) of blood collection, or number of punctures during blood collection.

Effect of the Intervention

NFCS

Scores for each analysis were significant. The control group's median scores were significantly higher when compared with the experimental group. This indicated greater pain experienced by the control group in all phases. Mean NFCS scores can be found in Table 3.

When the cutoff point was used, no statistically significant difference was found when comparing the groups in the blood collection phase, with 90.3% and 100% for the experimental and control group, respectively ($P = 0.238$). For the other phases (squeezing and recovery), a statistically significant difference was found between the groups, with 35.5% for the experimental group against 93.1% for the control group in the squeezing phase ($P = 0.000$) and 19.4% for the experimental group against 75.9% for the control group in the recovery phase, respectively ($P = 0.000$).

Sleep-wake State

Both groups showed different behaviors during the procedure. The experimental group's scores were significantly lower in all 3 phases ($P < 0.001$), with a predominance of the sleeping state, except during the blood collection phase. During the antisepsis plus blood collection, compression, and recovery phases, 41.9%, 78.0%, and 87.1% of the babies in the experimental group were in this state, respectively, against 0%, 6.9%, and 10.0% in the control group.

Heart Rate

The interaction was significant ($F_{1,55} = 17.03$; $P < 0.01$). Post-hoc comparisons indicated that there were no significant differences for the 2 groups during baseline or compression. However, HRs were found to be significantly higher for the control group when compared with the experimental group during antisepsis plus blood collection and recovery. Mean HRs can be found in Table 4.

Sucking

Mean number of sucks per minute in each phase was: 5 minutes before antisepsis plus blood collection = 36, antisepsis plus blood collection = 17, compression = 22, and recovery = 12. Friedman's nonparametric test was significant ($\chi^2 = 18.6$; $P < 0.01$). Therefore, the sucking rate was higher before the heel lance and the rate dropped as the invasive procedure began.

DISCUSSION

Breastfeeding was found to be effective for relieving pain caused by the blood collection for full term newborn screening and this finding was consistent across all outcome measures. Newborns receiving breastfeeding 5 minutes before the procedure, during, and afterward demonstrated less physiologic and behavioral responses of pain in comparison with newborns held in their mother's arms and not breastfed.

A study indicated the limiting effect of having breastfed the infants for only 2 minutes before starting the procedure,

TABLE 2. Infant Characteristics in Experimental and Control Groups

Variables	Experimental Group (n = 31)	Control Group (n = 29)	*P*
Infant's sex-frequency (%)			
Male	15 (48.4)	11 (37.9)	0.414 (ns)
Female	16 (51.6)	18 (62.1)	
Delivery type, frequency (%)	(n = 29)*		
Normal	16 (55.2)	17 (58.6)	0.791(ns)
Cesarean	13 (44.8)	12 (41.4)	
Hospitalization on day of blood collection, frequency (%)			
Yes	17 (55.2)	16 (55.2)	0.979 (ns)
No	14 (44.8)	13 (44.8)	
Birth weight (g), mean (SD)	3167.7 (± 517.5)	3299.5 (± 477.7)	0.311 (ns)†
Apgar at 1 min, mean (SD)	8.19 (± 1.74)	8.31 (± 1.17)	0.694 (ns)‡
Fifth-minute Apgar score, mean (SD)	9.58 (± 0.72)	9.76 (± 0.51)	0.305 (ns)‡
Total time of blood collection (s), mean (SD)	262.03 (± 113.34)	237.90 (± 87.53)	0.362 (ns)†
Number of puncture during blood collection, mean (SD)	1.14 (± 0.44)	1.10 (± 0.31)	0.965 (ns)‡
Mother's mean age (y), mean (SD)	27.8 (± 7.6)	26.6 (± 6.4)	0.505 (ns)†

*For χ^2 calculations, 2 forceps deliveries were excluded from the experimental group.
†Student *t* test.
‡Mann-Whitney *U* test.
ns indicates statistically nonsignificant.

TABLE 3. Relative Median Scores and SDs for Facial Activities on the NFCS Scale During Blood Collection, Compression, and Recovery in the Experimental and Control Groups

Phases	Experimental Group, n = 31	Control Group, n = 29	U Value-*P*
Blood collection			
Mean (± SD)	0.62 (± 0.28)	0.94 (± 0.11)	
MD (range)	0.71 (0.00-1.00)	1.00 (0.46-1.00)	116.5 < 0.001
Compression			
Mean (SD)	0.12 (± 0.22)	0.66 (± 0.29)	
MD (range)	0.00 (0.00-0.73)	0.73 (0.00-1.00)	88.0 < 0.001
Recovery			
Mean (± SD)	0.11 (± 0.27)	0.51 (0.36)	
MD (range)	0.00 (0.00-0.87)	0.53 (0.00-1.00)	184.0 < 0.001

NFCS scores are expressed as a proportion of total score. Scores nearer to 1.0 indicate more facial actions associated with pain. Group mean scores are provided for each of the phases with SDs in brackets. The variation in the number of cases included in each analysis reflects ability to view the face in the facial video recordings. The Mann-Whitney *U* test compares the median scores for each group.

NFCS indicates Neonatal Facial Activity Coding System.

which may have affected the behavioral aspect of breastfeeding, which may enable milk's calming influences to extend beyond its taste.[14] The authors highlight that taste receptors for sucrose and breast milk may not all work at the same rate, leading to a delay in response for some solutions.[14] In this study, a 5-minute breastfeeding time before the beginning of the procedure, which is longer than in earlier studies, was chosen due to the need to analyze the psychologic effect of breastfeeding.

The control group's HR rose during the procedure and remained elevated during the recovery phase. Although HR of the experimental group rose during the procedure, it did not reach the levels of the control group and returned to baseline HR levels in the recovery period. The lower scores for sleep-wake state during the recovery phase in the experimental group reflect the fact that many infants had fallen asleep. The conclusion is that breastfeeding infants had less pain than the control group infants.

An assessment was made of several variables not typically evaluated in earlier studies. This includes sleep-wake state and rate of sucking. By investigating sleep-wake state, instead of merely the presence or absence of cry, we could better evaluate the behavioral state. This evaluation made it possible to describe the most frequent states experienced by infants and to relate them to the neonates' sucking frequency.

We are not aware of any other study that has investigated breastfeeding as a nonpharmacologic measure for pain relief in newborns and evaluated sucking frequency before, during, and after the procedure. These data were very important to assess the effectiveness of breastfeeding, as the absence of sucking would jeopardize the intervention. Moreover, it was important to evaluate how infants' sucking frequency changes from one phase to another, evidencing a decrease throughout the procedure.

The decrease in average sucks per minute in this study very probably resulted from the infants' pauses during acute pain. However, during recovery, pauses were more gradual and sucking often came to a full stop, as many infants reached the stage of deep sleep.

All mothers were breastfeeding for no less than 7 days. Thus, in sucking, the infants would swallow the milk present in the breast and feel the effects of sucking by 2 means: tactile sensation in their oral cavity and gastric sensations in the digestive tract as a consequence of ingestion. They would also experience comfort from being held by their mothers' arms.

In terms of variations in human milk components during breastfeeding, the solution fraction is predominant at the beginning, which is rich in water-soluble components. In the intermediary phase, the suspension fraction is marked by casein micelles, which are progressively replaced by the fat droplets in the emulsion fraction, whose concentration at the end of the breastfeeding session is 5 times as high as at the beginning. This increased fat content is related to nutritional concerns and hunger satiety.[31] Thus, we believe that the satisfaction resulting from the sucking time helped the infants a lot to recover better.

In this study, the total time between the start of breastfeeding and the end of recovery may have been sufficient for some infants in the experimental group to reach the feeling of satiety and, consequently, remain in deep sleep during recovery. In contrast, this time may have been enough to simply calm them down and achieve deep sleep, independently from the feeling of satiety.

Limitations of this study were small sample size and that the observers obviously recognized the 2 groups when they were evaluating the recordings. However, they were not aware of the purpose of the study.

TABLE 4. Mean Values and SDs for Heart Rate (bpm) for Experimental and Control Group by Phases

Phases	Experimental Group (n = 31)	Control Group (n = 29)	*P*
1. Baseline mean (SD)	133.5 (± 13.2)	130.7 (± 14.0)	0.42
3. Antisepisis plus blood collection, mean (SD)	146.7 (± 20.8)	172.7 (± 21.5)	< 0.01
4. Compression mean (SD)	147.0 (± 25.7)	158.6 (± 28.6)	0.113
5. Recovery mean (SD)	133.6 (± 12.4)	162.6 (± 24.9)	< 0.01

Mean heart rate with SD in brackets for each group and 4 phases of the study. The Student test compares the mean scores for each group.

The methodology used in this study differs from earlier studies in 4 respects: the different phases of the blood collection procedure for newborn screening were evaluated separately; the breastfeeding intervention covered the period from 5 minutes before the procedure until the end of recovery; the sucking frequency was assessed during the intervention and the sleep-wake state was fully assessed (not merely crying).

On the basis of our results, we recommend the use of breastfeeding as a safe and effective nonpharmacologic intervention for pain relief during that procedure in full-term newborns. It may be equally effective for other similar needle insertion procedures. For the health team, treating neonatal pain represents a highly relevant action with a view to a newborn's well being.

Although several studies have been made to improve pain management in neonates, strategies should be developed to reduce the gap between research and care practice. Simple interventions that involve neither great costs nor operational problems need further exploration.

We recommend breastfeeding because it is a natural intervention, without additional costs, which can easily be applied in different acute pain situations due to the fact that mothers can freely access and participate in care for their child at the neonatal unit and in outpatient care.

Future studies need to be undertaken to compare the efficacy of a longer duration of breastfeeding (as investigated in this study) with other nonpharmacologic measures such as sucrose and other pain inducing procedures. Furthermore, the stratification of the groups by sex should be made to analyze the effect of this variable on pain responses of the preterm under breastfeeding intervention.

ACKNOWLEDGMENTS

The authors thank all the contributors who made this study possible, most notably mothers and their infants, and nurses of the Hospital at Ribeirão Preto School of Medicine, University of São Paulo.

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